PRICE—TWENTY-FIVE CENTS

FM AND TELEVISION

JUNE 1945

FM ON THE DENVER & RIO GRANDE

TO THE AMERICAN PEOPLE:

Your sons, husbands and brothers who are standing today upon the battlefronts are fighting for more than victory in war. They are fighting for a new world of freedom and peace.

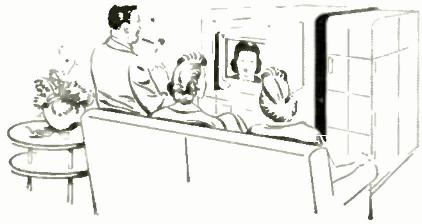
We, upon whom has been placed the responsibility of leading the American forces, appeal to you with all possible earnestness to invest in War Bonds to the fullest extent of your capacity.

Give us not only the needed implements of war, but the assurance and backing of a united people so necessary to hasten the victory and speed the return of your fighting men.

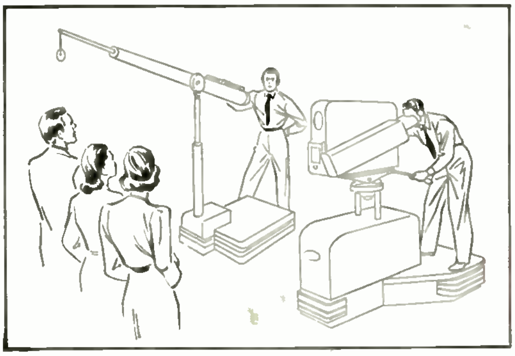
Directory of R. R. Signal Engineers

★ ★ E d by Milton B. Sleeper ★ ★

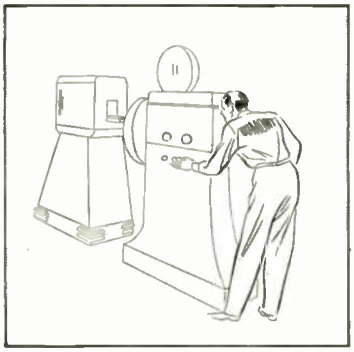
DuMONT—FOR THE TOOLS OF TELEVISION



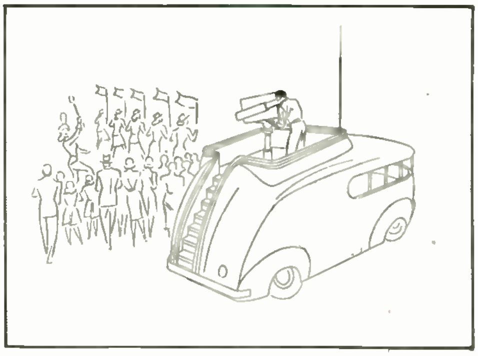
DuMONT POSTWAR TELEVISION BROADCASTING EQUIPMENT



LIVE TALENT STUDIO. DuMont's Iconoscope Cameras pick up the scene and action. An electronic viewfinder enables cameramen to see exactly what looker-listeners see at home. DuMont's Sound Boom picks up voices and music.

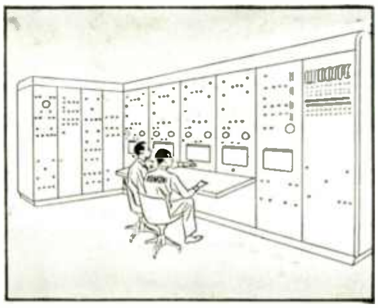


FILM STUDIO. Motion pictures, newsreels, commercials, etc., on 16 mm and 35 mm films require specially adapted projectors and DuMont Film Pickup Cameras.

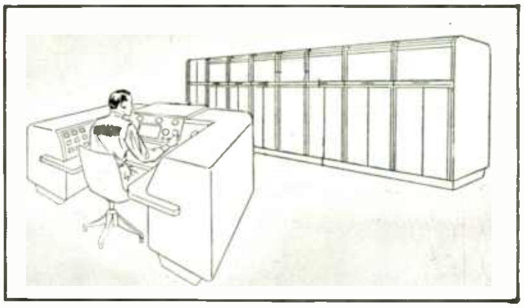


FIELD EVENTS. A DuMont-equipped Television Truck is a small station in itself . . . including cameras, control and sound equipment, relay transmitter and directional antenna. The relay receiver is located with the main transmitter.

PRODUCER'S CONTROL DESK. Monitors show scenes being picked up by different cameras . . . with the largest monitor showing the scene selected for broadcasting. The producer sees the scene exactly as looker-listeners see it on DuMont Telesets.



MASTER CONTROL BOARD. The Master Control Board is the heart of the television station. Engineers manipulate shading and other controls to add technical refinements with electronic artistry to all programs.



TRANSMITTER AND CONSOLE. All meters, oscillographs, controls and clocks are separately mounted in the console for safety, easy visibility and centralized operation. Video and audio signals (sight and sound) are transmitted from different antennae located on the same transmitting tower.

DuMont knows television. • DuMont has equipped more television stations than any other company. These stations are demonstrating the efficiency, the extreme flexibility, the rugged dependability and the greater economy of DuMont Television Broadcasting Equipment.

• DuMont has pioneered in television station operation. It has thus set a broad profit pattern for postwar commercial television.

• DuMont recognizes your needs. It offers the DuMont Equipment Reservation Plan which insures early peacetime delivery and personnel training.

• Study television's economies — get in touch with DuMont today.

DUMONT *Precision Electronics and Television*

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

NATIONAL RECEIVERS ARE THE EARS OF THE FLEET

OFFICIAL U. S. NAVY PHOTOGRAPH

MOVING IN ON PELELIU

A flotilla of rocket-firing LCI's, out in the foreground clouded in rocket smoke, have smothered the Jap beach defenses. Cannon firing "Alligator" tanks plow through calm water, to blast the way for assault troops. This is D-day on Peleliu, and the Americans have come to stay.

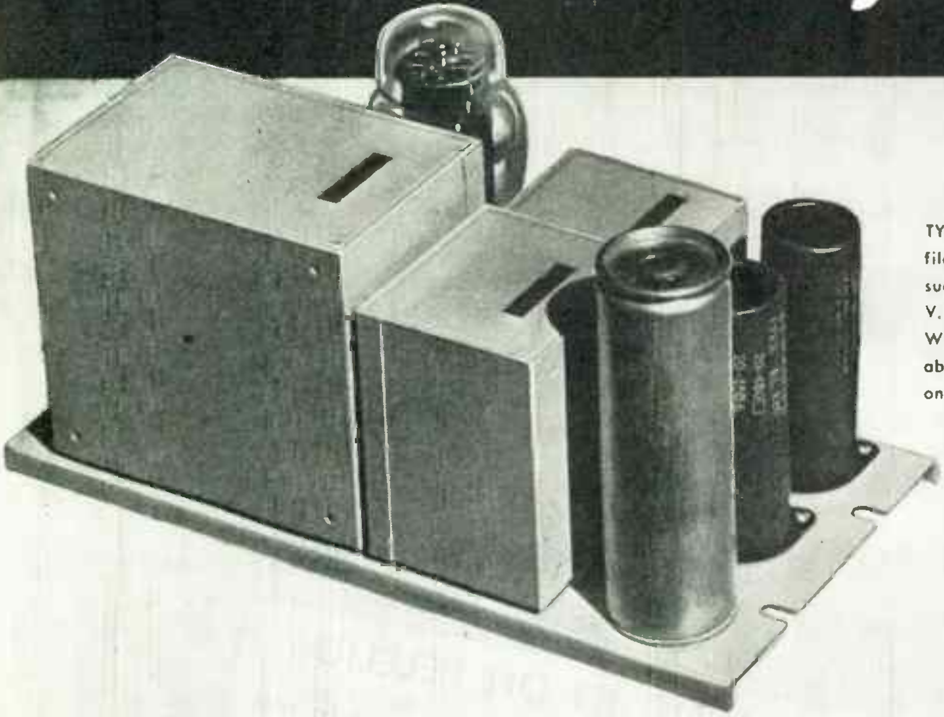
Three out of four of the Navy's ships — landing craft or larger — are equipped with receivers designed by National.

NATIONAL COMPANY

MALDEN MASS, U. S. A.

NATIONAL RECEIVERS ARE IN SERVICE THROUGHOUT THE WORLD

201 SERIES *Rectifiers*



TYPE 201A RECTIFIER. Designed to furnish filament and plate current to line amplifiers such as the Langevin 102 Series. Delivers 275 V. at 75 M.A., 6.3 V. at 8 A. Length 10 [illegible]/32". Width 5 7/32". Maximum height 6½" (5½" above, 1" below mounting chassis). Occupies one third Langevin Type 3A mounting frame.

Type 201 Series Rectifiers consist of Type 201A, described above, and 201B. Type 201A is supplied with a single filter stage, whereas Type 201B has a dual filter stage. Latter type designed to supply filament and plate power for quiet pre-amplifiers such as Langevin Type 106 or 111. In addition supplies associated line amplifiers such as Langevin 102 Series. These units possess excellent regulation and low ripple content.

Send today for complete engineering information about these and other Langevin apparatus.

The Langevin Company
INCORPORATED
SOUND REINFORCEMENT AND REPRODUCTION ENGINEERING

NEW YORK	SAN FRANCISCO	LOS ANGELES
37 W. 65 St., 23	1050 Howard St., 3	1000 N. Seward St., 38

FM AND TELEVISION

FORMERLY: FM RADIO-ELECTRONICS

VOL. 5 | JUNE, 1945 | NO. 6

CONTENTS

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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

Time is a precious commodity to the railroads. Delays in the operation of trains are reflected directly by net earnings. Conversely, reduction of running time cuts operating costs and improves service to shippers and passengers. On this basis alone radio has proved, under extensive tests, that it will pay dividends to railroad operators. However, radio cannot come into use by the roads overnight. It must prove to railroad men the degree of reliability that radio engineers know it possesses. It must win new friends by demonstrated service. This it has begun to do already. Just as police chiefs and patrolmen say now, "We couldn't run our departments without it!" Soon we shall have railroad officials saying the same thing.

WHAT'S NEW THIS MONTH

Too Little Too Late

THE lack of wise, progressive, well-organized leadership in the radio manufacturing industry, the indifference of manufacturers and broadcasters toward one another and their common problems, the inadequacy of the FCC's academic and legalistic approach to its responsibilities, and the ineffectiveness of labor leaders who preach politics instead of production has never been more apparent than at this critical time.

During the past five years, radio production and development facilities have been built up to a level which makes this industry one of the major employers of factory workers and engineering talent.

Under leadership able to coördinate the interests and activities of all concerned, it should be possible to maintain a level of radio production during the period of peace and reconstruction so high as to create new jobs in civilian distribution, sales, service, and operation which will not only absorb any reduction in factory workers and engineering personnel, but will also give employment to radio-trained men released from the Armed Forces.

The best thinking of the FCC, the manufacturers, the broadcasters, and the officers of the radio labor unions should be directed on planning toward this end, so that technical progress during the wartime years of personal trial and sacrifice will give reality to the happiness and security implied in what we call our American Way of Life.

If the radio industry cannot do this in peace, then all its contribution to the prosecution of the war is meaningless and futile.

The Most Pressing Need ★ Thanks to the experience gained with FM for civilian emergency and military services during the past five years, much equipment is available for the new communications and relay systems to be operated above 25 mc. Moreover, ample frequencies have been allocated, and WPB restrictions have been relaxed sufficiently that manufacturers and operators can project postwar plans with confidence and certainty.

The new FM communications field, which includes police, fire, forestry, railroad, taxi, bus, truck, facsimile, citizens radio, rural phone, special emergency, and similar services represents a tremendous new market which did not exist before the

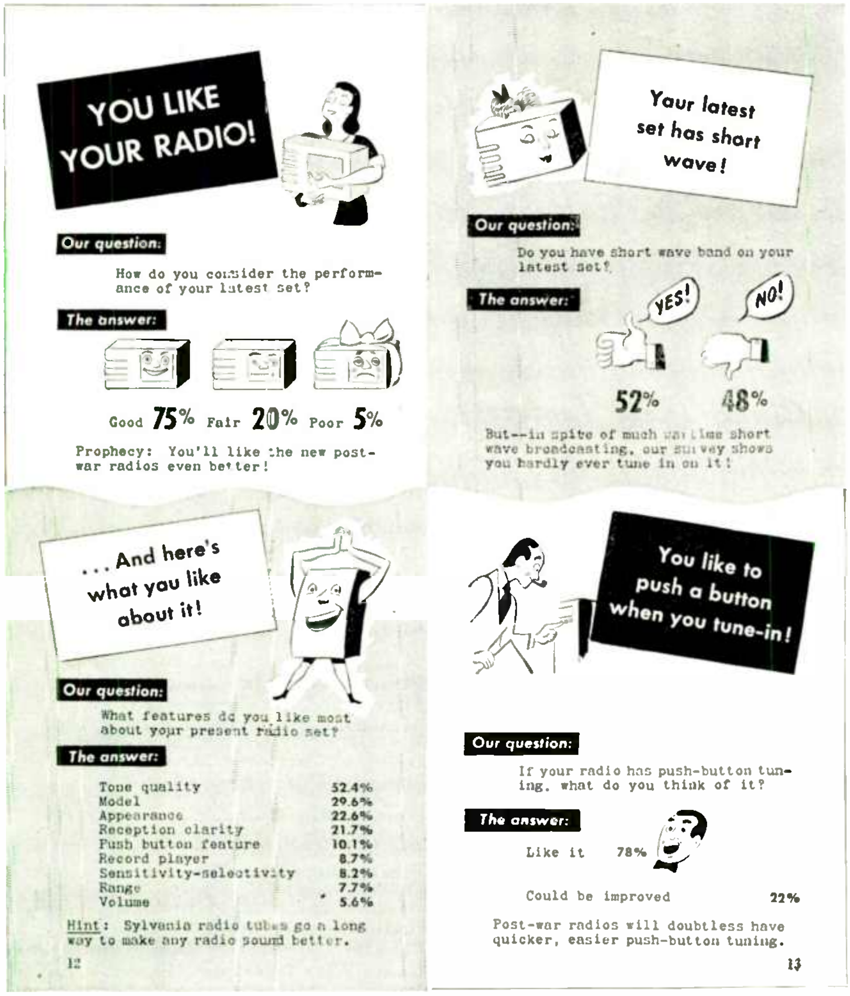
(CONTINUED ON PAGE 78)

SYLVANIA NEWS

ELECTRONIC EQUIPMENT EDITION

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

SYLVANIA ISSUES NEW BOOKLET ON PUBLIC'S POST-WAR WANTS IN RADIO AND TELEVISION



Here is a typical two-page spread from the booklet "They Know What They Want," which summarizes the results of a nation-wide survey of public preferences in radio sets.

Summarizing the results of a recent nation-wide survey, a new booklet, "They Know What They Want," is now being widely distributed. This survey was conducted by one of America's leading market research organizations—at the request of Sylvania Electric's Sales Research Department.

CIRCULATION AMONG CONSUMERS

The booklet is being mailed to consumers in response to inquiries stimulated by questionnaire-type advertisements appearing in national magazines. Through these advertisements Sylvania Electric is continuing its study of public preferences in radio sets. Public distribution of the booklet is expected to be helpful in maintaining the popular interest in post-war radio sets which has been created by Sylvania's advertising.

VALUE TO INDUSTRY

In addition, "They Know What They Want" is being widely circulated among the electronic equipment manufacturing industry. Providing a convenient digest of the public's desires, the booklet should prove helpful to set manufacturers in planning post-war designs that will appeal to buyers' tastes.

Copies of the booklet are available on request to set manufacturers for distribution to their engineering departments and sales forces. A more complete and detailed presentation of the survey findings has also been prepared, and will be shown to interested manufacturers on request to the nearest Sylvania sales office.

ADVERTISERS INDEX

ENGINEERING SALES

Stewart-Warner: Has appointed the newly-formed partnership of Shirley & Onstad, Minot, North Dakota, as distributor for its radio line in the Minot-Fargo territory. Don Shirley and James Onstad are newcomers to radio.

Stromberg-Carlson: Radios are to be distributed in the Birmingham area by Clark & Jones. This concern was founded by H. S. Jones, Sr. in 1898.

Recordit Company: 315 N. 7th Street, St. Louis, has changed its name to Recordit Distributing Company, to further identify the firm's activities in the distributing field.

General Electric: Paul Chamberlain, who has sales-managed the transmitter division at Schenectady up to the present time, has been moved to Bridgeport, as sales manager of the receiving set division. This is familiar ground to him, for he started on receiver sales and distribution in 1925, at St. Louis, later going to G.E. distributor Oehlitree Electric in Pittsburgh, and finally to Schenectady in 1942.

