PRICE FIFTY CENTS

FM AND TELEVISION

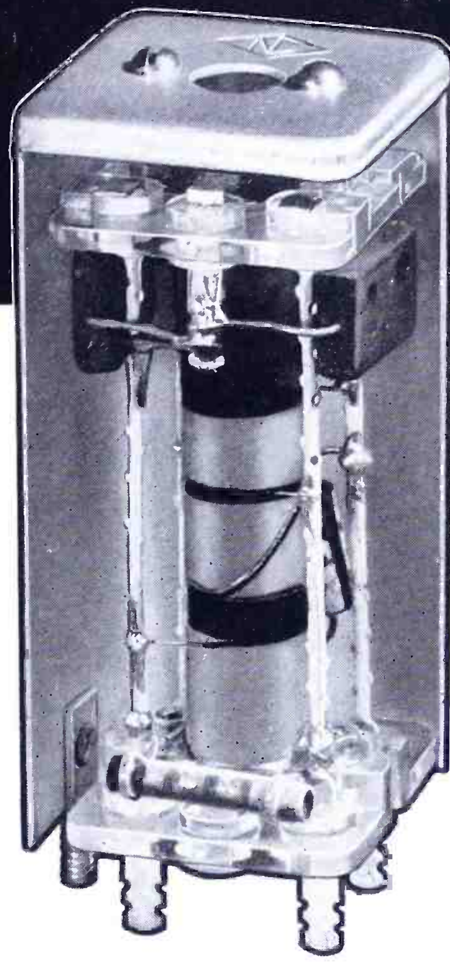
JUNE 1947

10 KW. FM FROM FOUR TETRODES

(SEE PAGE 3)

★ ★ Edited by Milton B. Sleeper ★ ★

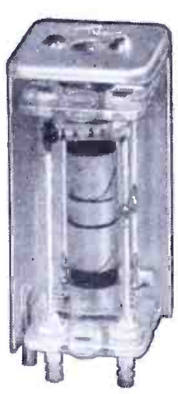
● The IFL, IFM, IFN and IFO transformers all operate at 10.7 mc and are designed for use in FM or AM superheterodyne receivers. The transformer cans are 1 3/8" square and stand 3 1/8" above the chassis.



● The IFL discriminator transformer is suitable for use in conventional FM receiver discriminator circuits and is linear over a band of ±100 KC.

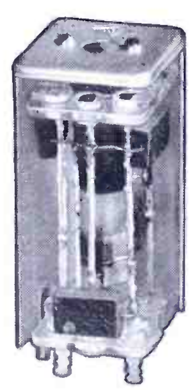
Please write to Department 14, National Company, for further information

THE WHOLE OF YOUR EQUIPMENT DEPENDS ON ITS PARTS



● The IFM is an IF transformer with a 150 KC bandwidth at 1.5 db attenuation. Approximate stage gain of 30 is obtained when used with 6SG7 tube.

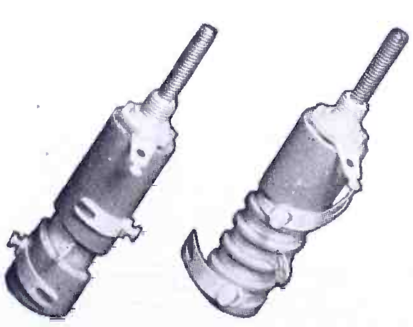
● The IFN is an IF transformer with a 100 KC bandwidth at 1.5 db attenuation. Approximate stage gain of 30 is obtained when used with 6SG7 tube.



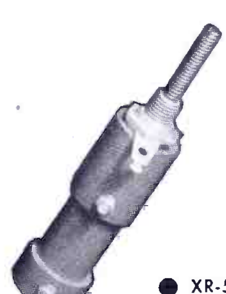
● The IFO is an FM discriminator transformer of the ratio type and is linear over a band of ±100 KC.

. . . You can't afford to jeopardize the success of expensive equipment by using inferior parts. Through long practical experience manufacturers, engineers, and laboratory research workers have all found that it pays to use National parts in constructing new apparatus. Good materials and exacting workmanship have made them a by-word for dependability and long-life.

Send for the new 1947 National catalog containing over 600 parts today.



● The AR-2 and AR-5 coils are high Q permeability tuned RF coils. The AR-2 coil tunes from 75 mc to 220 mc and the AR-5 coil tunes from 37 mc to 110 mc with suitable capacitors.



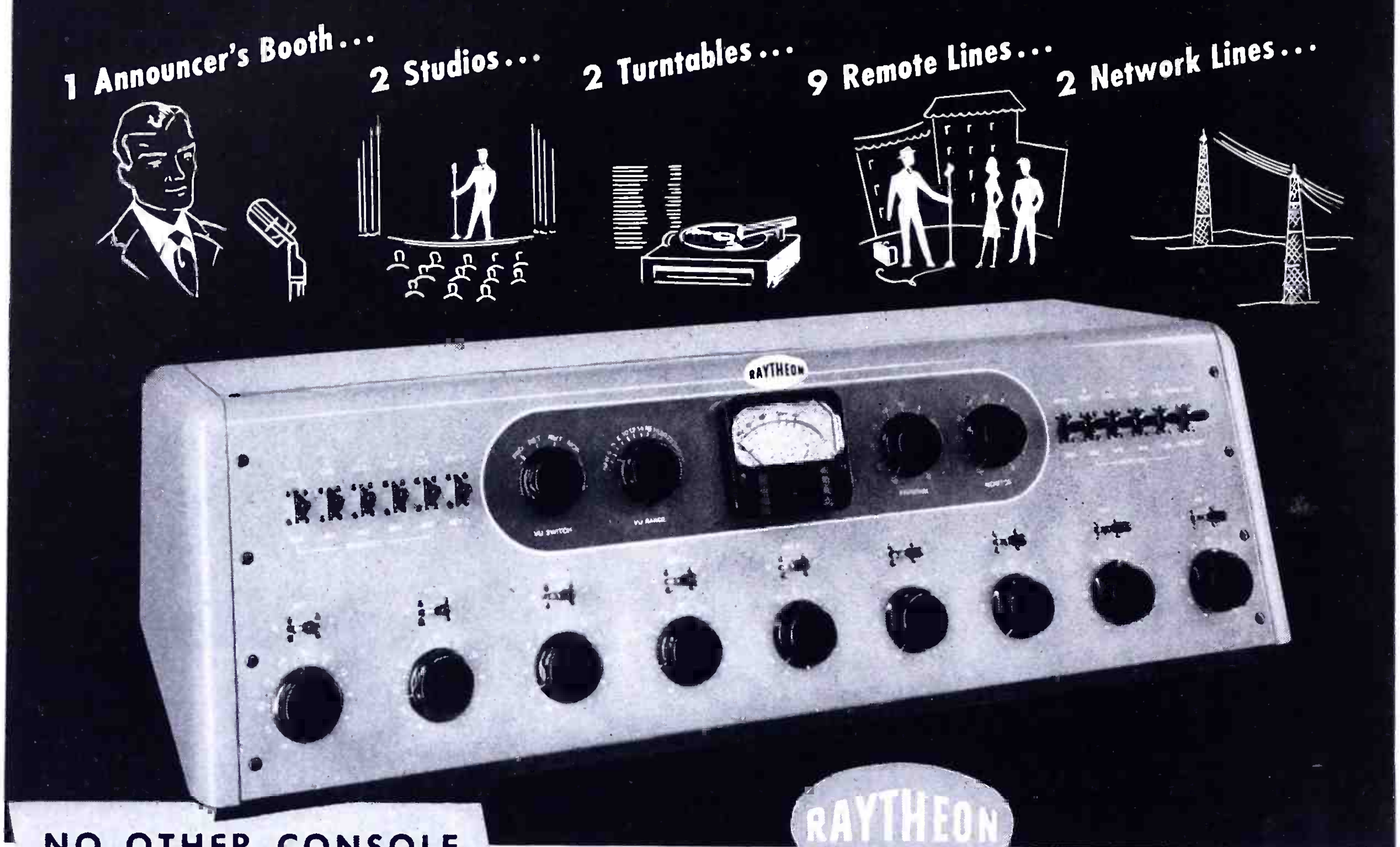
● XR-50 coil forms may be wound as desired to provide a permeability tuned coil. The form winding length is 11/16" and the form winding diameter is 1/2". The iron slug is 3/8" diameter by 1/2" long.

National
EST. 1914

National Company, Inc.
Malden, Mass.

MAKERS OF LIFETIME RADIO EQUIPMENT

All controlled by 1 STUDIO CONSOLE



NO OTHER CONSOLE
offers all these outstanding features . . .

Seven built-in pre-amplifiers — put 5 microphones and 2 turntables, or 7 microphones, on the air simultaneously.

Nine mixer positions — lead to 5 microphones, two turntables, one remote line and one network line.

Nine remote and two network lines — may be wired in permanently.

Most dependable, trouble-free switches used throughout.

Frequency Response 2 DB from 30 to 15,000 cycles. Ideal speech-input system for either AM or FM.

Distortion less than 1%, from 50 to 10,000 cycles.

Noise Level minus 65 DB's or better. Airplane-type four-way rubber shock mounting eliminates outside noise and operational "clicks."

Meets all FCC Requirements for FM transmission.

Dual Power Supply provides standby circuit instantly available for emergency use.

Instant Access to all wiring and components. Top hinged panel opens at a touch. Entire cabinet tilts back on sturdy full-length rear hinge.

Providing *complete* high-fidelity speech-input facilities for the modern station . . . with all control, amplifying and monitoring equipment in a *single compact cabinet* . . . the Raytheon RC-11 Studio Console handles any desired combination of studios, remote lines or turntables, broadcasting and auditioning simultaneously through two high quality main amplifier channels.

Telephone-type, lever action 3-position key switches reduce operational errors to a minimum; while efficient, functional appearance and smart two-tone metallic tan blend well with other studio equipment.

Priced remarkably low . . . write for details!

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FM AND TELEVISION

FORMERLY, FM MAGAZINE and FM RADIO-ELECTRONICS

VOL. 7 — JUNE, 1947 — NO. 6

CONTENTS

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Published by: FM COMPANY

Publication Office: 264 Main St., Great Barrington, Mass. Tel. Great Barrington 500
New York: 511 Fifth Avenue, New York 17, Rel. VA 6-2483
Chicago: MARIAN FLEISCHMAN, 360 N. Michigan Ave., Tel. STAte 4822
Pasadena: MILO D. PUGH, 35 S. Raymond Ave., Pasadena 1, Calif. Tel. Madison 6272

FM Magazine is issued on the 20th of each month.

Single copies 50¢ — Yearly subscription in the U. S. A. $5.00; foreign $6.00. Subscriptions should be sent to FM Company, Great Barrington, Mass., or 511 Fifth Avenue, New York 17, N. Y.

Contributions will be neither acknowledged nor returned unless accompanied by adequate postage, packing, and directions, nor will FM Magazine be responsible for their safe handling in its office or in transit. Payments are made upon acceptance of final manuscripts.

THIS MONTH'S COVER

This month's cover picture is of great interest to FM transmitter engineers and designers because it discloses the method used by REL to obtain 10 kw. output on the FM broadcast band of 88 to 108 mc.

REL's solution is the use of four Eimac internal anode tetrodes, with a very smart plumbing arrangement combined with soundproofing. This 10-kw. amplifier, operating at 80% efficiency, can be driven from a ½-kw. exciter, or a 1-kw. driver working at reduced power. The new name Quadriline comes from this 4-tube design.

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

MEMBER, AUDIT BUREAU OF CIRCULATIONS

WHAT'S NEW THIS MONTH

FM Set Designs

WALTER BUEHR certainly started something with his article on "High Fidelity FM at Mass-Market Prices" in our March issue. It couldn't have been more perfectly timed, for the sharp break in AM set sales came just when that issue appeared.

The comments were all very favorable and represented many different points of view. Even the following letter wound up with a pat on the back:

"Man, you're just the customer I am looking for. After reading your article on design emphasis, there is little doubt that you will want to buy my functional automobile. It costs you $200 less than a real automobile, but think of the real value you are getting.

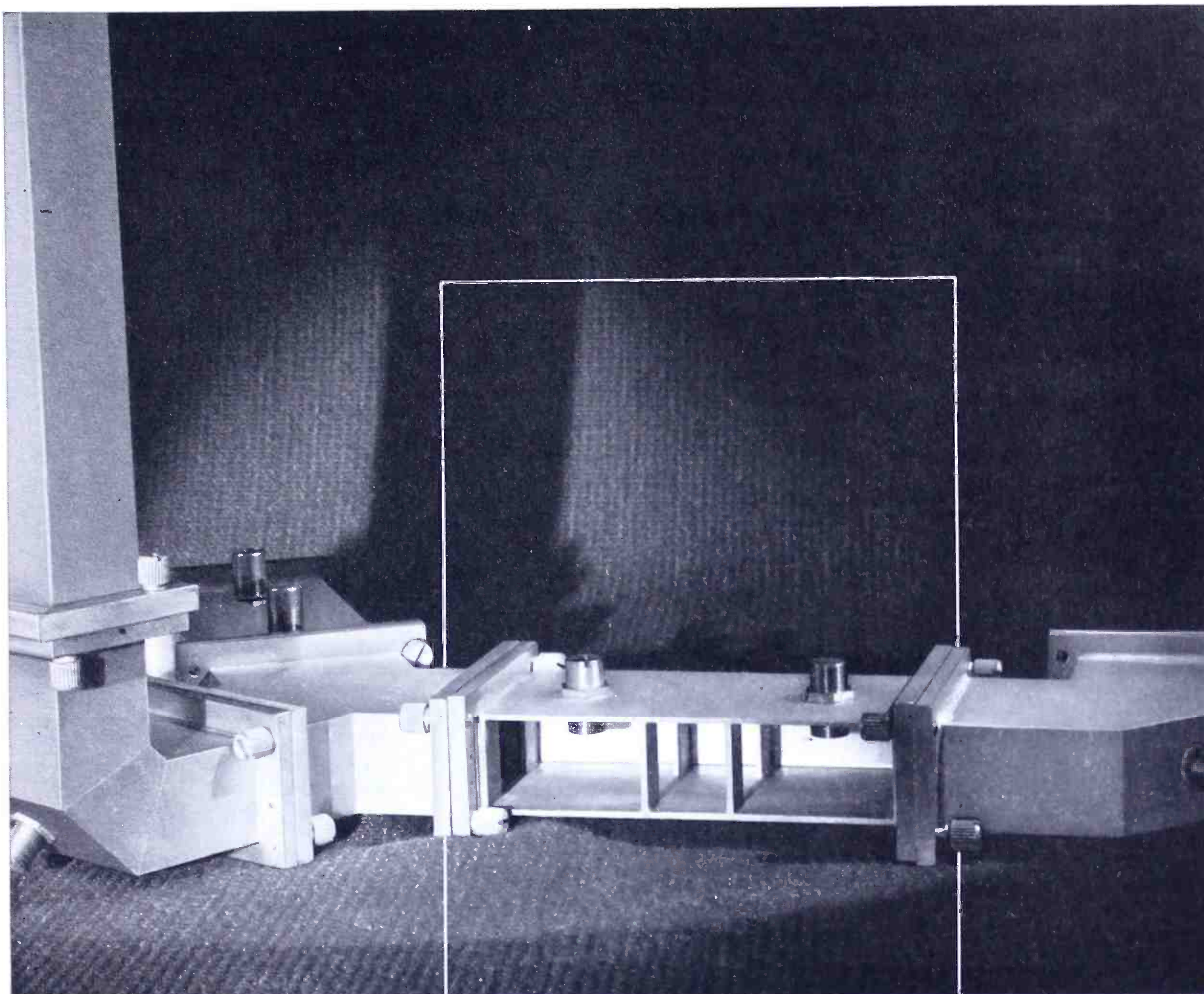
"After all, what is an automobile — it is essentially an engine and a seat mounted on four wheels. Why not stop there? The motor needs protection against dust and prying fingers. Fine! Put a large soap box over it and you have a functional unit. The soap box is unfinished, but you as the customer can stain or paint it to suit your personality. If you have little personality, you can leave it unfinished. Here is real flexibility.

"To keep the overall job small in size, it is possible to mount the driver in with the engine. The exhaust heats him in winter and the fan cools him in summer. The finished (woops — unfinished) product will be priced low enough to permit the development of a mass market. 'No kidding, boy, you got something there.'" The letter was signed *Vitamin Flintheart.*

Mr. Newell T. Crolius, of Radio Wire Television, Boston, had this to say:

"In reviewing the March issue of *FM* AND TELEVISION, we took special notice of Mr. Buehr's article on page 31. In our shop here in Boston, we are emphasizing the very ideas which are illustrated in this article, and feel that the customers interested in high-quality reproducers are growing more and more inclined to 'junk the furniture'. As a matter of fact, a good portion of our business has been in what we term custom-built jobs, many of which have been set up in a manner similar to the methods Mr. Buehr describes.

"Material such as this, in written form, is rare as you know. Hence we would appreciate your advising us as to whether reprints of the above article are available for distribution, for they will aid us greatly in our service to customers interested in this type of equipment."



PRODUCTS & LITERATURE

So many new instruments, components, and materials are being brought out that space does not permit us to publish illustrated descriptions of them all. Accordingly, rather than selecting a few each month, we have established this new department of Products & Literature so that a great number of brief descriptions can be published. From these, you can select items which interest you, and send for catalogs or bulletins. We'll appreciate it if you will meantion FM and TELEVISION in your requests.

Terminal Lugs of minature size, intended for small radio assemblies, hearing aids, microphones, and meters. Silver-plated, machined lug 3/32 in. in base diameter, projecting 3/32 in. above a 1/64 in. terminal board. Roll-over shank is .25 in. long. Also available with .45-in. shank. — Cambridge Thermionic Corp., 445 Concord Ave., Cambridge, Mass.

Photo, C-R, and Special Tubes are described in a 16-page booklet, giving technical data and terminal diagrams on 113 types. Section on photo-tubes shows outline dimensions and spectral-sensitivity curves for equipment design use. Price 10¢ — Booklet CRPS-102, Commercial Engineering, Tube Department, RCA, Harrison, N. J.

Reproducer Heads of high-fidelity design for broadcast stations, recording studios, theatres, and factory sound systems. Vertical, lateral, and universal types are available, each equipped with diamond-point stylus. All types are interchangeable on plug-in tone arm mounting. Response is rated as flat from 40 to above 11,000 cycles. — Radio Music Corp., East Port Chester, Conn.

FM Receiver for 88–108 mc. A7-tube straight FM table model designed to make FM reception available at low cost. Can also be used as an FM tuner in conjunction with AM sets. — Electronics, Inc., 934A Bowen Building, Washington, D. C.

Stand-Off Terminals with the lugs and threaded inserts or screws molded into melamine or mica-filled phenolic. Sizes suitable for use on radio receivers and transmitters. — Winchester Co., 6 E. 46th St., New York 17.

Keying Relay designed to operate up to 20 pulses per second on 5 milliamperes with .125 watt in the coil, up to 40 or 50 impulses at higher wattage ratings. Design features rugged precision construction, with steel base, annealed Armco iron core with ground pole face, Oilite bearings, ⅛-in. silver contacts. Can be supplied in hermetically-sealed case. — Signal Engineering & Mfg. Co., 154 W. 14 St., New York 11.

Beat-Frequency Generator for use with an oscilligraph to show frequency-amplitude characteristics. Eliminates hand-plotting curves for amplifiers, filters, transformers, and balanced circuits. Sweep rate of 5 to 8 seconds is particularly adapted to speaker testing. Technical bulletin gives complete data. — Clough Brengle Co., 6014 Broadway, Chicago 40.

Television Receiver, table model with 10-in. tube. This is the first television receiver offered for sale by Philco. Manual controls include television station selector, brightness, contrast, sound channel volume, and tone. — Model 1000, Philco Corp., Philadelphia, Pa.

Voltage Regulator, tube operated, holds voltage at any selected output value from 110 to 120 volts, with line voltage variations from 95 to 135 volts. Wave form distortion under normal conditions is 1 to 2%, and only 3% under extreme, adverse conditions. Operates on any load up to 1 kva. — Model 1E5101, Superior Electric Co., 53 Laurel St., Bristol, Conn.

FM-AM Antenna System for stores, designed to permit perfect demonstrations from floor models. System comprises a roof antenna, mast, coaxial down-lead, constant output amplifier, and a radiating wire from which each demonstration model can pick up signals. Amplifier gain is 30 to 40 db on FM band, and 40 to 60 db on AM band. — L. S. Brach Mfg. Co., 200-F Central Ave., Newark 4, N. J.

FM Booklet, describing the advantages of FM, and illustrating Stewart-Warner FM-AM table models and consoles, and FM-AM-TV console. — Stewart-Warner Corp., Chicago 14.

Magnetic Materials and their electrical properties are analyzed in graphs and charts presented in a new 32-page brochure. Of special value is a chart which presents the comparative properties and applications of various core materials, with their trade names. Copies of "Magnetic Materials" are available on request. — Allegheny Ludlum Steel Corp., 2020A Oliver Bldg., Pittsburgh.

Test Instruments for checking radio circuits and tubes. New types include counter tube tester with double-faced meter, multi-tester, pocket-size signal generator with fixed frequencies of 1,500, 550, 465, and 456 kc., and two signal tracers. — Radio City Products Co., Inc., 127 W. 26 St., New York 1.

Non-Spill Fly-Weight Batteries, no larger than 2 penlight dry cells, weigh only 1 oz., yet are rated at 50% more watts output than 2 class C dry batteries. Transparent plastic case is leakproof, and all free-flowing electrolyte is eliminated. Output of 2.2 volts is steady through 98% of usable life for any one charging. Size ⅞ by 9⁄16 by 1 13⁄16 in. Special charger is available. Vitamite Co., 227 W. 64 St., New York City.

Wide-Band Antenna designed for FM and television reception on 44 to 216 mc. A multi-element assembly of aluminum rods, carried on a short aluminum support. — Type FMTV44216, Interstate Mfg. Corp., 138-A Sussex Ave., Newark 4, N. J.

Printed Circuits assembled on a small ceramic plate comprise .1 mfd. coupling condenser, 250 mmf. plate RF bypass condenser, .25 meg. plate load resistor, and .5 meg. grid resistor. Details of this unit and its use are contained in bulletin 943F. — Centralab division of Globe Union, Milwaukee, Wis.

Portable Transcription Player for broadcast and professional use. The 16-in. turntable operates at 78 or 33⅓ RPM. Supplied with vertical, lateral, or universal pickup. Output impedance 30,250, and 500/600 ohms. — Model TP-13, Radio-Music Corp., East Port Chester, Conn.

Oscillograph Power Supply in portable case provides continuously variable DC voltage from 5,000 to 10,000 volts, with regulation within 20% of no-load voltage on loads up to 200 microamperes. Ripple voltage less that .5%. Uses RF oscillator with its own power supply, RF step-up transformer, half-wave rectifier, and filter. — Model 263-A, DuMont Labs., Inc., Passaic, N. J.

Folded Dipole with or without reflector for FM reception, or for television on 44–88 mc. Short mast is supplied, with roof mounting bracket. — Ward Products Co., 1523 F East 45 St., Cleveland 3, Ohio.

Miniature Tube Guide, giving characteristics and base diagrams of 72 types. Very useful information for circuit engineers and designers. — Bulletin M, Hytron Radio & Electronics Corp., Salem, Mass.

Vacuum Condenser, 2⅓ ins. in diameter by 6⅓ ins. long has 50 mmf. capacity, rated at 60 amperes, 30 kv. peak potential. Other ratings will be available. — United Electronics Co., Newark, N. J.

Outdoor Microphone designed to withstand severe shocks and abuse. All components are replaceable. Rated response 40 to 9,000 cycles, adjustable impedance 200 or 500 ohms. Designed for stand mounting. — St. Louis Microphone Co., Inc., 2726F Brentwood Blvd., St. Louis 17, Mo.

Facsimile HAS BEEN TALKED FOR YEARS

Now You Can Do Something About It!

It has always been said, "Facsimile some day will be made an adjunct to home radio and not cost too much."

This was and is an objective that Alden designers have never lost sight of.

We find our present 4.1 inch recorded line recorder (made to 4.1 inch proposed standards of the TR11 Committee on Facsimile, Transmitter Section, R.M.A. Eng. Dept.) has the simplicity needed for home use, works on the turn on of a switch wherever an FM set receives a satisfactory sound signal and it is suited for manufacture by production methods so we are pricing it now, not in the future, at $100.00. This is only the present price — volume manufacture will lower it.

To make it a package, it is housed in a mahogany chairside cabinet priced at $100.00 — with a custom built amplifier priced at $50. Thus for $250.00 and an FM set you are ready for reception.

What About Transmission

Broadcasters find all they have had to do to go on the air is roll in an Alden Scanner, plug the line cord into an AC outlet, the output into the speech amplifier and they are on the air.

The scanner is a negligible percentage of station's investment and it enables it to render another service that will promote the sale of FM sets and increase the FM audience.

Write for further details and quotations and advise if you have received our "Brown Book" on facsimile.

Alden PRODUCTS CO. 117 NORTH MAIN STREET BROCKTON 64-FM, MASSACHUSETTS

ENGINEERING SALES

Stewart-Warner: New distributors for Stewart-Warner radios are L. Luria & Sons, Inc., 400 S.W. 2nd Avenue, Miami, for southern Florida, and Andrews Distributing Company, 406 S. Columbia Street, South Bend, for 18 counties in northern Indiana and southern Michigan.

Corning Glass: C. John Phillips has resigned as manager of Corning's electronic sales department, to join Pittsburgh Plate Glass. Now the Corning electronic sales department has been merged with industrial sales, under the management of William H. Tomb.

Chicago: Wells Sales, Inc., handling radio parts and equipment, has moved to larger quarters at 320 N. LaSalle Street.

Magnavox: Pierre F. Marshall has been named advertising manager for the Magnavox line of radios, components, and audiovisual training aids.

Eimac: New sales representative for Eitel-McCullough tubes in Missouri, Kansas, eastern Nebraska, and Iowa, except Cedar Rapids, is Clyde H. Schryver. His headquarters are at the Merchandise Mart, Kansas City, Mo.

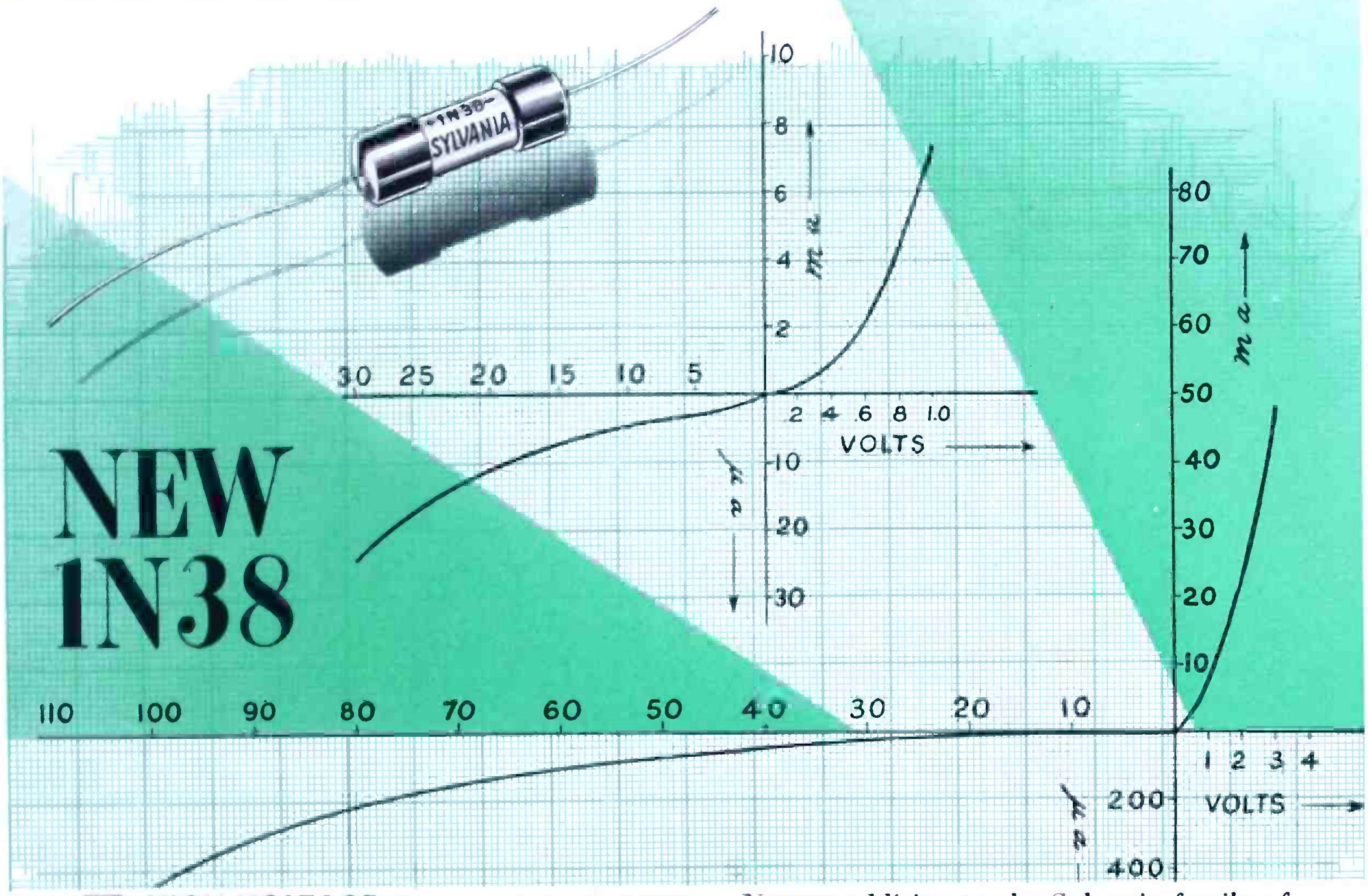
Federal: Just back after a year's special assignment in Italy, Clyde E. Dickey has been named general sales director of Federal Telephone and Radio Corporation. During 19 years with the parent IT & T Company, he was director general of the Spanish Telephone Company and vice president and general manager of the Cuban Telephone Company.