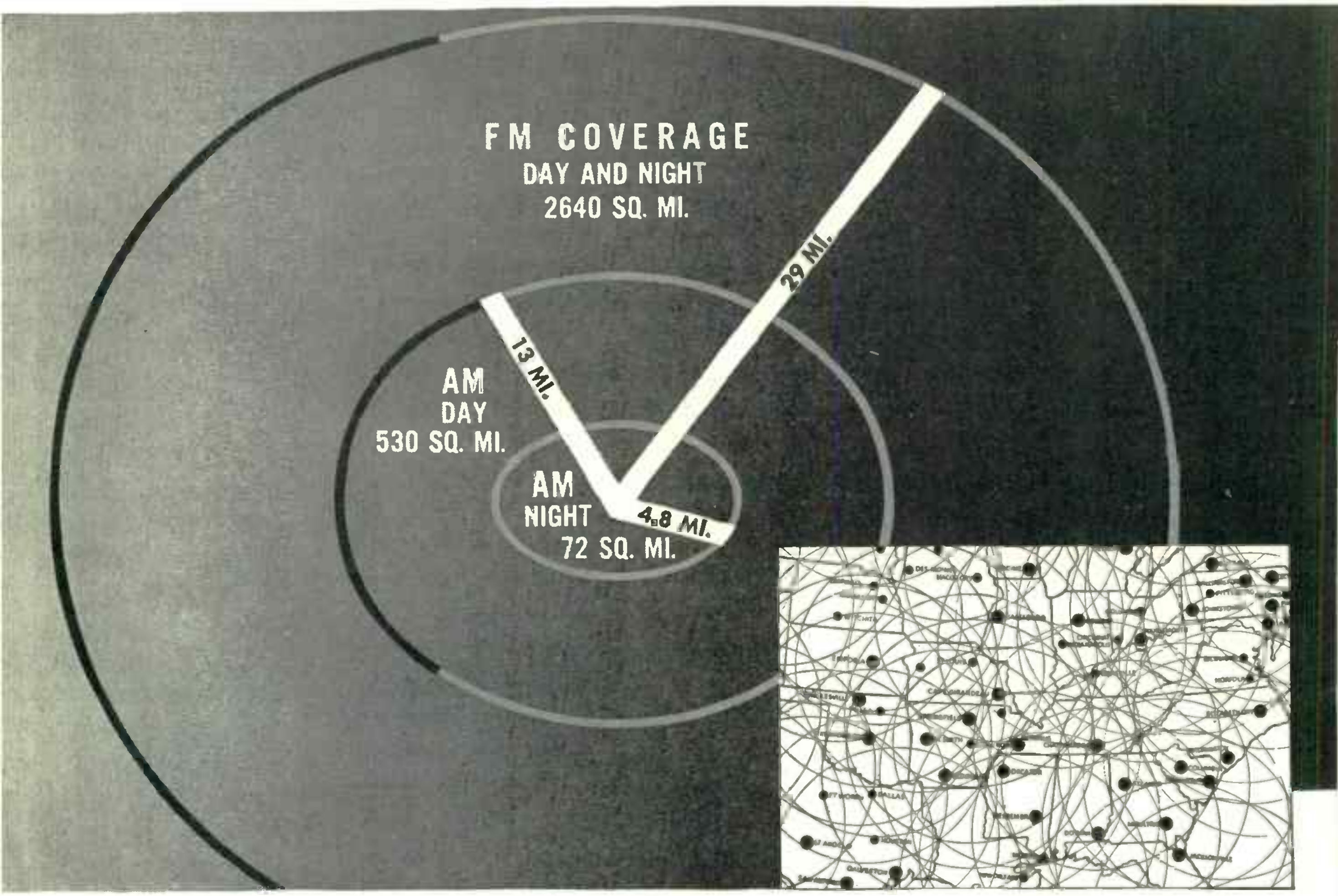
James D. McLean, M.I.T. graduate and radar expert, who shifted from the General Electric laboratory to head up television transmitter equipment sales, has been appointed manager of sales for the transmitter division, succeeding Chamberlain. He will continue to make his headquarters at Schenectady.

Meisner: Godfrey Wetterlow, formerly with Philharmonic Radio, has been named eastern sales manager for Meisner's phonograph division. He will make his headquarters at Greenwich, Conn.

Barker Brothers will handle this line in Los Angeles and Southern California. O. R. Coblentz is manager of Barker's radio division, with L. B. Brittain as engineering consultant. Branch stores are operated at Alhambra, Glendale, Hollywood, Huntington Park, Inglewood, Long Beach, and Santa Monica.

(CONCLUDED ON PAGE 87)

FM does it...



Effective signal-coverage comparison of an FM station and a 1400-kc AM station. Most AM stations could enjoy better coverage by switching to FM. Moreover, their FM signals would neither cause interference with other stations nor be affected by interference from other stations.

Station interference pattern produced by AM stations on the 1400-kc channel. Dots indicate location of stations. Large circles indicate possible 400-mile interference range. At night, areas in which the circles overlap usually are subject to serious heterodyne interference. This pattern is typical of many crowded regional and local channels.

PLAN YOUR FM STATION NOW—50 FM BROADCAST STATIONS ARE ON THE AIR AND OVER 300 APPLICATIONS ARE PENDING. Write for the General Electric booklets covering FM station planning, equipment description, and general station operation. These publications describe G-E transmitters, antennas, associated equipment, and contain operating data from FM station records.

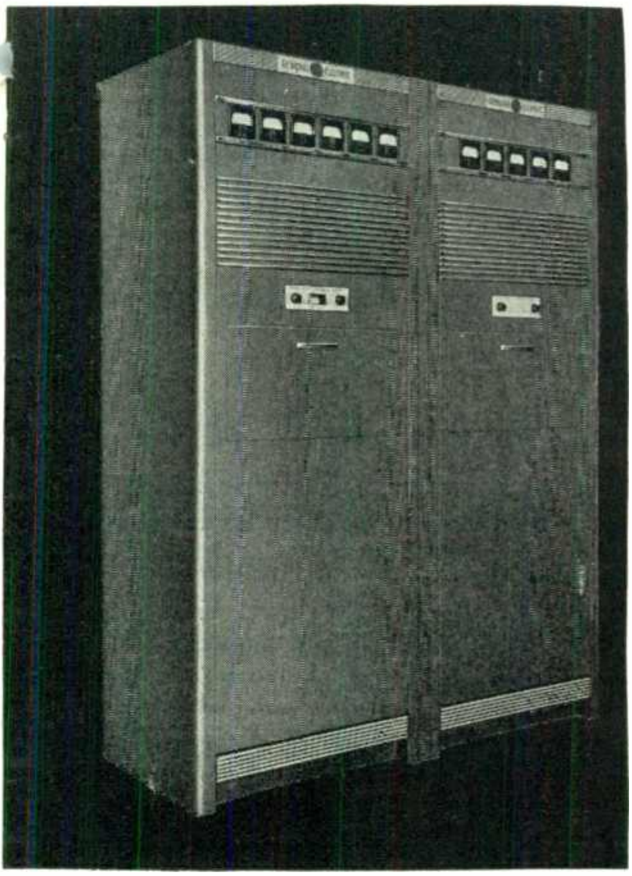
STUDIO AND STATION EQUIPMENT • TRANSMITTERS

GENERAL ELECTRIC

160-C11—6914

. . day and night

5 times the coverage by day 35 times the coverage by night



THE PRE-WAR G-E 1-kw FM TRANSMITTER

General Electric's post-war FM equipment will include significant developments in circuits, components, and layout that will contribute directly to the quality and economy of your broadcasting system.

ESTABLISH A POST-WAR PRIORITY ON DELIVERY OF YOUR FM EQUIPMENT. In order to enable you to obtain a post-war priority on delivery of transmitters and associated equipment, General Electric offers you the "G-E Equipment Reservation Plan." This plan will assure you of prompt post-war delivery of your transmitting equipment. Write for your copy of "The G-E Equipment Reservation Plan." *Electronics Department, General Electric, Schenectady, N. Y.*

Regardless of your present power, if you face a coverage problem, if you share a crowded channel, consider FM. In nearly every case FM will provide better coverage of the *same* area at *less* cost, or better coverage of *more* area at the *same* cost.

Wherever station interference presents a problem, look to FM for better coverage. Consider, for example, the case of the 1400-kc channel in the broadcast band. Here, eighty-five AM stations share the same frequency. Eighty-one of them are rated at 250 watts and at night are capable of causing serious heterodyne interference up to 400 miles. This interference greatly reduces nighttime coverage. Engineering data indicate that under conditions of average ground conductivity (3×10^{-14} EMU) and with an antenna height of 331 feet, the effective range of these stations over flat country would be:

AM Service	*Range*	*Coverage*
Day	13 miles	530 square miles
Night	4.8 miles	72 square miles

Compare this with the coverage of a 250-watt FM station using a single-bay antenna 331 feet high broadcasting over the same terrain:

FM Service	*Range*	*Coverage*
Day *and* Night	29 miles	2640 square miles

Thus, FM gives five times the coverage by day; *thirty-five times the coverage by night!* To your audience this means improved service. To you, this means a larger audience and better service to advertisers.

When you plan your FM station, make full use of General Electric's vast background of experience in the FM field. G.E. is the one manufacturer with experience in designing and building complete FM systems—from transmitters to receivers. G.E. has designed and built more FM broadcast transmitters than any other manufacturer. G.E. has furnished a large percentage of today's half-million FM home receivers. G.E. has supplied six complete studio-transmitter FM relay links with thousands of hours of regular operation to their record. General Electric's experience in the FM broadcasting field includes more than three years of programming through its own FM proving-ground station WGFM at Schenectady, where every transmitter development is tested before it is offered to the industry.

Tune in General Electric's "The World Today" and hear the news from the men who see it happen, every evening except Sunday at 6:45 E.W.T. over CBS network. On Sunday evening listen to the G-E "All Girl Orchestra" at 10 E.W.T. over NBC.

ANTENNAS • ELECTRONIC TUBES • HOME RECEIVERS

FM • TELEVISION • AM *See G.E. for all three!*

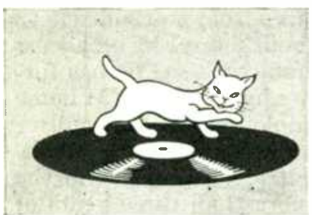
"The following is electrically transcribed..."

on PRESTO discs!

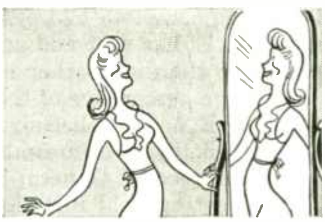
How are great commercials born? Rinso's happy little wash-day song was born in the woods. An advertising man, trying to get away from it all, listened raptly to the song of a bob-white—the special three-note call Bob uses to sell himself to his mate. "Golly," said the ad man, "why couldn't we . . ." And the rest is soap history.

Rinso "spots" are cut on PRESTO discs. *Most important transcriptions are.* For recording engineers know that PRESTO discs give finer results with less margin for error—*actually perform better than most of the recording equipment on which they are used.* That's why you'll find, in most large broadcasting stations, recording studios and research laboratories, the standard recording disc is a PRESTO.

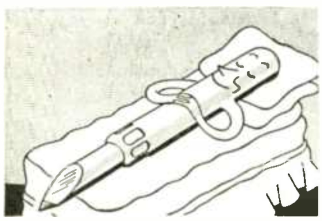
WHY BROADCASTING STUDIOS USE MORE PRESTO DISCS THAN ANY OTHER BRAND



Less Surface Noise



No Distortion



Easier on Cutting Needle

No Fussy Needle Adjustments

WORLD'S LARGEST MANUFACTURER OF INSTANTANEOUS SOUND RECORDING EQUIPMENT AND DISCS

PRESTO

RECORDING CORPORATION

242 West 55th Street, New York 19, N. Y.

Walter P. Downs Ltd., in Canada

TRANSFORMER COMPONENTS

for every application

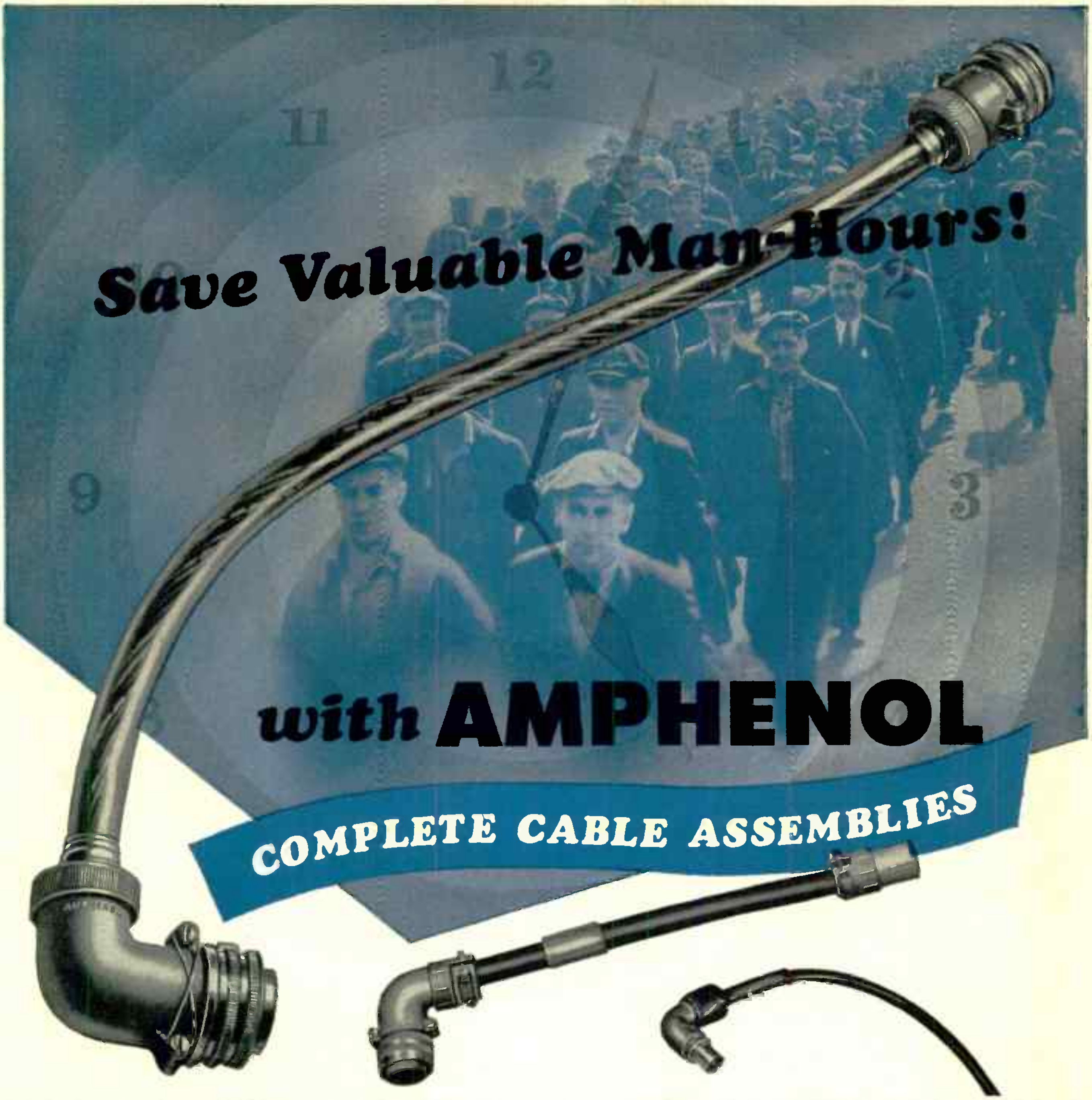
Foremost Manufacturers of Transformers to the Electronic Industry

ARMY-NAVY E — ALL PLANTS

May we cooperate with you on design savings for your applications . . . war or postwar?

United Transformer Corp.

150 VARICK STREET NEW YORK 13, N. Y.
EXPORT DIVISION: 13 EAST 40th STREET, NEW YORK 16, N. Y., CABLES: "ARLAB"



With Amphenol COMPLETE Cable Assemblies you have only one source of supply . . . issue only one purchase order . . . cut your procuremen cost . . . reduce your labor and tool cost . . . eliminate production and assembly worries . . . all of these add up to a substantial savings in valuable man-hours and manufacturing cost.

Tremendous volume production has necessitated the creation of countless jigs, fixtures and special equipment with resultant lower assembly cost, precision and quality workmanship, and dependability that characterizes all Amphenol products.

. . . Engineered to your specifications . . . Efficiently assembled . . . Exacting precision in testing—three additional reasons why you should specify Amphenol complete, quality Cable Assemblies.

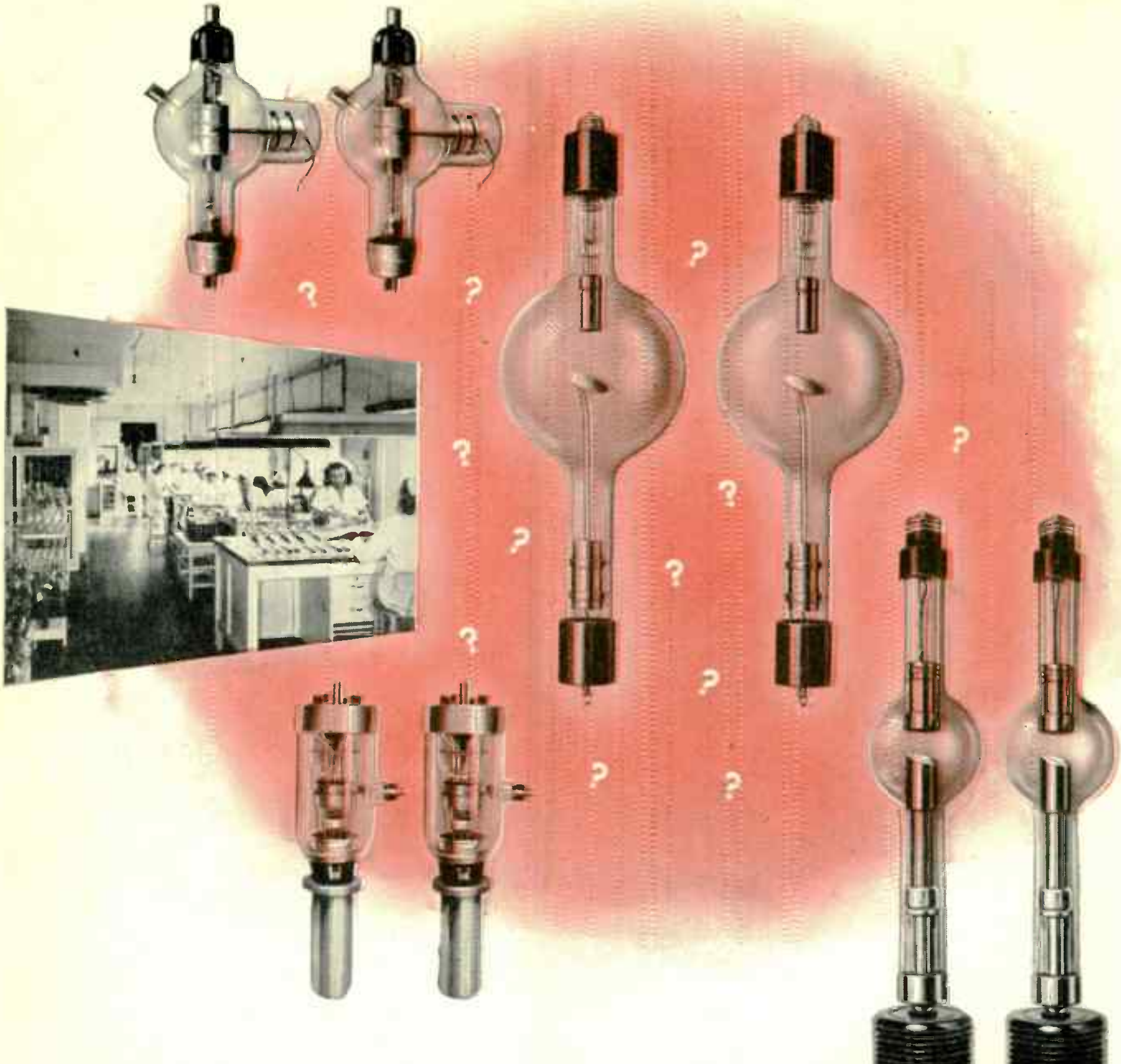
Your inquiry will receive prompt, careful and confidential consideration.