RCA: Elmer D. Eades has succeeded W. L. Rothenberg as manager of RCA's southern regional office at Citizens and Southern Bank Building, Atlanta. Rothenberg has been moved to the RCA tube department, Harrison, N. J., as renewal sales manager.

Sorenson: New general sales manager for Sorenson & Company, Stamford, Conn., is Edward R. McCarthy, formerly with Pneumatic Products and General Motors.

Chicago: The Salescrafters, Inc., headed by Ray R. Hutmacher, has opened offices at 510 N. Dearborn Street, Chicago. Hutmacher, who resigned recently from McGuire Industries, will handle Carbonneau speakers and other lines for sale to manufacturers and parts jobbers.

HIGH VOLTAGE FREQUENCY TEMPERATURE CRYSTAL



HIGH VOLTAGE. The new Sylvania 1N38 Crystal is designed for a back voltage of 100 volts maximum.

HIGH FREQUENCY. With its shunt capacitance of only 0.8 to 1.1 $\mu\mu$f, the 1N38 is ideal for high frequency use.

HIGH TEMPERATURE. Rectification efficiency decreases only .0007% per degree temperature rise from 27° to 75° C.

Newest addition to the Sylvania family of Germanium Crystals, the 1N38 is of compact, space-saving design. Pigtail leads permit easy soldering into position.

Back resistance is as high as 2½ megohms.

Minimum life is 5,000 hours at 22.5 ma DC.

Write for full details

Electronics Division, 500 Fifth Avenue, New York 18, N. Y.

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Accessibility is the keynote of this mechanical and electrical design. True vertical-chassis construction . . . used by RCA since 1935 . . . provides unimpeded up-draft ventilation, makes every component easy to reach and easy to remove. Unit-type assembly makes for flexibility, easy installation, and simple modification for higher power. Due to small unit sizes, it is particularly adaptable for high-building installations where equipment must be moved in by elevators.

3 dependable kilowatts of FM

. . . with the RCA type BTF-3B

You are looking at a 3-kw FM broadcast transmitter built strictly for professional transmitter engineers who know transmitters—yet is so simple that inexperienced personnel can tune it in minutes. It has every proved feature required for proper operation and it's free from tricks and gadgets.

You'll be interested in these facts

Fact No. 1—This transmitter uses RCA's simple, straightforward, Direct FM-type exciter . . . inherently capable of holding distortion and noise level below that of any other exciter yet developed. Frequency control circuits give stability equal to crystal operation, do not affect modulation, and cannot take your carrier off the air. With only 4 r-f stages . . . 1 oscillator, 2 triplers, 1 buffer . . . it uses fewer tubes and no trick types.

Fact No. 2—The entire transmitter uses only 9 r-f tubes . . . 1 oscillator, 2 triplers, 1 doubler, 5 amplifiers. There are 2 modulator tubes and 10 rectifier tubes . . . excluding voltage regulators. Result: only 21 tubes can seriously affect your carrier. (15 regulators and control tubes do not contribute to transmitter outages.) *This total of 36 tubes is lower, we believe, than any similar transmitter of this power.*

Fact No. 3—The BTF-3B uses the RCA-perfected Grounded-Grid circuit in both the driver and final amplifiers. It's simple to tune. It requires no neutralization. It's more stable than older, more conventional amplifier circuits.

Fact No. 4—The final amplifier uses RCA's vhf Disc-Seal tube, type 7C24 . . . especially designed for grounded-grid operation in our 1-, 3-, 10-, and 50-kw FM transmitters. Quantity-produced, fully field-tested, rugged, and inexpensive, the RCA-7C24 is the best-suited tube yet designed for this service.

Fact No. 5—Shielded tank circuit design of the final amplifier eliminates r-f current flow in transmitter housing. Result: greatly reduced housing radiation compared with conventional tank circuits . . . and greatly reduced r-f pick-up in nearby audio circuits. Reason: outer tubing of concentric tank operates at ground potential . . . provides a near-perfect shielding for its inner conductor.

Fact No. 6—Single-ended output circuits provide greater stability and are easier to adjust (no balancing required) than push-pull circuits—particularly at FM frequencies. Single-ended circuits provide easier matching to the grounded transmission lines universally used in FM service.

Full information is yours for the asking. Write RCA, Dept. 35-F, Broadcast Equipment Section, Camden, N. J.

BROADCAST EQUIPMENT

RADIO CORPORATION of AMERICA

ENGINEERING PRODUCTS DEPARTMENT, CAMDEN, N.J.

In Canada: RCA VICTOR Company Limited, Montreal

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FM Broadcast Transmitter
Type BTF-3B

We put ourselves into our work...

Skilled workmen always take great pride and satisfaction in performing effort that creates extra touches of quality.

We are fortunate in the high calibre of craftsmen who serve our organization. Here are men who like their work and who approach each new project with enthusiasm and confidence . . . who are forever working out new and ingenious methods of doing something a bit better.

Time and time again keen minds and skilled hands in our plant have licked that familiar old bugaboo, "It can't be done" by figuring out ways to do the unusual or the "impossible."

Have you a tough problem in sheet metal? We may have the solution waiting for you. Let us quote on your cabinets, housings, chassis, racks, boxes and enclosures—however unusual the design.

Write for our new catalog.

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. . . . *Custom Craftsmen in Sheet Metal* . . . . .

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Belmont Radio Corporation
3633 So. Racine Avenue
Chicago 9, Illinois

Carr Industries Inc.
1269 Atlantic Avenue
Brooklyn 16, N. Y.

Communication Measurements Laboratory
120 Greenwich Street
New York 6, New York

Cole Instrument Co.
1320 So. Grand Avenue
Los Angeles 15, California

Electronic Corporation of America
353 West 48th Street
New York 19, N. Y.

Electro-Voice, Inc.
Carroll & Cecil Streets
Buchanan, Michigan

Emerson Radio & Phonograph Corp.
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New York 11, N. Y.

Essex Wire Corporatic
1601 Wall Street
Ft. Wayne 6, Indiana

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Schenectady 5, New York

General Electronics Inc.
1819 Broadway
New York 23, N. Y.

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460 West 34th Street
New York 1, New York

Hoffman Radio Corporation
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Los Angeles 7, California

Hytron Radio & Electronics Corp.
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Johanns & Keegan Inc.
62 Pearl Street
New York 4, N. Y.

E. F. Johnson Company
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Waseca, Minnesota

National Union Radio Corporation
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Newark 2, New Jersey

Navigation Instrument Co., Inc.
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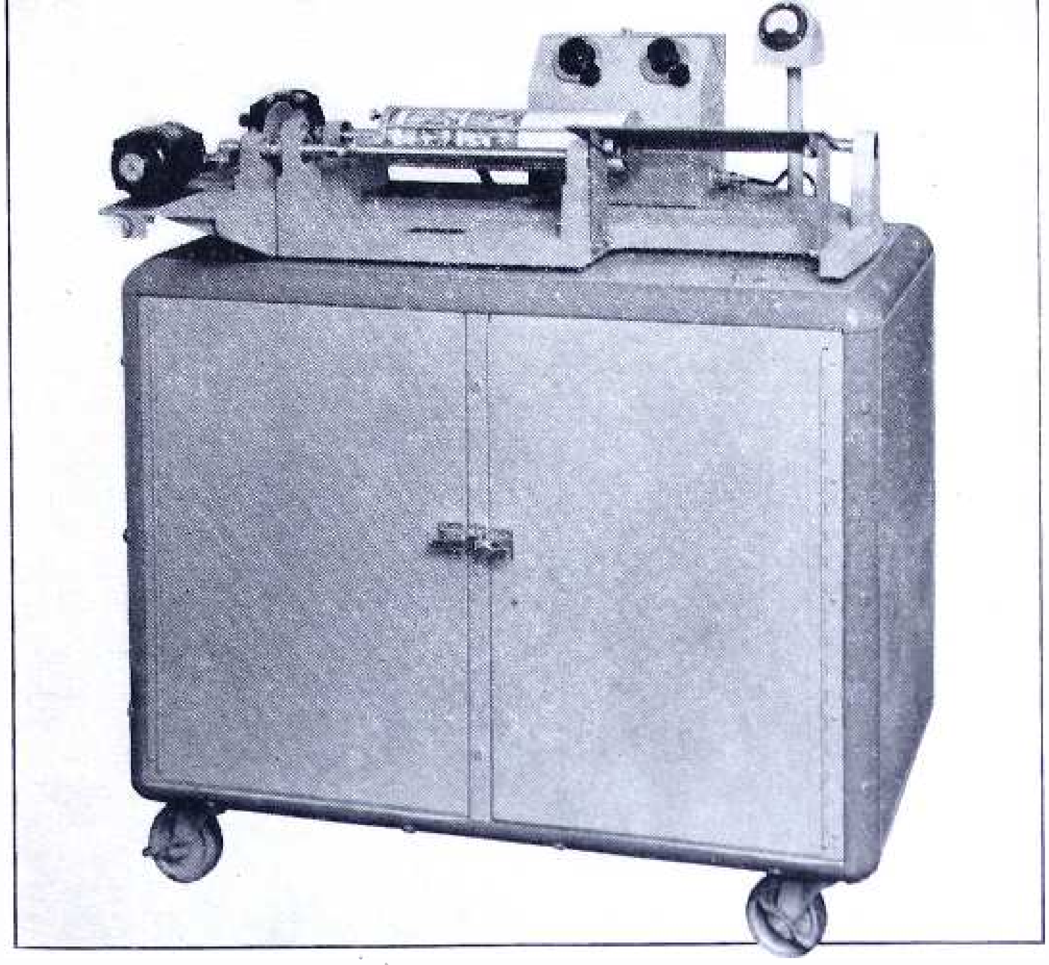


FIG. 1. ONLY THIS UNIT IS NEEDED TO BROADCAST FACSIMILE FROM AN FM STATION

FACSIMILE IS READY FOR HOME USE

A Review of Facts Which Indicate the Basis for Setting Standards, and the Method for Launching Facsimile Service

BY MILTON B. SLEEPER

THERE'S been no end of discussion about the technical status of facsimile and its possibilities as a new radio service and an advertising medium. In fact, there's been so much conversation that the fear has been expressed that facsimile is being talked to death. We have had a considerable number of articles about it in *FM and Television* Magazine. I've done a lot of talking about it myself, not only with those who are engaged in developing the equipment, but with FM set manufacturers and with newspaper and broadcast station executives who are interested in home facsimile transmission.

So I know about most of what's going on from all angles. Putting all the facts together, a bird's eye view of the situation looks something like this:

Facsimile Is Ready ★ Technically, facsimile is ready to start as a commercial service for use in home and industry. All the kinks and tricks that make the difference between special demonstrations and daily use are known and have been ironed out. Scanning equipment for FM broadcast station use is available at nominal cost. A complete installation, ready to plug into a 115-volt, 60-cycle power supply and into the speech input of an FM transmitter, comes to less than \$4,500. A rather elaborate installation, planned to meet all emergency requirements, costs under \$6,500. Fig. 1 shows a unit that does the complete electrical job of scanning the copy and translating shades between black and white into electrical impulses.

As for the receiving end, recorders are in production, and are available at \$100 each. Also required is an amplifier, costing \$50 between the FM receiver and the recorder. Later, when set manufacturers build an additional circuit into receivers, the special amplifier will not be needed.

Such a recorder is illustrated in Fig. 2. This very simple unit contains the motor and all the actuating mechanism. When a button on the top of the case is pushed, the cover flies up, and a new roll of paper can be inserted much more easily than is possible in any corresponding bathroom fixture that has been invented so far.

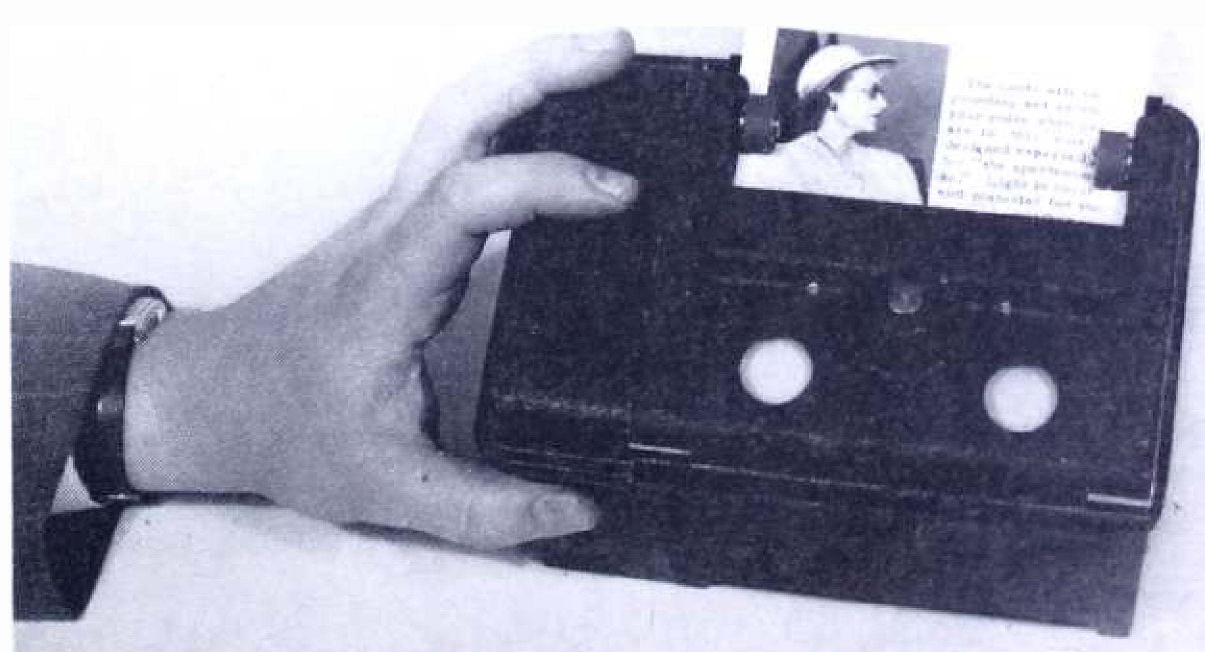
No Technical Difficulties ★ The best way to show the overall simplicity of facsimile transmission and reception is to use a personal experience as an illustration.

On Friday afternoon, May 16, I was at Harvey Radio, in Cambridge, Mass., talking to Frank Lyman about his FM station W1XHR, and the FCC's proposed grants for Boston that would enable him to start commercial FM broadcasting. We got onto the subject of programming. Then I told him about the facsimile equipment I had seen in operation the day before at the Alden Products plant in Brockton, some 30 miles away.

Frank Lyman said: "Why not get the equipment over here so we can transmit from W1XHR and put on a demonstration tomorrow at the New England Conference of the IRE?"

I looked at my watch. It was after three o'clock. Well, if the equipment I had seen was as perfect and dependable as it had seemed to be, perhaps it could be set up in time. At least, I could ask. It was after four when I reached Milton Alden. He said: "Sure, let's try it." We discussed the

FIG. 2. THIS UNIT IS A COMPLETE 4½-IN. RECORDER. IT RUNS FROM ANY FM SET



technical details. There was no problem at the transmitter. A receiver with a 600-ohm output was needed, and that was available from Harvey Radio's laboratory.

When we went to dinner at six-thirty, the Alden equipment had not arrived, but on our return, an hour and a half later, the scanner was ready to connect to the transmitter, and the receiver and recorder were set up at Hotel Continental, with a dipole faced toward W1XHR.

Promptly at nine, when the FM broadcast program ended, the scanner was started. As soon as the level was adjusted, we phoned the Continental, where the IRE meeting was to be held next day, and learned that the facsimile recorder was working perfectly.

Pretty simple, wasn't it? As a matter of fact, in all my years of seeing special demonstrations set up, and of setting up a few myself, I've never known one to click so perfectly.

There's just a little more to this story. Early the next morning, some thirty companies set up their booths in the same room at the Continental Hotel, and plugged in all kinds of instruments and devices on the same line as that supplying the facsimile receiver. One big display, right near the receiver, carried Allied relays that clicked on and off all day long. By the time everything had been plugged in, the line fuses let go! Bigger and still bigger fuses were inserted, and finally held, but under those conditions there's no telling what voltage was being fed into the receiver.

Despite the conditions of severe interference and bad voltage regulation, only a little readjustment was necessary to get perfect facsimile performance. The equipment ran continuously all day, until evening, when the show ended. What made this demonstration doubly impressive was the fact that the recorder was not one of the conventional models designed for home use, but an enormous bulletin-board type, shown in Fig. 3, which enlarges the copy to a width of 16 ins.

All kinds of program material was used, ranging from news and advertising to announcements of things taking place at the IRE meeting. The latter were phoned to W1XHR, and appeared a few minutes later on the bulletin-board recorder.

With facsimile equipment so highly perfected, what, if anything, is holding it up? Let's take a look at that angle:

The Matter of Standards ★ Before facsimile can be broadcast on a commercial basis, universal transmission standards must be set by the FCC. This is to assure the public that any make of home recorder will operate from signals transmitted by any FM station in the United States.

Both the RMA and the RTPB have been working on the problem of arriving at standards to be submitted to the FCC. As we know from experience with the RTPB television and FM panels, the establishment of standards is seldom approached from the technical angle only. If that were so, agreements could be reached readily.

Unfortunately, engineering considerations become involved with matters of company policy and strategy. This is true in the case of facsimile. So far, agreement has been reached on the following standards:

1. Recording is to provide 105 lines per inch.

FIG. 3. BULLETIN BOARD RECORDER GIVES 4 TIMES ENLARGEMENT

2. The paper is to advance at 3.43 ins. per minute.

And that is as far as the RMA and RTPB have gone. Remaining is the question of the paper width. There are other details to be settled, but the paper width is the controlling factor which has not been established.

What Width Paper? ★ Let's forget company strategies and policies, and look at this matter from the purely practical approach. The public has no convictions about the width of recording. There's been a lot of discussion about recording width related to the width of newspaper columns. Probably not one reader in 10,000 knows the width of a newspaper column,[1] and no one except the publishers and advertisers care how wide it is. So as far as the people who will buy the machines are concerned, the exact width is a matter of secondary importance. But the public does want:

1. Clear, readable type and illustrations as good, or preferably better, than in newspapers.
2. A price for the recorder that is reasonably related to a good FM receiver.
3. Operation from standard FM receiver models.
4. If possible, multiplex sound and facsimile reception.

As for the cost of paper, if the program material and quality of reception are adequate to create popular demand, paper cost will be a secondary consideration.

While there is no specific requirement as to paper width, the width is directly related to the cost of the recorder, and the audio frequency band required to operate the recorder. These are actually the factors which give the answer to the paper width question.

Discussions on this point in the RMA and RTPB have centered on recording width of 4.1 ins. and 8.2 ins. We know that a thoroughly practical 4.1-in. recorder is available right now in commercial form, manufactured from production tools, jigs, and dies, for sale at $100. When the recording width is broadened to 8.2 ins., the cost of facsimile recorders is increased by a much higher ratio. In fact, 8.2-in. recorders are currently priced at $685. That spread represents the difference between a nation-wide demand and no demand at all! Presumably, both the 4.1- and the 8.2-in. models can be reduced in price, but if the latter were cut by 50%, it still could not be sold to the public.

What the RMA-RTPB engineers and the strategists haven't considered is the fact that facsimile must compete with another new service, namely, television. If the price of home facsimile recorders is not substantially lower than 5-in. television receivers, we can just hang facsimile on a peg, and forget it.

Actually, what gives facsimile its great promise as a national service is the fact that 4.1-in. home recorders can be produced in quantities to retail under $100, with reasonable trade discounts. There is the starting point for arriving at the recording width on which standards can be set!

The audio frequency band required to operate a recorder contributes some other design criteria. The keying frequency for facsimile transmission 4.1 ins. wide, with 105 lines per inch and a paper feed of 3.43 ins. per minute is 1,500 cycles. To reproduce black and white type and line drawings, a sub-carrier frequency of 1.5 × 1,500 cycles or 2,250 cycles is adequate.

(CONTINUED ON PAGE 54)

[1] On an 8-column newspaper page, the column width is 2 ins., and on a 7-column page, the column width is 2⅛ ins.

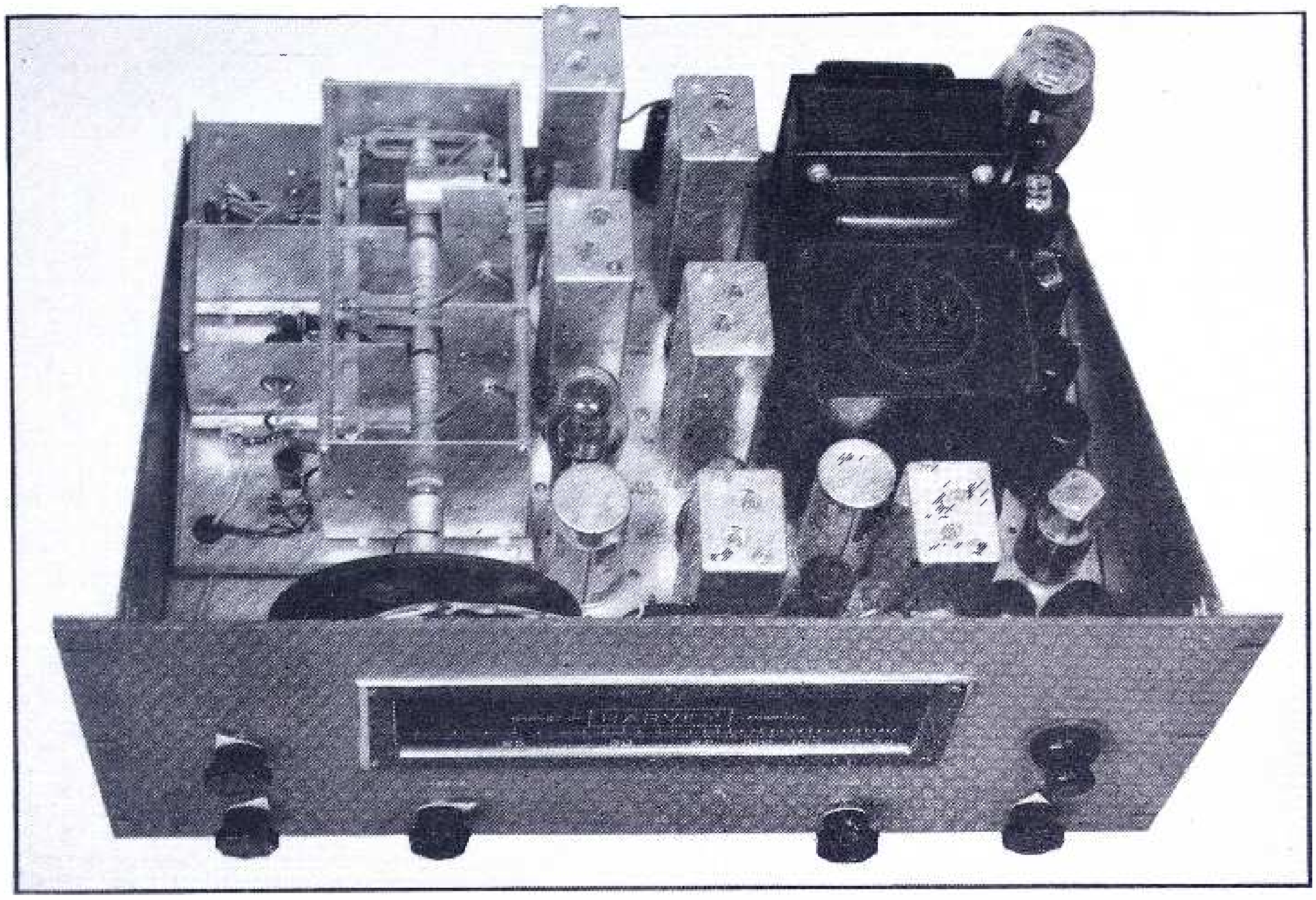


FIG. 1. CONSTRUCTION AND ARRANGEMENT OF THE HARVEY DOUBLE SUPERHETERODYNE FM RECEIVER, COVERING 85 TO 115 MC.

HARVEY DOUBLE SUPERHETERODYNE FM RECEIVER

A Straight FM Model with 1 Microvolt Sensitivity, and Full Fidelity Audio Characteristics

BY BERNARD J. COSMAN AND ARTHUR W. RICHARDSON *

IN THE later stages of the development of FM station W1XHR, during the fall and winter of 1945, a definite lack of receivers which could reproduce the station quality was encountered. We therefore started the design of a receiver designated as model 193-R. The final design has proved so satisfactory that it is being offered for sale as an FM station monitor, relay-link receiver, or for the discriminating home user. Two views of this receiver and the complete wiring diagram are presented here.

The ideal receiver, in our opinion, should incorporate

1. Sensitivity: RMA quieting signal of 1 microvolt
2. A high degree of oscillator stability
3. A band width of 250 kc.
4. Good limiter action
5. Linear discriminator
6. Squelch (Inter-channel receiver noise suppression)
7. Accurate tuning mechanism
8. Treble tone control adjustable in octaves and bass boost control to compensate for reproducer deficiencies or ear response
9. Audio amplifier with a linear response of 20 to 15,000 cycles, negligible harmonic response, and output impedance low enough to damp out shock vibration of the speaker (resonant hang-over)

Sensitivity ★ In order to operate the limiters on the very weak field strengths prevailing, particularly when poor antennas are used, it is necessary to incorporate sufficient gain to quiet the set on signals of about 1 microvolt. To accomplish this at relatively high frequencies, a stage of RF amplification incorporating a 956 tube feeding into a 6AK5 mixer is utilized. The output of the 9002 oscillator is condenser-coupled into the same grid of the mixer. The oscillator circuit is designed to track 10.7 mc. lower in frequency than the incoming signal at all points on the tuning condenser. This results in a difference frequency of 10.7 mc. which is amplified by a 6AB7 tube coupled by wide-band IF transformers to a 6K8 second mixer. Here it is mixed with the output of a crystal-controlled oscillator at 6.1 mc., and the difference frequency of 4.6 mc. passed on to another wide-band amplifier stage of similar design. The signal is then coupled to two limiter stages, using a 6SH7 and a 6AC7. The double superheterodyne principle is valuable in eliminating possibilities of regeneration which might exist in such a high-gain amplifier if all stages operated at the same frequency, and provides a high image-rejection factor on the one hand and good selectivity characteristics and gain on the other.

Oscillator Stability ★ No compensating devices for oscillator drift have been found necessary other than the use of regulated B supply voltage. The use of high *Q* circuits and high quality circuit components results in an oscillator which holds its frequency so closely that no drift is apparent after a short warm-up period.

Bandwidth Considerations ★ One of the most important problems in the design of a high fidelity FM receiving system is that of choosing the proper bandwidth and transmission characteristics for the IF amplifier. This problem is one which is frequently analyzed improperly or not well enough understood to afford a reasonable basis for design. There seems to be a great tendency for many engineers to consider only peak frequency deviations in an FM system, and to work out system bandwidths on this consideration alone. Theoretically, it is impossible to get perfect fidelity with any practical FM

* Respectively Chief Engineer and Project Engineer, Harvey Radio Laboratories, Inc., Cambridge, Mass.

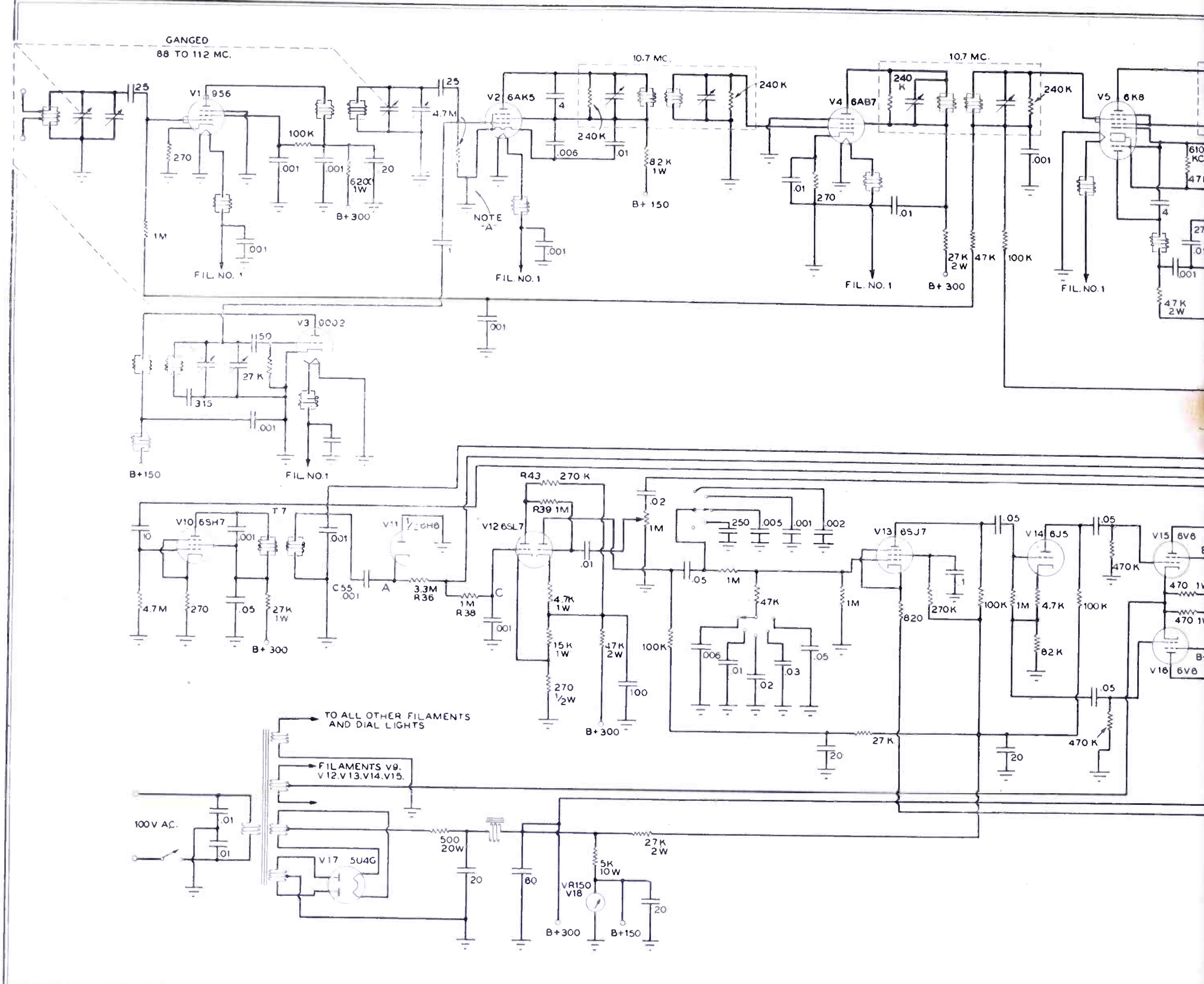


FIG. 2. CIRCUIT DETAILS OF THE DOUBLE SUPERHETERODYNE AND THE SQUELCH ARE DISCLOSED HERE FOR THE FIRST TIME

receiving or transmitting system because the nature of the intelligence-carrying side-band structure of a frequency-modulated wave is such that, in the limit, an infinite bandwidth is necessary. Practically, however, it is possible to make a choice as to the fidelity limit of the receiving system, and to set up bandwidth accordingly. In other words, the point must be determined at which the side-band structure of the received FM wave will be clipped, assuming that the energy thereby removed from the signal is consistant with the distortion limits prescribed for the overall system.

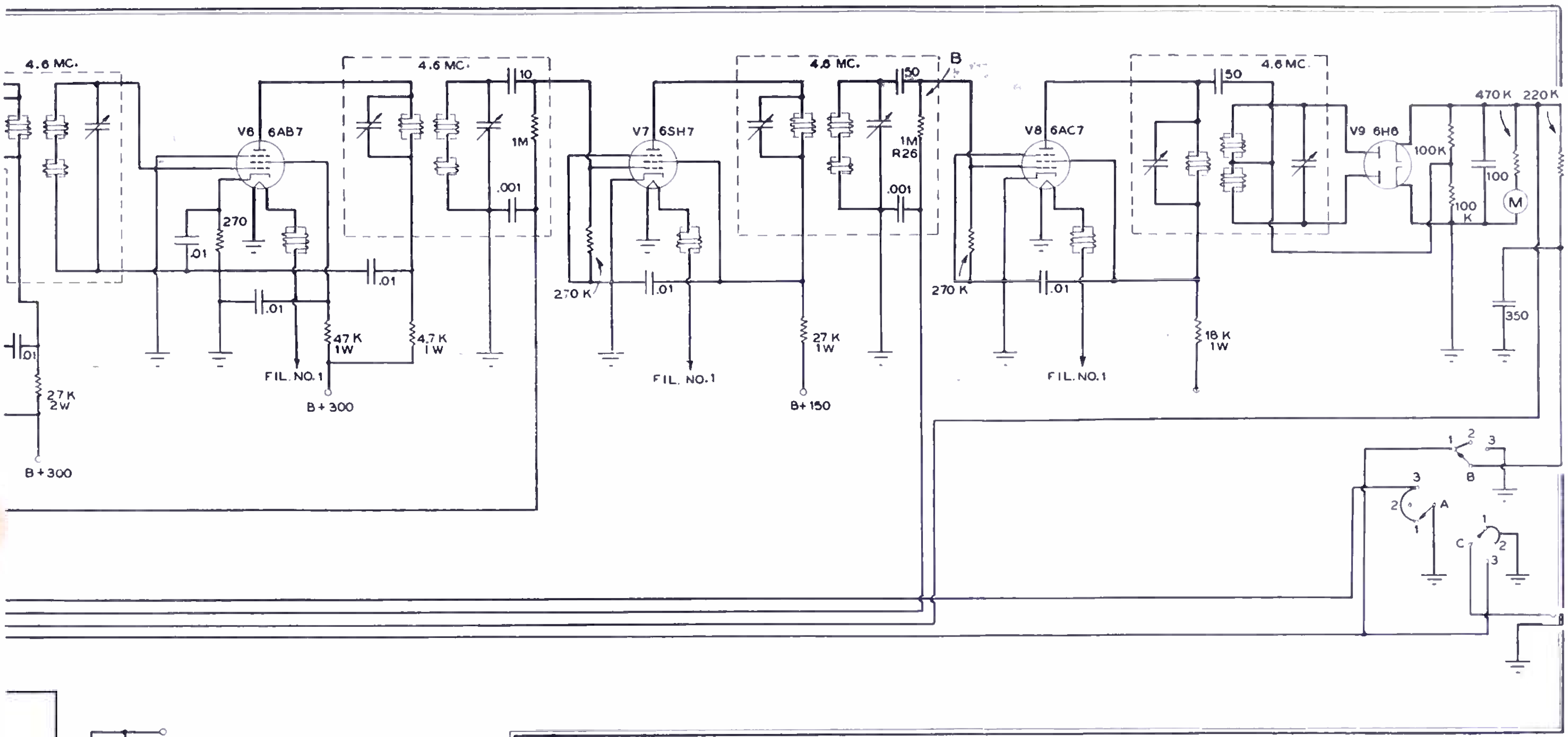
Table 1 may serve to illustrate the problem more clearly. This table demonstrates quantitatively how the side-band structure of an FM signal varies with the modulation index, or deviation ratio, which is the ratio audio of modulating frequency to peak frequency swing. In this case, an audio frequency of 15 kc. is considered as the highest frequency to be detected. With an index of 5.0 (75 kc. deviation at the 15 kc. sinusoidal rate) the 8th sideband still has an amplitude equal to about 2% of the total signal intensity. The 8th sideband is, of course, removed 120 kc. (8 x 15 kc.) from the carrier frequency.

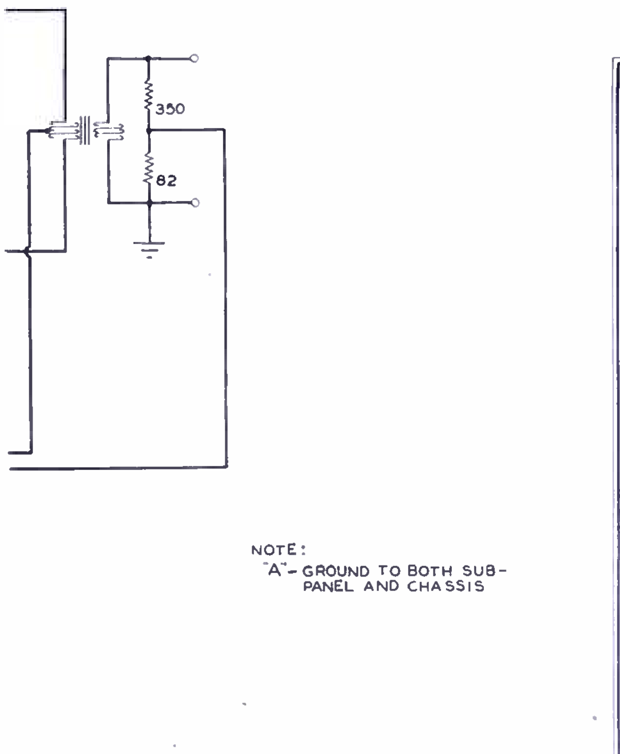
TABLE 1

Relative strength of sideband frequencies expressed in percentage of the total output current (or voltage) for various values of modulation index

Mod. Index	I_0 Carrier	I_1	I_2	I_3	I_4	I_5	I_6	I_7	I_8	I_9
	Percentage Sideband Current Strengths									
0.1	99.75	4.99								
0.2	99.0	9.95								
0.3	97.76	14.83								
0.4	96.04	19.6								
0.5	93.85	24.23	3.1							
1.0	76.52	44.01	11.49	1.96						
2.0	22.39	57.67	35.28	12.89	3.4					
3.0	26.01	33.91	48.61	30.91	13.2	4.3	1.14			
4.0	39.71	6.6	36.41	43.02	28.11	13.21	4.91	1.52		
5.0	17.76	32.76	4.66	36.48	39.12	26.11	13.1	5.34	1.84	
6.0	15.06	27.67	24.29	11.48	35.76	36.21	24.58	12.96	5.65	2.12

Thus, if the fidelity limits require the transmission of this sideband, it is obvious that the undistorted bandwidth should be at least 250 kc. This condition, however, dictates that any over-modulation (peak swings greater that 75 kc.) will be subject to increasing fidelity deterioration due to the clipping of significant side-bands outside the 240-kc. width. At this point, one realizes that there are many practical reasons for limiting the band-





width to 240 kc., aside from the basic considerations of signal-to-noise ratios.

First, consider over-modulation. There are usually two different ways in which this occurs in non-limiting systems. Transient peaks due to high-level playing of percussion instruments, particularly the piano, wherein the audio complexity may be such as to give as much as a 30 db peak-to-rms sound-pressure ratio, cannot help but overload the receiver IF system seriously, by sideband clipping. Distortion from this cause can never be eliminated, because it is probably physically impossible to design a transmitting and receiving system with a good signal-to-noise ratio that still has enough dynamic range left to carry peaks 20 db above nominal 100% rms modulation level. Bandwidth, therefore, makes very little difference in the receiving fidelity of this type of signal.

Sustained levels of over-modulation are often caused by musical blasts from jazz band wind instruments, with considerable energy in the pre-emphasized portion of the audio range. Even though a VU meter may register only 100% rms modulation level, the audio complexity still may be as high as 10 db in peak-to-rms ratio. Although any well-designed FM transmitter can handle this type of signal without serious distortion, the effect of insufficient band acceptance in the receiver is immediately noticeable. The actual FM modulation index for this type of audio signal is too complicated to analyze easily, but one may draw a number of significant conclusions from steady-state conditions at the lower and middle register audio tones.

For example, if 75 kc. deviation is obtained with a 750-cycle note, the modulation index is 100. Bessel function calculation for these large indices indicate that although the number of sidebands becomes larger as the frequency is lowered, very few important sidebands extend beyond the 150-kc. bandwidth point for very low frequencies. A system 240 kc. wide would, therefore, easily allow for 150% modulation for low frequencies, whereas a 150-kc. system allows for no overload. Under the sustained over-modulation condition mentioned above, the sideband structure may well extend to a width of 250 kc. for an rms swing of 75 kc. It is here that the 150-kc. system is entirely inadequate, and at least a 240-kc. pass-band is necessary, quite apart from any consideration of the general requirement of 240-kc. bandwidth normally based on a modulation index of 5.0 for a 15-kc. audio signal.

Table 1 shows that a bandwidth of 150 kc. for an index of 5.0 cuts off three sidebands where amplitudes are above or nearly 2% of the total signal level, these levels being 13.1, 5.34, and 1.84%. If even momentarily the index increased 6.0, about 29% of the sideband structure is clipped off and is thereby lost to the intelligence of the signal. This can be found merely by averaging according to the following relation:

$$\sqrt{(24.58)^2 + (12.96)^2 + (5.65)^2 + (2.12)^2} = 28.6\%$$

It does not follow that this represents the actual distortion in the transmission, because other factors must be taken into consideration, the most important of which is the linearity of the phase-shift characteristic in the pass-band of the IF system. In order for a high-fidelity signal to be recovered from the IF channel, all the sidebands of the signal must be transmitted without changes in amplitude (clipping) or phase. Therefore, it is essential that, in addition to proper bandwidth, the IF structure should be such as to mostly nearly yield a linear phase characteristic. Since, with simple tuned coupled circuits, it is impossible to change the attenuation curve without changing the phase curve, the most satisfactory IF amplifier is one which is critically coupled (slightly overcoupled is near enough), and having a very symmetrical attenuation characteristic of adequate bandwidth. It turns out that it is possible to increase fidelity only at the expense of signal-to-noise ratio if bandwidths greater than 240 kc. are used.

Limiter Action ★ The use of two limiter stages in cascade results in excellent limiter action when the proper time constants are chosen for the associated circuits. In our factory at Cambridge, which is a perfect bedlam of electrical interference of all sorts, quieting signals from the Yankee Network Station at Paxton are readily received with a piece of wire about 2 ft. long for an antenna.

Linear Discriminator ★ The discriminator is a semi-conventional Foster-Seeley type, with coupling and constants carefully chosen for linear response across the

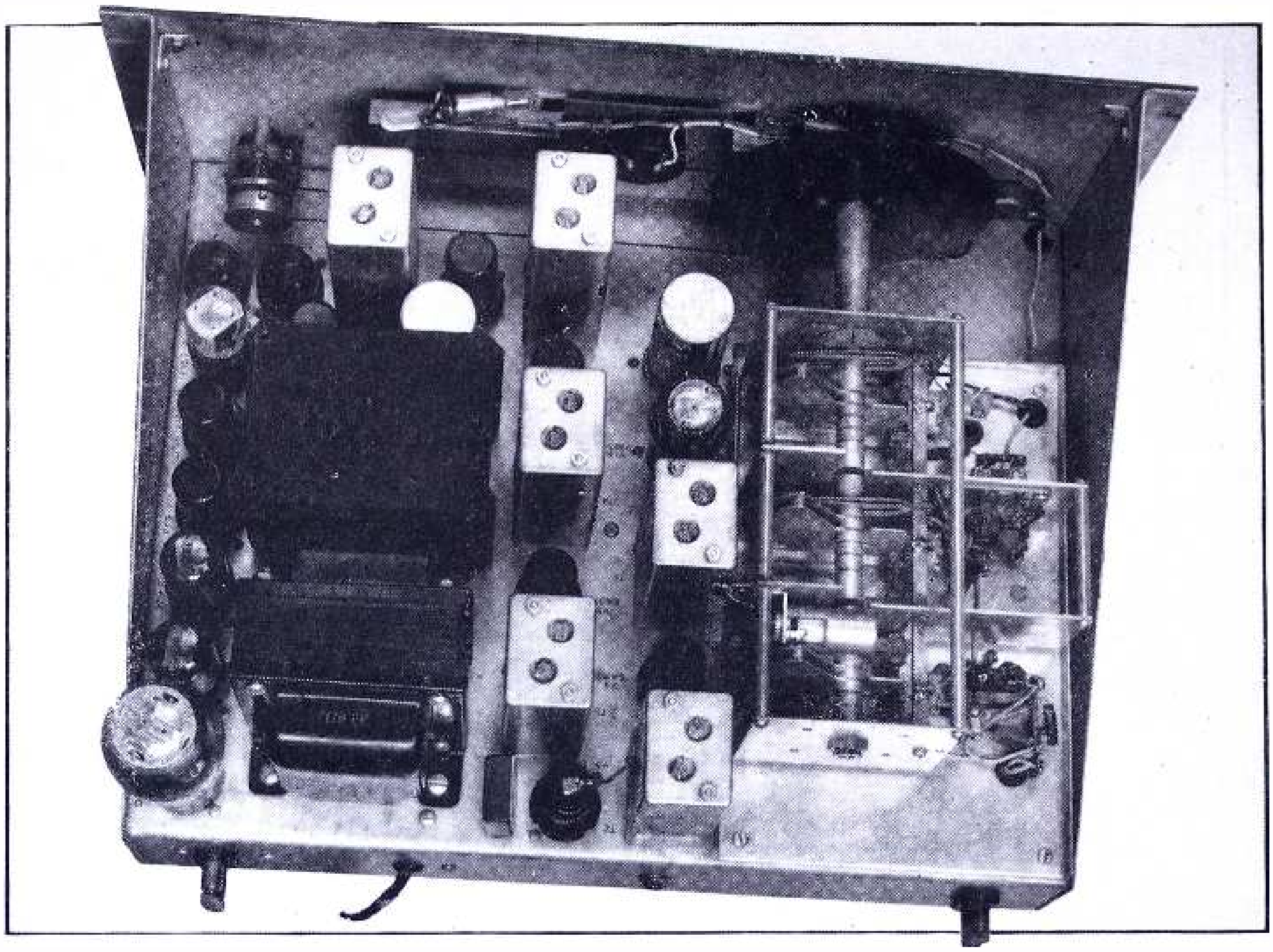


FIG. 3. A FEATURE OF THIS FM RECEIVER IS THE RUGGED TUNING CONDENSER AND THE MASSIVE OUTPUT TRANSFORMER

pass-band. Precise alignment of this as well as the overcoupled IF stages is insured by the use of the Harvey Visalgen.[1]

Squelch ★ Because the inter-station noise of a high-gain FM receiver is rather annoying, a squelch circuit is incorporated, using the principles proved out in the Harvey Model 501 emergency communication receiver. As this may be unfamiliar to readers not acquainted with police radio equipment, a short description of the action will be given.

When no signal is being received, as when the set is tuned between stations, noise voltage appears at the discriminator output. Referring to the schematic, Fig. 2, high frequency components of this noise are fed into the grid of a noise amplifier V10. The output circuit of this tube is a tuned band-pass transformer T7, which passes noise frequencies above the usable audio spectrum through coupling condenser C55 to the cathode of a noise rectifier V11. The noise frequencies produce a positive voltage at point A of a T network comprising R36, R38, and R26. A small negative voltage is also produced by the rectifying action of the grid cathode circuit of limiter tube V8, which is applied to the opposite end of the T, at Point B. The resultant of these two voltages, which is positive when no carrier is being received, is applied through the leg of the T to the control half of the V12, point C. This grid is then biased so that the tube draws current and the plate voltage becomes less positive due to the drop across R43. The grid of the amplifier section of V12, connected to the plate of the control half through a resistor R39, becomes sufficiently negative with respect to its cathode to cut off plate current, and the amplifier is squelched.

When a carrier is received, the negative voltage derived from the rectified grid current of V8 becomes large and, since there is no high frequency noise voltage due to the quieting action of the signal on the limiters, the positive voltage on the T network drops out, the bias on the control tube becomes predominantly negative, and the tube cuts off. Its plate voltage becomes fully positive, therefore, and the grid of the amplifier section is correspondingly raised from cutoff to Class A operation. This results in a fast-action squelch.

Tuning Mechanism ★ A 9-in. edge-lighted plastic dial is used to give sufficient band spread. There is a choice of either 5-to-1 or 15-to-1 stepdown for either fast or slow tuning. A zero-center, 50-microampere meter mounted behind a window in the dial furnishes a means of tuning accurately to the center of the signal.

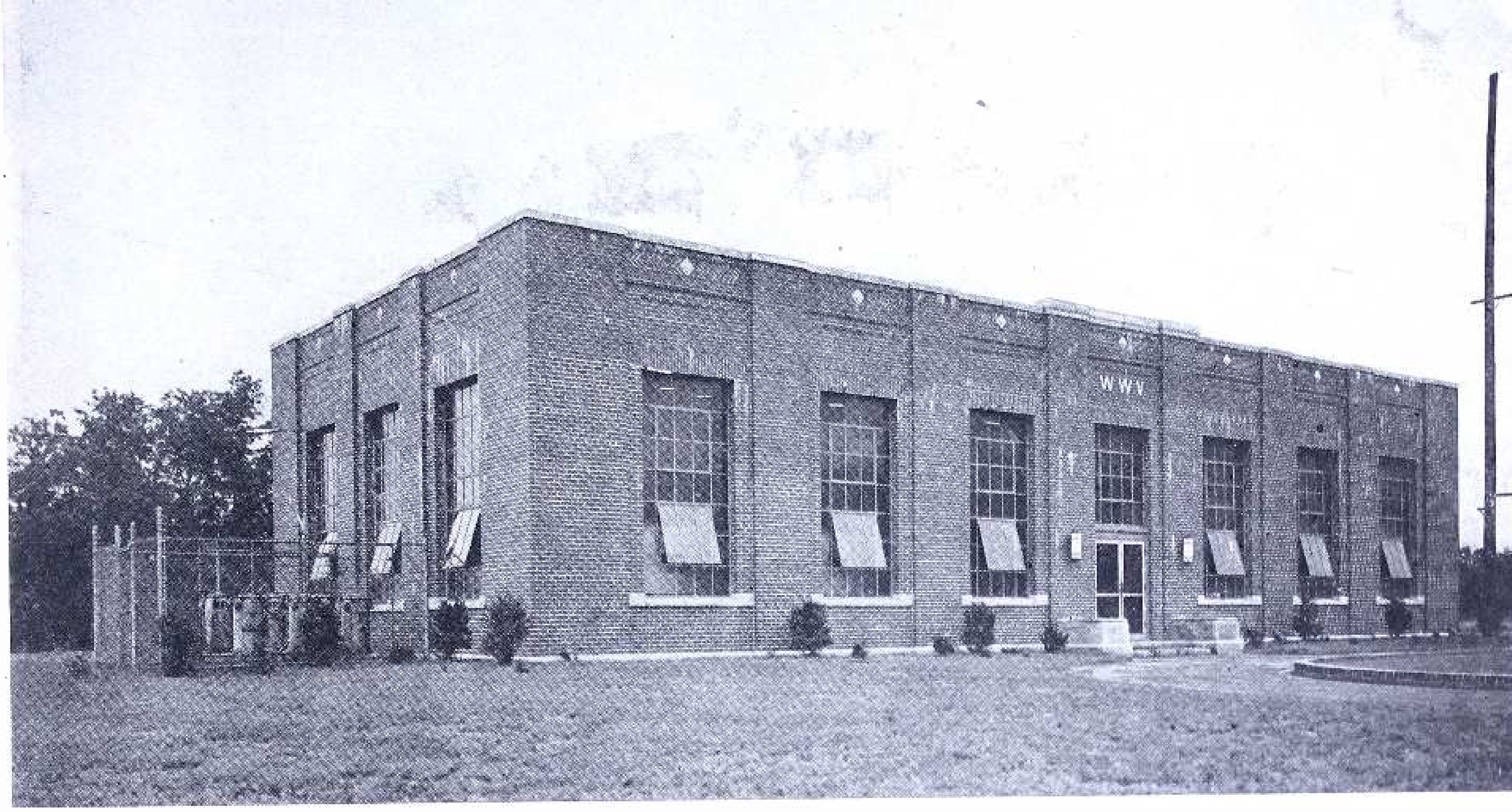
Tone Control ★ Two 5-position tone controls are incorporated. The treble control is so designed that each step cuts off an octave from the high frequency response. The bass control gives two settings of bass below normal and two above and, since the audio amplifier responds to frequencies below 20 cycles, the control is very effective.

Audio Response ★ The audio amplifier is a conventional resistance-coupled amplifier with phase inverter and push-pull output circuit. Careful design has resulted in a frequency response which is flat well beyond the limits of any available reproducer. When used with an output transformer of such excellence as the U.T.C. LS-52, the push-pull 6V6-GT output tubes furnish ample power, and the overall gain is sufficient to allow the use of heavy degenerative feedback, the benefits of which are well known. Measurement of transient response of the audio system feeding a speaker load has indicated that pentodes, when used with a high-quality output transformer and proper feedback characteristics, can equal in performance amplifiers using low impedance triodes because, in the last analysis, the output impedance of the pentode circuit is greatly reduced, and the equivalent output circuits become identical. The other advantages of using pentodes are obvious, and they afford a very compact power amplifier system.

Components ★ Consistent with the general technical features of the set, only highest quality components have been specified. For example, the 3-gang tuning condenser is massively constructed of silver-plated brass in such a manner as to eliminate microphonics in the oscillator stage and rotor-contact resistance troubles, and to counteract common impedance coupling due to cross-currents in the rotor shaft. The entire RF amplifier, oscillator, and mixer stages are effectively mounted directly on the condenser chassis, so that the unit is essentially an RF head which bolts to the main chassis. Polystyrene has been used to insulate the stators, and

(CONTINUED ON PAGE 51)

[1] See "How to Align FM Receivers" by Bernard J. Cosman, *FM* and Television, July, 1946 and "Data on the Browning FM–AM Tuner" by F. A. Spindell, *FM* and Television, February, 1947.



STATION WWV, LOCATED NEAR WASHINGTON, D. C., AND OPERATED BY THE BUREAU OF STANDARDS ON A 24-HOUR SCHEDULE

WWV STANDARD FREQUENCY BROADCASTS

How the Central Radio Propagation Laboratory of the National Bureau of Standards Makes Primary Frequency Standards Available to the Radio Industry

BY W. W. GEORGE*

THE progress of the radio industry in the use of high frequencies, and the crowding of more and more services into the various bands has increased the need for and the use of extremely accurate frequency-measuring equipment. And as tolerances have been steadily decreased, calibrating means of an extremely high order of accuracy have become an essential facility in factories, laboratories, and field installations.

Radio station WWV, operated by the Central Radio Propagation Laboratory of the National Bureau of Standards, at Washington, D. C., provides primary frequency standards for calibration and measurement purposes by the transmission of eight radio frequencies. These are: 2.5, 5, 10, 15, 20, 25, 30, and 35 mc. Seven or more transmitters are on the air at all times, day and night. This insures reliable coverage of the United States, and extensive coverage of other parts of the world.

The accompanying photographs show some of the details of the installation at WWV. The basic component of all the services, with the exception of the radio propagation disturbance warnings, is a quartz crystal unit with a series-resonance frequency of approximately 100,000 cycles per second. Using vacuum-tube circuits, the crystal oscillates continuously, and the resulting frequency is multiplied and divided to give the appropriate frequencies for the five services. Three separate crystal units and associated apparatus are maintained at the station. As the entire service depends upon the maintenance of constant frequency, the crystal units are sealed in painstakingly insulated boxes and kept in a vault approximately 25 ft. below the surface of the earth, under conditions of constant temperature and humidity.

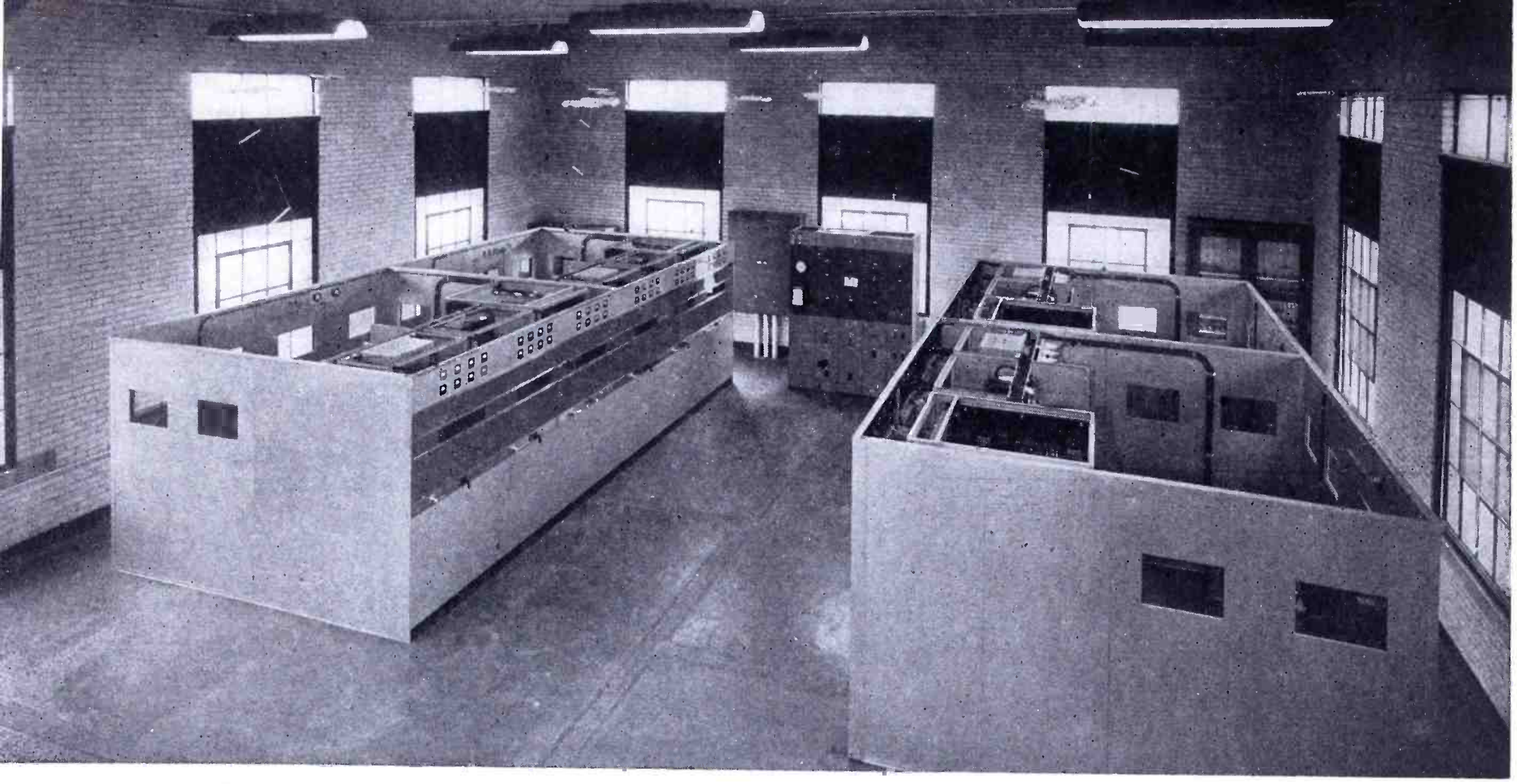
The national standard of frequency, of which the National Bureau of Standards is the custodian, is fundamental to much of the work in radio, electronics, and acoustics, and in other fields where measurements require accurate frequencies. Any desired frequency, including those throughout the microwave region, can be precisely measured, by reference to the standards broadcast by the station, with the aid of one or more auxiliary oscillators, harmonic generators, and radio receivers. The accuracy of each of the transmitted radio and audio frequencies is better than 1 part in 50 million. All the transmitters operate with vertical, non-directional antennas.

The services provided by WWV transmissions are: 1) standard radio frequencies, 2) time announcements, 3) standard time intervals, 4) standard audio frequencies, 5) standard musical pitch, 440 cycles per second, corresponding to A above middle C, 6) radio propagation disturbance warning notices. All of the frequencies are useful for field-intensity recording by persons interested in studies of radio propagation. The four highest frequencies are broadcast particularly for this purpose. The radio frequencies and other data are:

Mc.	*EST*	*Output Kw.*	*AF*
2.5	7:00 P.M. to 9:00 A.M.	1.	440 cycles
5	7:00 P.M. to 7:00 A.M.	10.	440
5	7:00 A.M. to 7:00 P.M.	10.	440 and 4000
10	continuously	10.	440 and 4000
15	continuously	10.	440 and 4000
20	continuously	0.1	440 and 4000
25	continuously	0.1	440 and 4000
30	continuously	0.1	440
35	continuously	0.1	440

The station call letters and other announcements in voice are given each hour and half hour.