Depend upon AMPHENOL Quality.

Depend upon AMPHENOL *Quality*

AMERICAN PHENOLIC CORPORATION
Chicago 50, Illinois
In Canada • Amphenol Limited • Toronto

U.H.F. Cables and Connectors • Conduit • Fittings • Connectors (A-N, U.H.F., British) • Cable Assemblies • Radio Parts • Plastics for Industry



CAN YOU TELL WHICH TUBES ARE BETTER ?

Two tubes of the same type may look exactly alike, but if one was assembled in the Machlett "White Room" while the other was put together under average factory conditions, there would be a considerable difference between them. In lighting, cleanliness and conditioned environment, the "White Room" resembles a hospital operating room, and tubes passing through it remain free of internal contamination that would lessen their stability, shorten their life. Such tubes will give full-rated, predictable performance, and prove uniformly economical and satisfactory. It was to achieve such improved results that Machlett built the first "White Room" in the industry — subsequently adopted by others. Many still newer Machlett techniques, such as this, continue to improve the quality and performance of our products. In this way, Machlett leadership in the electron tube field is maintained.

When you need a medical or industrial X-ray tube, or an oscillator, amplifier, or rectifier for radio or industrial purposes, select a Machlett. It will pay you in stability of operation and long life. For information as to available tubes, write Machlett Laboratories, Inc., Springdale, Connecticut.

ML-500, a high-frequency triode. Maximum plate dissipation 500 watts with full power input at frequencies up to 50 megacycles.

MACHLETT

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

SE 100
TELEVISION TRANSMITTER

How SHERRON Serves The TELEVISION INDUSTRY

- **Engineering Consultation**
- **Laboratory Facilities**
- **Manufacturing**

The service that has fathered the Sherron reputation in the field of custom-built electronic equipment is now available also to the television industry.

Our capacity for this broadened function is based upon an extensive experience with equipment employing: video amplifiers . . . cathode ray tubes . . . oscillograph controls . . . and circuits related to television.

All our departments are staffed with expert personnel trained to tackle each problem realistically. Hard-headed, practical aims govern every phase of our work. This is true of our Design section, as it is of our Engineering division, Development and Manufacturing departments.

As accredited manufacturers of custom-built electronic equipment for manufacturers exclusively, we can serve you in the development and design of the following to your specifications:

TELEVISION TRANSMITTING . . . Video and Audio
STUDIO CONTROL DESK . . . Exclusive control for technical direction
MASTER CONTROL BOARD . . . 5 Available Video Channels
TRANSMITTER CONTROL DESK . . . Featuring operational controls for both Video and Audio

Sherron Electronics

SHERRON ELECTRONICS COMPANY

Division of Sherron Metallic Corporation

1201 FLUSHING AVENUE, BROOKLYN 6, N. Y.

"Where the Ideal is the Standard, Sherron Units are Standard Equipment"

Again it's HYTRON—Easy on the Battery!

HY1269 HY31Z HY65 HY69 HY1231Z

In mobile operation, the battery is the kingpin. Two-way police radio takes it out of the battery twenty-four hours a day. Conservation of battery power during stand-by periods is mandatory.

Instant-heating Hytron tubes with thoriated tungsten filaments came to the rescue of police radio. Only when on duty, does police radio equipment draw power when Hytron tubes are used. Filament and plate power go on together.

And that's not all. The Hytron HY31Z, HY65, HY69, HY1231Z, and HY1269 are rugged. HY65 performance in two-way motorcycle police radio has proved this. Including 12-volt filament tubes for marine applications, Hytron's instant-heating line is versatile. Concentration is on the R. F. beam tetrode — work horse of transmitting tubes — but also included is the HY31Z twin triode for Class B. One type can power a whole transmitter — R. F. and A. F. — thus simplifying the spares problem (e.g., Kaar Engineering transmitters built around the HY69).

Wartime uses are bringing additions to the Hytron instant-heating line. Watch for future announcements.

OLDEST EXCLUSIVE MANUFACTURER OF RADIO RECEIVING TUBES

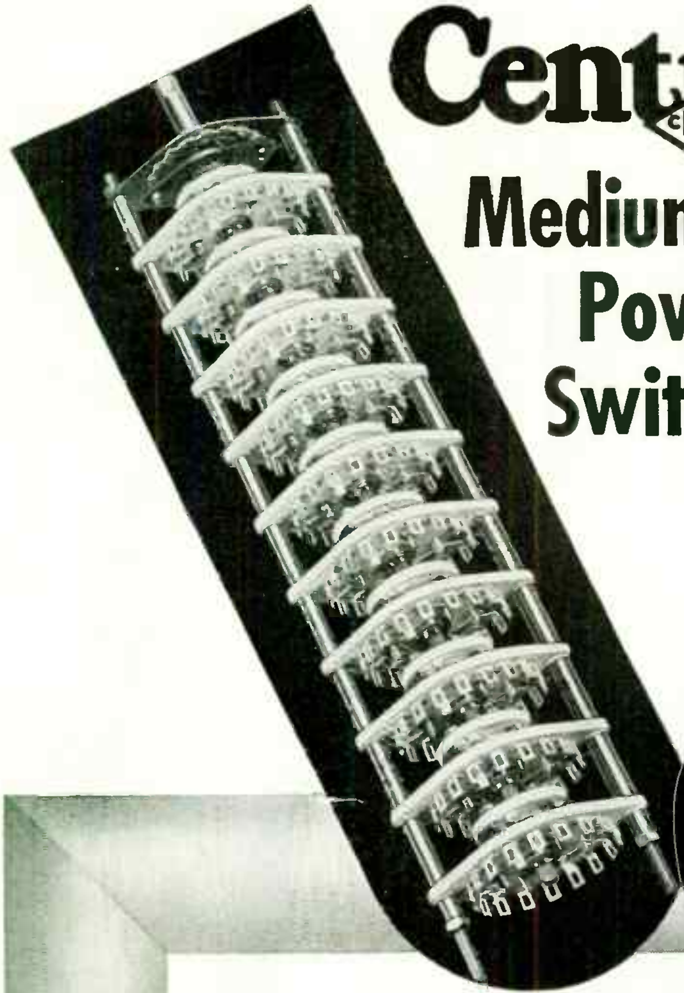
HYTRON

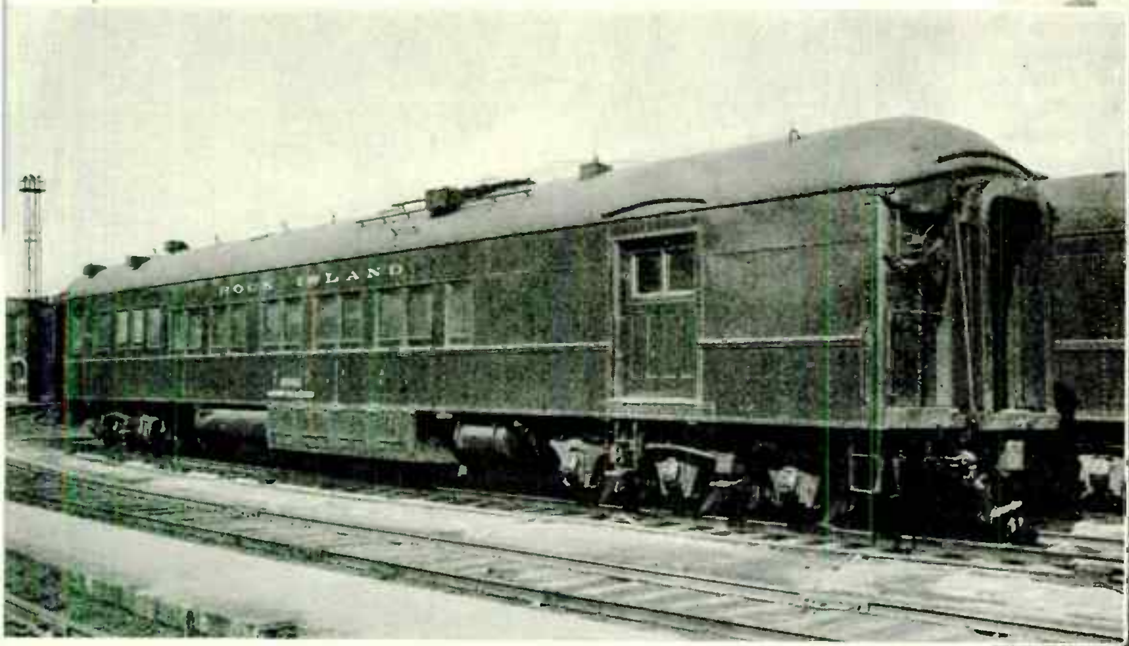
RADIO AND ELECTRONICS CORP.

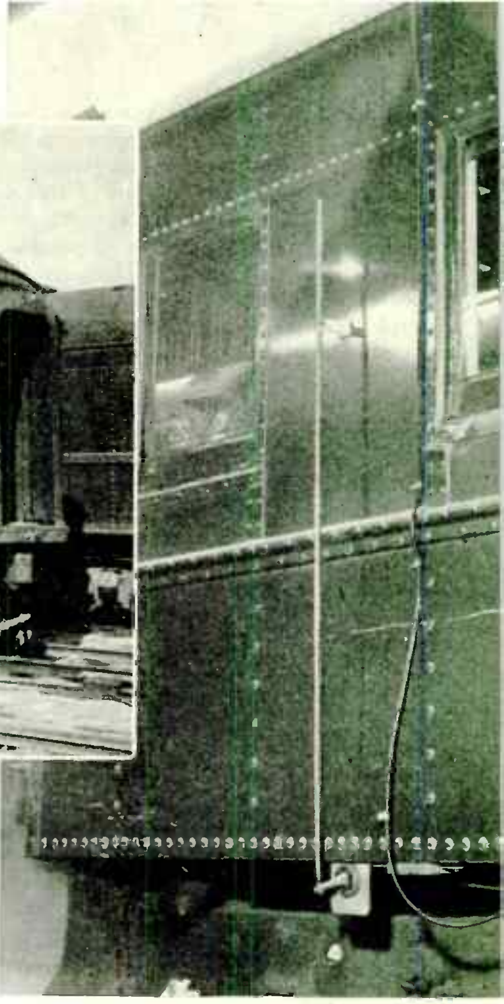
MAIN OFFICE: SALEM, MASSACHUSETTS

PLANTS: SALEM, NEWBURYPORT, BEVERLY & LAWRENCE

FORMERLY HYTRON CORPORATION







FM ON THE ROCK ISLAND

Description of a Radio Communications Laboratory on Rails

BY NORMAN WUNDERLICH *

FIG. 1, LEFT: THE ROCK ISLAND'S RADIO LABORATORY CAR. FIG. 2, ABOVE: A DETAILED VIEW OF ONE ANTENNA

TO THE now-familiar radio communication laboratory installations on airplanes and trucks, the Rock Island Railroad has now added such an installation in a car which rolls on rails. In fact, the laboratory illustrated here is the Rock Island's second of a series.

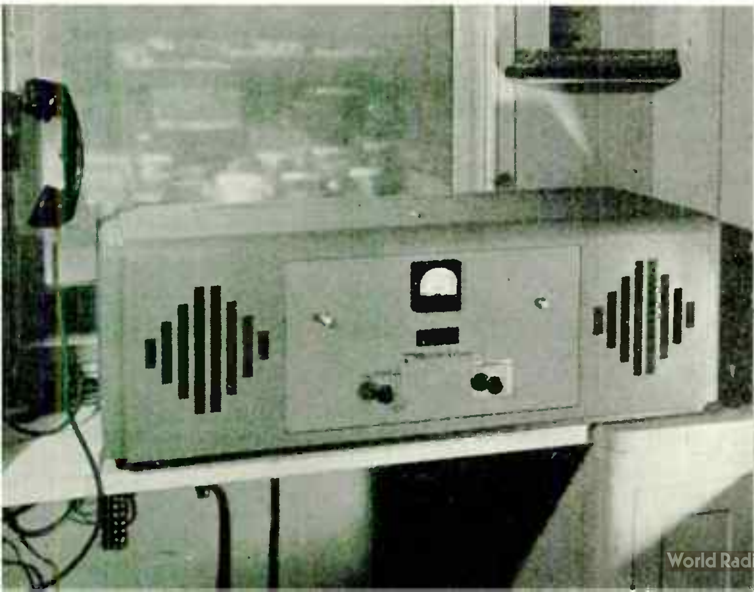
The first was set up in an old caboose. However, it was soon learned that it was necessary to use a car as modern as the equipment to be put in it. The construction of the caboose was such that it could only be hauled behind medium-fast freight or slow passenger trains, and the limited facilities which had been provided were not adequate for all the conditions of research and emergencies the equipment was called upon to meet.

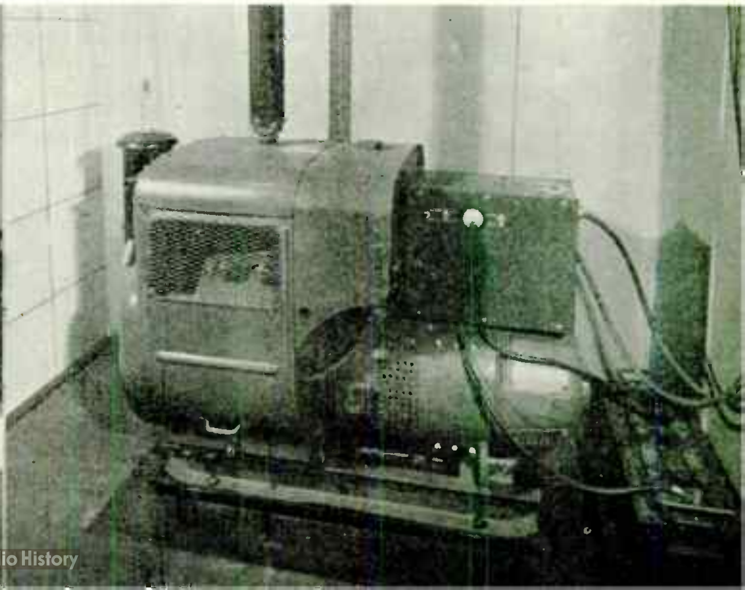
Since the road had embarked on an extensive radio communications project, the caboose was abandoned, and a completely new laboratory was set up in the car pictured here. Fitted with passenger trucks, this car can be hauled on the fastest run, and has the added advantage that a crew of 13 can eat, sleep, and work in it. Even a shower has been provided.

An office space at one end of the car, to the left in Fig. 1, also serves as an operating room, where communications are handled when the laboratory is sent out on

* Communications Division, Galvin Mfg. Corporation, 4545 Augusta Blvd., Chicago 51, Ill.

FIG. 3, LEFT: FM TRANSMITTER-RECEIVER IN THE OPERATING ROOM. FIG. 4, RIGHT: THE 5-KW. AC POWER PLANT FOR 115 VOLTS





emergency or test runs. A modified 30- to 40-mc. Motorola FM transmitter-receiver unit is installed for this service. One of the two antennas is shown in Fig. 2. The other is mounted on the opposite side of the car, and is connected in parallel. Although they do not project above the roof of the car, these antennas provide ample transmitting and receiving range of a symmetrical pattern with respect to the length of the car.

In addition to the press-to-talk microphone in the operating room, Fig. 3, there is another in the laboratory section, so that the standard communications equipment can be operated from there during special tests and measurements.

Next down the car are the galley, always stocked for emergency runs, the shower, and bunks for the crew. Then come the laboratory, Fig. 5, and the power room, shown in Fig. 4.

The laboratory is very completely equipped for making measurements and field strength recordings, and for handling repairs, as well. Checks on transmission between 28 and 145 mc. can be made with an FM-AM receiver and a single-wire antenna running on stand-off insulators along the roof. A third antenna, on the square mounting just above the door, Fig. 1, is used with other 160-mc. gear.