* Chief, High-Frequency Standards Section, Central Radio Propagation Laboratory, National Bureau of Standards, Washington, D. C.



INTERIOR VIEW OF STATION WWV, SHOWING FOUR OF THE TRANSMITTERS FOR BROADCASTING PRIMARY-STANDARD FREQUENCIES

Time Announcements ★ The audio frequencies are interrupted precisely on the hour and each 5 minutes thereafter. Following an interval of precisely 1 minute, they are resumed.

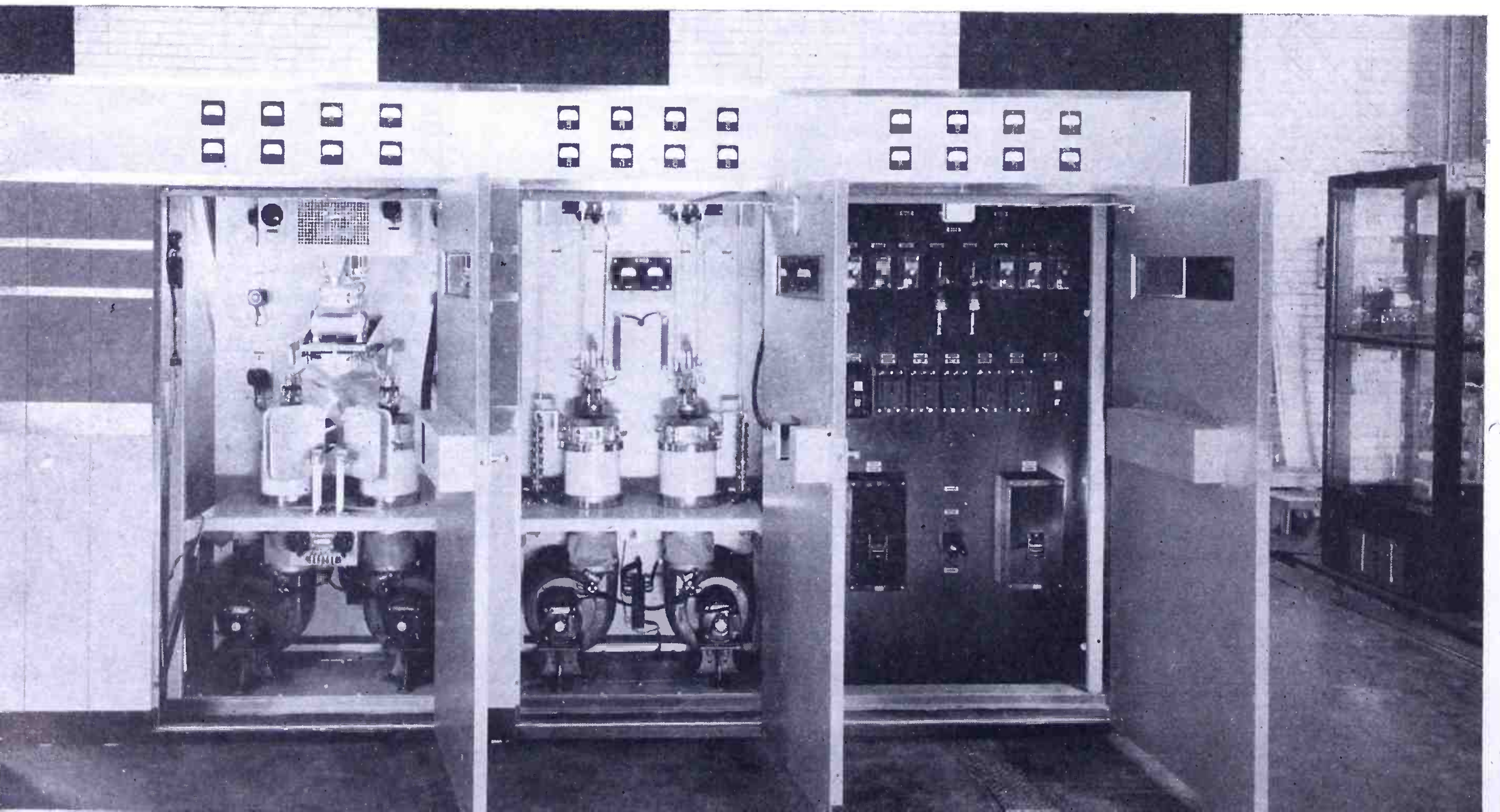
The beginnings of the periods, when the audio frequencies are interrupted, are in agreement with the basic time service of the U. S. Naval Observatory, so that they mark accurately the hour and the successive 5-minute periods.

Eastern standard time is announced in telegraphic code each 5 minutes. This provides a quick reference to correct time where a timepiece may be in error by a few minutes. The 0- to 24-hour system is used, starting with 0000 at midnight. The first two figures give the hour and the last two figures give the number of minutes past the hour. For example, at 4:55 P.M., or 1655 EST, four figures (1, 6, 5, and 5) are broadcast in code. The time announcement refers to the start of an announcement interval, i.e., when the audio frequencies are interrupted. It occurs immediately after the beginning of each 5-minute interval. At the hour and half-hour it is followed by the station announcement in voice.

Standard Time Intervals ★ There is on each carrier frequency a pulse of 0.005 second duration which occurs at intervals of precisely 1 second. The pulse consists of 5 cycles, each of 0.001 second duration, and is heard as a faint tick when listening to the broadcast; it provides a useful standard time interval, for purposes of physical measurements, and for quick and accurate measurement or calibration of timing devices and very low frequency oscillators. It can be used as an accurate time signal. On the 59th second of every minute, the pulse is omitted. The 1-minute, 4-minute, and 5-minute intervals, synchronized with the seconds pulses, are marked by the beginning or ending of the periods when the audio frequencies are off.

A time interval of 1 second marked by the pulse is accurate, as transmitted, to 1 microsecond (0.000001 second). An interval of 2 minutes or more is accurate to 1 part in 50,000,000.

CLOSE-UP OF ONE OF WWV'S TRANSMITTERS THE RF STAGE IS AT THE LEFT, WITH THE AF AMPLIFIER IN THE CENTER SECTION



The 1-minute interval is provided in order to give time and station announcements, and to afford an interval for the checking of radio-frequency measurements free from the presence of the audio frequencies.

Standard Audio Frequencies ★ Two standard audio frequencies, 440 cycles per second and 4,000 cycles per second, are broadcast. They are given on radio carrier frequencies, as shown in the table.

The two standard audio frequencies are useful for accurate measurement or calibration of instruments operating in the audio or supersonic regions of the frequency spectrum. They may also be used for accurate measurement of short time intervals.

The accuracy of the audio frequencies, as transmitted, is better than a part in 50,000,000. Transmission effects in the medium (Doppler effect, etc.) may result at times in slight fluctuations in the audio frequencies as received. The average frequency received is, however, as accurate as that transmitted.

Standard Musical Pitch ★ The frequency of 440 cycles per second is the standard musical pitch, A above middle C. It is broadcast for 4 minutes and interrupted for 1 minute. This sequence is repeated continuously on each of the radio carrier frequencies. This service is useful to musicians and those concerned with the manufacture or maintenance of musical instruments. Since 1925, the standard in the music industry of the U. S. has been 440 cycles.

Radio Propagation Disturbance Warning Notice ★ A warning of radio propagation conditions is broadcast in code on each of the standard radio carrier frequencies at twenty and fifty minutes past the hour. If a warning is in effect, a series of W's, in the telegraphic code, follow the time announcement; if no warning is in effect, a series of N's follows the time announcement.

A warning means that radio propagation disturbance is anticipated within 12 hours, or is in progress, with its most severe effects on radio transmission paths crossing the North Atlantic; i.e., those paths for which the control points of transmission lie in or near the northern auroral zone. Radio propagation disturbance is characterized by low intensities, accompanied by flutter or rapid fading on the normal frequencies used at the different times of the day, or by complete blackout of signals. By shifting to lower-than-normal frequencies for that time of day, it may be possible to get signals through, although with lower-than-normal intensity. Owing to increased auroral-zone absorption during the disturbance, however, it may be impossible to have usable transmission on any high frequency. Also, during a period of radio propagation disturbance, direction-finder observations may be unreliable.

If no warning is in effect, satisfactory transmission should be possible on the normal frequencies.

The usual daily time for changing the announced warning is 2100 GMT (4 P.M., EST). The warning is, however, issued at any hour when disturbance becomes noticeable or anticipated. The announcement is returned to normal whenever conditions seem quiet. Thus any time a radio operator questions reception on North Atlantic paths, it would be advisable to check with the WWV announcement to see whether conditions are considered by the Bureau sufficiently disturbed to make a warning desirable.

Some one of the frequencies of WWV should be receivable at every location in the United States. Only during very severe storms would reception of WWV within the continental United States be difficult. For some Canadian or other users for whom the transmission path from WWV enters into or near the northern auroral zone, it may be impossible to receive any of the WWV frequencies at usable intensities during even moderate storms. It is probable, if no WWV frequency can be heard at hours when normally audible, that a warning is in effect.

The use of WWV for issuing the Bureau's North Atlantic radio disturbance warning makes the service available to all users of high-frequency receivers. The service should be of use in explaining or anticipating radio propagation conditions existing over North Atlantic States during severe radio propagation disturbances.

The radio disturbance warning does not apply to sudden ionospheric disturbances, which are unpredictable. These occur only at times when at least part of the transmission path is in sunlight. This type of disturbance is characterized by the received intensity dropping to zero, very rapidly, usually within a minute or so, and remaining out from a few minutes to two hours. The effect is greater on the lower high frequencies, and on paths close to the equator or whose control points are close to noon. Usually the only transmission possible during a sudden ionosphere disturbance is by VLF or by ground waves over short paths. The use of the highest frequency available, as long as it is below the maximum usable frequency for the path in question, may shorten the duration of the fadeout. During the next few years, while approaching sunspot maximum, these sudden ionosphere disturbances will increase in intensity and frequency of occurrence. They are caused by eruptions on the sun, more of which are observed during the years around sunspot maximum.

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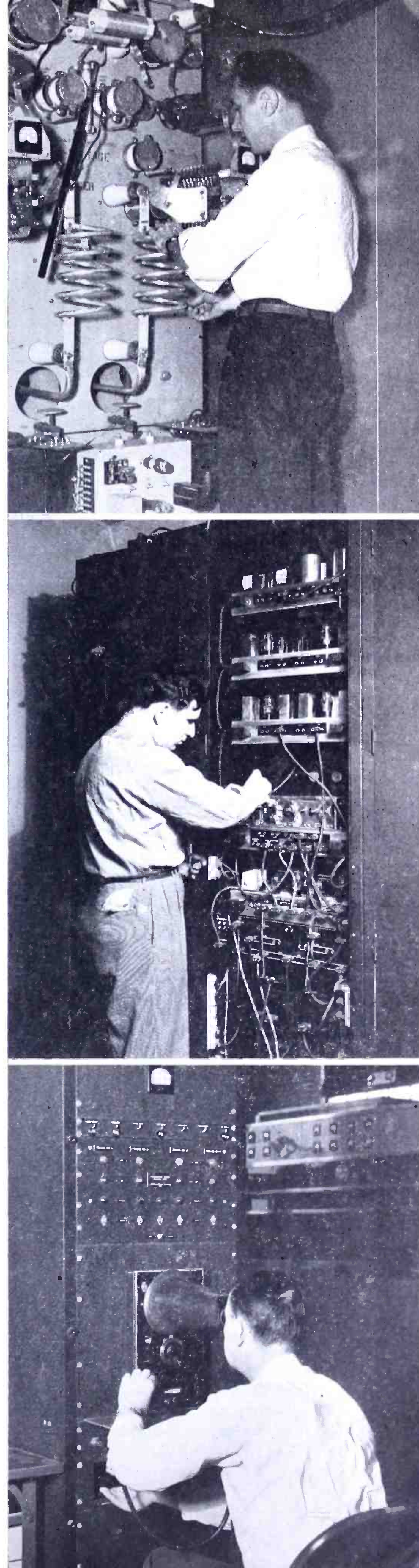


TOP: TRANSMITTER OUTPUT STAGE. CENTER: AF AND TIME-INTERVAL GENERATOR. BOTTOM: CHECKING MODULATION ADJUSTMENT ON OSCILLOSCOPE

SPOT NEWS NOTES

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

Cheap FM Sets: "A cheap FM set would be, in our opinion, a mistake at the present time. Any such set would necessarily, with today's knowledge, be low in sensitivity and have poor selectivity in relation to the established standards of AM. Such performance would do irreparable harm to FM before it had a chance to prove itself as a service." — from the RMA-FMA liaison Committee report submitted by Ben Abrams, Emerson; H. C. Bonfig, Zenith; L. F. Hardy, Philco; E. A. Nicholas, Farnsworth; S. P. Taylor, W. E.; R. C. Cosgrove, Crosley.

1948 IRE Show: Annual New York City conference and engineering show will be held at the Grand Central Palace on March 22nd through the 25th. For exhibit information, address William C. Copp, exhibits manager, 303 W. 42nd Street, New York 18.

Waltham Mass.: New Commercial products division has been set up by Raytheon, to handle broadcast equipment and industrial tube-operated devices. Frank S. Horning is sales manager of the new division, with William A. Gray assistant, John H. Beedle production manager, David D. Coffin chief engineer, and Everett G. Fraim engineer in charge of speech input and microwave applications, installation, and service. Ben Farmer and Warren Cozzens will handle mid-west sales from 7475 N. Rogers Avenue, Chicago.

Chicago Television: An order for television equipment totalling over $225,000 has been placed with G.E. by WGN, Inc. Using a 5-kw. transmitter and an antenna on the Tribune Tower, effective radiated power will be 18.5 kw. It is estimated that service will be provided over a radius of 45 miles. Carl J. Meyers is director of engineering for WGN.

Labor Problem: Sosthenes Behn, president of IT & T, discussing labor troubles at Federal's New Jersey plants: "The UEW definitely is out to run our factory, and we don't intend to let them do it. They are very good people, but they have very poor leadership." Which reminds us that when James Carey, now CIO secretary, and Julius Emspack, the Brow of UEW, lived together on West 24th Street, the only reading material we ever saw in their apartment was a set of volumes on the life and works of one of the Russian revolutionaries. As we remember it, it was Lenin.

James D. McLean: Has resigned as manager of transmitter sales for G.E. to become commercial manager of Philco television station WPTZ.

Quick, Henry, the Flit: FM listeners in Omaha have been puzzled over hearing crickets chirping in their radios. They know the answer at KOAD, however. The crickets are in the molding around one of the studio walls, and efforts to dislodge them have been only partly successful.

IMSA Meeting: Annual convention will be held September 29 to October 2 in the Patlind Hotel, Grand Rapids, Mich. Discussions will cover traffic, fire, and police signals, and radio communications. For details on the convention and exhibits, write Irvin Schulsinger, 8 E. 41st Street, New York 17.

AM WITH FM QUALITY?

THE failure of many AM broadcasters to grasp the fundamental principles and advantages of Frequency Modulation, and the significance of FM as a means of providing improved service to radio listeners is highlighted by a 6-column San Francisco newspaper advertisement in which KYA claims to deliver AM programs with "FM Quality."

KYA doesn't leave itself a leg to stand on in making this claim, for the whole advertisement features almost continuous recorded programs from 5:30 A.M. to midnight. Goodness knows, not even FM stations can put out anything that sounds like high fidelity from such program material as that!

San Francisco: KLBS-FM demonstration week was marked by big-space newspaper advertising on Philco FM receivers. Principal participants were Sherman Clay, Longs, Offenbach's, and distributor Thompson & Holmes. Special programs for store demonstrations were so successful in selling sets that KJBS-FM agreed to continue the plan for a second week.

New FCC Rules: A new Industrial, Heating, Scientific, and Medical Services Section has been established in the Emergency and Miscellaneous Division of the FCC's Engineering Department to administer new rules and regulations concerning diathermy and industrial tube-operated heating equipment. Equipment now in use, or manufactured prior to July 1, 1947 will be exempt from the new rules for 5 years, provided no serious interference is caused to an authorized radio service. Electric signs, window displays, garage door-openers, and model airplanes will fall within the scope of the rules. Type approvals will be issued on new devices after approval by the FCC Laboratory Division.

Name Change: Effective May 15th, the Galvin Manufacturing Corporation name was changed to Motorola Inc. Action was approved by the stockholder on that date.

Philip G. Caldwell: Appointed manager of sales of the G. E. transmitter division, succeeding James D. McLean. Caldwell has been with G. E. since 1932. In 1944 he was named sales manager of marine and aircraft radio equipment, and in 1946, sales manager of television equipment. He will make his headquarters at Syracuse.

Tone Preference Tests: Tests conducted by Dr. Harry F. Olson at RCA's acoustics research laboratories show results which differ sharply from conclusions reached by CBS and Western Electric engineers. Dr. Olson used acoustic treatment which simulated living room conditions, with a partition capable of cutting off all frequencies above 5,000 cycles. Music was supplied by musicians, not transcriptions. Of the listeners between 30 and 40 years of age, 75% preferred the full frequency range, but this choice was expressed by only 59% of the listeners between 14 and 20. "Listeners in the latter age group," Dr. Olson stated, "are probably influenced by listening to radios, phonographs, and juke boxes rather than orchestras and are, therefore, conditioned to a restricted frequency range."

Height-of-Something-or-Other: New AC-DC AM receiver weighing 3½ lbs. in a plastic case is being featured in national advertising under the headline: "Console performance in a Jewel Case." We can't argue the point, though, because our big *Webster's Dictionary* doesn't give an applicable definition of "console".

Microwaves for Costa Rica: Compania Radiografica Internacional de Costa Rica, an affiliate of Tropical Radio, is installing Raytheon 4,000-mc. equipment for communication between San Jose and Las Pavas. Telegraph and telephone channels will be multiplexed.

Philip I. Merryman: Manager of NBC's planning and development division has resigned to form a new consulting firm in partnership with H. V. Anderson of New Orleans. Mr. Merryman has been retained by NBC as a consultant. The new firm has offices in New York and New Orleans, and a laboratory in Baton Rouge. In Washington, the firm is represented by Chambers and Garrison.

KKLA: FM station owned and operated by Angelus Temple of Los Angeles has been granted a power increase to 58 kw. effective radiated power. Transmitter will be a 10-kw. Collins unit.

Oliver J. Greenway: Works manager of International Resistance Company since 1944, has been appointed a vice president of the Company.

NEWS PICTURE

THE 3,000-mc. dish on this water tower is part of an experimental microwave system now being tested by Motorola in conjunction with the Greyhound Corporation for service between Chicago and Lombard, 19 miles to the west.

Plan is to extend the present FM system by which buses nearing Chicago report to the main office. In this new installation, signals from the buses are picked up on 43.34 mc. at Lombard and fed into the microwave transmitter. The dish illustrated above is directed toward a receiving installation on the Chicago Board of Trade Building. In this way, the bus-to-headquarters range is greatly extended, and no telephone lines are needed between Lombard and Chicago.

This is another example of the expanding use of microwaves for point-to-point service. The equipment is simple, inexpensive, and requires very little maintenance, representing a highly satisfactory substitute for land lines, at a great saving in expense for one-way or two-way communications.

GOVERNMENT VS. COMMERCIAL COMMUNICATIONS

New York Gateway Decision Is Warning to Commercial Systems Against Government Encroachment

BY JEREMIAH COURTNEY *

THE Federal Trade Commission has recently published a report [1] which views with alarm the "sharp upward sweep" in the merger of business firms, and particularly the acquisitions that have taken place in several of the traditionally "small business" fields. Inferentially at least, bigness, in and of itself, is condemned in private business.

But how does our biggest business operate? Has anyone ever even heard of a Government agency whose history has not been one of constant expansion of its jurisdiction, its interests and activities? Looking just at the radio field for the moment, why are all the taxis of the country presently confined in frequency use to a single pair of frequencies that even with FM equipment can accommodate satisfactorily no more than 100 cabs in any one area? Why is the Bell System's FM urban mobile service limited to three pairs of frequencies when it needs 300 in the New York City area alone, according to a petition filed recently with the Federal Communications Commission by the American Telephone & Telegraph Company? Why are the police, the railroads, the utilities, and many other FM safety radio services required to assay the sharing of unused television channels for their legitimate needs when no one, not even the Commission, can predict whether or not such sharing will destroy both the television service and the sharing safety service?

The answer to all these questions is not hard to find. Look at the frequency spectrum. One-half of it bears the label "Government". While every private business has to justify its frequency needs to the FCC, the spectrum's biggest user does not. Worse yet, the Government has encroached on frequencies which the Commission has set aside for non-government use. And, having once latched on to the industry frequencies, it has strenuously resisted every effort of the industry affected to regain them.

The importance of limiting the Government's peace-time frequency allocations to its demonstrated needs, and of vigilantly preventing any encroachment upon industry frequencies is illustrated by the experience of the aviation industry, whose frequencies the Civil Aeronautics Administration began to use during the war.

Background Information ★ Whether international aviation communications of an operational nature shall be privately or governmentally handled remains an open question, though the applications filed by Aeronautical Radio, Inc. (ARINC) for new aeronautical radio facilities at New York for the purpose of settling that question were acted upon early this year by the Federal Communications Commission.

The background of that hearing is not without interest to all radio services. Before the war, Pan-American Airways was the sole certificated trans-Atlantic commercial airline operator. In June of 1945, however, certificates authorizing extensive trans-Atlantic operations were granted for a period of seven years to American Export Airlines (which had previously had only a temporary certificate) and Transcontinental and Western Air, as well as Pan-American.

American Airlines (which acquired control of American Export in 1945 and whose name was then changed to American Overseas Airlines) and TWA had been obtaining their air-ground-air communications services in domestic operations from ARINC, the communications organization formed by U.S. air lines to coördinate and conserve frequency-use by all airlines throughout the country. The expansion of international air commerce and the entry of the domestic operators into the international field made it desirable, in the judgment of American Airlines and TWA (Pan-American took a neutral position) for ARINC to render the same communications services internationally that it was rendering domestically.

Government vs. Industry ★ ARINC accordingly filed applications with the FCC for the necessary facilities to serve aircraft flying the Europe-North America route. Although the ARINC applications requested only frequencies which were available for the use proposed under the FCC's Rules and international treaty, the applications were designated for hearing *because the frequencies requested were almost all then authorized to the Civil Aeronautics Administration,* which opposed the grant of ARINC applications!

It is interesting to note, too, how these frequencies became authorized to the CAA. The first radio station facilities serving aircraft flying the Europe-North America route were constructed by Pan-American under FCC authorizations issued in 1936. Pan-American's first survey flights were made in 1937, and commercial service was established in 1939. From that time until June 1941, Pan-American furnished all the required communications services for its trans-Atlantic operations from its own station. In June 1941, the CAA station at New York took over the functions previously performed by the Pan-American station there, whose operations were then discontinued.

In that way, the CAA acquired the New York frequencies previously authorized for non-government use. During the war period, CAA took over the services of other Pan-American stations at San Francisco in 1941, Miami in 1944, and Seattle in 1945. The proposal, in all those three cases, as well as in the New York case, originated with the CAA. In 1943, the CAA built a station in New Orleans, prior to any Pan-American operations out of that port, so that by 1946 the CAA was operating five aeronautical stations serving international flights.

Test Case ★ At that juncture, ARINC began its test case to recover from the CAA the frequencies at New York necessary to service aircraft flying the Europe-North America route. The question presented by the ARINC applications was whether it would be in the public interest for the Commission to authorize industry operation at a particular international gateway of radio facilities serving aircraft flying the Europe-North America route, when a government agency was presently rendering and prepared to render this type of service at that gateway. It should be noted that ARINC had not asked for any frequencies for the regulation of air traffic, for radio aids, or for the collection and distribution of meteorological information (all of which the applicant regarded as proper governmental functions), but had confined its frequency requests to those that would be used only for company-type operational communications such as messages affecting the control, movement, and disposition of the company-owned planes in flight.

The public hearings on ARINC's New York application lasted three days — January 7, 8, and February 25, 1946 but the FCC's decision was not issued until

(CONTINUED ON PAGE 42)

* Courtney, Krieger and Jorgensen, 1707 H St. N.W., Washington, D. C. *Editor's Note:* Jeremiah Courtney was formerly Assistant General Counsel of the FCC, in charge of Safety Services. He acted as FCC Counsel in the New York gateway case and in the 1945 Pan-American proceedings for the use of additional frequencies in the Caribbean Sea. In July, 1946 he resigned from the FCC to enter private law practice.

[1] "Present Trend of Corporate Mergers and Acquisitions" available from the Government Printing Office, Washington, D. C.

FM BROADCAST TRANSMITTERS USING PHASITRON MODULATION

Design and Circuit Information on the G.E. 250-Watt Basic Exciter, and Amplifiers Up to 50 Kw.

BY L. O. KRAUSE *

THE General Electric series of FM broadcast transmitters for operation in the new 88- to 108-mc. band have been designed around a new phase-modulation scheme originally proposed by Dr. Robert Adler of Zenith Radio Corporation. This system has for its major element the tube now well-known to the industry as the Phasitron, which is designated as the GL-2H21.

The theory of operation of this unique tube, and its action in FM transmitter circuits have been discussed at length elsewhere.[1] It is the purpose of this paper to describe the application of the Phasitron to commercial types of FM broadcast transmitters. These include the 250-watt basic exciter, and combinations of power amplifiers to increase the output to 1, 3, 10, 25, and 50 kw.

250-Watt Basic Exciter Unit ★ A complete transmitter in itself, the 250-watt equipment is also a part of all higher-power transmitters. This results because higher power is obtained in each case by merely adding coördinated amplifier "blocks" to the basic unit.

Fig. 1 shows a front view of the 250-watt transmitter with the door open. The individual panels that make up the complete assembly are identified in the illustration.

The unit is straight-forward in electrical design, as is apparent from a study of the block diagram in Fig. 2, and the simplified schematic diagram, Fig. 3. The following basic stages, excluding rectifiers, are employed: audio amplifiers, crystal oscillator, phasitron modulator, frequency multipliers and power amplifiers.

A closeup of the phasitron, mounted in its socket, is shown in Fig. 4. The Permalloy shield, also visible, slips on and off over the phasitron and the modulation coil easily, being held by grounding spring fingers. Fig. 5 illustrates the mounting and modulation coil, with the phasitron removed. Installation is a simple plug-in process, as with any receiving-type tube.

The final tubes, type GL-5D24 or 4-250A, require direct air-cooling on the seals. The base seals need about 5 cfm per tube to insure adequately low seal temperatures. In addition, a small blast of air must be directed against the anode seal. Fig. 6 is a detail of the upper left corner (rear view), of the transmitter. The seal-cooling blower with its associated duct is shown. Air is directed horizontally through the base of each tube from a close-fitting semicircular opening. Part of the air is bled off and directed against the plate seals. There is no mechanical contact between the blower housing and the air duct, as a ¼-in. gap separates them.

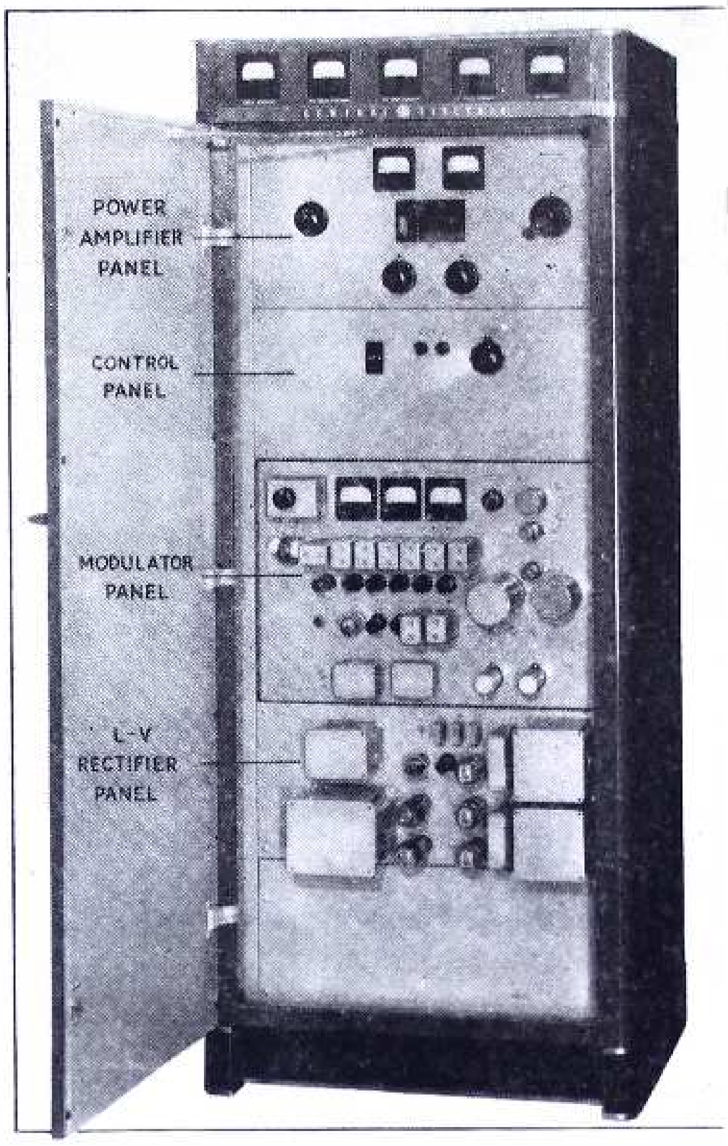


FIG. 1. BASIC 250-WATT EXCITER UNIT

1-Kw. Transmitter ★ This unit is a class C amplifier in a cabinet exactly like that of the exciter, so that they present a symmetrical appearance when they are combined. Only electrical interconnections are required when the amplifier is added to the exciter.

Fig. 7 shows the front of the 1-kw. transmitter with the doors closed. The exciter is at the left and the amplifier at the right. Overall dimensions are 75 ins. high, 25 ins. deep, and 72 ins. wide.

The internal construction of the amplifier is such as to provide ready access to all components. This is illustrated in Fig. 8, a rear view of the amplifier only. The high-voltage power supply is located on the cabinet floor. The next section mounts the tube-cooling blower. The control circuit components are mounted in a vertical arrangement in the right-hand half of the next section, with the plate tank at the left. The uppermost portion contains the grid-driving circuits.

The amplifier stages employ a pair of type GL-7C29 triodes in a conventional cross-neutralized push-pull amplifier. Resonant open transmission lines are used for the grid and plate RF circuits.