FIG. 5. THE LABORATORY SECTION IS COMPLETELY EQUIPPED FOR MAKING AND RECORDING FIELD STRENGTH AND OTHER MEASUREMENTS, AND FOR REPAIRS

Thus, experimental work can be carried out on all the channels now provided by the new FCC allocations for railway radio communications. These include 60 channels in the 152- to 162-mc. band, plus channels to be allocated between 74 and 78 or between 104 and 108 mc., and certain others which will be shared with television on the lower frequencies on a mutually non-interfering basis.[1]

A small closet across from the laboratory test bench contains two Motorola Signal Corps type walkie-talkies and two handie-talkies. They can be seen in Fig. 6. Considerable information has been collected already concerning the use of such units in various emergencies, including those where it is necessary to send a brakeman to the rear under conditions of snow and fog that his lantern cannot be seen for any useful distance.

Experience has already indicated that both of these units will probably become standard equipment on trains moving over routes which operate complete radio communications systems.[2] Eventually, a specific routine will be worked out for the operation of portable equipment for communication between the brakeman and the conductor or engineer. It is easy to see how valuable the handie-talkie can be for getting information from the brakeman to the engineer of a long freight train, for example. These are among the problems which are being investigated and studied, and to which the work being done in this railway radio laboratory will give the answers.

Another interesting piece of equipment is the Dictaphone recording equipment shown in Fig. 7. Circuit arrangements are provided so that it can be used to record speech on any of the radio equipment under test.

It is felt by some railroad officials that it will be necessary to record all communications under conditions of routine operation. Whether or not recordings will serve

[1] See the table of frequency assignments for 25 mc. to 30,000 mc., released by the FCC on May 17, 1945, published in *FM* AND TELEVISION for May, 1945, page 23.

[2] A summary of the railway radio services, formulated by Panel 13 of the Radio Technical Planning Board was published in *FM* AND TELEVISION for December, 1945.

FIG. 6. WALKIE-TALKIES AND HANDIE-TALKIES WILL PLAY AN IMPORTANT PART IN RAILROAD RADIO COMMUNICATIONS

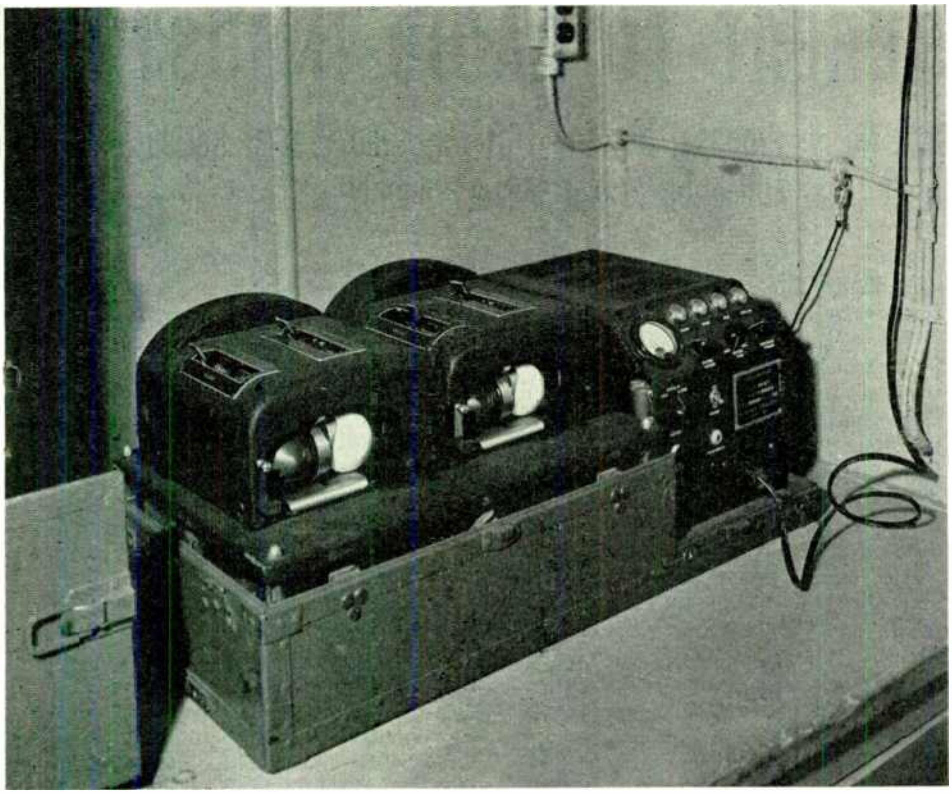


FIG. 7. THIS DICTAPHONE RECORDING EQUIPMENT CAN BE CUT IN ON ANY OF THE RADIO TRANSMITTERS AND RECEIVERS TO TAKE DOWN CONVERSATIONS

a useful purpose can be determined only by experience. While some orders are now issued in writing, others are given only by visual signals. Perhaps the feeling that, when orders are transmitted by radio, all communications must be recorded comes from a lingering lack of confidence in its reliability, rather than from actual need. Here, again, is a practical, operational question which this laboratory will settle in due course of time.

Behind the laboratory section is the power room, occupying the end of the car. Here a 5-kw. gasoline engine driven generator furnishes 115 volts at 60 cycles for the radio and electrical equipment, and for the fluorescent lights used throughout the car. This section is sound-proofed so that, even when the car is not in motion, the noise from the gasoline engine does not interfere with work in the laboratory or the operating room.

Radio apparatus such as will be standard equipment for railway radio communications does not require such a large generator. However, this installation was planned to meet any special needs, and the 5-kw. power plant was chosen accordingly.

A simple switch operates an electric starter connected to the storage batteries seen at the right of Fig. 4. Then charging current is furnished to the batteries when the generator is running. Exhaust fumes from the engine pass through a muffler and a pipe which goes through the roof of the car.

Two self-contained, trunk-mounted FM transmitter-receiver units, Fig. 8, are stored in the power room. They can be used for various emergency communications services, but their particular purpose is to patch telephone lines broken by storms or floods. The transmitters operate on different frequencies, to permit simultaneous transmission and reception in two directions. Automatic ringing devices are provided with this equipment, so that breaks of several miles can be patched, and the line kept in use.

The design of the portable antennas used with the trunk units is of special interest. In Fig. 8, the bases are at the left, with the collapsible antennas leaning against the cover of the box above. The bases can be secured to telephone poles, or driven into the earth. A coaxial cable is attached permanently to each base, and plugs into a receptacle on the front of the trunk unit. As shown in Fig. 8, there is a loudspeaker secured to the cover of each unit. In addition, a push-to-talk handset is carried inside each case.

Experience of the greatest value is being obtained with the installation, both as to the reliability of radio communications and as to operating procedure. These are equally necessary. First of all, railroad officials are only beginning to realize that radio has outgrown the uncertainty characteristic of equipment which, in years past, the roads tried unsuccessfully to use. That lack of confidence can, indeed, be overcome only by demonstrations under service conditions.

Then there is the matter of working out procedures for using radio. Methods of communicating and signally by waving papers and lanterns seem, to the outsider, much too slow and extremely old-fashioned. However, their certainty is known from years and years of use, and it would be unreasonable for railroad men to abandon them overnight for means that are untried and which, to them, are completely unfamiliar.

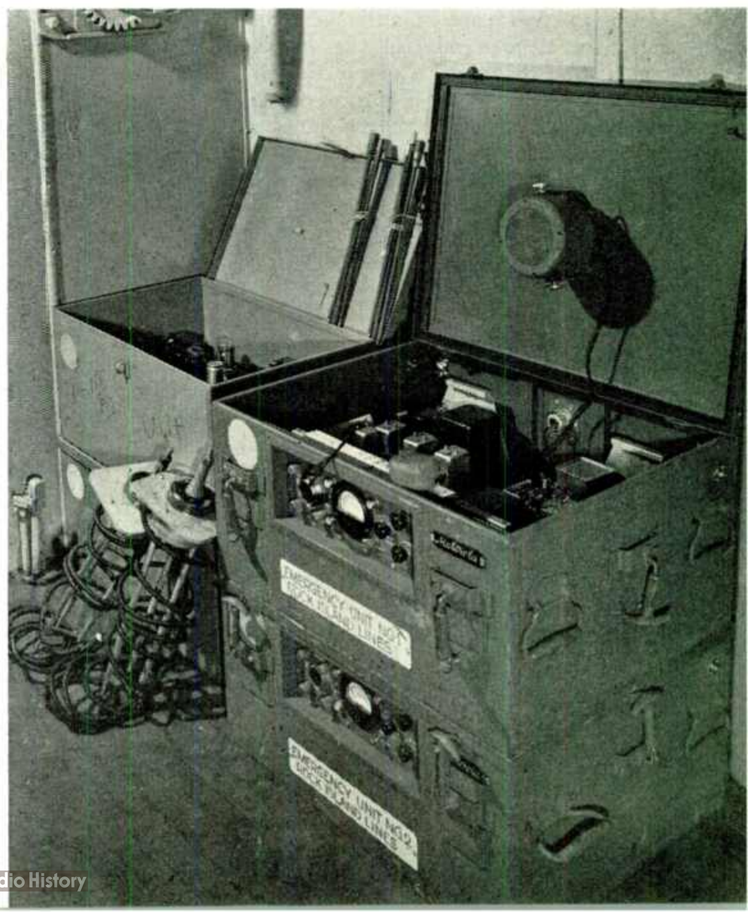


FIG. 8. TRUNK-MOUNTED FM UNITS, WITH PORTABLE ANTENNAS ARE USED TO PATCH LINES BROKEN BY STORMS

FCC DELAY IS THREAT TO RADIO INDUSTRY

FM Manufacturers Favor FCC's No. 1 Proposal for 44–108 Mc., and Predict Serious Unemployment If Final Allocation Is Not Made Promptly

On May 25th, the FCC issued a 225-page *Report of Allocations from 25,000 kc. to 30,000,000 kc.*,[1] of which more than half is devoted to FM broadcasting. Concerning the proper position in the spectrum for this service, the Commission said: "In making an allocation for FM, it is the Commission's purpose to make provision for a service which will not be simply a new and improved broadcast service but which will be the finest aural broadcast service which is attainable under the present state of the radio art. The Commission confidently expects that in the years to come this service will develop to a point where there may be between 1,000 to 3,000 FM transmitters and between 50 million and 100 million FM receivers in the hands of the public."

As for the tuning range of FM receivers: "In order to provide an adequate number of channels for FM it will be necessary to allocate a total of 20 megacycles. Eighteen megacycles will be assigned exclusively to FM and will provide 90 channels. The other 2 megacycles will be available initially for assignment to stations exclusively rendering a facsimile broadcast service. It is expected that ultimately this service will find its place in the band allocated for that purpose in the 400-mc. region[2] and that these 2 megacycles will also be available for FM. It is, of course, contemplated that all FM receivers shall cover the entire 20-megacycle band."

Gratification has been expressed in all quarters at the Commission's attitude toward channel width and fidelity standards. The Report states: "In order to realize FM's capabilities of transmitting sound with all of its realism of tone and the suppression of noise and other interference, it is necessary to utilize a channel wide enough to discriminate against noise and other interference. . . . The Commission is of the opinion that an integral part of FM will be lost if the present standards of fidelity are lowered, or the present signal-to-noise ratio reduced. The economy of spectrum utilization urged by the advocates of the narrower channel will be far less than the significant advantages that will be lost by such a change and, accordingly, the Commission is retaining the present 200-kc. channel."

Unfortunately, the remaining essential factor which the FCC must determine — the exact band of FM broadcast frequencies — has not been decided. According to the Report: "The choice between the three alternatives[3] discussed is not easy, as each has much to commend it. Alternative 1 (50 to 68 mc.) involves the least dislocation of the existing FM broadcast service and makes possible the continuance of existing techniques in transmitter design and receiver construction. Problems from the standpoint of shadows and tropospheric propagation appear to be less than at higher frequencies. On the other hand, if the predictions are borne out, there may be substantial interference both from Sporadic E[4] and from F2.

"Conversely, alternative No. 3 (84–102 mc.) involves the maximum modification of present techniques of transmitter design and receiver construction, which it is predicted will make equipment more costly. Shadows and tropospheric propagation may be increased although, if the predictions are borne out, they will not be substantially worse. On the other hand, interference from Sporadic E and F2 will be negligible.

"Alternative No. 2 (68 to 86 mc.) involves a compromise between alternatives 1 and 3. Sporadic E and F2 interference will be greatly reduced but will not entirely disappear; tropospheric propagation and shadows may be slightly increased. In addition, there is the image response problem resulting from television channels on either side of the FM band."

The Report then explains the plan to take time to collect data on propagation at the higher frequencies before assigning FM frequencies although, "It, of course, will not be possible to collect any further data with respect to the effects of F2 until the next sunspot maximum, which is not expected until 1948. . . . However, equipment considerations should not be complicated by moving to the higher frequencies unless it is clear that there will be definite advantages from a propagation standpoint."

What do the radio manufacturers think of the FCC's Report? Some company executives declined to make any comment for publication because their engineers have been asked to serve on the FCC's committee to investigate FM propagation. Privately, those we have queried have deplored the delay, expressed the opinion that Alternative No. 1 should be adopted *now*, and have been very definite in saying that the value of any data obtained during the summer is of no importance compared to the risk of harm to the industry which may result from the delay in assigning FM and television frequencies. The one exception was W. P. Hilliard of Bendix Radio, who merely commented that: "Thinking of the long-term effect on permanent FM allocations, I believe the FCC action is in the interest of the public and the industry." However, it does not appear that Bendix Radio plans to manufacture FM receivers, as they have not made any announcement of such intentions as far as we know.

Here are the texts of some of the communications we received:

PILOT RADIO CORPORATION

E. L. HALL, *Executive Vice President*

The *technical* necessity of conducting Frequency Modulation tests up to 108 mc. this coming summer is more than doubtful, because any tests on the complex issues involved will be of necessity inconclusive. It has been brought out in various committee meetings, public hearings, and secret hearings, that if the tests are to mean anything, they must cover a wide range of frequency, power, and geographical location. They must also take into account the time of day, the season of the year, and particularly the period within the eleven-year sunspot cycle. Such tests, if they are to be conclusive, will have to extend over a period of years. The coördination and analysis of such tests, leading to a conclusion which might be accepted by all concerned, would be in itself a stupendous task. The evil results of indecision pending the outcome of these tests would far outweigh the problematical good which might come out of any agreement for change, if indeed an agreement of any kind could come out of such a process.

The *commercial* necessity of attending to the Frequency Modulation market the moment civilian production is permitted

[1] The complete allocations, listed by services, were published in *FM* and Television for May, 1945, page 23.

[2] Unless it is found practical to duplex facsimile and sound broadcasting. — *Editor's Note.*

[3] See Alternative assignments for 44 to 108 mc. *FM* and Television for May, 1945, page 23.

[4] See "Memorandum on Sporadic E Interference" by Major Edwin H. Armstrong, *FM* and Television for May, 1945, page 35.

by the Government should be overwhelmingly clear to everybody who has any knowledge of the Frequency Modulation market as it developed before the war, and of its importance for our industry as a whole after the war.

Some of us might not hesitate to disregard completely the great harm that would be done to the public and to our industry if practically all Frequency Modulation sets in the hands of the consumer (many of them high priced units) were to become obsolete with a change in frequencies. *Nobody, however, could possibly overlook the fact that any uncertainty about future FM frequencies will create most difficult and almost chaotic conditions for our industry, and that unemployment will be created were we compelled to neglect this definitely established market.*

The public, as well as every expert, knows that table models and phonograph combinations of higher quality, and consequently higher price, should have a Frequency Modulation band, and the public undoubtedly will refuse to buy this type of merchandise without the FM feature. This condition in turn will force every manufacturer (and we shall be quite a crowd after the war) to concentrate on the manufacturing of small, low-priced AM radio receivers.

Considering the tremendous increased productive capacity of our industry, it is not difficult to foresee that the demand for low-priced receivers will be met very quickly under such conditions, and that over-production, with all its evil effects, will jeopardize within the very near future the greatest opportunity of our industry in many years.

In summarizing, we wish to say that our industry must be permitted to move into the future firmly and with clear conceptions of technical conditions. Concerted efforts of the administrative and legislative branches of the government, as well as intelligent coöperation of our own industry must prevent a situation which can, even temporarily, endanger the Frequency Modulation market and the future of our industry for the sake of highly dubious technical speculation.

FREED RADIO CORPORATION

ARTHUR FREED, *Vice President*

We believe *the decision of the FCC to postpone frequency allocations for FM broadcasting until after tests are completed will cause very serious unemployment in the event that civilian production is authorized prior to completion of tests* and will place manufacturers vitally interested in FM production in a position where they will be unable to obtain satisfactory delivery of raw materials when they are ready to proceed with their production plans.

TELEVISION BROADCASTERS ASSOCIATION

Federal Communications Commission:

Gentlemen:

The Board of Directors of the Television Broadcasters Association, Inc., at its regular meeting held in Philadelphia, Pennsylvania, on Friday, May 25, 1945, adopted the following resolution:

A RESOLUTION

Whereas, the press release issued by the Federal Communications Commission on May 17, 1945 indicated that with respect to television frequencies, there would be three possible alternative allocations, the selection to be deferred to permit tests to be carried out by an engineering group, including the Commission's staff, over a period of at least three months;

And Whereas, cutbacks in use of personnel, plants, and material for military purposes in the electronics industry are now taking place and will become more rapid, while several months of design and production engineering must follow the definite allocation of channels before civilian production in quantity can use such released labor and, furthermore, regional and individual assignments of frequencies must follow such allocation of frequencies and local construction and employment by individual stations will be further deferred;

And Whereas, technical considerations of design and wasteful interference with other services make the second alternative undesirable, and since the first alternative is preferred because of its long range superiority for television considering all factors, now therefore

Be it resolved, That the Federal Communications Commission is earnestly requested to adopt at once for television alternate Plan No. 1 which gives television

68 to 74 mc. 78 to 108 mc.
174 to 216 mc.

Be it further resolved, That the television industry continue to cooperate in the proposed propagation tests for use in establishing regional standards of interference and regional assignment of television frequencies.

ZENITH RADIO CORPORATION

E. F. MCDONALD, JR., *President*

I am delighted by the Federal Communication Commission's wise decision to conduct tests to determine the best wave band for FM instead of arbitrarily kicking it upstairs to the undesirable and untried 84- to 102-megacycle band.

Although the preponderance of technical experts favored leaving FM in the 50-megacycle area where it has given unequalled service for the past five years, a series of tests to further prove that this is the best location will be helpful. I am confident that these tests will indicate the desirability of assigning to FM the 50- to 68-megacycle band, rather than the alternative bands of 68–86 or 84–102 megacycles which have been proposed. The selection of the 50- to 68-megacycle band will save the public millions of dollars in the purchase of new radios. If FM cannot use the 50- to 68-megacycle band, then certainly television cannot, because television is much more susceptible to interference than is FM.

I am sure that the radio industry, if called upon, will coöperate, and Zenith will do its share, to conduct these tests as rapidly as possible. *It will take some time after final allocations are announced for manufacturers to complete their engineering and get ready for production. In the meantime, the date of reconversion is rapidly approaching. Unless FM is ready to go on the day we get the green light from WPB, tens of thousands of new jobs will be lost.*

Should, as I believe probable, the final decision be to place FM in the 50- to 68-megacycle band, I earnestly recommend that for a period of two or three years the Commission widen it to include also 48–50 megacycles. These are in tuning range of FM sets now in the hands of the public and, by assigning a number of stations to these frequencies, present set owners would continue to get value from their receivers.

STROMBERG-CARLSON COMPANY

RAY. H. MANSON, *President*

I have refrained purposely from making any comments for publication on the recent announcement of the FCC that no definite allocations would be set up for FM and television until field tests are made this summer, as I believe the engineers of the Commission are trying to get sufficient facts to do a good job by both of these services.

It is doubtful, however, whether sufficient information can be obtained this summer to provide the answers for a perfect system, as it would take another sun spot cycle to complete all of the tests necessary to learn all of the vagaries of

(CONCLUDED ON PAGE 38)

SPOT NEWS NOTES

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

FCC Is Asked for Action: Following the passage of a resolution by TBA asking the FCC for immediate assignment of frequencies scheduled in Alternative No. 1 (*FM* & T, May '45, page 23), and a confirming resolution by FMBI, Arthur Freed, vice president of Freed Radio Corporation, invited the Armstrong FM licensees to meet at the Waldorf Astoria on June 6th for a discussion of the situation. Major Armstrong was invited, but he declined to attend, explaining that he is taking a position only with respect to the technical aspects of the propagation questions.

After a considerable discussion which centered around the problem of postwar security for present civilian radio workers and engineers and radio-trained veterans, and of making FM receivers immediately available to implement the expansion of FM broadcasting to the 1,000 to 3,000 new stations predicted by the FCC, the following resolution was passed and transmitted by wire to the FCC Commissioners:

WHEREAS, the manufacturers of FM radio receivers and transmitters, are engaged in vital public service;

AND WHEREAS, Frequency Modulation has been recognized as a superior method of radio broadcasting;

AND WHEREAS, the manufacturers of FM radio equipment are large employers of labor in the fulfillment of military contracts;

AND WHEREAS, cutbacks in use of personnel, plants and materials for military purposes in the electronics industry are now taking place and will become more rapid, while several months of design and production engineering must follow the definite allocation of channels before civilian production in quantity can use such released labor; regional and individual assignments of frequencies must follow such allocation of frequencies and local construction and employment by individual stations will be further deferred; and, furthermore, the undersigned manufacturers seek to anticipate the need for providing jobs for such factory employees as are released by the lower postwar level of production, and for the employment of radio-trained war veterans who will seek to enter civilian radio set distribution, sales, and service, and the operation of new FM broadcast stations;

AND WHEREAS, in order to assure maximum, continuous employment with minimum dislocation, it is necessary to initiate plans for the manufacture of FM sets and broadcast transmitters without further delay, to anticipate adequately the time when civilian production can be resumed;

AND WHEREAS, the recent action of the FCC in postponing the allocation of frequencies to FM will, in the opinion of the undersigned, representing the pioneer manufacturers of FM radio receivers and broadcast transmitters, have the following results:

1. Because preliminary engineering on FM sets cannot start until the new allocations have been announced, prompt conversion from military to full civilian production will be seriously delayed.

2. If the manufacture of FM sets cannot be started promptly, this will reduce the potential set production by a very substantial percentage. This will be reflected by unemployment resulting from the delay in allocating FM frequencies.

3. Discrimination in favor of manufacturers producing AM (standard broadcast) sets, against the manufacturers of FM sets, inasmuch as AM manufacturers can place orders for components now, thus tying up future deliveries of components for FM sets.

4. The experience of the pioneer FM manufacturers who built FM equipment before the war, and have been building FM equipment for military use during the war, indicates that nothing will be gained by delay for further propagation tests, and furthermore, that the alternative allocation No. 1 will best serve public interest, convenience, and necessity.

5. The nationwide introduction of FM will be seriously delayed, if new sets offered after the war are for AM only, and will have a prejudicial effect on the expansion of FM broadcasting.

6. If the FCC alternative allocation No. 1 is adopted immediately, it will facilitate the design planning of postwar FM sets, and make it possible for all those employed in the radio industry to continue their efforts on military production with the assurance that the hardships of reconversion have been reduced to a minimum. The proposed delay, possibly complicated by the allocation of higher frequencies, will unduly prolong the period of preparation for the manufacture of FM receivers and transmitters. Now, therefore

BE IT RESOLVED, that the undersigned pioneer FM radio manufacturers endorse the recommendation of the Frequency Modulation Broadcasters, Inc. and Television Broadcasters Association, and strongly urge that the FCC adopt at once the alternative allocation plan No. 1 as proposed by the Commission.

SIGNED:

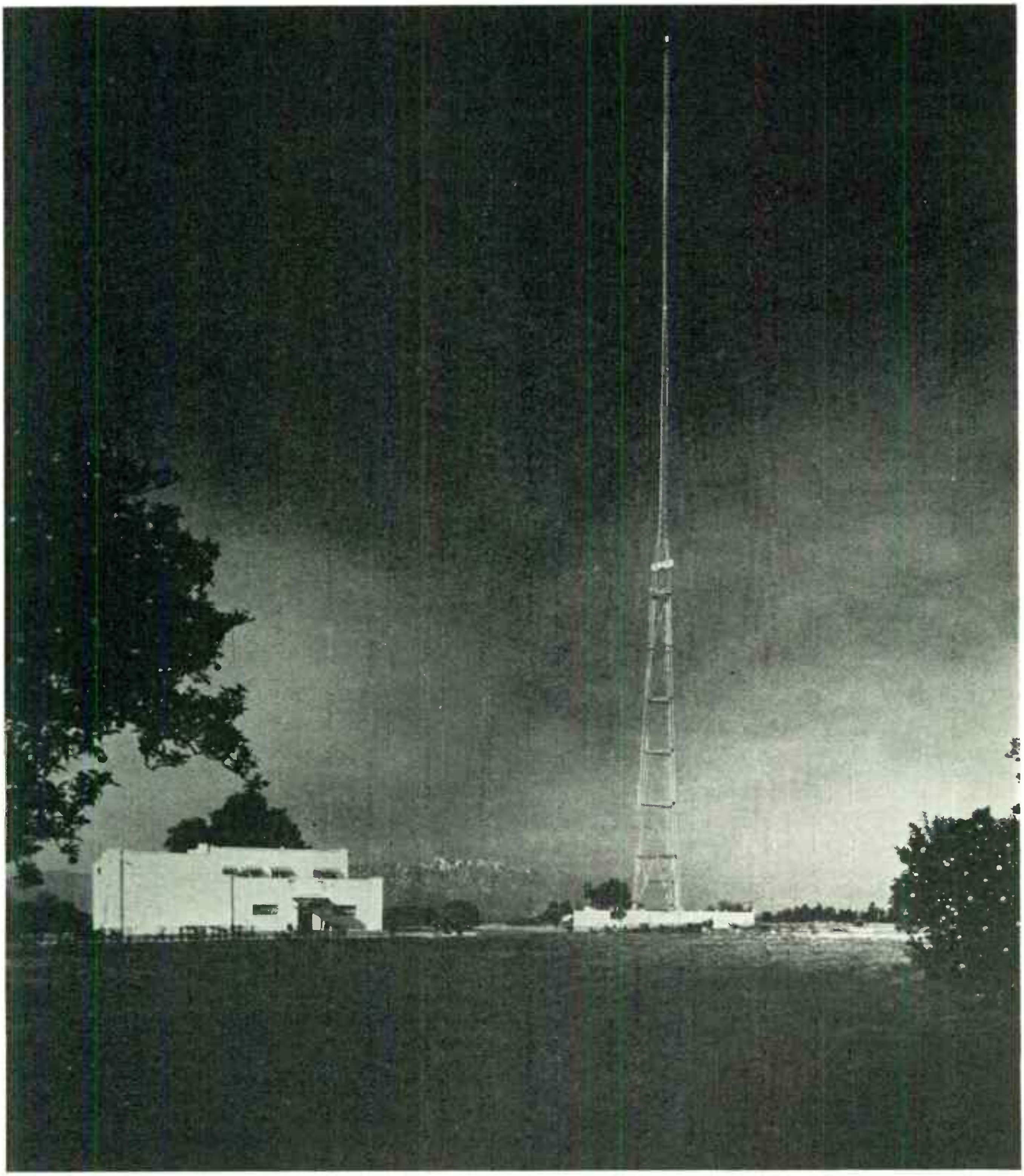
Ansley Radio Corp., Long Island City, N. Y.
Espey Manufacturing Co., Inc., New York.
Freed Radio Corporation, New York City.
Garod Radio Corporation, Brooklyn, N. Y.
General Electric Company, Schenectady.
Meissner Manufacturing Co., Mt. Carmel, Ill.
Pilot Radio Corp., Long Island City, N. Y.
Radio Engineering Labs., Inc., L. I. City, N. Y.
Scott Radio Labs., Inc., Chicago, Ill.
Stromberg-Carlson Co., Rochester, N. Y.
Zenith Radio Corporation, Chicago, Ill.

ARTHUR FREED, Freed Radio Corporation
Conference Chairman

Kilgore Committee: Has issued a 400-page monograph entitled "Wartime Technological Developments," based on a study by the Labor Department's Bureau of Labor Statistics. Concerning postwar FM and television, the report states that receiver prices "may be higher than those of comparable prewar models." As to FM broadcasting: "It is freely predicted that, except for a few clear channels and other AM stations serving primarily rural areas, FM will replace AM broadcasting within a decade after the war." Such a prediction should be qualified by the explanation that AM may, in some instances, provide superior rural coverage over flat terrain, but FM rural coverage has proved far superior where there is high ground on which the transmitter can be located. Copies of this report can be obtained from the Senate Subcommittee on War Mobilization, Senate Office Building, Washington, D. C.

Contract Cutbacks: Have already necessitated release of employees by several large radio manufacturers. Melvin E. Kearns, assistant director of WPB Radio & Radar Division, has issued an estimate for military production requirements of $220,000,000 per month for the next four months, adding: "Beyond that, the outlook is uncertain." However, this estimate does not indicate the true condition which the industry faces in the immediate future because it does not take into account the 4-billion-dollar cutback in aircraft production, in which radio and radar equipment is a substantial item. In addition, the Signal Corps is making sharp cutbacks in its radio contracts. When the revised

(CONTINUED ON PAGE 85)



NEWS PICTURE

STATION KPRO, Blue affiliate located at Riverside, California, in one of the richest west coast markets, plans to erect a television transmitter on 9,100-ft. snow-topped Cucamonga Peak (see background). To AM station illustrated will be added an auditorium seating 500, and an outside garden studio built around a swimming pool. General Electric 4-kw. video and 1-kw. aural transmitters are planned for service to the great farming communities of Southern California. Intention is to step the transmitters up to 40-kw. and 10-kw. respectively, later on. Owners have a distributing organization to handle and develop receiver sales. Special service programs will feature farm experiments, garden growing, and nursery demonstrations. Call letters KARO have been reserved for the time when construction is authorized.

FM BROADCASTING & COMMUNICATIONS HANDBOOK

Chapter 5: Continuation of FM Transmitter Circuits: Discussion of Armstrong Modulator

BY RENÉ T. HEMMES

IN THE preceding chapter, the generation of FM signals by the use of reactance-tube modulators was discussed. It was noted that the reactance-modulated oscillator cannot be crystal-controlled because, during modulation, the reactance variation must cause the oscillator frequency to swing over a considerable range. Lacking crystal control or other means for frequency stabilization, the average or center frequency generated by the oscillator is subject to drift which may extend beyond the frequency stability limits established by the FCC.

The drift can be minimized by the use of frequency stabilization circuits in which the center frequency of the transmitter output, or a subharmonic thereof, is compared to the frequency of a reference crystal oscillator. When the center frequency drifts away from the assigned value, the stabilization circuits exert corrective measures upon the reactance-tube modulator, or upon the modulated oscillator, to bring the center frequency back to the correct value.

At best, however, such circuit arrangements represent an indirect solution to the problem of maintaining the frequency stability, because the center frequency component is compared with the reference *following its generation.*

The direct solution lies in having the center frequency component of the signal under crystal control *during its generation.* With the stability of the center frequency established at the source, auxiliary frequency stabilization circuits, together with their potential troubles, are eliminated from the transmitter.

The Armstrong phase-shift modulator circuit provides a direct solution to the problem of maintaining the frequency stability of an FM transmitter. The center frequency component of the FM wave is generated by an oscillator that is crystal-controlled and therefore of very high frequency stability. Thereafter, the sideband components, which are generated in a modulator that is excited by the same oscillator, are combined in such phase with the center frequency component as to produce a voltage having a slight degree of frequency modulation. The frequency-modulated voltage is then passed through a multiplication system which increases the center frequency and the slight frequency deviation by such factors as will give the desired transmitter output frequency and frequency deviation. Finally, the voltage is used to excite a series of power amplifier stages to raise the power to the required level for the transmitter output.

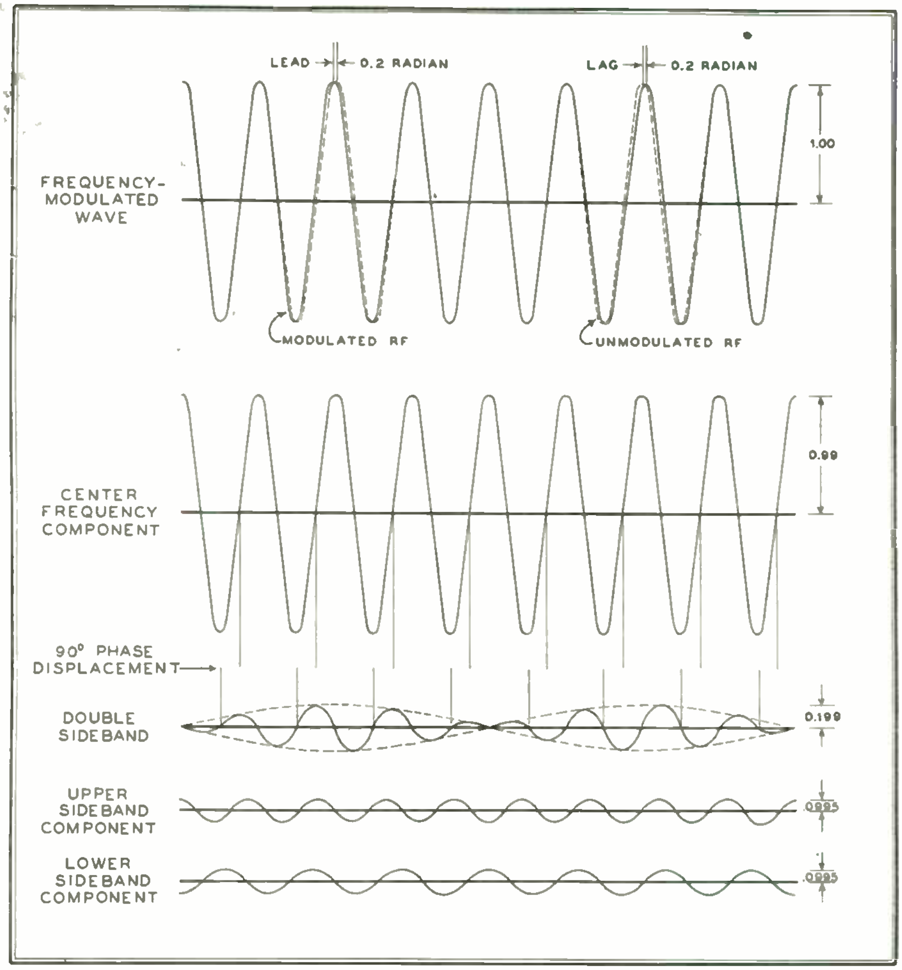


FIG. 40. COMPONENTS OF FM WAVE HAVING AMPLITUDE OF 1.00 AND MODULATION INDEX OF 0.2. NOTE 90° PHASE DISPLACEMENT OF DOUBLE SIDEBAND

To present a clear picture of the operation of the Armstrong phase-shift modulation system, the creation of the frequency-modulated wave will be described graphically and with reference to the original simple form of the Armstrong modulator. Thereafter, the features of the new and improved Armstrong modulator circuit will be explained.