The grid line is built of X-band waveguides, closely spaced as Fig. 8 shows. The resulting low impedance of the line prevents the tube and circuit capacitance from producing excessive fore-shortening. Coarse tuning of the grid circuit is done by adjusting a shorting-bar. Fine tuning adjustments are made from the panel by varying a standard multi-plate capacitor

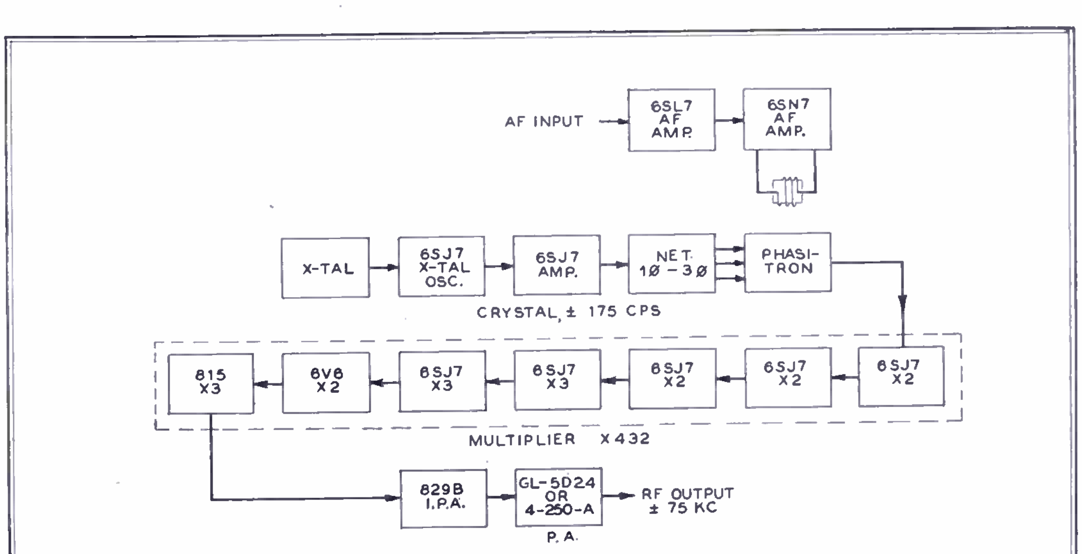
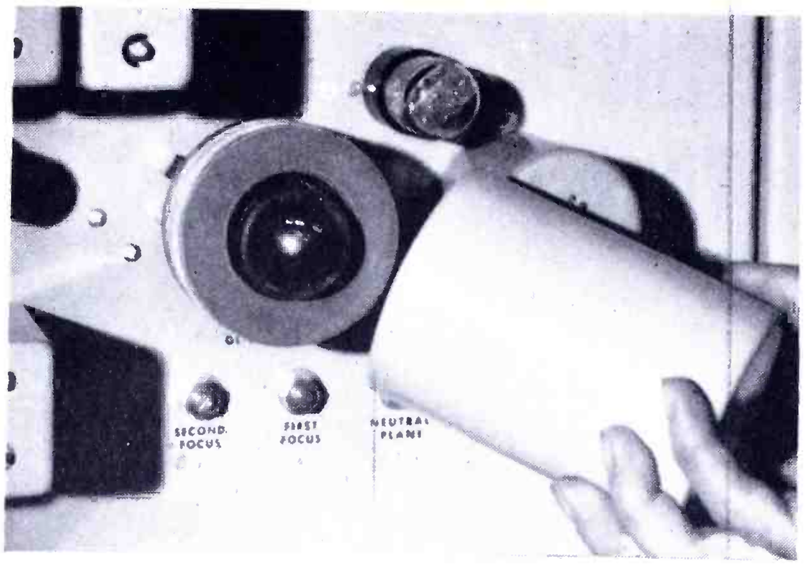


FIG. 2. BLOCK DIAGRAM SHOWING THE PHASITRON FM MODULATOR SYSTEM

* Broadcast Engineering Section, Transmitter Division, General Electric Company, Syracuse, N.Y.

[1] See "Phasitron Modulator" by Dr. Robert Adler, *FM and Television*, Dec. 1945, and "Phasitron FM Transmitter" by F. M. Bailey and H. P. Thomas. *Electronics*, Oct. 1946.



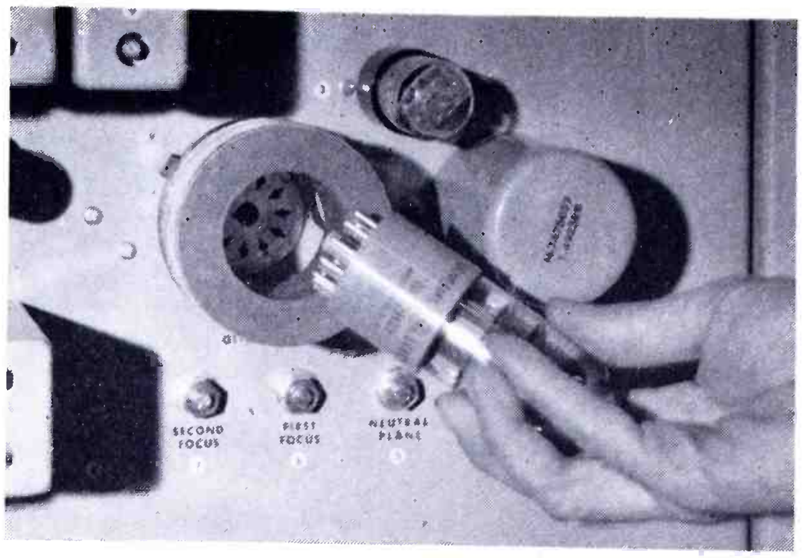
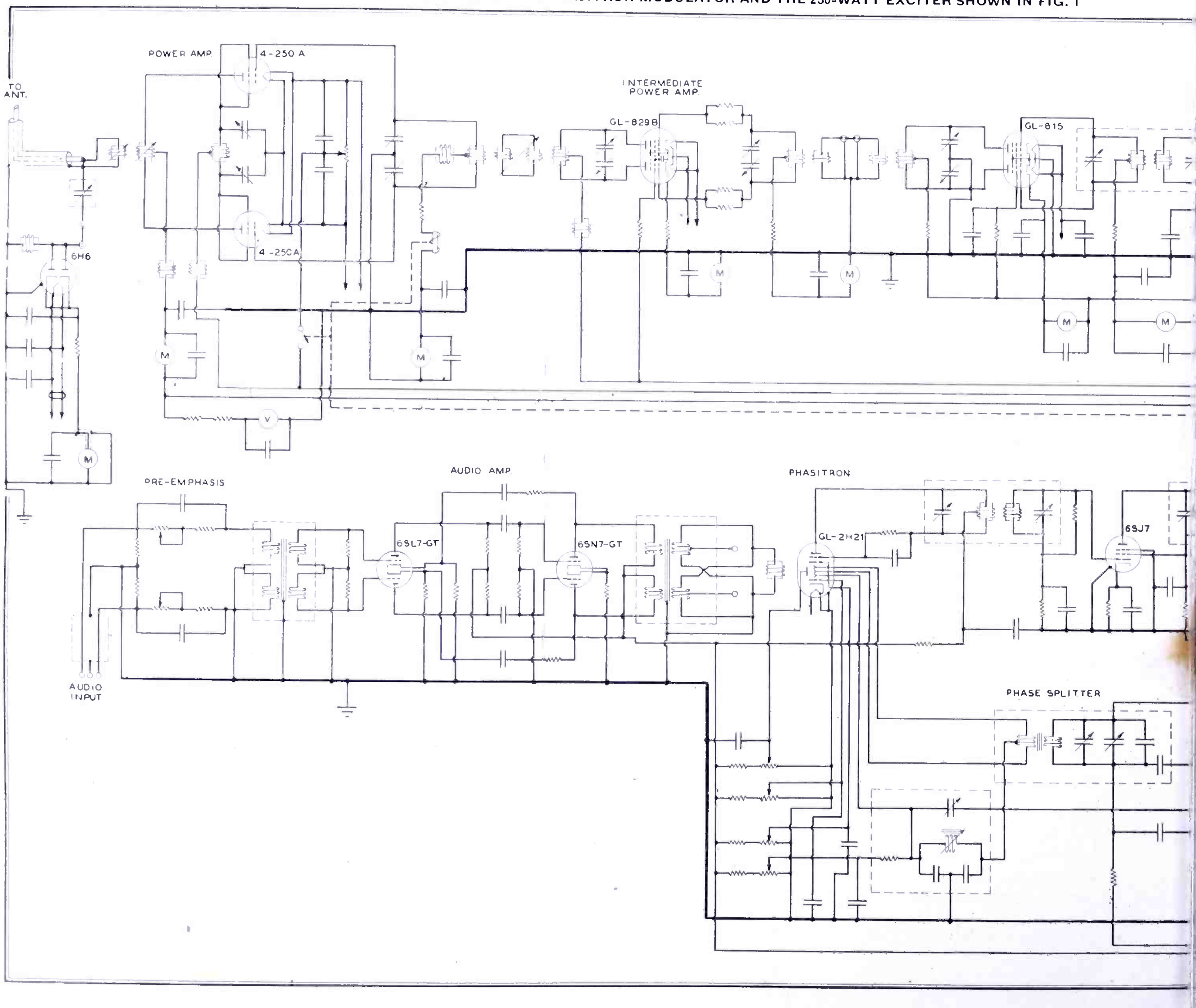


FIG. 4. PHASITRON TUBE WITH THE SHIELD REMOVED. FIG. 5. NOTE THE MODULATION COIL SURROUNDING THE PHASITRON

connected across the open end of the line. This capacitor is visible in the upper-left of Fig. 8. The panel grid-tuning adjustment is wide enough to cover 4 mc., or approximately 20% of the total FM band. This is sufficient to make the setting of the shorting bar non-critical.

Unbalanced hairpin loop coupling is made to the grid line for excitation. The loop terminates a piece of ⅞-in. transmission line carried back to the output of the exciter. Because of the low-impedance construction of the grid line, the driving loop must be located quite near it to produce adequate coupling. To prevent unequal grid drives resulting from capacitive coupling to the unbalanced loop, a Faraday shield is placed between the

FIG. 3. COMPLETE SCHEMATIC WIRING DIAGRAM OF THE PHASITRON MODULATOR AND THE 250-WATT EXCITER SHOWN IN FIG. 1



loop and the line. This shield can be seen in Fig. 8.

The plate line comprises two 2⅝-in. tubes spaced 1 in., and mounted vertically. As well as forming part of the resonant circuit, each line section serves as the socket for one of the amplifier tubes and as a cooling-air guide. The type GL-7C29 has air-cooled, external-anode construction. The anode slides inside the plate-line section until a stop is reached. The lower ends of the plate-line sections open into an electrically insulated chamber pressurized by a blower with filtered air. Power amplifier plate voltage is interlocked with the air-flow by a centrifugal switch located in the blower motor, so that the power is cut off if the air flow stops.

Coarse tuning, as with the grid line, is accomplished by adjusting a shorting bar. Fine tuning is done by means of a special capacitor mounted near the open end of the line. The rotor of this capacitor is controllable from the panel. The capacitor is designed to have a high ratio of maximum to minimum capacity, with a very low minimum. This permits a panel tuning range of approximately 2 mc., or 10% of the FM band. The wide tuning range of both the grid and plate circuits results in great ease of adjustment.

The neutralizing capacitors are not controllable from the panel. This is not necessary, since amplifier tubes can be changed without appreciably upsetting neutralized operation. In fact, the amplifier remains completely stable without any readjustment.

Power is coupled from the plate tank into a 51.5-ohm, ⅞-in. transmission line by an untuned hairpin loop. This coupling is adjustable from the panel. A relative indication of coupled power is furnished by a vacuum-tube voltmeter connected to the transmission-line input. The voltmeter reading is adjustable to a nominal indication of 100%.

The amplifier requires an RF driving power of approximately 100 to 150 watts for 1-kw. output. Plate efficiency over the band averages 63%.

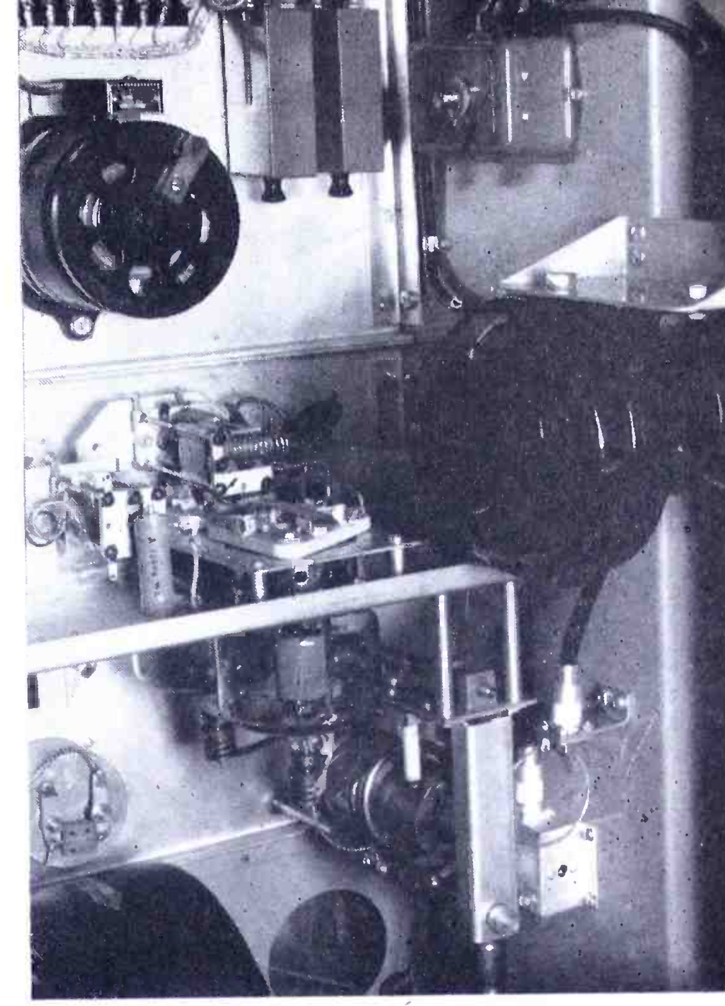


FIG. 6. BLOWER FOR FINAL TUBES

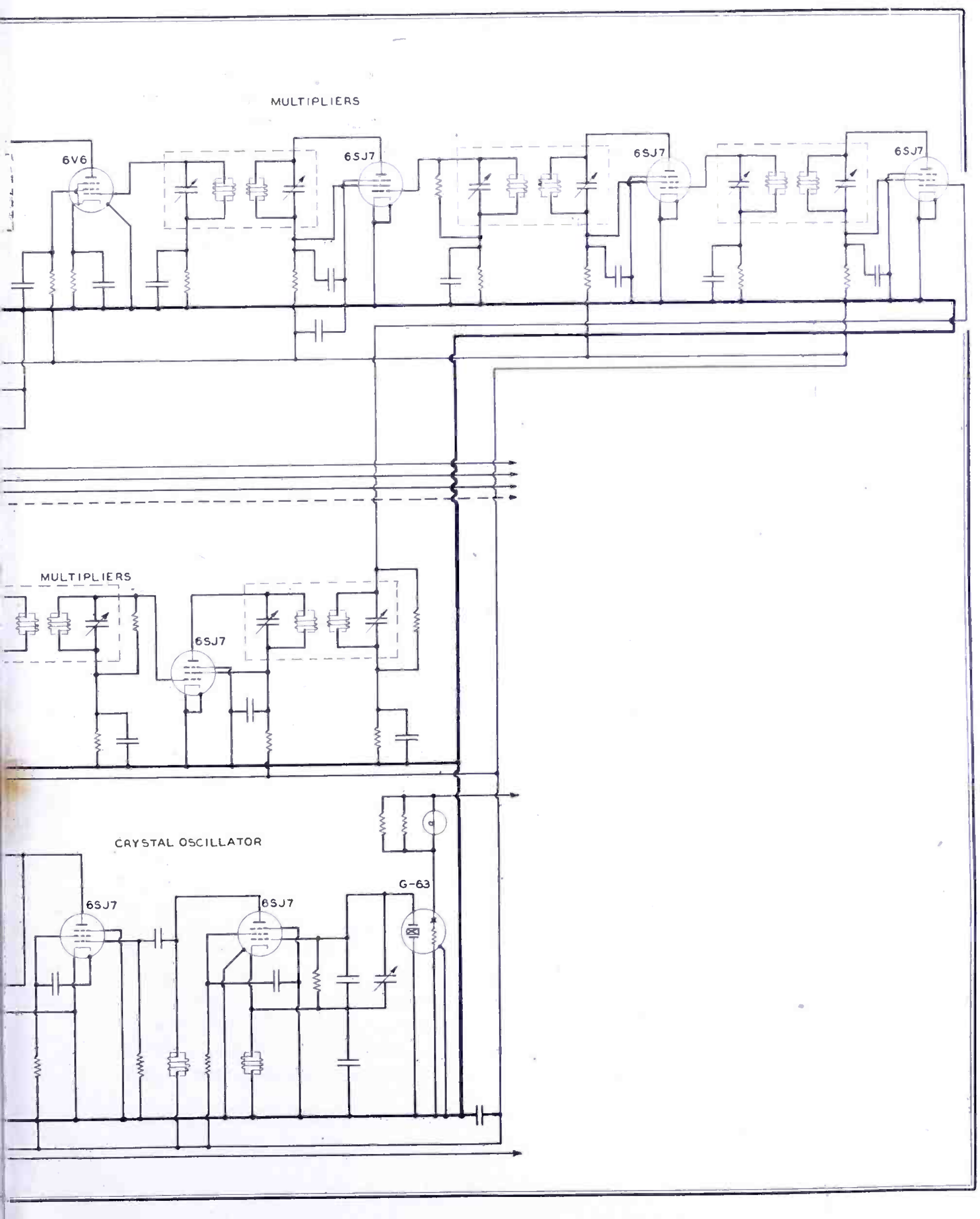


Plate power is supplied by a pair of type GL-8008 tubes in a conventional full-wave rectifier, which furnishes 2,650 volts to the amplifier. Surge-current protection is provided for the rectifier tubes by a resistor in series with the filter capacitors, to limit the inrush current. This resistor is short-circuited after a brief time delay when plate voltage is applied. This delay is long enough to allow the capacitors to become almost fully charged before the resistor is shorted out. DC overload protection is provided by means of a relay in the plate return lead, while the AC is protected by a magnetic type of circuit breaker.

The transmitter is designed to operate from 195 to 240 volts, single-phase, 50 or 60 cycles. A variable transformer, in conjunction with a bucking transformer, makes the transmitter operating voltage continuously adjustable to 200 volts. This is the proper primary voltage. Voltage boost is obtained when the variable transformer passes the neutral point and reverses the phase to the bucking transformer.

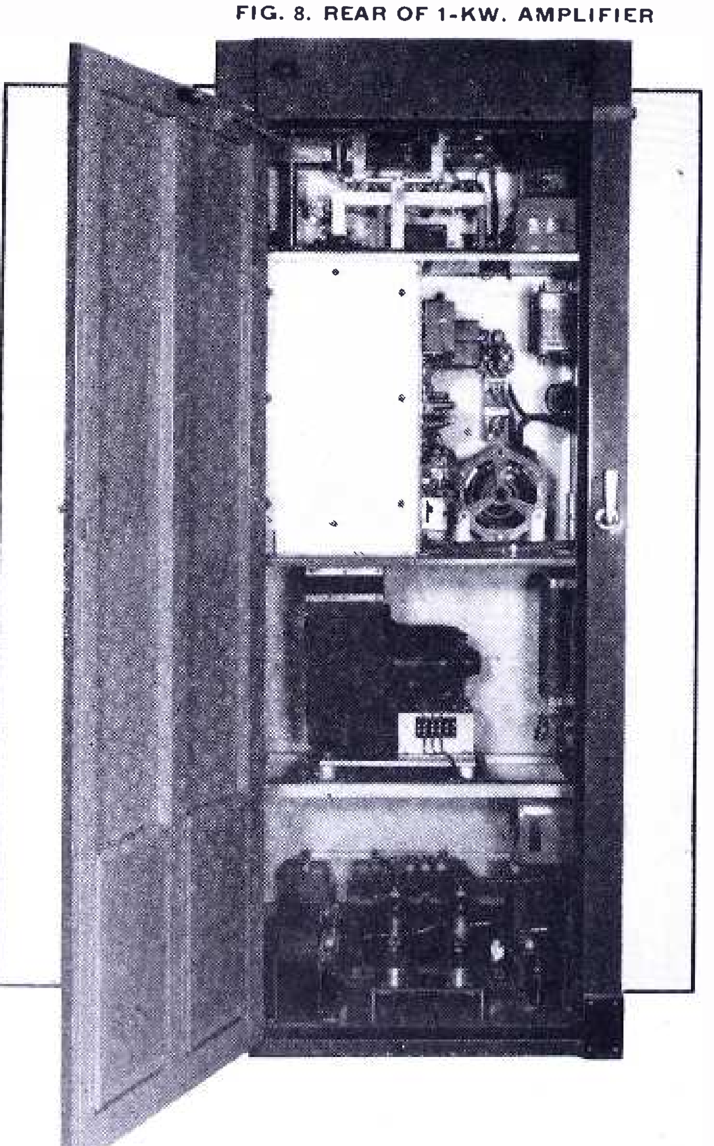
The control circuit is completely isolated from the power line by a 200-to-115-volt stepdown transformer. Such isolation increases safety. The voltage stepdown permits the use of standard relays and other control elements. For 50-cycle operation, the control circuit voltage is made 95 volts, resulting in proper rms current for the AC relays. The control circuit includes automatic reclosing of the plate contactor in case of plate overload. Where the amplifier is used in humid locations, a cabinet heater can be supplied.

FIG. 7. FRONT OF THE 1-KW. UNIT

3-Kw. Transmitter ★ The 3-kw. transmitter comprises the exciter, an amplifier in a cabinet similar to that of the exciter, and a sturdy cubicle housing the amplifier plate-power supply. The cubicle serves as a spacer between the two cabinets. It is 4 ins. wider than the 1-kw. spacer, making an overall length for the 3-kw. equipment of 76 ins. Otherwise the two units are identical in external appearance. No mechanical reconstruction is necessary when adding the amplifier to the exciter. Fig. 9 is a front view with the doors open. The exciter is at the left and the amplifier at the right.

The internal layout of the amplifier cabinet is similar to that of the 1-kw. set as indicated by a comparison of the rear views in Figs. 8 and 10. The arrangement of the 3-kw. plate supply in the spacer-cubicle is clearly shown in Fig. 10. The small power supply located just above the blower in the amplifier cabinet supplies voltage for the final screens.

FIG. 8. REAR OF 1-KW. AMPLIFIER



A pair of GL-7D21 tubes serves as the final amplifier in a push-pull circuit. The type GL-7D21 is a new tetrode having co-planar, disc-seal construction, though the tube elements internally are coaxial cylinders. Each cylinder flares out to its disc. An interesting feature of this construction is an apparent reduction in effective internal capacitance when used with transmission-line type tanks. The elements act as a continuation of the transmission line, producing less shortening of the line than would occur if the capacitance were effectively lumped across the end of the line. The anode is external and air-cooled.

The grid line is constructed of X-band waveguides. It is coarsely tuned by adjusting the shorting bar, with a standard multi-plate capacitor, mounted at the open end, for fine tuning. The rotor control of this capacitor is extended to the front panel. Excitation is coupled into the grid tank by means of an unbalanced hairpin loop. A Faraday shield is placed between the loop and the grid line to prevent unbalanced grid drive because of unbalanced electric coupling.

The plate RF circuits are visible in Fig. 11, in which the plate RF shield has been removed. The plate tank comprises a pair of vertically mounted tubes 3¼ ins. in diameter spaced 1 in. The upper portion of each is telescopic. The anode of the type GL-7D21 slips down into this telescopic section, while the section with the amplifier tube is lifted, forcing the tube home into its socket. The socket is a series of spaced spring-finger rings. Thus a speedy and simple means is provided for changing tubes. It is only necessary to unlock the telescopic section and unclamp the tube. There are no connections to make. Fig. 12 illustrates the ease with which a final tube can be changed. The line section has been telescoped, and the tube, having been unclamped, is being removed.

The plate line also serves as a cooling-air duct. The lower end opens into an electrically insulated chamber, pressurized with filtered air by a blower, as in the 1-kw. amplifier. Low-pressure air is used to keep air-rush noise at a minimum. A centrifugal switch in the blower motor provides plate-voltage air-flow interlock.

Although the final tubes are tetrodes, improved operation results from the addition of a very small amount of cross-neutralizing capacitance. Feedback from only one of the plates to the opposite grid is used. The feedback capacitance is not critical and needs no adjustment over the frequency range, nor is it affected by tube change. It is so small that negligible effect is produced on the tuning points of the grid and plate circuits.

The tune-up of the amplifier is very simple, requiring only adjustments of the grid and plate circuits from the front panel. The wide tuning range on these two circuits makes adjustment of the shorting bars non-critical.

Power is coupled into the 51.5-ohm, 1⅝-in. output transmission line by a series-tuned loop. The tuning capacitor, visible in Figs. 11 and 12, requires no change in setting over the entire FM band. The transmission line voltage is sampled and rectified to give an indication of relative power, with the nominal reading adjusted to 100%.

The average plate efficiency of the amplifier is about 64%. Required driving power for 3-kw. output is in the range 100 to 150 watts, giving a power gain of 20 to 30 times.

The amplifier operates from 208 to 230 volts, 3-phase, 50 or 60 cycles. Plate voltage, about 3,750 volts, is supplied by 6 type GL-8008 tubes in 3-phase, full-wave connection. The primary of the rectifier transformer can be switched instantaneously from delta to wye connection at the panel. When wye-connected, the plate voltage is reduced to 58% of normal. This connection is used when the amplifier is tuned the first time, or whenever reduced power is wanted. In addition, primary taps are provided to permit compensation for local line voltage differences. Surge current protection is furnished for the rectifier tubes by means similar to that used in the 1-kw. amplifier. Plate voltage cannot be applied to the final stage until sufficient grid excitation obtains. This interlocking is provided by a relay coil in the DC grid current to protect the GL-7D21 tubes from excessive plate dissipation in case of excitation failure. Such protection cannot be furnished practically by cathode bias.

The screen voltage is furnished by a separate rectifier, a pair of GL-866A/866 tubes, in full-wave connection. This voltage is only 500 volts, and considerable power would be wasted if the screen voltage were obtained from the resistance divider across the high-voltage supply. A variable transformer, controllable from the panel, permits continuous variation of the screen voltage. When the plate voltage transformer is switched to wye connection, the screen voltage is reduced simultaneously.

DC overload protection is furnished by relays in both the plate and screen return loads. AC protection results from use of a magnetic overload-breaker for the main power switch. Circuits are included to give automatic reclosing of the plate contactor, should a brief power-line failure or a plate overload occur.

Filament voltage for the type GL-7D21 tubes is continuously variable from the panel for proper setting independent of line voltage variations. This is done by use of a variable transformer supplemented with a line-bucking transformer.

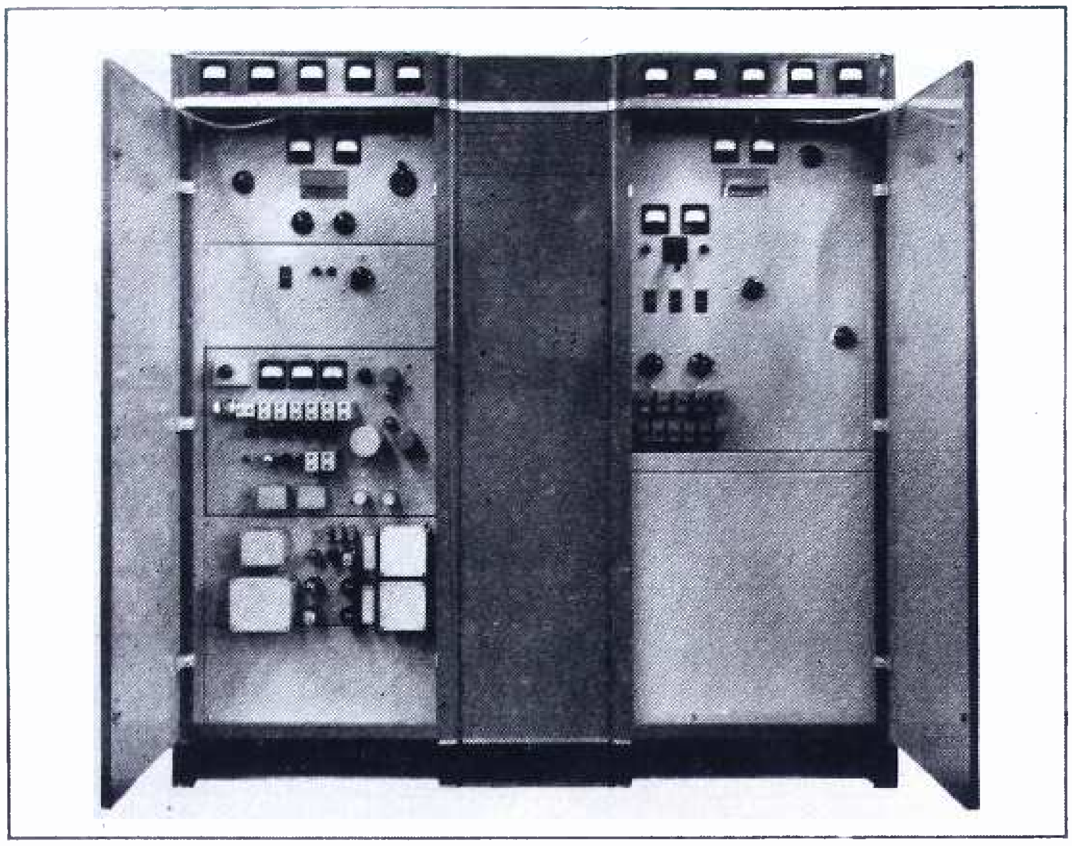


FIG. 9. THE 3-KW. AMPLIFIER COMBINED WITH THE 250-WATT EXCITER UNIT

For safety, the control circuit is isolated from the power line by a step-down transformer. The circuit operates at 115 volts on 60 cycles, or 96 volts on 50 cycles.