Slightly Modulated AM and FM Waves ★ Before considering the method by which FM waves are produced by the Armstrong modulator, it is well to review the points of similarity and difference of slightly modulated AM and FM waves.

In Chapter 1, AM and FM waves were analyzed and shown to be comprised of components at the carrier frequency and at sideband frequencies. The amplitudes of these components were found to depend upon the amplitude of the modulated wave and upon the degree of modulation.

It was noted that with modulation at a single modulating frequency, the AM wave has only one pair of sideband components, regardless of the degree of modulation, up to 100%. The FM wave, on the other hand, can have a large number of sideband components, depending upon the modulation index. However, when the modulation index is less than 0.2, that is, with very slight frequency modulation, only one pair of sidebands has sufficient amplitude to be significant, and the amplitudes of these sidebands are proportional to the modulation index.

It was further pointed out, in Chapter 1, that the center frequency and sideband components of a slightly modulated FM wave can be the same *in amplitude and in frequency* as the components of a partially modulated AM wave. It was stated, however, that this does not mean that the two waves are identical. In the case of the FM wave, the sideband components are differently phased with respect to the carrier, so that when they are added to the carrier, a wave of constant amplitude and varying frequency is produced, rather than a wave of varying amplitude and constant frequency.

Figs. 40 and 41 offer specific examples of the condition mentioned above. At the top of Fig. 40 is shown the wave form of an FM current having an amplitude of 1 ampere and a modulation index of 0.2. At the top of Fig. 41 is shown the form of an AM current having an average amplitude of 0.99 ampere and a modulation percentage of 20.1.

When these waves are analyzed by the methods given in Chapter 1, it is found that *both* waves have 1) a carrier frequency component with an amplitude of 0.99 ampere, 2) a lower sideband component, at carrier frequency minus modulating frequency, with an amplitude of .0995 ampere, and 3) an upper sideband component, at carrier frequency plus modulating frequency, also having an amplitude of .0995 ampere.

In Figs. 40 and 41 the carrier frequency components are shown immediately below the modulated waves. When the carrier frequency component is subtracted from the modulated wave, the remainder is the sum of the two sideband components, called the double sideband. The double sidebands are shown beneath the carrier frequency components in Figs. 40 and 41.

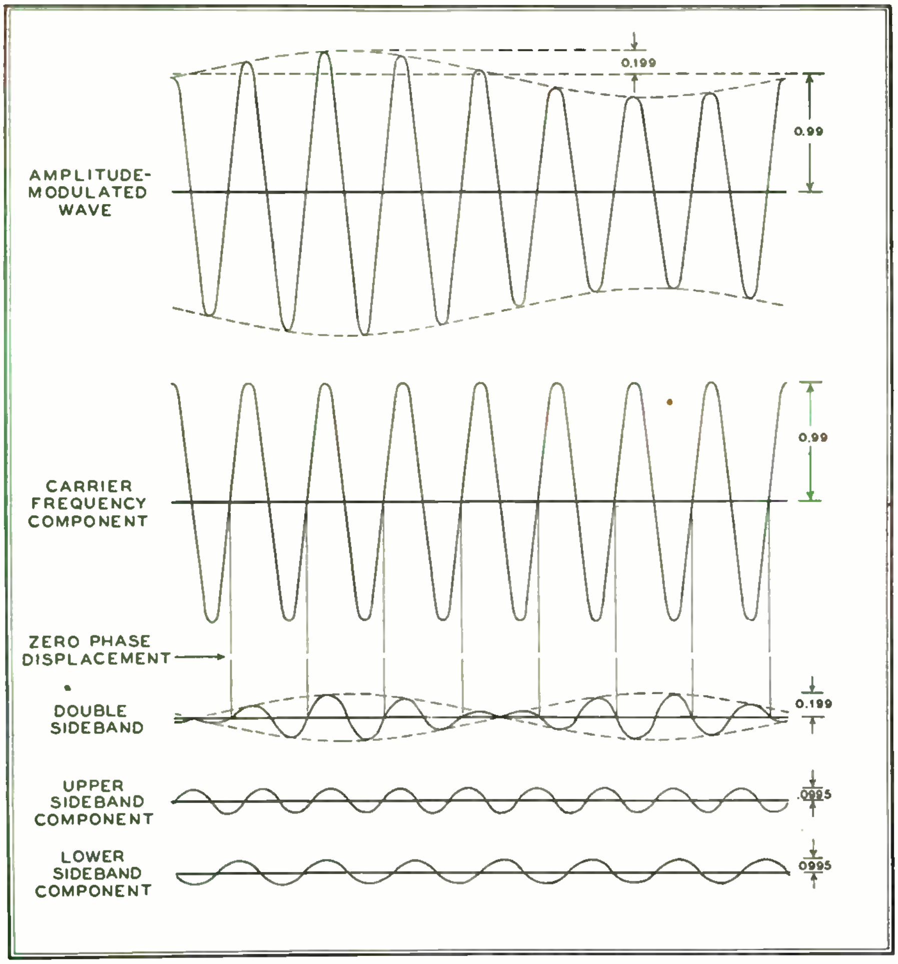


FIG. 41. AM WAVE HAVING SAME COMPONENTS AS FM WAVE IN FIG. 40. NOTE, HOWEVER, THE ZERO PHASE DISPLACEMENT OF DOUBLE SIDEBAND

In spite of the fact that the amplitudes and the frequencies of the components of the wave in Fig. 40 are the same as the respective components of the wave in Fig. 41, it is found that the sum of these components produces a frequency-modulated wave in Fig. 40 and an amplitude-modulated wave in Fig. 41. Why?

The answer lies in the phase relationship of the sidebands with respect to the carrier. It will be observed that in the case of the amplitude-modulated wave, Fig. 41, the intercepts of the double sideband wave with the time axis occur simultaneously with the intercepts of the carrier frequency component. On the other hand, in the case of Fig. 40, the intercepts of the double sideband occur at instants differing by one-quarter cycle from the instants of the intercepts of the carrier frequency component. In the case of Fig. 41 the summation of the components gives an amplitude-modulated wave. In Fig. 40 the summation of the *same* components, *but with the sidebands shifted 90° along the time axis,* gives a frequency-modulated wave.

Principle of Armstrong Modulator ★ The scheme of operation of the Armstrong modulator can be understood by reference to Figs. 40, 41. The double sideband current of Fig. 41 is created in a special type of AM modulator, excited at the carrier frequency but employing a circuit which suppresses the carrier frequency component in the modulator output. The double sideband is then displaced along the time axis, to the extent of one-quarter cycle, by a 90° phase-shift device. The phase relationship between the carrier frequency and the double sideband then becomes that shown in Fig. 40. If the double sideband component and carrier component are now combined in the proportions of amplitude shown in Fig. 40, the frequency-modulated wave at the top of Fig. 40 is produced.

Excellent frequency stability of the carrier component is assured by the use of a crystal-controlled oscillator for generating the original carrier frequency component.

Of course, only a slight degree of frequency modulation is obtainable, because only one pair of sidebands is added to the carrier. However, if the carrier frequency is made low, so that a sufficient number of frequency multiplying stages are employed in raising the frequency to the assigned transmitting frequency, the frequency deviation is increased by the same factor as the frequency is increased in each multiplier stage. Thus a large frequency deviation can be obtained from a frequency-modulated wave whose initial frequency deviation is quite small.

Original Armstrong Phase-Shift Modulator ★ A block diagram of original arrangement of the Armstrong modulator is shown in Fig. 42. The elements involved in the creation of waves having a slight frequency modulation at a given modulating frequency are enclosed within the dotted line. The circuit diagram for these elements is shown in Fig. 43.

It will be seen that the output of a

crystal-controlled oscillator at a frequency in the order of 200 kc. is applied simultaneously to the carrier frequency amplifier stage and to both grids of the balanced modulator.

The balanced modulator serves to produce the double sideband illustrated in Fig. 41. The grids of the modulator tubes in Fig. 43 are connected in parallel to the oscillator, but the plates are connected in pushpull to the load circuit $C_1L_1L_2C_2$. The condensers C_1 and C_2 serve to neutralize the reactances of L_1 and L_2, giving a purely resistive path for the RF components of the modulator plate current. This brings the RF components of the plate currents into phase with the common grid voltage, and hence into phase with each other.

The voltages appearing across the two halves of the secondaries of the transformer are inserted in opposite polarity in the screen grid returns of the two tubes. Thus during the first alternation of the audio modulating voltage, one screen is rendered *more* positive by the voltage across one half of the transformer secondary, while the other screen is rendered *less* positive by an equal voltage across the other half of the secondary.

This creates an unbalance such that the net RF field sweeping the coil L has a polarity determined by the predominant RF component of plate current, and a strength dependent upon the degree of inequality of the RF components of the plate currents of the two modulator tubes.

During the second alternation of the modulating voltage, the unbalance is shifted in the opposite direction, and the net RF field sweeping coil L is reversed in polarity.

In this way the net RF field sweeping coil L changes polarity as the audio modulating voltage changes its polarity, and the strength of the net RF field varies as the instantaneous value of the audio modulating voltage. Hence the balanced modulator produces a field about L_1L_2 that has the wave form of the double sideband illustrated in Fig. 41. Moreover, the field has the same phase relation with respect to the carrier voltage on the modulator grids as that shown for the double sideband with respect to the carrier frequency component in Fig. 41.

The voltage induced in coil L, however, has a phase displacement of 90° with respect to the inducing field. This is inherent in the process of induction. For example, the maximum induced voltage occurs at the instants when the inducing field is changing most rapidly. Similarly, the voltage induced in L is zero at the instant when the inducing field has reached a condition of maximum expansion and is stationary for an instant before contracting. Thus there is a 90° phase displacement between voltage induced in L and the net RF field about L_1L_2. Since L is untuned, no further phase shift occurs before the voltage induced in L is applied to the grid of the sideband amplifier stage. In view of the 90° phase shift of the modulator output, the phase relationship of the RF components of plate current of the sideband amplifier and the carrier frequency amplifier, Fig. 43, will be that shown for the double sideband and center frequency components, Fig. 40. If the amplitudes of the RF currents are also in the proportion shown in Fig. 40, then when the currents are drawn through a common load resistor R_L, the voltage wave across R_L will have a slight frequency modulation as shown at the top of Fig. 40.

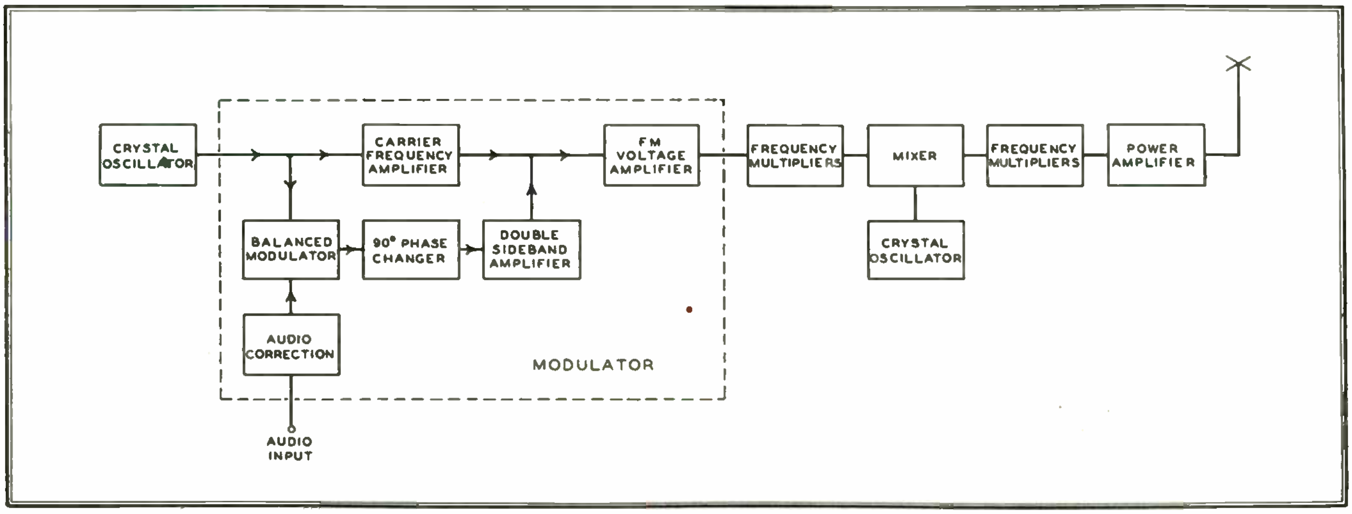


FIG. 42. A BLOCK DIAGRAM OF THE ORIGINAL ARMSTRONG PHASE-SHIFT MODULATOR CIRCUIT

Since the RF components of the plate currents flow toward the common junction of L_1 and L_2 from opposite ends of $C_1L_1L_2C_2$, it follows that when the tubes are well matched and operating with equal voltages on the tube electrodes, the RF voltage induced in coil L, equally coupled to L_1 and L_2, will be zero, because the effects of the field created about L_2 are cancelled by the effects of the field created about L_1.

However, if the tubes are not well matched, or if the voltages applied to the tubes are not equal, then the RF component of the plate current of one tube will be greater than that of the other tube. The *net* RF field set up around L_1L_2, which sweeps coil L, will then have a polarity dependent upon which tube has the larger RF component of plate current. The strength of the net RF field will vary as the degree of unbalance between the two tubes.

In the modulator of Fig. 43, the tubes are deliberately unbalanced during modulation by applying the audio modulating voltage at the primary of transformer T_1.

Comparison of the frequency-modulated wave in Fig. 40 with the dotted curve of an unmodulated wave of the same average frequency shows that the effect of adding the double sideband component (after 90° displacement along the time axis) to the carrier component is to create a wave that is alternately advanced and retarded in phase with respect to the carrier. Hence the circuit of Fig. 43 is called the Armstrong *phase-shift* modulator.

The greater the ratio of the amplitude of the double sideband component to the amplitude of the carrier component, the greater the phase deviation of the wave created by combining the two components. However, if the amplitude of the double sideband is made greater than about one-fifth of the amplitude of the carrier, so that the phase deviation is greater than about 0.2 radian, then two undesirable effects will become evident. 1) The wave will have appreciable amplitude variation as well as frequency variation, and 2) the phase deviation will no longer be proportional to the amplitude of the double sideband, as determined by the amplitude of the modulating voltage.

Thus only a slightly modulated FM wave should be produced in the phase-shift modulator. As long as the amplitude of the double sideband is less than one-fifth of the carrier amplitude, making the modulation index less than 0.2 and the phase deviation less than 0.2 radian, then the phase deviation will be proportional to the amplitude of the audio modulating voltage, and an essentially distortionless modulated wave will be produced.

Alternate Circuit Arrangements ★ There are a number of alternate arrangements of the Armstrong phase-shift modulator, all operating on the same principle of combining the double sideband with the carrier frequency component in *phase quadrature*, that is, after displacement by 90° along the time axis. For example, the *grids* of the balanced modulator tubes may be excited by voltages 180° out of phase with each other, while the *plates* are connected in parallel to a common load. The same suppressed-carrier double sideband output will be obtained. Another arrangement commonly employed is to insert the 90° phase-shift in the excitation of the modulator rather than at its output. Various other devices can be used for obtaining the 90° phase-shift.

A simple alternate arrangement of the Armstrong modulator is shown in Fig. 44. Here the oscillator output is applied to three voltage dividers in parallel. The first of the dividers is purely resistive throughout and the portion of the oscillator voltage tapped off the divider is applied without shift of phase to the carrier frequency amplifier tube. The RF current passed through the plate load resistor R_L by this tube is therefore in phase with the oscillator voltage.

The second of the voltage dividers consists of an RC network in which the resistance of R very greatly exceeds the reactance of C at the oscillator frequency. The current in this branch therefore is practically in phase with the oscillator voltage applied to it but the small voltage across C *lags* the current by 90°. Hence it also lags the oscillator voltage by 90°. The voltage across C is used to excite one of the modulator tubes.

The third of the voltage dividers consists of an RL network in which the resistance of R very greatly exceeds the reactance of L. Again, the current in the network is practically in phase with the applied voltage from the oscillator but the voltage taken from L for excitation of the modulator tube *leads* the current and the oscillator voltage by practically 90°.

Thus the grids of the balanced modulator are excited by voltages which respectively lag and lead the oscillator voltages by 90°, and are therefore 180° out of phase with each other. In effect, the grids of the modulator tubes are excited in pushpull, while the plates are connected in parallel. If the tubes are balanced, the RF components of the plate currents are equal and opposite at every instant. Under a condition of balance, no RF current flows in the common lead of the two modulator tubes to the load resistor R_L, and the only RF voltage appearing across R_L is that created by the flow of the carrier frequency amplifier RF plate current.

On the other hand, if the modulator tubes are alternately unbalanced in one direction and then in the other by an audio voltage applied in pushpull to their screen grids, the flow of RF current is alternately favored in one tube and then in the other. The net RF current in the common lead from the plates of the modulator tubes to the load resistor R_L will no longer be zero. The net current will have a polarity dependent upon which of the modulator tubes has the predominant RF component of plate current, as determined by the polarity of the audio voltage. The net current will have an amplitude dependent upon the degree of unbalance existing between the tubes, as determined by the amplitude of the audio voltage. Thus the wave form of the net RF current of the two modulator tubes will be that of the double sideband illustrated in Fig. 40. In view of the 90° phase shift introduced in the excitation, the relation of the double sideband current in R_L to the carrier current in R_L will also be that shown in Fig. 40. If the peak amplitude of the double sideband is one-fifth of the amplitude of the carrier, the voltage drop across resistor R_L will have the wave form of the frequency-modulated wave shown at the top of Fig. 40.

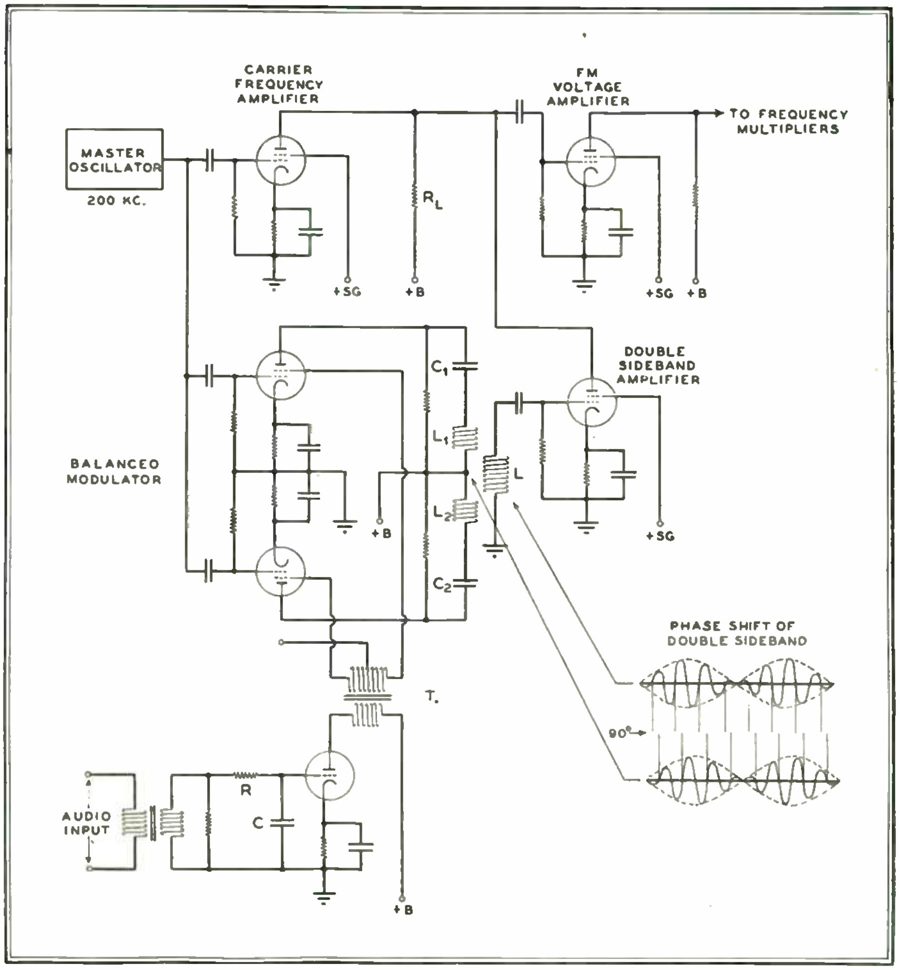


FIG. 43. CIRCUIT FOR PRODUCING SLIGHTLY MODULATED FM WAVES

Audio Frequency Correction ★ In the preceding discussion, a single fixed modulating frequency has been assumed. During the transmission of speech and music, however, the modulating frequency is varied, and components at several frequencies are often present at the same time. What effect will a change in modulating frequency have upon the wave produced in the circuits of Figs. 43 and 44?

It is noted in Fig. 40 that there are two instants of peak phase deviation for each cycle of the modulating frequency. In other words, during each cycle of the modulating frequency, the FM wave alternately acquires a maximum amount of lead and then a maximum amount of lag with respect to an unmodulated carrier of the same average frequency. The amount of the maximum lead or lag that is acquired depends upon the ratio of the peak amplitude of the double sideband to the amplitude of the carrier component, and does age, which determines *how many times per second* the output wave alternately acquires the lead and lag.

In Chapter 4, however, it was stated that the FM wave must have a frequency deviation that is proportional to the amplitude of the modulating voltage but independent of its *frequency*.

To meet this specification for the transmitter output, it is necessary to counteract the characteristic of the modulator circuit whereby an audio modulating voltage of a given amplitude having a high frequency

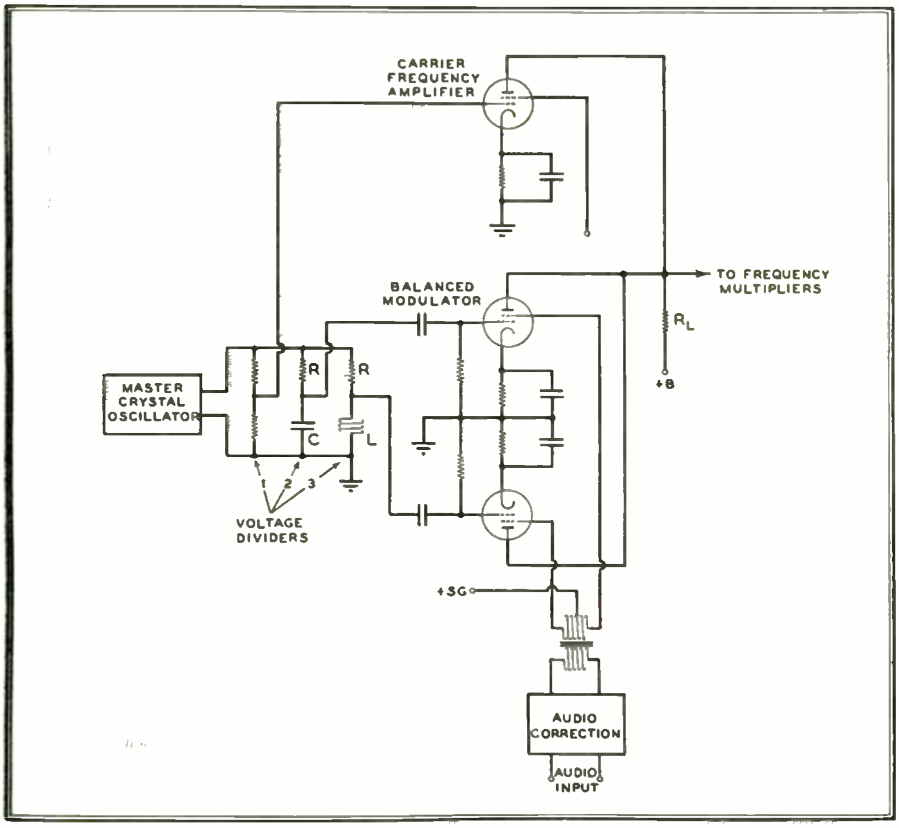


FIG. 44. AN ALTERNATE FORM OF THE ARMSTRONG MODULATOR

not depend on the modulating frequency.

When the frequency of the audio voltage at the modulator is increased without changing the amplitude, more cycles of the modulating voltage occur within any given time period, and the time interval between the successive instants of maximum lead and lag is reduced. This causes the time periods of the cycles of the FM wave to change by a greater amount from one cycle to the next so that the same maximum amount of lead or lag is produced in the shorter time interval.

Hence the modulator circuits of Figs. 43 and 44 have the characteristic of giving a frequency deviation that is proportional to 1) the amplitude of the modulating voltage applied to the screen grids of the modulator which determines the *maximum* amount of lead and lag acquired, and 2) the frequency of the modulating voltage, would cause a greater frequency deviation than an audio modulating voltage of the same amplitude having a lower frequency.

The problem is handled quite easily by inserting an audio frequency correction network in the audio channel before the audio voltage is applied to the screen grids of the balanced modulator.

The circuit of a typical correction network is shown at the lower left of Fig. 43. In this case, a series RC network is connected across the loaded secondary of an audio transformer. The resistance of R is quite high compared to the reactance of C so that, for any given *amplitude* of the applied voltage, practically the same current flows in the RC network regardless of the *frequency* of the applied voltage. Since the reactance of C varies inversely as the frequency, the voltage taken from C for excitation of the correction amplifier tube is practically inversely proportional to the frequency.

By rendering the amplitude of the modulating voltage inversely proportional to its frequency before applying the voltage to the screen grids of the balanced modulator, the characteristic of the modulator, by which a greater frequency deviation is produced at higher modulating frequencies is *discounted in advance.*

Thus, the maximum frequency deviation of the output wave is made proportional to the *amplitude* of the audio modulating voltage before correction, but independent of the *frequency* of the modulating voltage. The audio frequency correction network is an essential element of the phase-shift modulator designed to produce FM waves that are modulated over a range of audio frequencies.

Frequency Deviation Multiplication ★ In order to obtain distortionless modulation from the phase-shift modulator, it has been stated that the maximum phase deviation of the FM voltage at the output should not exceed 0.2 radian. In other words, the modulation index of the FM voltage across R_L in Figs. 43 and 44 should not exceed 0.2.

A maximum modulation index of 0.2 for a transmitted FM wave would, of course, be quite insufficient to permit realization of the noise and interference reduction characteristics of the FM system. However, the modulation index of an FM signal can be increased, after generation and before transmission, by passing the signal through a series of frequency multipliers. Each multiplier stage increases the frequency deviation and the modulation index of the signal by the same factor as the center frequency is increased.

How much frequency multiplication will be required to obtain a frequency deviation at the transmitter output sufficient to realize the benefits of the FM system?

The accepted ratio of the maximum frequency deviation of the transmitter output wave to the highest modulating frequency is 5 to 1. For example, in FM broadcast service, the maximum frequency deviation is 75 kc. for a highest modulating frequency of 15 kc., equivalent to a modulation index of 75/15 or 5, and a maximum phase deviation of 5 radians.

However, the largest modulation index and phase deviation of the transmitted wave occur with full modulation at the *lowest* modulating frequency. For example, if the lowest audio frequency in the FM broadcast service is taken as 50 cycles, then with a deviation of 75 kc. at full modulation, the modulation index becomes 75,000/50 or 1,500, equivalent to a phase deviation of 1,500 radians.

Hence, in FM broadcast service, where the range of modulating frequencies is 50 to 15,000 cycles and the maximum frequency deviation is 75,000 cycles, the transmitter should incorporate sufficient multiplication to raise a maximum phase deviation of 0.2 radian at the output of the phase-shift modulator to 1,500 radians at the transmitter output. This calls for a multiplication of at least 1500/.2 or 7,500.

If doubler stages are used throughout the multiplication system, 13 stages are necessary, giving an overall multiplication of 2^{13} or 8,192. A combination of 5 doubler and 5 tripler stages can be employed, giving an overall multiplication of $2^5 \times 3^5$ or 7,776.

used to excite the modulator should be in the order of 190 to 200 kc. If a much lower oscillator frequency were employed, such as 50 kc., the sideband frequencies would differ from the carrier by such a large percentage that the modulator circuits would discriminate somewhat against one sideband or the other, thus causing distortion. In fact, sideband correction networks were required in some of the earlier modulators operating at frequencies considerably less than 200 kc., in order to overcome this effect.

If the oscillator frequency is taken at about 200 kc., and if straight frequency multiplication of at least 7,500 is employed to hold the phase deviation of the put, however, is just as great as that of the multiplied frequency fed to the mixer.

Thus, by the use of the mixer stage and crystal-controlled oscillator, it becomes possible to multiply the frequency deviation by more than 7,500 times, while multiplying the center frequency by a factor in the order of 200 or 250.

The frequency of the crystal-controlled oscillator is made such as to yield a beat frequency at the output of the mixer stage that can be multiplied to give the exact assigned carrier frequency.

For example, if the assigned frequency is 42.3 mc., and there is multiplication of 96 times between the output of the mixer and the input of the power amplifier, then

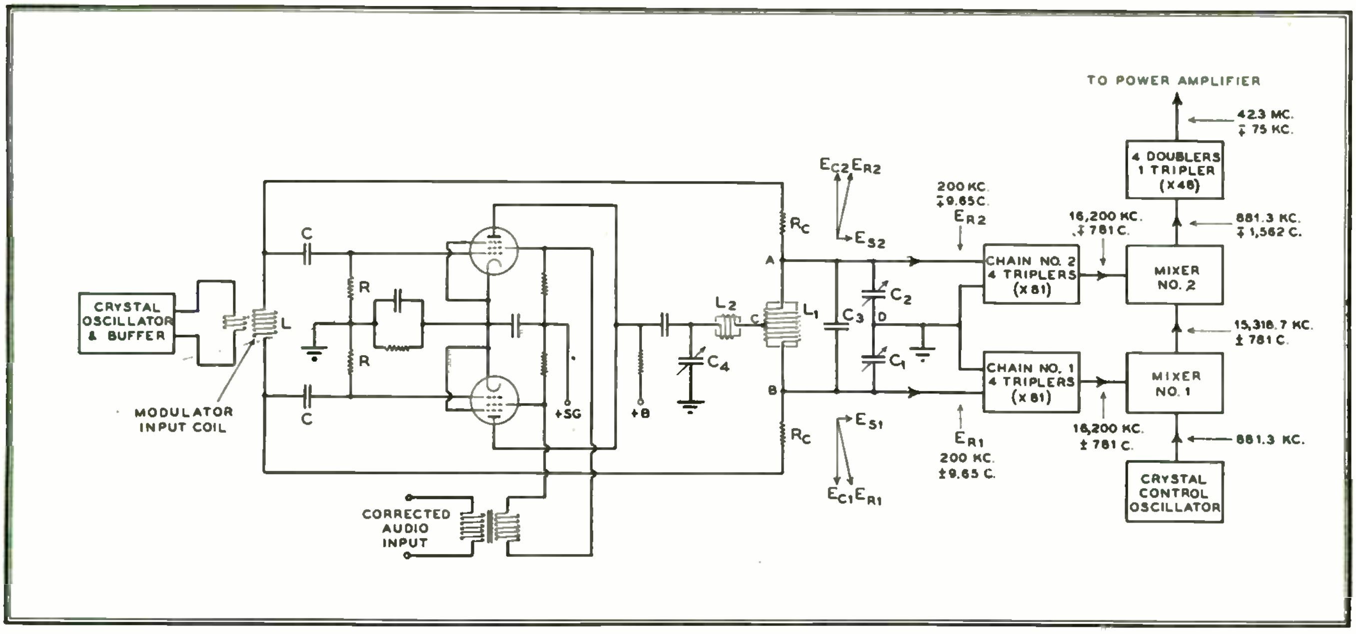


FIG. 45. CIRCUIT OF THE IMPROVED ARMSTRONG PHASE-SHIFT MODULATOR OF THE TYPE USED IN THE LATEST FM BROADCAST TRANSMITTER INSTALLATIONS

In the latter case, for a condition of full modulation at 50 cycles, the phase deviation at the output of the phase-shift modulator is 1,500/7,776 or .193 radian, corresponding to a modulation index of 0.193. At modulating frequencies higher than 50 cycles, the phase deviation at the transmitter output is less than 1,500 radians, making the phase deviation at the output of the phase-shift modulator less than 0.193 radian. Thus at all modulating frequencies in excess of 50 cycles, the phase-shift modulator is operated within the phase deviation limit of 0.2 radian, while at frequencies somewhat lower than 50 cycles, the maximum phase deviation of the modulator is not sufficiently in excess of 0.2 radian to cause serious distortion.

Center Frequency Multiplication ★ Where the highest modulating frequency is 15,000 cycles, as in FM broadcasting, the frequency of the crystal-controlled oscillator modulator within 0.2 radian, then the center frequency after multiplication will be at least 7,500 × 0.2 or 1,500 mc., or far beyond the band of frequencies assigned to FM broadcasting.

It is clear, then, that the center frequency can not be multiplied by as many times as the frequency deviation. Yet each multiplier stage increases the center frequency by the same factor as the frequency deviation.

The problem is easily solved by the use of a converter, or mixer stage, inserted in the chain of frequency multipliers, as shown in Fig. 42. The multiplied frequency at the point of insertion is applied to the mixer, along with a fixed frequency from a crystal-controlled oscillator, differing from the multiplied frequency by a known amount. The center frequency of the mixer output is the difference of the two frequencies at the input, producing a new center frequency of a much lower order. The *frequency deviation* at the mixer out- the frequency at the output of the mixer is 42,300/96 or 440.6 kc. The frequency of the crystal-controlled oscillator must be 440.6 kc. less than the multiplied frequency applied at the mixer input.

If the master oscillator has a frequency of 200 kc., and if this frequency is multiplied 81 times before application to the mixer, then the multiplied frequency at the mixer input is 16,200 kc. To obtain a frequency at the mixer output of 440.6 kc., the frequency of the crystal-controlled oscillator should then be 16,200 — 440.6 or 15,759.4 kc.

While the frequency of the crystal-controlled oscillator used with the mixer is chosen with the thought of obtaining a particular output frequency from the transmitter, it must not be assumed that the frequency stability of the transmitter, Fig. 42, is determined by the second oscillator alone. As a matter of fact, the stability depends on the frequency stability of both oscillators.

The stability of the transmitter arrangement illustrated in Fig. 42 is less, theoretically, than if the frequency were determined by a single crystal-controlled oscillator. In practice, the output frequency drift with both oscillators under crystal control is a small fraction of that allowed under FCC regulations. Furthermore, a new Armstrong modulator circuit has been designed, in which the frequency stability is determined entirely by the crystal-controlled oscillator at the mixer.

Improved Armstrong Phase-Shift Modulator ★ The circuit of the improved Armstrong phase-shift modulator, employed in broadcast transmitters, is shown in Fig. 45.

The output of a crystal-controlled oscillator operating at a frequency in the order of 200 kc., is passed through a buffer amplifier whose tuned output circuit is inductively coupled to the input coil L of a balanced modulator.