Rear door interlocks are provided for automatic removal of plate voltage. At the same time both the plate and screen voltages are grounded.

10-Kw. Transmitter ★ This comprises a 3-kw. transmitter with rectifier and power amplifier cabinets added. Each cabinet measures 48 ins. wide by 34 ins. deep by 84 ins. high, a size sufficiently small to make location easy. The overall transmitter length becomes 14 ft. 11 ins.

Individual cabinets, from left to right, are: 10-kw. rectifier and control, 250-watt basic exciter, 3-kw. plate supply (no front access door), 3-kw. RF amplifier, and 10-kw. RF amplifier.

Addition of the amplifier to the 3-kw. exciter requires only electrical interconnections. No mechanical reconstruction of any kind is necessary because the transmitter is completely self-contained.

A pair of General Electric type GL-5518 triodes, employed as a grounded-grid push-pull amplifier, serves as the final stage. The type GL-5518, specially designed for this 10-kw. transmitter, is an air-cooled successor to the efficient, water-cooled, GL-9C24. The bottom cylinder of the tube is the air-cooled anode. About 2 ins. above this is the ring-seal grid contact. The next two smallest ring-seals are those of the filament. The type GL-5518 exhibits excellent operating characteristics at FM frequencies. A pair of them is ample for a conservative 10-kw. output. Sturdy tungsten filaments have sufficient emission to allow operation at reduced filament voltage for long life expectancy.

Physically, the RF circuit of the amplifier is similar to that of the 3-kw. type except that the circuit elements are larger. Fig. 13 is a closeup, partial view of the rear of the 10-kw. amplifier, showing the major portions of the RF circuits. The filament circuit appears just above the upper shelf. It is quarter-wave tuned, and built of closely-spaced rectangular sections. A shorting bar allows coarse adjustment. Fine tuning is accomplished by a variable capacitor located near the filament terminals. Excitation is coupled into the filament circuit from the 3-kw. driver by means of a balanced coupling loop. Transformation from unbalanced to balanced driving signal is made by special RF plumbing located inside the box just above the filament circuit, Fig. 13. The transforming section is extremely broad-band, and no tuning of any kind is provided or required. The balanced coupling insures equal drive to the final tubes.

The plate circuit appears in the middle left of Fig. 13. The rear tube has been removed. Normally, a shield plate completes the housing around the plate circuit. This shield is held by quick-release fasteners for ready removal if tube change is necessary.

The plate circuit consists of a pair of vertically-mounted tubes 5½ ins. in diameter, spaced approximately 1 in. apart. The upper portion of each is telescopic. The anode of the GL-5518 is clamped in this telescopic section. Manual rotation of the section automatically raises the section and tube until grid contact is made with spring fingers. Then the section is locked in place. It is only necessary to secure the filament connectors by means of thumb nuts. This process represents a speedy and simple means for changing tubes.

A shorting-bar provides coarse plate-tuning, while fine tuning is panel-controlled through a rack and pinion which moves a capacitance plate toward or away from the upper end of the tank.

RF output power is coupled by a balanced loop into a 3⅛-in. output transmission line. Balanced coupling to unbalanced output is provided by a transforming section identical with the driving system, except for larger size.

Balanced output coupling is important to the maintenance of circuit and tube

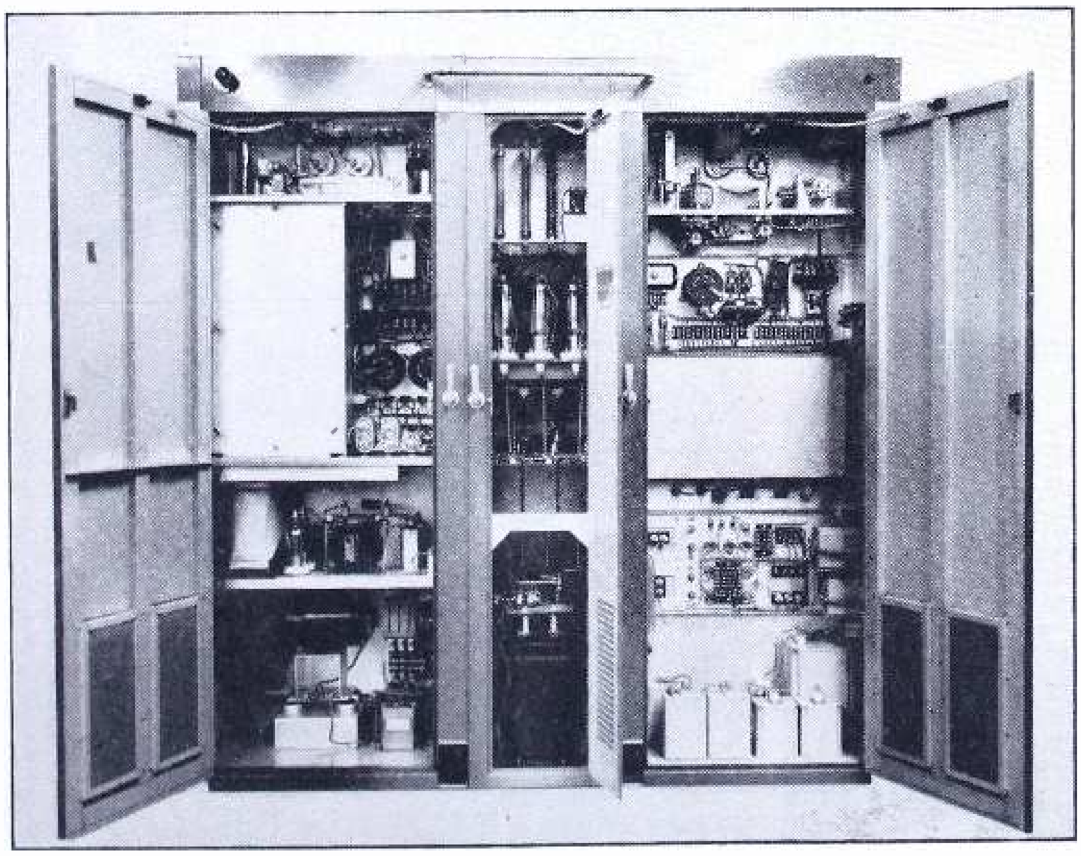


FIG. 10. REAR VIEW OF THE 3-KW. TRANSMITTER SHOWS PLATE SUPPLY AT THE CENTER

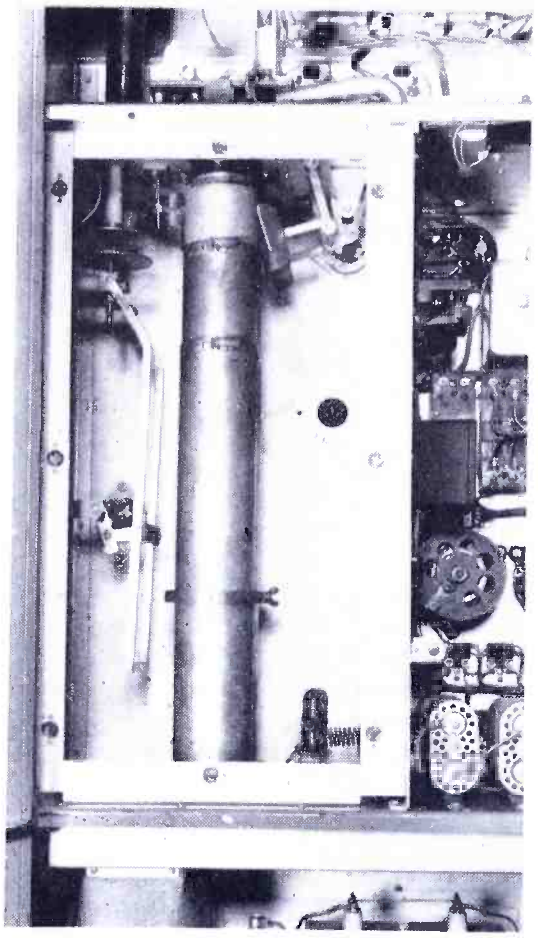


FIG. 11. RF SHIELD HAS BEEN REMOVED TO SHOW PLATE RF CIRCUITS

balance. The plate circuit lines also serve as anode-cooling air ducts. Cooling air is drawn in through filters in the rear of the cabinet, through the cooling fins of the tube radiators, down the plate line to the air blower, and thence exhausted through an air duct at the top of the cabinet. The blower is located on the cabinet floor, just under the lower shelf shown in Fig. 13. In this way the cool, incoming air, flowing over the glass envelopes of the tubes, materially assists in keeping this glass at a safe operating temperature. An air-flow interlock is provided to protect the tubes in case of cooling-air failure.

Although the grounded-grid circuit inherently has low power gain, a driving power of less than 2.5 kw. is sufficient to obtain 10-kw. output with good efficiency. Under these conditions, the actual efficiency is from 60 to 65%, and the ratio of the output power to DC input at the amplifier is between 75 and 80%. This high apparent efficiency is due to "feed-through" of driver power.

The high-voltage rectifier and control circuits for the amplifier are located in a separate cabinet, Fig. 14. The control relays are mounted on the right wall, and the power contactors on the left wall in this rear view. The top of the high-voltage transformer appears in the lower right, and the rectifier tubes in the upper center. The equipment operates from 208 to 230 volts, 3-phase, 50 or 60 cycles. Plate voltage, about 5,500 volts, is supplied by 6 type GL-8008 tubes in 3-phase, full-wave connection. As in the 3-kw. amplifier, the primary of the main plate transformer can be switched instantaneously from delta to wye connection at the front panel. The rectifier tube filaments are all quarter-phased with respect to their anode currents for long life operation when the plate transformer is in delta connection. Surge current protection is provided by a primary resistance stop-start circuit.

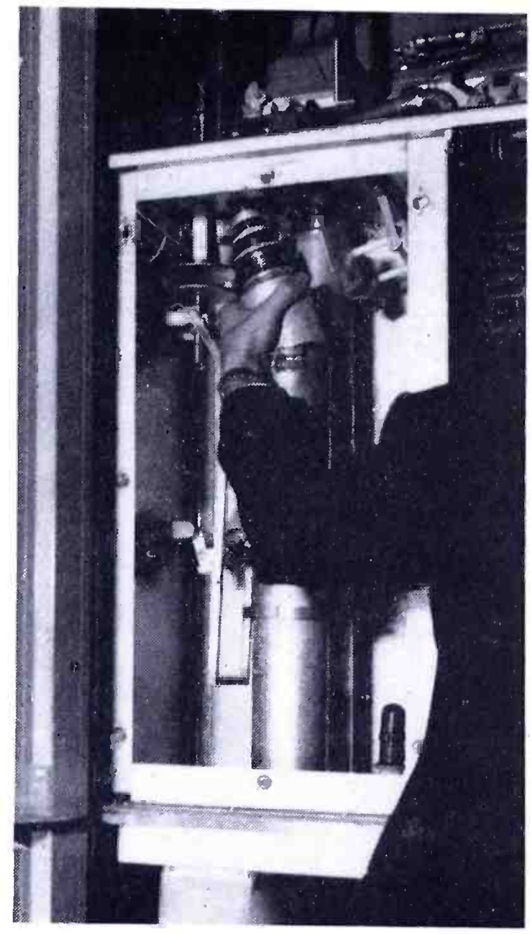
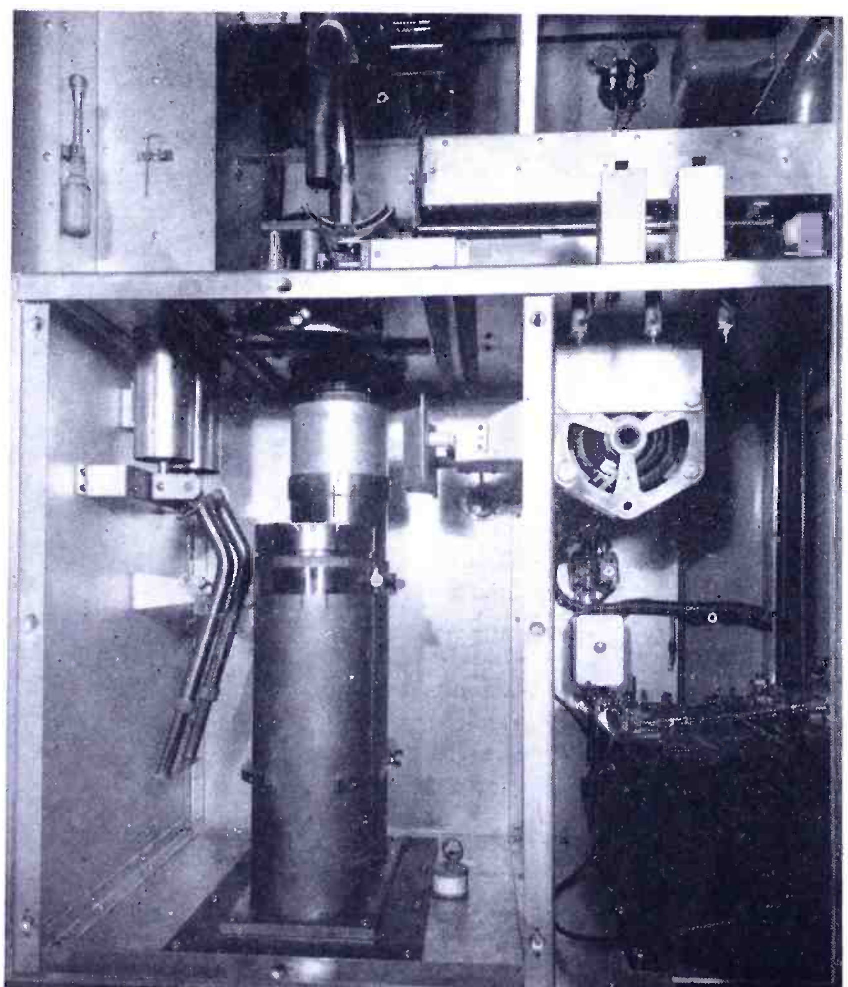


FIG. 12. TELESCOPED LINE SECTION PERMITS REMOVAL OF FINAL TUBE

Fuseless overload protection is employed throughout this equipment. Both DC and AC overload relays protect the main rectifier. Magnetically-operated circuit-breaker type switches are used in the blower motor, control, and filament circuits. In addition a main line circuit breaker, built into the amplifier, has am-

(CONTINUED ON PAGE 52)



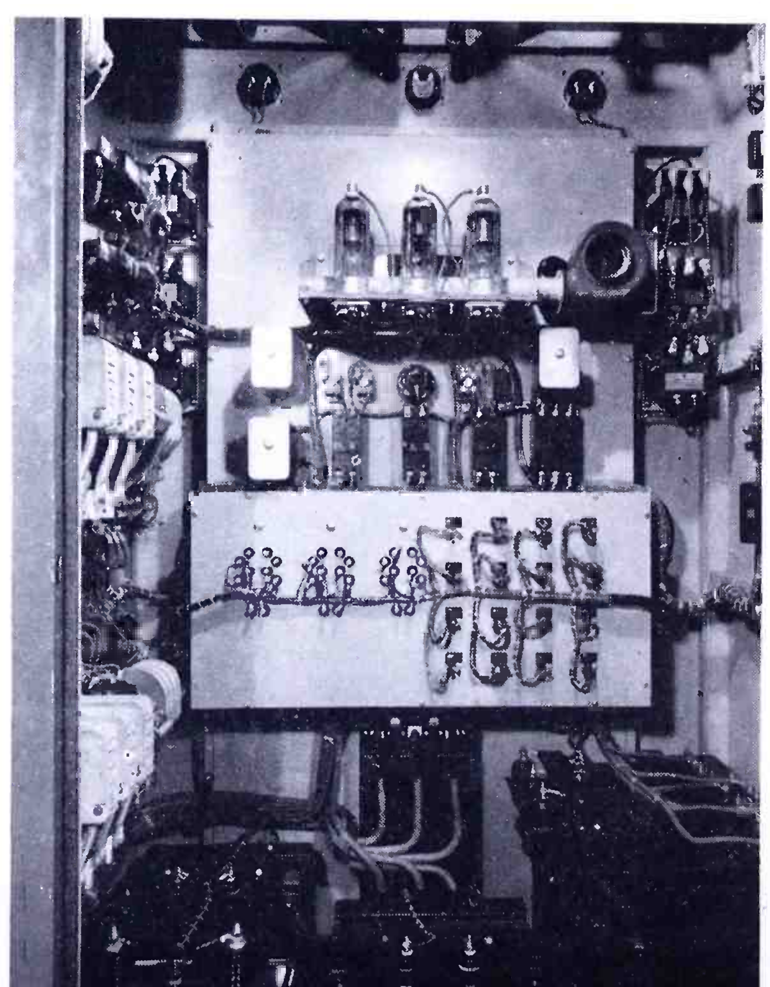


FIG. 13. CLOSE-UP VIEW SHOWING REAR OF 10-KW. AMPLIFIER. FIG. 14. HIGH-VOLTAGE RECTIFIER AND CONTROL CIRCUITS

TELEVISION HANDBOOK

CHAPTER 2—Characteristics of Television Images

BY MADISON CAWEIN

Video and Audio Waves ★ All information is transmitted from one point of space to another by means of the transfer of energy, which requires time. This transfer may be made in the so-called direct manner as, for instance, by the use of moving, material objects, such as balls rolling in a time sequence; or, in a less obvious manner, by the radiation of energy.

Radiant energy is a form of energy about which not too much is known. It involves the transfer of mass throughout all of the space surrounding a point of origin; and the transfer takes place at constant speed, i.e., the speed of light.

Radiant energy is a wave motion in space and time, which involves the transfer of electric and magnetic fields.

In general, a wave is a periodic, functional relationship between the magnitude of some physical thing and an interval of time. One period of the wave is called a *cycle*. The time elapse from the start of a cycle to any occurrence in the cycle is called the *phase* of that occurrence. Thus, phase is a ratio of times-of-occurrence, and is a pure number.

The number of units of phase in a complete cycle is entirely arbitrary. It has been taken as equal to the number of angular units in a circle, as a matter of mathematical convenience. The time rate of change of phase of a wave is called *phase velocity*, or sometimes *angular velocity*.

Energy is radiated through space at the speed of light in such a fashion that at any point of space the wave motion of the increase or decrease of the electric and magnetic vector fields is a sinusoidal function of the time. This is illustrated in Fig. 27, which is a graph of the change in intensity of the electric vector in a broadcast wave at 100 megacycles, as related to time. Time is plotted as the abscissa in intervals of 1/100,000,000 of a second, starting at the instant when the electric vector is

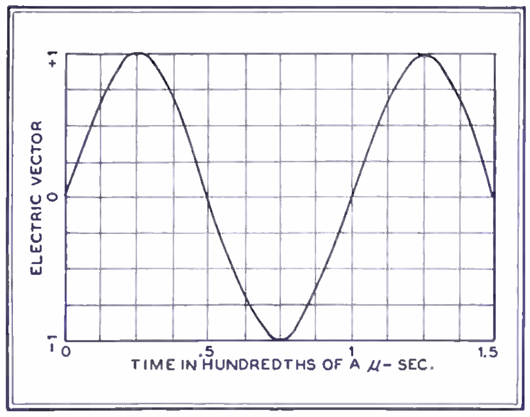


FIG. 27. PLOT OF ELECTRIC VECTOR

zero. The fact that the electric vector reverses polarity means that the force of action on an electron at this point in space changes from an attraction to a repulsion each 200,000,000ths of a second.

The electric and magnetic vectors which constitute radiant energy will induce potentials in conductors exposed to the radiation by virtue of the action of the electric fields on the electrons in the conductors. When a potential wave is induced across a conductor, a current will flow therein. If the conductor is a pure resistance, the wave-shape of the current is identical to that of the induced potential. If, however, the conductor circuit contains a reactive component, such as a coil or capacitor, it is an experimental fact that the phase velocity of the current, which is inversely proportional to the periodicity, is always equal to that of the induced or applied potential, but the functional relationship between amplitude and phase, which is called waveform, is

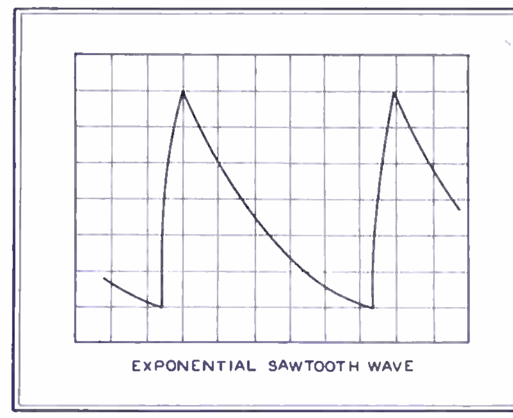


FIG. 28. REPLOT OF SAWTOOTH WAVE

differentiated and/or integrated with respect to time. Thus, any complex potential-wave across a reactance will produce a complex current-wave of the same periodicity but of different shape.

The change in shape of current waves with respect to potential waves is of extreme importance in television. All television information is transmitted by means of wave motions either in space or in conductors. Unless the wave form of the current follows that of the potential exactly, a distortion in time and position of a reproduced picture element will occur with respect to the transmitted element.

The importance of change of shape of waveform in television can be seen by an examination of the waveforms which were shown in Fig. 4. If the current flowing through an inductor has the sawtooth waveform shown in this figure, the potential induced across the inductor due to this current would have the impulsive form of the pedestal shown in Fig. 4. The waveform of the pedestal is proportional at every instant of time to the slope of the sawtooth current wave, and is called the *derivative* of this wave. Inductors have a property of developing a potential which is proportional to the derivative of the current flowing there through. This is due to the fact that an electric current has inertia, and every change in current in an inductive circuit is opposed by an induced potential which is proportional to the time-rate-of-change of the current.

If the current flowing through an inductor has the parabolic form shown in Fig. 4, then the potential across the inductor

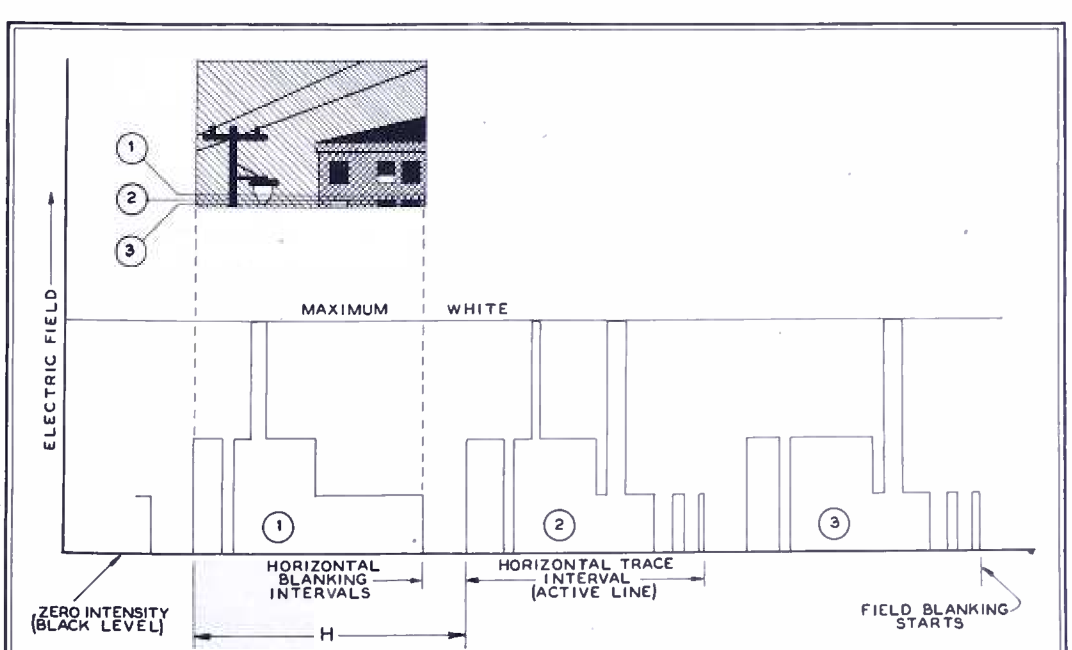


FIG. 29. WAVEFORM OF ENERGY REPRESENTING THREE PICTURE LINES AT 1, 2, AND 3

will have a sawtooth form, because the sawtooth waveform is the derivative of the parabolic waveform.

The facts stated in the two paragraphs above would be reversed in sequence if the reactance through which the current is flowing were capacitive rather than inductive. Thus, if impulsive current flows into a capacitor the potential built up across the capacitor will be of sawtooth waveform, and if a sawtooth current flows into a capacitor the potential developed across capacitor will be of parabolic form. This is due to the integrating effect of capacitance. That is, the potential developed across a capacitive reactor is proportional to the time-integral of the current flowing into it. Another way to state this fact is that the current flowing through a capacitor is proportional to the time-rate-of-change of the potential existing across it.

The importance of phase in the maintenance of waveform can be seen by reference to Fig. 28, which is a replot of the sawtooth waveform of Fig. 4 except that the phase of each of the harmonic components which compose the sawtooth wave has been retarded a slight amount relative to the phase of the fundamental component. The phase retardation of these components is very slight, as shown in Table 2. Retarded phase means that the peak value of the component occurs later than it should. For the tenth harmonic component, this retardation amounts to approximately 16° out of 360°, which is of the order of 5%. It can be seen by an examination of Table 2 that the retarded phase of the higher frequency components becomes constant. Actually, the maximum value of this retardation is approximately 17.7° in the example chosen, which occurs approximately at the 30th harmonic and is constant for all higher harmonics. It is, therefore, the phase advance of the fundamental relative to the higher components which causes a linear sawtooth to degenerate into the so-called exponential sawtooth wave which was plotted in Fig. 28.

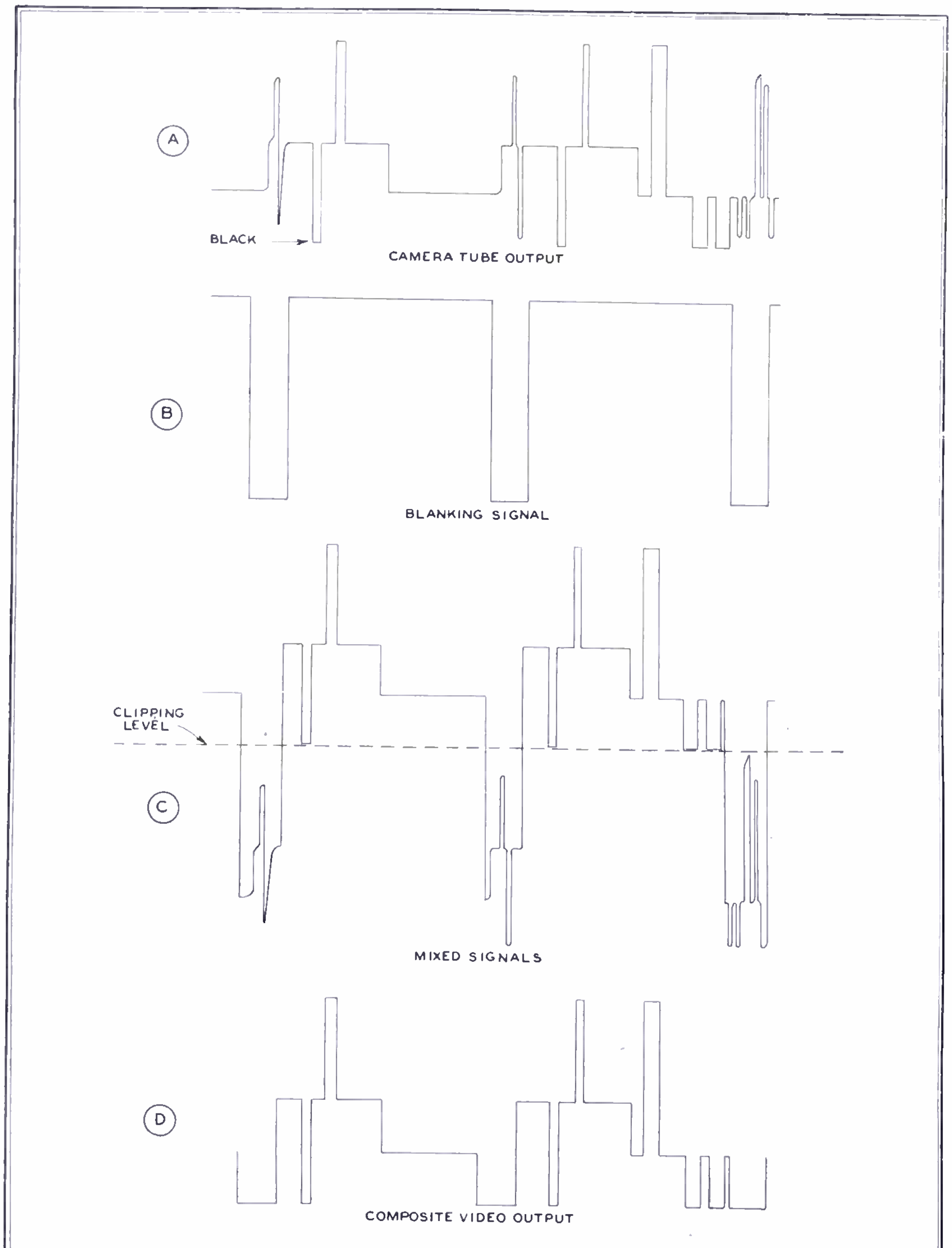


FIG. 30. MANNER BY WHICH THE COMPOSITE, TRANSMITTED SIGNALS ARE PRODUCED

TABLE 2

RELATIVE PHASE RETARDATION FOR THE HARMONIC COMPONENTS OF AN EXPONENTIAL SAWTOOTH WAVE

Component	*Relative Amplitude*	*Phase Relative to Fundamental*
1st Harmonic (Fundamental)	100%	0°
2nd	47.7	8.65
3rd	29.0	11.65
4th	19.3	13.15
5th	12.9	14.05
6th	8.6	14.67
7th	5.3	15.10
8th	3.0	15.42
9th	1.2	15.67
10th	0	15.88
(31st)	3.1	(17.7)
(101st)	0.9	(17.7)

With this brief introduction to the theory of complex waves, a more detailed discussion of waves concerned in various parts of the television system will be set forth in the following sections.

1. Video Information ★ Video information is transmitted by means of a complex waveform of energy. This energy may be either radiated, electromagnetic energy in space or electric energy in a conductor. In either case, the intensity of the electric field which is being transmitted by radio broadcast or by wire will have a form substantially as shown in Fig. 29. Fig. 29 is the graph of a video wave, already shown for a brief interval as the portion of Fig. 1, labeled V.

The waveform of Fig. 29 shows the change in the electric field being transmitted during the last several lines of one of the even-numbered fields of an RMA standard television picture, near the start of the field pedestal which occurs at the bottom of the picture. Each interval labeled H represents one complete line of the picture. The rectangular pedestals immediately preceding and following each line of information are the blanking pulses which establish black level. The amplitude of these pulses is shown as zero during the pedestal interval. Zero level in the video wave corresponds to complete blackness on the cathode-ray tube screen. During this blanking interval, the cathode-ray tube grid is of such potential as to just cut off the beam current so that there is no light on the screen. Immediately following the blanking period, the electric field depends upon what the illumination in any particular line of the picture happens to be. In Fig. 29 this illumination is shown as half-white, or half the maximum illumination which occurs along the line. The example chosen is for three lines as shown in the small insert picture in Fig. 29.

It will be observed that the variations in the video wave correspond to the illumination levels in the picture along these three lines. For example, there are two points at absolute black along each line and two points at maximum white. The remainder of the illumination values along each line vary between different shades of gray.

The video wave is made up of two separate waves, and thus is in itself a composite wave. The two components of the wave which conveys video information are shown in Fig. 30, for several lines of the picture. Curve A is representative of the line-by-line video signal which would be generated at the camera tube as, for instance, in a dissector, during the trace and retrace portions of the horizontal deflection cycle. The signals generated during the trace portion of the cycle are the desired signals which it is necessary to transmit in order to obtain a picture.

A corresponding, backwards video signal is generated during the retrace at a much faster rate. The frequency band for this undesired signal is much wider than that for the desired signal, so that picture element pulses are not as sharp and usually are not of the same amplitude during the retrace as during the trace. This is shown in the blanking interval of curve A. This retrace signal, if transmitted and allowed to modulate the picture-reproducing tube, would create a ghost image during the retrace which would not correspond exactly in time with the desired image unless the timing of the horizontal synchronizing system were at least ten times more accurate than usual.

For this reason, the ghost signal generated during the retrace is blanked out by mixing in a blanking wave as shown in curve B in Fig. 30. The blanking signal and the video signal are mixed in a mixing amplifier in such a fashion as to produce a composite wave as shown in curve C. There the undesired signal level is far below the desired signal level. This composite wave is applied to a clipper, or limiting tube, which chops off the undesired portion and establishes the black level as shown in curve D of Fig. 30.

It is usual to control the pedestal amplitude from black level in accordance with the DC component, which is proportional to the background illumination of the picture. This can be done by using a photocell to pick up the average scene illumination and to control the clipping level accordingly, as shown in Fig. 31 by a block diagram.

With some types of pickup tubes it is not necessary to set the black level in accordance with the scene illumination as derived from a separate photocell. With the dissector tube, for instance, the blanking signal can be applied in positive polarity between the cathode and the anode, or between cathode and first multiplier surface in such amplitude as to completely cut off the flow of photo-current during the blanking interval. This system of establishing the black level is referred to as *cathode blanking*. It requires blanking pulses of rather large amplitude, however, since the cathode-anode potential in the dissector is usually of the order of several hundred volts. The system establishes black level directly because no photo-current can occur during the blanking interval. Since the level of the photo-current during the trace portion of the cycle is proportional to the illumination, the DC level or background illumination is automatically established by this means and no mixing amplifier is required in order to produce the output waveform of curve D, Fig. 30.

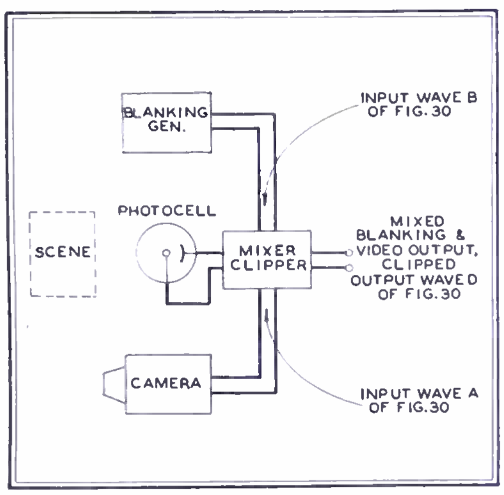


FIG. 31. CLIPPING LEVEL CONTROL

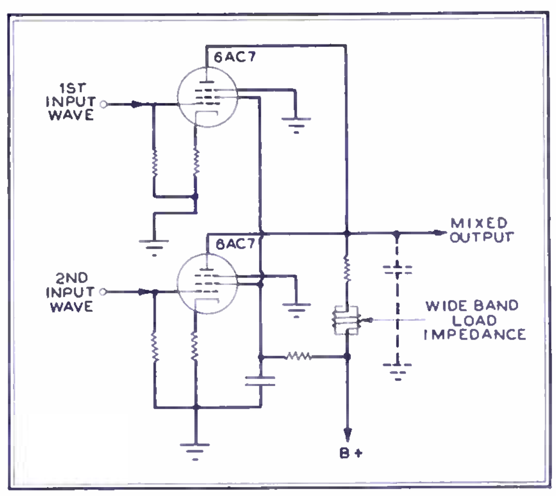


FIG. 32. MIXING AMPLIFIER CIRCUIT

The composite video wave can be used to produce a picture on any cathode-ray tube monitor which is synchronized by separate signals with the camera for both horizontal and vertical deflection circuits. It can be transmitted over cables to remote points and is utilized for modulating the transmitter. The cables, however, must be capable of transmitting a band of frequencies at least 4 mc. wide, and preferably 12 mc. wide, in order to take full advantage of all the information derived from the picture in accordance with RMA standards.

Before this wave is used to modulate a transmitter, it is usually mixed with the synchronizing information by means of a mixing amplifier as shown in Fig. 32. The simple form of mixing amplifier consists of two pentodes with their plates connected in parallel, and with a common load impedance which is uniform over the band of frequencies contained in the widest band of the two input signals. One input signal is applied to one grid, and the other to the second grid of the mixing amplifier. Levels are adjusted by the gain controls of the separate tubes. The video-wave information occupies a wider band than the synchronizing-wave information, which will be described in the next section.

2. Synchronizing Information ★ In order to produce a television picture at a monitor or receiver which is as nearly an exact duplicate of the transmitted scene as possible, great accuracy is necessary to synchronize or time the deflection generators at the receiver in exact step with those of the transmitter. This is accomplished by transmitting synchronizing pulses either separately, as is usual for monitors, or composite with the video wave, as is usual for transmitters.

Two types of synchronizing pulses must be transmitted: the horizontal and the vertical. If these signals are transmitted separately over separate circuits, it is usual to transmit a continuous wave of horizontal pulses approximately as shown in Fig. 33, curve A, having a periodicity of 15,750 pulses per second to conform with RMA standards. The vertical synchronizing pulse in this case is also a continuous wave as shown in curve B, Fig. 33, with a periodicity of 60 cycles per second. Usually, in this case, the vertical pulse is considerably wider than the horizontal pulse in relation to the entire cycle of either deflection system. Separate horizontal sync pulses usually have a width which is approximately 10% of the horizontal deflection cycle. This means that the duration of the pulse is approximately 1/150,000 of a second.

A reference to the discussion in Section 1, Part 2 of Chapter 1 will show that at least the 30th harmonic of the horizontal frequency is required to transmit this synchronizing pulse with good fidelity and good waveform. This means that approximately a band width of only 500,000 cycles is required for transmitting the horizontal synchronizing pulses.

The vertical pulse used for separate sync usually has a width in time of approximately 3% of the field-deflection period, but can be made much more narrow than that. It would never be as narrow in time as the horizontal pulse, however, so that the frequency band necessary for transmitting synchronizing signals is determined by the horizontal pulse.

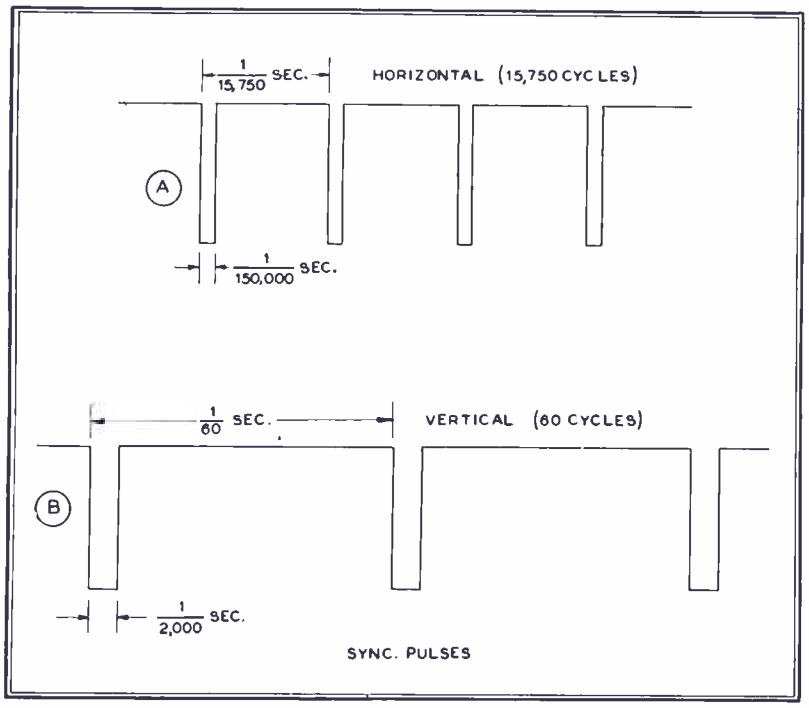
Synchronizing signals are so timed in relation to blanking signals that they occur somewhere after the start of the blanking pulse and end somewhere before the end of the blanking pulse, as shown in Fig. 34. Thus, when they are mixed with a composite video wave in a mixing amplifier, they are applied in such polarity as to add to the amplitude of the blanking interval. Since the maximum amplitude of the blanking pedestal denotes black level, the synchronizing signals occur in the blacker-than-black region of the composite television video wave as shown in curve C of Fig. 34. Since the cathode-ray tube screen is black during the entire blanking interval, the synchronizing pulses do not show in the picture at all. They can be seen, however, by misadjusting the black level at the receiver tube so that the background is gray during the blanking interval, in which case the synchronizing signals show up as black bars.

The simple vertical signal shown in Fig. 34 is not used for transmitting vertical synchronizing information in the United States. That signal will be discussed in Section 4. It suffices here to discuss the obtain a better signal-to-noise ratio in the audio channel. A de-emphasis circuit having a 75-microsecond time-constant is introduced at the demodulator circuit of the receiver. This time-constant is the reciprocal of the pre-emphasis time-constant, and serves to restore the audio characteristic. By this means a considerable reduction in noise is obtained, amounting to approximately 15 decibels at the high frequency end of the audio band.

The audio carrier is always spaced at 4.5 mc. above the video carrier to which it is related in a television channel. This 4.5-mc. spacing is crystal-controlled at the transmitter.

to which the horizontal deflection oscillator at the receiver may be caused to respond, without interruption.

The preparatory pulses which precede and follow the serrated pulse are 12 in number usually, 6 preceding and 6 following the vertical serrated pulse. Their purpose is to prepare the vertical integrating circuit at the receiver on alternate fields so that the peak amplitude of the vertical pulse derived at the receiver will be practically identical on each alternate field, despite the fact that a horizontal pulse occurs alternately on odd and even fields at a half line and a full line before the start of the preparatory region. This integrating circuit will be described com-



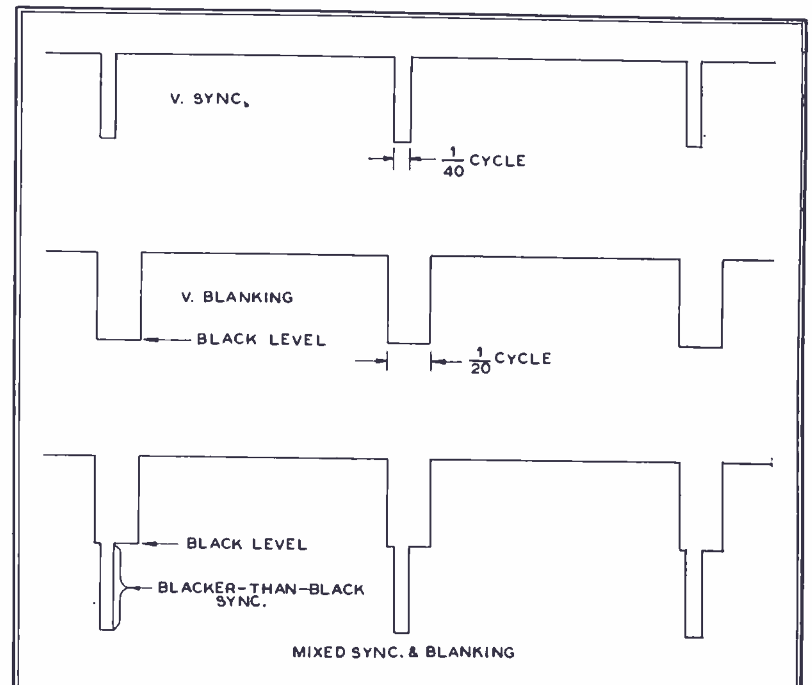


FIG. 33. THE TWO TYPES OF SYNCHRONIZING PULSES REQUIRED. FIG. 34. MIXED SYNC AND BLANKING SIGNALS

simpler case in order to illustrate the system.

By virtue of an amplitude excursion for the sync signals into the blacker-than-black region of the picture, it is possible to separate the synchronizing wave from the video wave at the receiver by means of a variety of simple clippers or limiters. Circuits for accomplishing this separation will be discussed under the receiver section in Chapter 3.

3. Audio Information ★ It is RMA standard practice to use Frequency Modulation for the audio channel accompanying a television signal. The standard deviation of the audio carrier is ± 25 kc. (This deviation may be changed to 40 kc.)

The subject of the audio wave has been very thoroughly discussed in the STANDARD *FM* HANDBOOK, and will not be repeated here. It will suffice to mention only special points in regard to audio practice in television.

Pre-emphasis is introduced into the audio wave so that the amplitude-frequency characteristic rises as shown in Fig. 35. The purpose of this pre-emphasis is to increase the amplitude of the high frequency audio components in order to

4. Composite RMA Standard Wave ★ The actual form of the synchronizing signal used for television broadcasts was shown in Fig. 1 as indicated in the region of the wave labeled S.

The composite RMA standard wave consists of composite video and blanking information which has been mixed with composite synchronizing information. The composite video and blanking information has been described under Section 1 of this Chapter and illustrated in Fig. 30. The composite synchronizing information consists of horizontal synchronizing pulses as shown in curve A of Fig. 33, mixed with other signals which occur during the vertical blanking interval as shown in Fig. 36.

These other signals comprise what is known as the vertical synchronizing information. It consists of a group of very narrow preparatory pulses which occur at twice the horizontal synchronizing frequency, and of a group of several wider pulses at this same double frequency. The group of wide pulses is 6 in number, and is of 3 lines-width duration. This group of pulses is known as the serrated, vertical, synchronizing pulse. The serrations are introduced in order to give a periodicity

pletely under Section 7 of Part 4 in Chapter 3. It is not described here because it will be necessary to consider first the action of differentiating and integrating circuits in more detail. This is described under camera deflection circuits.

If it were not for the fact that an interlaced system of scanning is employed in modern television, it would suffice to use the simple form of vertical synchronizing pulse shown in Fig. 33. In order to interlace, however, since there is a half-line difference in the occurrence of horizontal synchronizing pulses in alternate fields, it became necessary to adopt the preparatory type of serrated signal so that alternate, vertical fields will occur in exact time relation of 1/60 second apart without interference from horizontal pulses.

5. Methods of Modulation ★ The various types of waves of information accompanying a television broadcast signal have been described. These waves include the video wave, the synchronizing wave, and the audio wave. All of these waves are relatively low in frequency-content compared to the carrier wave which they modulate.

The carrier-wave assignments for commercial television were shown under the

section on definitions, and under the word "channel." The carriers are at least 10 times as high in frequency as the modulating envelopes, and on the top channels they are nearly 50 times as high in frequency.

Two methods of video modulation will be described. One of these consists in utilizing the composite RMA standard wave of Fig. 1 to control the grid of the RF modulator at the transmitter. In this case the carrier oscillator signal can be injected into the cathode of the modulator. The composite wave is applied to the grid with the synchronizing peaks positive so that the modulating output in the plate circuit of the modulator increases to a maximum value on the tips of the synchronizing peaks. This system is known as negative modulation and is standard in the United States.

Signals corresponding to maximum white in a television picture produce *inward* modulation of the carrier, and tend to reduce the carrier level to substantially zero. Actually, there is some leakage of unmodulated carrier through the capacitances of the modulator so that absolute

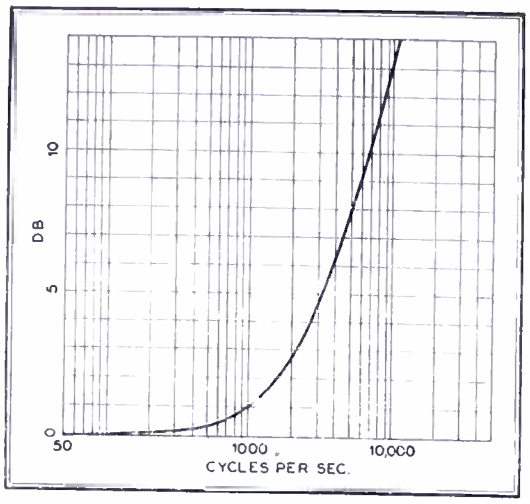


FIG. 35. PRE-EMPHASIS FOR AUDIO

zero, or white level, can never be obtained in practice. It is for this reason that in Fig. 1 the white level is shown as 15% of carrier, + 0, − 15%. The − 15% tolerance does not occur in practice.

Another system of modulation is in use in England, and was in general use before the war throughout Europe. In this system the composite, video wave is applied to the grid of the modulator so that the tips of the sync peaks are negative, as was shown in Fig. 2. The synchronizing signals in this system tend to cut off the carrier, except for leakage through the modulator. The amplitude of the synchronizing peaks is such in the positive-modulation system as to drive the modulator to cutoff. In this manner a uniform level of modulation is obtained on the synchronizing peaks.

In the negative modulation system, the uniform level of outward modulation is obtained by driving the modulator, which can be the power output tube, to maximum peak values beyond the average rating of the tube. In this manner a greater peak power is obtainable than in the positive modulation system because the synchronizing peaks endure for only brief intervals of time, and the average power level is within ratings.

The second advantage derived from the use of negative modulation has to do with the fact that the peak carrier amplitudes are constant. This is not true in the positive modulation system where the peak carrier varies with the white content of the picture, being a maximum only when a highlight occurs. For this reason AVC can be used with the negative modulation system and cannot be used with the positive modulation system. If AVC were used in the British system it would tend to smooth out the illumination levels of the carrier and to compress the whites in the picture, thus producing a gamma correction of varying intensity and of undesirable nature. The British do not use AVC. Some United States receivers use AVC and some do not, but the important point is that AVC can be used when desired in this system.

(*To be continued next month*)

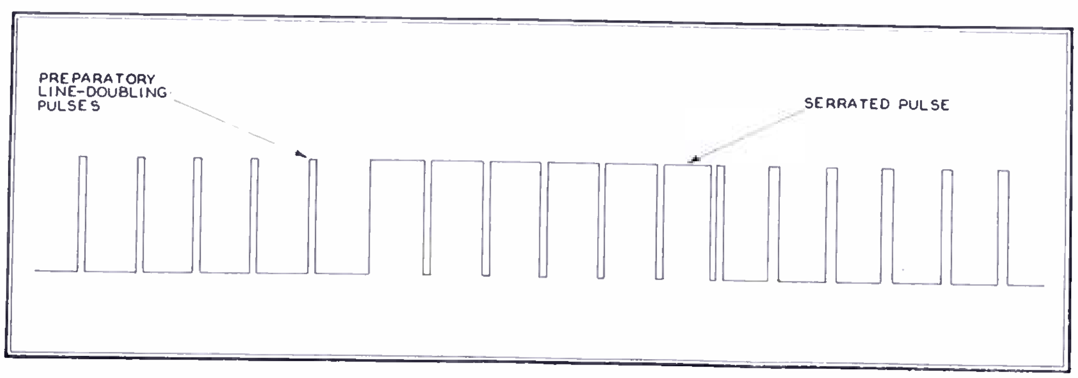


FIG. 36. SIGNALS WHICH OCCUR DURING THE VERTICAL BLANKING INTERVAL

COMMUNICATIONS

(CONTINUED FROM PAGE 30)

almost a year later. In a terse 1-page order dated December 30, 1946 and released January 6, 1947 without further explanation, the FCC, with the agreement of the parties, then dismissed without prejudice the New York gateway proceedings and granted the ARINC applications in part.

Plenty of Nothing ★ The extremely limited nature of the ARINC grant is evidenced simply by a comparison of what ARINC requested with what it got. To serve aircraft flying the Europe-North America route, ARINC asked the FCC for 23 aeronautical frequencies, and got 3; asked for 11 aeronautical fixed frequencies, and got 5. But even more important than the disparity in numbers was the disparity in the nature of the use made of the frequencies asked for and given.

The frequencies ARINC asked for were, for the most part, authorized to the Civil Aeronautics Administration.[2] The frequencies ARINC got were those already authorized to ARINC and used by it principally in domestic operations.[3] Add to these considerations the fact that the channels granted by the FCC's order were all below 19 mc., and of propagation characteristics which prevent their effective duplication domestically and on the Europe-North America route. Then it requires no great perspicacity to conclude that, substantially, ARINC's applications were denied.

But the form of a decision is sometimes as important as its substance. As an examination of the narrow question before the FCC shows, it may fairly be said that the ARINC New York gateway decision falls in this category. The Commission had three courses of action open to it in disposing of the questions raised by the ARINC applications and the evidence presented in the course of the hearing:

1 — Denial; or

2 — Grant; or

3 — Grant, in part. (This last alternative might be qualified in various ways, as for example, by requiring ARINC to share the frequencies granted, or some of them, with the CAA.)

Bearing in mind that all the frequencies in question were legally subject to assignment by the FCC for non-government use, and by the Interdepartment Radio Advisory Committee (acting on behalf of the President) for government use[4], an unqualified grant or denial of the ARINC applications would have had a highly

(CONTINUED ON PAGE 50)

[2] Of the 23 aeronautical frequencies requested by ARINC for air-ground-air communications with aircraft flying the Europe-North America route, 16 were authorized to the CAA New York station, WSY. The 11 aeronautical fixed frequencies requested by ARINC for point-to-point communications with aeronautical fixed stations on the Europe-North America route were all authorized to WSY at New York.

[3] The FCC's December 30, 1946 order granted ARINC the use of the following frequencies on the Europe-North Atlantic route: 4110, 6520 and 10125 kc. for aeronautical purposes; and 2612, 4690, 6550, 10125 and 18360 kc. for aeronautical fixed purposes. These aeronautical frequencies are assigned to the Blue chain and are used domestically in the central and far west states. The aeronautical fixed frequencies 2612, 4690 and 6550 are used on a point-to-point circuit between Fort Worth and Mexico City; 18360 is used on a point-to-point circuit between San Francisco and Honolulu; and 10125 is used in the meteorological North Atlantic service.

[4] See FCC Memorandum Opinion of February 21, 1946, in Docket No. 6988. The present two-agency control over the spectrum has worked in the past only by reason of the close coöperation extended between the FCC and IRAC in frequency assignments. This anomalous condition, probably in no small part responsible for the result reached in the instant case, clearly requires correction by the vesting in one agency of complete and exclusive control over the entire radio spectrum.

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FM broadcasters will be particularly interested in the following features of REL's revolutionary but obviously sensible and practical 10-kw. transmitter design:

1. Low Filament Power — only 150 watts per tube.

2. Low Tube Cost — replacement tubes cost $108 each.

3. Driving Power — the 10-kw. Quadriline transmitter can be driven with approximately ½ kw. The REL 1-kw. driver has more than twice the power needed.

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5. Quiet Operation — although an abundance of air is employed to insure long tube life, sound-proofing is a simple matter because there are no circulating currents in the housing.

6. Metering — there is continuously visual screen grid metering for each tube. These meters provide most of the information required to insure steady and efficient transmitter performance.

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REL is the only manufacturer in the field to employ tetrodes in its complete line of transmitters, up to and including 10 kw. We offer the Quadriline transmitter with the firm conviction that it has no equal in the FM field today. For further details, address:

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WWV BROADCASTS

(CONTINUED FROM PAGE 27)

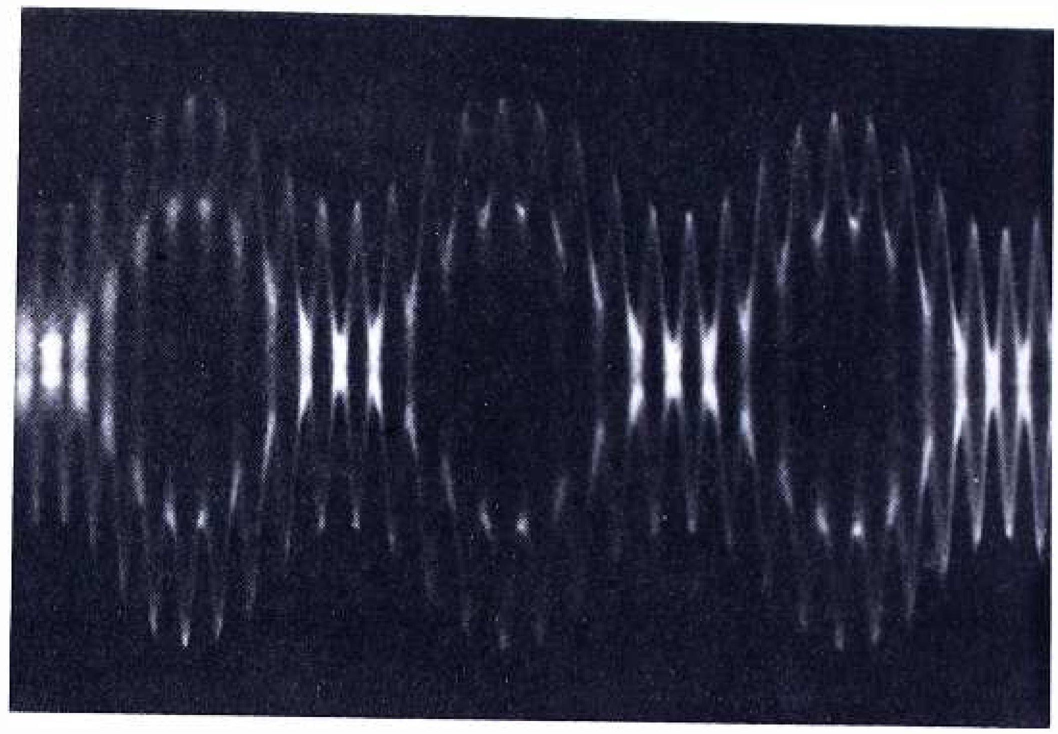
Distance Range of Reception ★ Of the radio frequencies on the air at a given time, the lowest provides service to short distances, and the highest to great distances. Reliable reception is in general possible at all times throughout the United States and the North Atlantic Ocean, and fair reception throughout the world:

A. By tuning to the different frequencies and selecting the one most suitable at that time. For nighttime conditions over the propagation path, lower frequencies than those used during the day are usually necessary because of skip, but received intensities on those frequencies are much greater than for daytime conditions.

B. By making use of techniques of prediction of usable frequencies.

In spite of the great number of variables affecting radio wave propagation and distance range, techniques exist for the prediction of usable frequencies over any specific path during any future month. By means of such techniques and the Central Radio Propagation Laboratory's forecast service, it is possible for a user to prepare for his locality a graph or table showing the best frequency for any period of the day in any month, three months in advance. Monthly publications giving these techniques and forecasts [1] can be obtained by writing to Central Radio Propagation Laboratory, National Bureau of Standards, Washington 25, D. C.

For continuous 24-hour reception without a break, the use of more than one receiver and antenna is necessary. With skilled operators to anticipate times for frequency shifting, and with schedules prepared as under (B) above as a guide, it may be possible in some cases to operate continuously with two receivers. For maximum certainty of reception, it is necessary to employ as many receivers as there are receivable WWV frequencies at the location, leaving them all in operation continuously and combining their outputs.



OSCILLOSCOPE VIEW OF 400 AND 4,400 CYCLES AS TRANSMITTED FROM WWV

The Bureau welcomes reports on reception, methods of use, or special applications of the service, particularly with reference to the higher frequencies which have been added recently. Correspondence should be addressed to: Central Radio Propagation Laboratory, National Bureau of Standards, Washington 25, D. C.

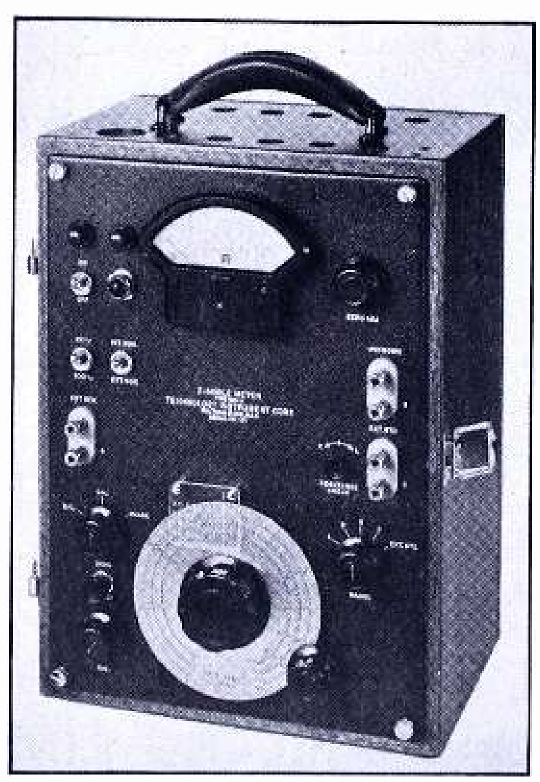
[1] "Basic Radio Propagations Three Months in Advance" available from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 15¢ per copy, or $1.50 per year.

Z-ANGLE METER

Some surprising discrepancies between calculated and actual characteristics of elements in radio circuits are being disclosed by measurements made with the new z-angle meter. A development of Technology Instrument Corporation, 1058-F Main Street, Waltham, Mass., this instrument is designed to measure the impedance and phase angle, over a range of 30 to 20,000 cycles, of such components as loudspeakers, microphones, transformers, transmission lines, phonograph pickups, and input and output circuits of amplifiers.

Balanced adjustment is accomplished by a single knob carrying a scale calibrated directly in impedance. Phase angle is shown by a direct-reading meter. Supplementary scales are provided on the dial to indicate the dissipation factor D of condensers and the storage coefficient Q of inductors. Also, to indicate whether the phase angle is leading or lagging, a button is provided to cut in an additional condenser. The sign of the phase angle, therefore, is determined by noting the direction of the resultant change in phase angle reading.

The instrument covers .5 to 100,000 ohms impedance in 4 ranges, accurate to ± 1% over the main decade on each scale. As a general-purpose laboratory instrument, the readings cover .5 to 100,000 ohms, 5 microhenries to 500 henries, .001 to 10,000 mfd., as well as Q of .1 to 10 and D of 10 to .1 by direct reading.



Z-ANGLE METER READS IMPEDANCE AND PHASE ANGLE AT 30-20,000 CYCLES

For impedance measurements, a balanced amplifier and VT voltmeter are used to provide a null balance. Only the impedance balance is required to read the value in ohms from the dial. When this balance is obtained, the voltages across the resistance standard and unknown impedance, and across the outputs of the balanced amplifier are equal in magnitude but not in phase. However, when the outputs of the balanced amplifier are switched to parallel connection, the resulting voltage is a direct measure of the phase angle of the unknown impedance. Thus the VT voltmeter can be calibrated in degrees of the phase angle. This also shows Q = Tangent θ, and D = cotangent θ.

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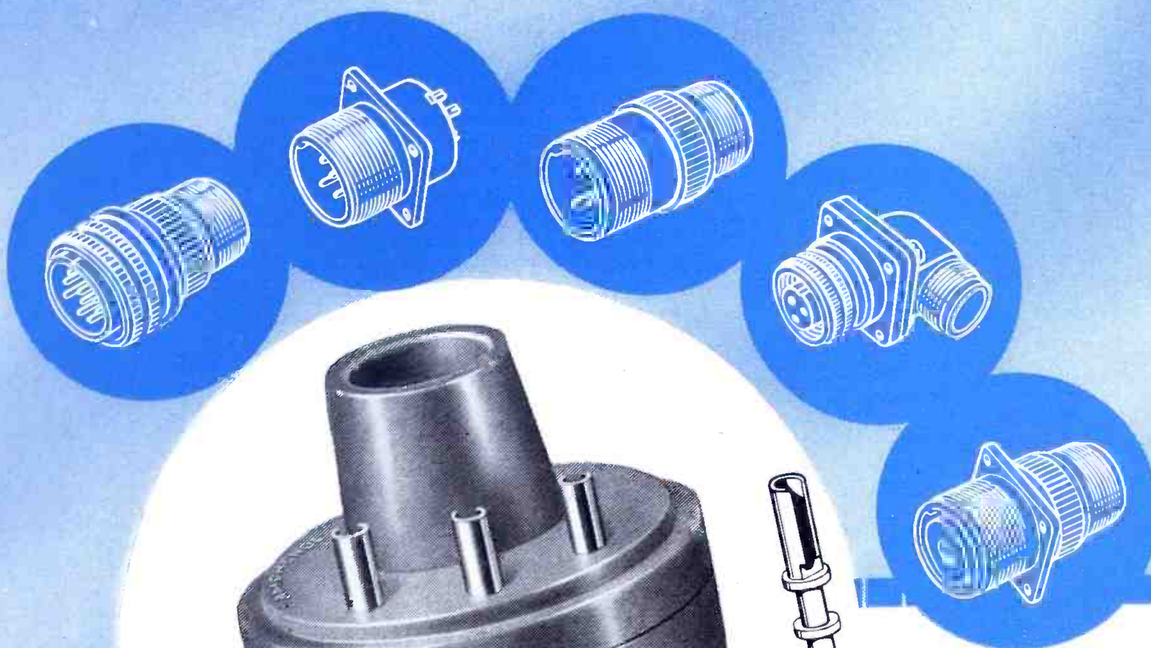
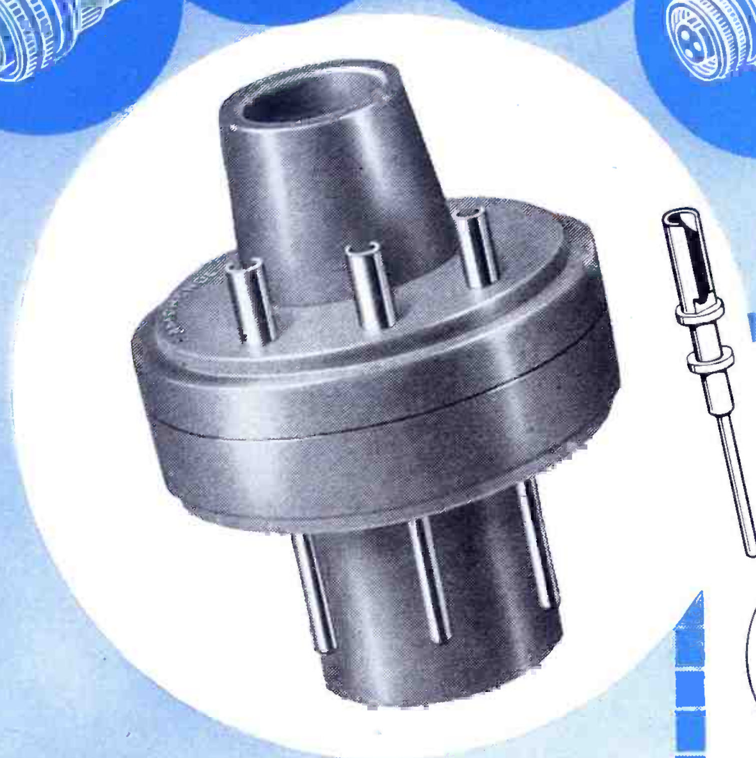
During 1947, General Electric will spend $1,000,000 on employee education. One-fourth of this will be used for the Student Engineer or Test Course, in which 3,000 employees are participating. Over 400 others will take the Business Training Course in accounting and business administration. Altogether, 60 courses are conducted throughout the Company's six operating departments.





The new 9728-410P high voltage AN connector insert, newest addition to the Amphenol family. It is one of more than 200 types available for use with the five basic shells shown.

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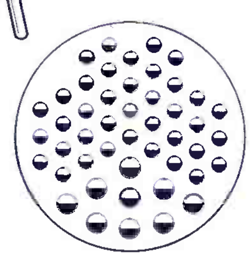

Amphenol terminals do not rotate, and they are properly aligned for fast, easy soldering. Ask the men on your production line how many hours a day this feature will save. Other exclusive features of Amphenol AN connectors will be described in a later issue.

How AMPHENOL AN Connectors Step Up Your Profit Potential

Standardized AN connectors provide a fast, foolproof way to connect any industrial electronic equipment which frequently must be disconnected from associated equipment or power source.

Their use also permits the prefabrication of associated wiring to accommodate one or many circuits. This greatly simplifies and lowers the cost of electronic installations. AN connectors also permit such equipment to be completely tested at the factory before shipment to user. Upon arrival it then can be connected for operation in minutes.

These advantages combine to widen the field in which electronics may practicably be applied. Thus they offer an increased sales and profit potential to makers of electronic devices.

The Amphenol AN connector family offers you a number of important points of mechanical and electrical superiority. It is comprised of over 200 styles of dielectric inserts. These are interchangeable in any of the five major Amphenol metal shell designs (each of which is available in eighteen sizes). The practically endless variety of possible combinations offers an efficient solution to any industrial electronic connector problem.

Amphenol inserts handle currents up to 200 amperes, voltages up to 22,000. Housings include types which are pressure-proof, moisture-proof and explosion proof. Standard elements also are available for thermocouple installations.

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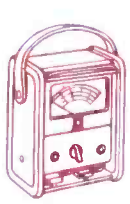

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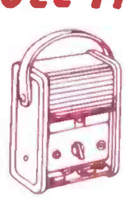

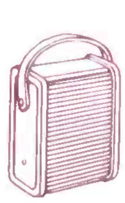

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At 20,000 ohms per volt, this instrument is far more sensitive than any other instrument even approaching its price and quality. The practically negligible current consumption assures remarkably accurate full scale voltage readings. D.C. current readings as low as 1 microampere and up to 10 amperes are available.

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Volts D.C. (At 20,000 ohms per volt)	Volts A.C. (At 1,000 ohms per volt)	Output	Milli-amperes D.C.	Micro-amperes D.C.	Ohms	
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10	10	10 V.	100		0-200,000	(1200 ohms center)
50	50	50 V.	500	Amperes D.C.	0-20 Megohms	(120,000 ohms center)
250	250	250 V.		10		
1000	1000	1000 V.		(5 Decibel ranges: —10 to +52 DB)		
5000	5000	5000 V.				

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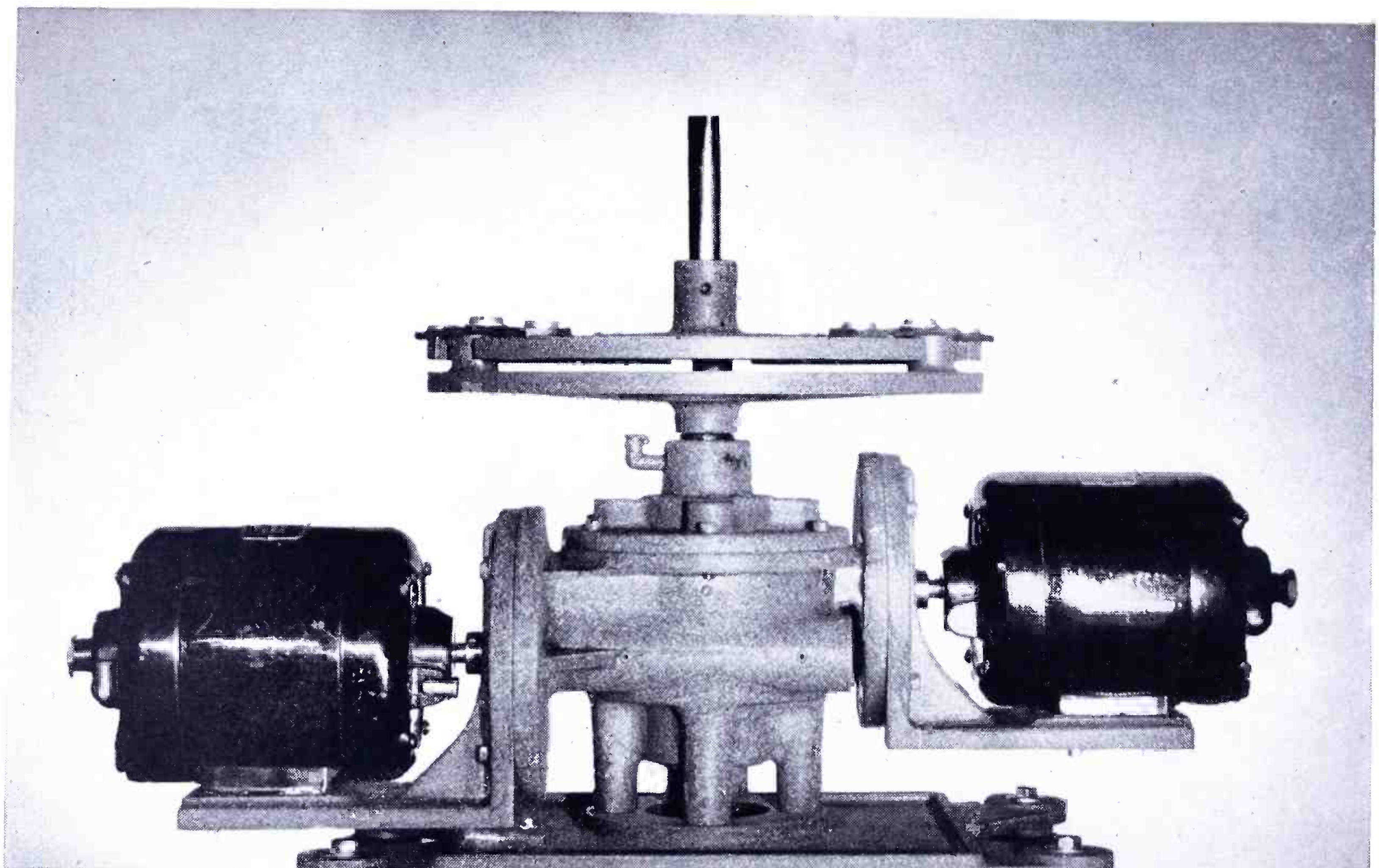
▶ The turntable is directly gear-driven at both 33⅓ and 78.26 rpm and two separate motors are employed — one for each speed. Speed may be changed instantly at any time by turning a mercury switch, without damage to the mechanism. *No frictional, planetary, or belt operated elements are used in this new drive mechanism.*

▶ The following points are of interest: *Motors*—Two 1800 rpm synchronous. *Speed*—Total speed error is zero. *Noise*—At least 50 db below program. *Starting*—Table on speed in less than one-eighth revolution at 33⅓ rpm. *Adjustment*—Construction is very rugged and no attention whatsoever is required—except lubrication.



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COMMUNICATIONS

(CONTINUED FROM PAGE 42)

significant impact upon the practical resolution of the question as to whether international operational communications are to be privately or governmentally handled. Assume, for example, that the ARINC applications had been granted at New York. There is little doubt that applications for private facilities at other international terminals would then have followed speedily,[5] both at points where the CAA is now authorized as well as at new international points where neither ARINC or the CAA is presently authorized. Conversely, outright denial of the ARINC applications would have had a very marked adverse effect on the institution of private facilities for company-type operational communications at international points, in two ways.

First, if the New York applications had been unqualifiedly denied, it would be highly unlikely that industry would plan or apply for facilities at other international terminals where the CAA was already operating. Secondly, even applications for facilities at new international points involving substantial outlays could hardly be undertaken by a prudent management in the absence of any clear policy that the CAA, when ready, might not also be authorized to operate at the same point, and with the same frequencies.

FCC Straddle ★ The significance of the FCC's gateway decision, therefore, flows as much from what the Commission failed to do, as from what it did. Actually, in granting the applications in part on the basis above outlined, the FCC merely preserved the uncertainty previously existing as to whether international aviation communications of an operational nature should be handled by industry or government.

While the Delphic nature of the Commission's decision therefore makes it difficult to predict with assurance what policies the Commission will follow in future international aviation communications cases raising this general question, it does seem reasonably clear that:

1. Frequency availability permitting, the FCC has no objection to authorizing industry facilities at international points already served by the CAA. (This is the precise holding of the New York gateway decision. In effect, the Commission said to the industry: You don't have to take service from the CAA at New York if you can get by on the 8 frequencies hereby authorized for your use at that terminal for the Europe-North America route.)

2. In considering frequency availability for industry facilities at international terminals already served by the CAA, it is not likely that the FCC, although empowered to do so, will assign for industry use any frequencies presently authorized for CAA use at such terminals. (The New York gateway decision, strictly interpreted, stands as a precedent for no more than the principle formulated in the preceding paragraph. But since no CAA-authorized frequencies were granted to ARINC at New York, despite the ARINC showing of little or no use on many of the CAA frequencies authorized there, this second principle, too, seems reasonably clear.)

3. If a need exists for communication facilities at any new international terminal where the CAA is not affording service, an industry application for appropriate facilities will be granted by the FCC. (If, as stated at 1 above, the FCC has no objection, frequency availability permitting, to authorizing industry facilities at an international terminal where CAA facilities already existed, the authorization of industry facilities where there are no CAA facilities represents an *a fortiori* case for a grant.)

4. If industry facilities are authorized by the FCC at an international terminal where no CAA service is given, and if the CAA were later to apply to IRAC for the use of any of the frequencies so authorized to ARINC, it is likely that the FCC, to

(CONCLUDED ON PAGE 51)

[5] ARINC counsel so indicated in his opening statement at the FCC hearing on the New York applications. See pp. 22, 23, Vol. 1, FCC Docket 6988.

COMMUNICATIONS

(CONTINUED FROM PAGE 50)

the extent that its membership in IRAC permits, would oppose the grant to CAA of any frequencies previously authorized to industry use at the point involved. (This fourth conclusion does not follow from the New York gateway decision as clearly as the preceding conclusions. However, if the FCC declined to authorize the use of any CAA-authorized frequencies to ARINC at New York, it would, by a parity of reasoning, be opposed to authorizing the use of any ARINC-authorized frequencies to the CAA at any points where CAA sought to duplicate an existing ARINC service.)

A Matter for the Congress ★ The combined impact of these separate conclusions makes it entirely clear that the FCC's New York gateway decision has not disposed of the question that has long troubled the aviation industry: shall all international operational communications be privately or governmentally handled?

Careful analysis of the action taken by the FCC with respect to the ARINC applications at New York shows, in fact, that the Commission was at pains not to attempt to settle this question. Its decision has so carefully preserved the *status in quo* that it amounts to little more than a declaration that the FCC is not the proper forum to decide whether all international operational communications shall be privately or governmentally handled. If, therefore, either a government or industry monopoly is to be established in the international aviation field for operational communications, in lieu of the disintegrated government-industry operation that presently exists at several points in the United States, it is now clear that the path to be pursued must be delineated by the Congress.

Further effort to settle this question should be watched closely by all U.S. communications services, for it may have a basic bearing on FCC planning for the assignment of all communications frequencies.

HARVEY FM RECEIVER

(CONTINUED FROM PAGE 24)

cross currents in the rotor have been blocked off by insulating the center section of the rotor shaft.

Erie ceramic trimmers are used throughout the receiver to insure long-lasting alignment. Advantage is taken of their temperature compensating characteristics in maintaining proper IF alignment.

This description may raise the question as to whether or not an appreciable improvement in performance results from such extreme refinement of design. From actual listening experience, we can answer this definitely in the affirmative. Such a

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HARVEY FM RECEIVER

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receiver is required to take advantage of the full capabilities of a high-quality speaker system. However, we might add this note for the benefit of FM broadcasters: Such an FM receiver installation shows up very clearly any deficiencies in the design, adjustment, or operation of an FM transmitter.

FM BROADCAST TRANSMITTERS

(CONTINUED FROM PAGE 36)

ple interrupting capacity to protect the entire transmitter.

The filament voltage of all tubes in the 10-kw. amplifier is continuously variable from the front panel. In addition, means are provided for separate filament voltage adjustment of each final amplifier tube. The filament currents of the two tubes have a 90-degree phase relation between them to reduce amplitude-modulation hum on the output carrier, and a feedback amplifier is used to reduce carrier amplitude-modulation to an extremely low level. A power-factor correction capacitor compensates the filament transformer power factor to reduce the power line KVA requirement.

Filament and plate voltage are interlocked with air flow. The plate contactor is reclosed automatically in case of power line failure of short duration or plate overload. A transmission line directional power relay removes plate power in case of reflected power because of transmission line or antenna arc-over, and automatically operates the recloser circuit. A complete supervisory light system is included to indicate any fault causing protective relays to operate.

25-Kw. Transmitter ★ The 25-kw. amplifier is a unit similar to the 50-kw. design. The plate power supply is reduced in rating, and the amplifier can be driven with the 3-kw. transmitter. The tubes and RF circuits of the 25- and 50-kw. amplifiers are identical. Therefore, the discussion will continue in detail with the 50-kw. unit.

50-Kw. Transmitter ★ A standard 10-kw. transmitter, with a rectifier and control cabinet added on the left and a high-power RF amplifier added on the right, comprise the major part of the equipment. Air-cooling equipment, a power and control cabinet, and a transmission-line cutback switch are also provided. The rectifier and amplifier cabinets are 6 ft. wide by 4 ft. deep. The overall length of the 50-kw. equipment is 26 ft. 4 ins.

The power amplifier stage consists of two type Z-1432 tubes in a balanced push-pull grounded-grid class C stage. These

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FM BROADCAST TRANSMITTERS

(CONTINUED FROM PAGE 52)

tubes are very similar in construction to those in the 10-kw. amplifier, except that they are physically larger. The Z-1432 has been especially designed for operation in grounded-grid circuits. The operating characteristics are such that the 10-kw. transmitter will drive the 50-kw. amplifier with an adequate margin of safety.

The filament or input circuit of the grounded-grid amplifier is half-wave tuned. Power is coupled into this circuit from the 10-kw. amplifier by means of a balanced coupling loop. Unbalanced to balanced drive is accomplished in a manner identical with that of the 10-kw. amplifier. Cooling air is drawn through the anode radiators and down through the plate lines. Design features include front-of-panel filament voltage control, independent control of power amplifier tube filament voltages, instantaneously delta-wye switching of the rectifier plate transformer, quarter-phase operation of power amplifier and rectifier tube filaments, and complete supervisory light system for location of faults.

The entire 50-kw. transmitter operates from 460 volts, 3-phase, 50 or 60 cycles. All power amplifier filament circuits and the entire 10-kw. section of the transmitter operate from 230 volts derived through a 2-to-1 step-down transformer. All control circuit voltages are 115 volts, isolated from the main power source.

Plate voltage, about 7,000 volts, is supplied to the power amplifier by 6 type GL-869B tubes in 3-phase, full-wave connection. A seventh tube can be maintained heated in a spare position.

Emergency operation is possible with the output transmission line cutback to the 10-kw. amplifier. Under these conditions, all power including filaments and air blower can be removed from the 50-kw. amplifier, and tube changing or servicing done while operating at reduced power. As in the 10-kw. amplifier, a directional power transmission line relay removes plate power in case of transmission lines or antenna arc-over, and automatically operates the plate recloser circuit.

Conclusion ★ In the design of the equipments just described, the following objectives have been met with a minimum of compromise.

1. Modulation is produced simply without sacrificing direct crystal control of the carrier frequency.
2. Construction is such as to provide complete accessibility to all components.
3. The design has been coördinated so that changing to a higher power rating requires only the addition of an amplifier block. No mechanical reconstruction is necessary; only electrical inter-connections are needed.

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FM BROADCAST TRANSMITTERS

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4. Control circuits provide the utmost in protection to personnel, tubes, and components without sacrificing reliability.

5. Simplicity of design has resulted in a line of transmitting equipment that is simple to adjust, and capable of long, reliable operation.

FACSIMILE IS READY

(CONTINUED FROM PAGE 20)

This requires an AF band width from 750 to 3,750 cycles. To transmit the tone shades of photographs, a sub-carrier of 2.3 × 1,500 cycles is needed, or an AF band from about 2,000 to 5,000 cycles. This is within the flat-response range of all reasonably good FM receivers.

These figures must be doubled if the recording width is increased to 8.2 ins. This brings us back to the receiver design, and receiver cost. Using a 3,500-cycle note for high-quality 4.1-in. facsimile requires flat receiver response of 2,000 to 5,000 cycles. That is within reason, for the average FM receiver will meet that requirement. But when the width is doubled, the frequency of the transmitted note must be increased to 7,000 cycles, and the audio band widened to 4,000 to 10,000 cycles. That is considerably beyond the range of flat response in moderately-priced FM receivers. Thus, the very expensive 8.2-in. recorder requires a higher-priced receiver to operate it.

The engineers' contribution of research and development has carried facsimile to the point of commercial practicability and application. Now production and merchandising experts must carry the ball. To be sure, there are more technical refinements to be made, but if the final determination of standards is left entirely to engineers, facsimile will never emerge from the laboratory as a marketable service.

In that connection, we recall that, during the FM hearings at the FCC, Mr. Porter, who was then Chairman, virtually chased some of the radio industry's best business brains out of the witness stand because they could not qualify as propagation experts.

When the matter of facsimile standards comes up for hearing, it is expected that Chairman Denny will give the business men, upon whom the commercial success of facsimile will finally depend, a chance to discuss the engineering aspects in terms of salable merchandise. We shan't get far with home facsimile if it is priced out of demand by standards which make the cost prohibitive.

Starting Facsimile Service ★ The establishment of standards merely brings facsimile up to the starting line, but does not set it

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FACSIMILE IS READY

(CONTINUED FROM PAGE 54)

moving toward the goal of nation-wide operation. In fact, it only raises the question as to when it will start, and how.

For all the interest shown by newspapers, nothing they have done so far indicates any intention to provide continuous, scheduled facsimile transmission. Rather, it appears that they are only interested to know what facsimile can do, in order to appraise it as a potential competitor.

After all, why should a newspaper go into facsimile unless it is forced to do so by some other organization that might embark on this service as a means of entering the newspaper field with no more investment than the cost of an FM station?

Before newspapers will have a reason to start facsimile broadcasting, home recorders must be sold. That's not a publisher's business. Many newspapers operate broadcast stations, but they have never sold radio sets.

So there are two reasons why newspapers will not take the initiative in getting facsimile under way. Starting this service calls for the combined efforts of those who will have a profit need and reason for the undertaking.

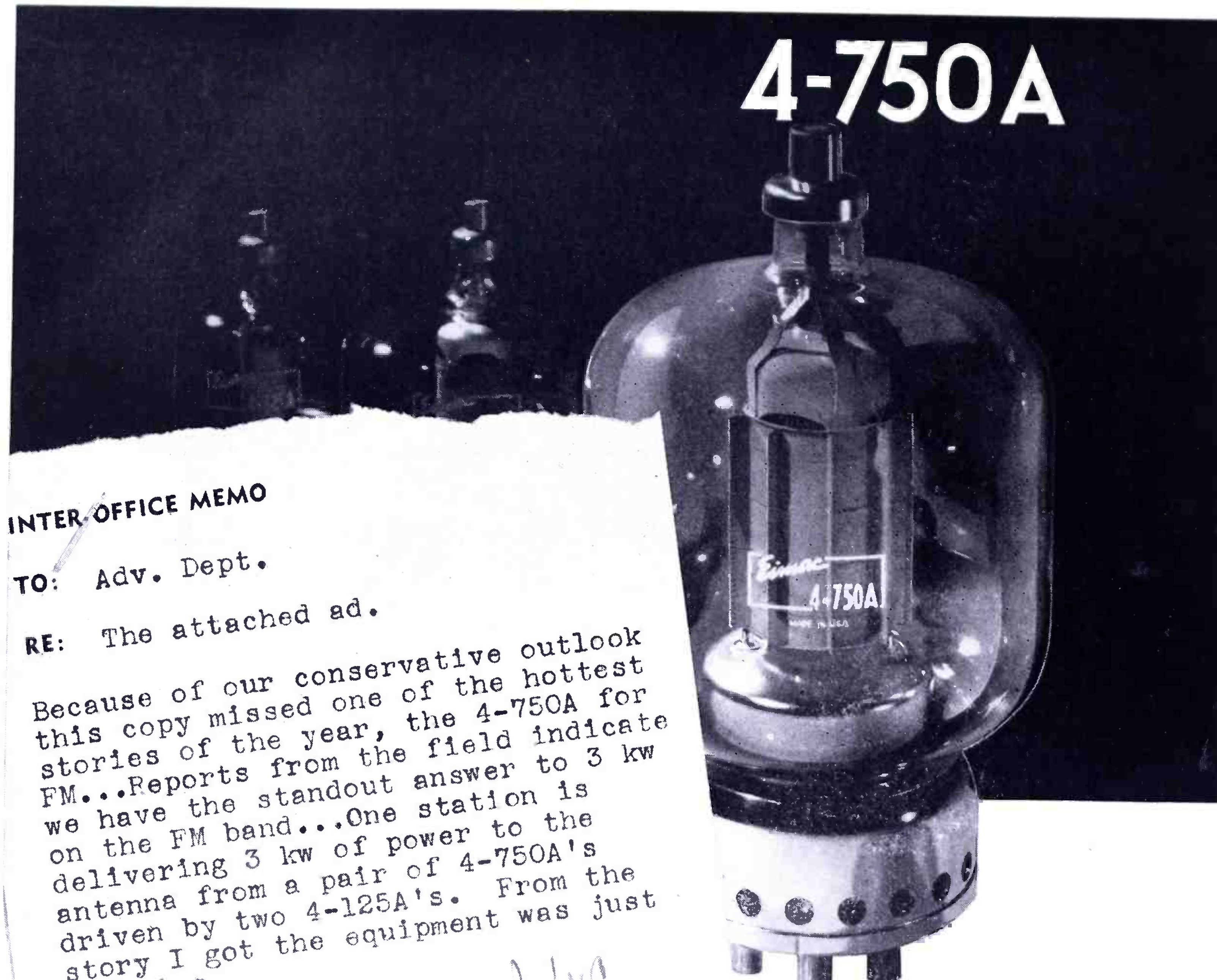
For example, if a manufacturer of facsimile equipment, an FM set manufacturer, and a broadcaster get together, that combination will contain the elements of aggressive, successful promotion because each will take a profit from performing the function for which he is organized.

The manufacture of recorders is as foreign to a radio plant as the production of variable condensers or record-changers. Facsimile equipment manufacturers have no setup for selling recorders to the public. And since they must be sold with receivers designed to operate them, the radio manufacturers are the logical choice for handling sales and service, through their established dealers. Finally, the broadcasters' business is to create, sell, and transmit programs.

When and wherever these elements are brought together, we shall have the beginning of public facsimile service. Once it starts on a continuing, scheduled basis, it will spread rapidly because 1) it will be a tremendously valuable service, 2) it will be a highly effective advertising medium, 3) the cost of equipment required for facsimile broadcasting is very small, and 4) the additional cost for an FM receiver with a 4.1-in. recorder can be brought to less than $100.

There are the commercial possibilities. They will become realities, however, only if the standards, as finally established by the FCC, assure commercial production of home recorders at a price that will permit the development of a mass market and mass production.

ADVERTISERS INDEX



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Input	26.85 μμf
Output	7.78 μμf
Maximum Ratings	
D-C Plate Voltage	6000 max. volts
D-C Plate Current	700 max. ma.
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