The voltage appearing across the modulator input coil L is applied to the 90° phase-shift network CRRC. At the applied frequency, about 200 kc., the reactances of CC very greatly exceed the resistances of RR, so that the current in CRRC leads the applied voltage from coil L by practically 90°.

The voltage drops across the resistors RR are therefore practically 90° out of phase with the voltage across the input coil L. The common cathode lead from the modulator tubes is connected to the common junction of RR, while the grids of the tubes are connected to the extremities of RR. Thus the grids are excited in opposite polarity by voltages across RR that have been shifted 90° along the time axis with respect to the voltage across the input coil L.

The modulator operates on the same principle as the modulator shown in Fig. 44, the carrier component being balanced out because the plates are connected in parallel while the grids are excited in push-pull. The net RF current drawn by the modulator plates has an amplitude proportional to the amplitude of the audio modulating voltage and a polarity dependent on the polarity of the modulating voltage. The current drawn through the load by the modulating tubes has the wave form of the double sideband in Fig. 40. The phase relation of this current to the voltage across the input coil L is the same as that shown between the double sideband and the carrier component in Fig. 40.

The manner in which the double sideband current and the carrier current are combined in the improved modulator, Fig. 45, differs from that employed in the circuits of Figs. 43 and 44. It will be observed that no carrier frequency amplifier tube is employed in the new circuit. The center frequency voltage at the modulator input coil is led through resistors R_C-$R_{C'}$, around the modulator, and is applied to the opposite terminals A, B of the tuned circuit $L_1C_1C_2C_3$.

With respect to the center frequency voltage applied at points A, B, the tuned circuit $L_1C_1C_2C_3$ is at parallel resonance, so that the current drawn from the input coil L through R_C-$R_{C'}$ is in phase with the input coil voltage. The center frequency voltage appearing across points A,B by virtue of the currents drawn through R_C-$R_{C'}$ is therefore in phase with the voltage at the modulator input coil. By grounding the common junction of condensers C_1 and C_2, *equal center frequency voltages of opposite polarity* are applied to the tripler grids, as shown by vectors E_{C1} and E_{C2} in the small vector diagrams.

by twice the amount of mutual inductance M. Thus, in diagram (B) of Fig. 46, the inductance offered by the coil between terminals A,B is $L_A + L_B + 2M$.

This leads to the three-terminal network of diagram (C), Fig. 46, which is the equivalent of the coil in diagrams (A) and (B). The equivalence can be easily checked by adding the inductances between each pair of terminals.

Between terminals A,C, the inductance is $L_A + M - M$ or simply L_A, the self-inductance of the turns in the upper section. Between terminals C,B, the inductance is $-M + L_B + M$ or simply L_B, the self-inductance of the turns in the lower section. Finally, between terminals A,B, the inductance is $L_A + M + L_B + M$, or $L_A + L_B + 2M$, that is, the sum of the self-inductances increased by twice the

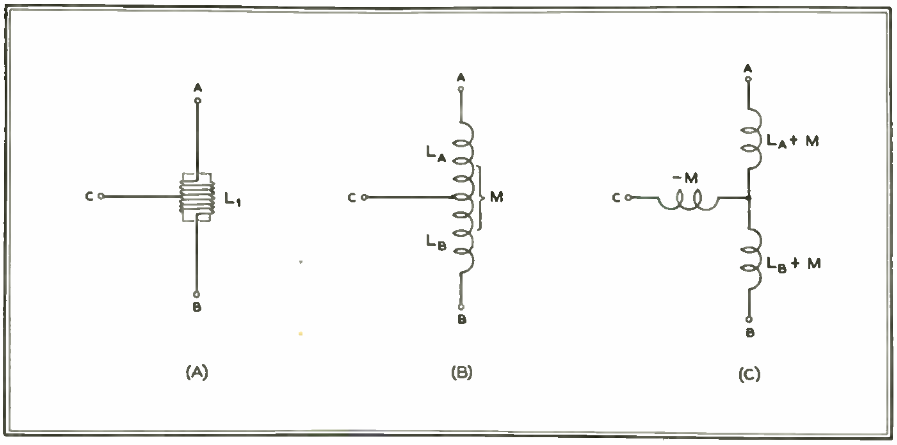


FIG. 46. COIL L_1 OF FIG. 45, AND ITS EQUIVALENT NETWORKS

mutual inductance, or again the value to be expected.

The above condition occurs in the absence of modulation. Actually, of course, during most of the time the transmitter is on the air, audio voltage is applied to the modulator screen grids and a double sideband is created. The manner in which the double sideband is added to the carrier by way of network L_2C_4 will now be explained.

The coil L_1, Fig. 45, has two terminals and a center tap, and can be regarded as a 3-terminal network. This is illustrated in Fig. 46, at (A). Each half of coil L_1 represents inductance in itself. This type of inductance is termed self-inductance, and is the amount of inductance offered by the turns in each half of the coil when the other half is disconnected. The self-inductances are denoted by L_A and L_B in diagram (B) of Fig. 46.

When both sections of the coil are connected in series, the field set up about each section sweeps across the turns of the other section. This effect is called mutual induction, and causes the inductance of the entire coil to be increased. The inductance of the coil becomes the sum of the self-inductances of its sections, increased

Coil L_1 of Fig. 45 can be replaced by the mathematically equivalent network of diagram (C) Fig. 46. This substitution has been made in Fig. 47, in which the circuits to which the output of the balanced modulator is delivered have been redrawn. In Fig. 47, the generator represents the double sideband voltage developed by the modulator. The capacity across L_1 of Fig. 45 has been assumed in Fig. 47 to reside entirely in two series variable condensers C_A and C_B, rather than in the form of a fixed capacity C_3 and two variables, C_1 and C_2, as in Fig. 45. This change has been made to simplify the explanation of circuit operation, since the fixed condenser C_3 of Fig. 45 is employed solely to avoid the use of excessively large variable condensers.

The tuned circuit $L_1C_1C_2C_3$, Fig. 45, is resonant to the center frequency voltage applied at terminals A,B. Thus, in Fig. 47, the total capacitive reactance of C_A and C_B in series is equal to the total inductive reactance of $L_A + M$ in series with $L_B + M$. Because of the circuit symmetry, the inductive reactance of $L_A + M$ equals the capacitive reactance of C_A, and the inductive reactance of $L_B + M$ equals the capacitive reactance of C_B. Therefore, between point E in Fig. 47 and ground, the parallel branches C_A, $L_A + M$ and C_B, $L_B + M$ are series resonant at the center frequency. The only opposition to current flow at the center frequency between point E and ground is the low resistance of the coil sections.

The inductance of coil L_2 is sufficiently in excess of the negative inductance $-M$ between points C and E to cancel $-M$ and to leave a positive remainder of inductance that can be tuned to parallel resonance at the center frequency by means of condenser C_4. In this way, the balanced modulator delivers its output to a resistive load.

The current in the inductive branch, comprised of L_2, $-M$, and the low resistances between point E and ground, lags the voltage applied from the double sideband generator by practically 90°. At point E, the current divides equally between the series resonant paths to ground. The voltages across the condensers C_A and C_B are equal to each other, and both of the voltages lag the branch currents by another 90°. Thus the double sideband voltages appearing across C_A and C_B are equal in magnitude, of the same polarity with respect to ground, with the phase of both voltages differing by 90 + 90 or 180° with respect to the sideband voltage at the balanced modulator output.

Since a 90° phase shift was introduced in the excitation of the balanced modulator which carried over into the modulator output, the subsequent shift of 180 degrees leaves the double sideband voltages appearing across C_A and C_B in phase quadrature with respect to the center frequency voltage appearing across the modulator input coil.

The center frequency voltage is applied in diminished amplitude at points A, B, causing center frequency voltages to appear across C_A and C_B in *opposite* polarity with respect to ground. The double sideband voltages across C_A and C_B are in the *same* polarity with respect to ground. It follows that the phase difference between the carrier and double sideband voltages across one condenser will be in the form of a 90° lead at the same time as the phase difference across the other condenser is in the form of 90° lag.

This is illustrated by the small vector diagrams in Fig. 45. The sideband voltages E_{S1} and E_{S2}, created across condensers C_1 and C_2, are in phase and equal. The center frequency voltages E_{C1} and E_{C2}, across the same condensers, are equal but of opposite polarity, each differing in phase from the sideband voltage by 90°.

The resultant frequency-modulated voltage E_{R1} appearing across C_1 *leads* the center frequency component E_{C1} at the same time as the resultant voltage E_{R2} across C_2 *lags* the carrier component E_{C2}. The resultants are therefore frequency-modulated voltages that are alike except for the fact that the frequency of one voltage is increasing at the same time as the frequency of the other voltage is decreasing.

Readers unfamiliar with vector diagrams will understand the situation by considering what would happen if the center frequency component in Fig. 40 were reversed before being combined with the double sideband. The summation would give a frequency-modulated wave

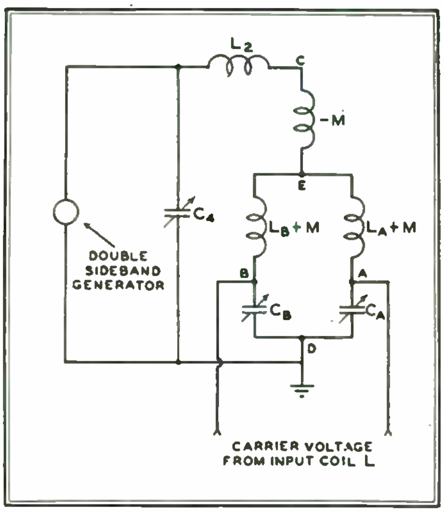


FIG. 47. OUTPUT OF BALANCED MODULATOR REDRAWN FROM FIG. 45

having its maximum lag at the instant when a maximum lead is shown in Fig. 40, and its maximum lead at the instant when the maximum lag is shown.

Thus the frequency-modulated voltage E_{R1} across C_1 is increasing in frequency while the frequency-modulated voltage E_{R2} across C_2 is decreasing in frequency. If the frequency deviation of the voltage is, say, 9.65 cycles, then the frequency-modulated voltage across C_1 can be described as having the frequency 200 kc. ± 9.65 cycles, while that across C_2 can be described as 200 kc. ∓ 9.65 cycles.

Frequency Multiplication System ★ Each of these two output voltages of the modulator, Fig. 45, is passed through its own chain of four triplers, giving a multiplication of both the center frequency and the frequency deviation by a factor of 3^4 or 81.

If the frequency at the input of tripler chain No. 1 is 200 kc. ± 9.65 cycles, then the output of the chain will have a frequency of 16,200 ± 781 cycles. Because of the opposite frequency deviation of its input, tripler chain No. 2 will deliver an output of 16,200 kc. ∓ 781 cycles.

The output of each tripler chain is applied to a mixer stage. Tripler chain No. 1 delivers a frequency of 16,200 ± 781 cycles to mixer No. 1. This mixer also receives a voltage from the crystal-controlled control oscillator, which has a frequency equal to the assigned carrier frequency of the transmitter divided by the overall frequency multiplication that follows the mixer stages. In the transmitter shown in Fig. 45, four doublers and a tripler follow the mixers, giving an overall frequency multiplication of $2^4 \times 3$ or 48. If the carrier frequency assigned to the transmitter is, say, 42.3 mc., then the frequency of the control oscillator is 42,300/48 or 881.3 kc.

With the control oscillator frequency of 881.3 kc. applied to mixer No. 1 together with the output of tripler chain No. 1 at 16,200 kc. ± 781 cycles, the difference frequency appearing in the output of mixer No. 1 is 15,318.7 kc. ± 781 cycles. This frequency is applied to mixer No. 2 along with the output of the tripler chain No. 2 at 16,200 kc. ∓ 781 cycles. The difference of the center frequencies is 16,200 − 15,318.7 or 881.3 kc. The difference of the frequency deviations, which at any time are of opposite sign, is twice the deviation of each frequency, or $2 \times 781 = 1{,}562$ cycles.

The frequency at the output of mixer No. 2 may therefore be described as 881.3 kc. ∓ 1,562 cycles. After passing through four doublers and a tripler, in which multiplication of 48 is obtained, the frequency becomes 42.3 mc. ∓ 75 kc., which is suitable for excitation of the power amplifier of the FM broadcast transmitter.

Advantages of the Improved Modulator ★ The most notable differences between the improved modulator and the earlier types arise from the use of two chains of triplers excited by the voltages from the phase-shift modulator.

When the outputs of the chains of triplers are combined with the output of a crystal-control oscillator in the two mixers, as described above, the center frequency of the output of mixer No. 2 is the same as that of the control oscillator, regardless of any small variations in the frequency of the oscillator used to excite the modulator.

Suppose, for example, that the frequency of the oscillator which excites the modulator drifts from 200 to 201 kc., that is, to a frequency 1 kc. too high. The center frequencies of the voltages at the inputs of the tripler chains will also be 1 kc. high, while at the output of the triplers, the voltages will be 81 kc. high. The output of mixer No. 1 will have a center frequency that is 81 kc. high, but the frequency at the output of mixer No. 2 will not contain the 81 kc. error, because it is the difference between two frequencies, *each of which* is 81 kc. high.

The frequency stability of the output frequency of the transmitter is therefore dependent on the stability of the control oscillator alone, and is independent of the first oscillator, used to excite the modulator. It is not imperative that the first oscillator be crystal controlled, although a crystal is usually employed as a matter of convenience, since it insures that the tripler chains will not be detuned by a large drift in the oscillator frequency.

Just as the effects of drift, or *slow* variation in the frequency of the oscillator used to excite the modulator, is balanced out, so also *rapid* variations are balanced out. Thus the improved modulator tends to overcome any slight noise or hum modulation that occurs in the first oscillator. Although earlier types of Armstrong modulators were remarkably free from hum and noise as compared to other modulators, the noise level in the new Armstrong modulator is still lower, being in the order of −70 db.

The incorporation of sufficient multiplication to give frequency deviation equivalent to full modulation, while requiring a phase deviation of not more than 0.2 radian at the output of the phase-shift modulator at the lowest audio frequency, obviates the possibility of distortion in the modulator.

For a modulation index of 0.2, the distortion inherent in the modulator is about 1%. This distortion occurs only with full modulation at the lowest audio frequency. At higher audio frequencies, and/or with less than full modulation, the modulation index is less than 0.2 and the inherent distortion disappears.

Pre-emphasis Network ★ It has been stated that the frequency deviation of the modulated wave should be proportional to the amplitude of the modulating voltage but independent of its frequency. This is the basis upon which all FM transmitters are originally designed and upon which they are adjusted in service.

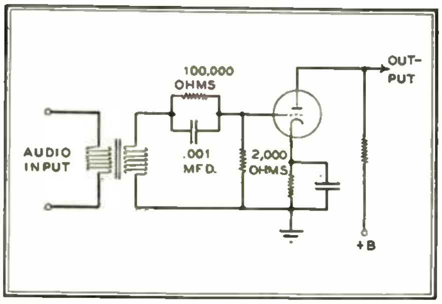


FIG. 48. NETWORK FOR INTRODUCING PRE-EMPHASIS

In the FM broadcast service, as explained in Chapter 2, it is desirable in the interest of noise reduction at the high frequencies, to employ pre-emphasis networks so that the frequency deviation is increased when the modulating frequency is increased, assuming that receivers incorporate de-emphasis networks to bring the high frequency components of the detected signal back into proper amplitude relation with respect to the low frequency components.

Fig. 48 shows a circuit which will permit the correct amount of pre-emphasis to be introduced. A .001 mfd condenser in parallel with a 100,000-ohm resistance is inserted in series with the lead to the grid of the audio amplifier tube, and a 2,000-ohm resistor is connected between grid and cathode. As the frequency is increased, a larger current flows through the condenser, producing a higher voltage across the 2,000-ohm resistor, so that the amplitude of the audio modulating voltage at the transmitter is increased.

Chapter 6 will deal with FM receiver circuit details.

FCC DELAY THREATENS INDUSTRY

(CONTINUED FROM PAGE 27)

transmission throughout the spectrum involved. However, tests of this kind will produce very valuable transmission information and it is interesting to note that the engineers of the FCC are inviting industry to participate in such tests, as co-operation of this kind will certainly have beneficial effects on the future of broadcasting.

Delays now, however, in fixing the frequencies to be assigned to FM and television throw an unnecessary burden of design on industry and cause great uncertainty in the planning of broadcast operations. This may result in large unemployment in both of these industries and loss of markets for radio and television equipment to other industries making civilian goods which will compete in the immediate postwar period for civilian dollars.

While it is true that most of the radio manufacturers in this country are busy with war work and that much of this work will continue throughout the Japanese phase of the war, there is no guarantee that drastic changes in requirements may not occur without any notice and thus relieve radio manufacturers of a large portion of their war load, which should be taken up immediately by civilian production.

In all my discussions with people who are interested seriously in FM and television operation, the FCC plan No. 1, which allocates 50–68 mc. for FM and channels above 68 mc. to television, is considered the most logical and the one which seems to provide the best answers to all of the problems involved. Thus, an early decision on the part of FCC to make this low FM allocation final would be a wonderful aid to both the broadcasters and the manufacturers and I trust that the FCC will see fit to make this allocation within the next few weeks.

ANSLEY RADIO CORPORATION

ARTHUR C. ANSLEY, *President*

I was much disappointed in the decision, of the FCC, on FM allocations. From a manufacturing point of view it is essential that the engineering of postwar radios should be completed far in advance of actual production. *The uncertainty caused by this decision will delay this work very seriously and in case of a sudden release of civilian production, I believe it would cause widespread confusion and unemployment.* It is especially serious to those manufacturers who believe in the future of FM, as we do, and who are counting on FM in most or all of their postwar models.

GALVIN MFG. CORPORATION

PAUL V. GALVIN, *President*

I was disappointed that the FCC was not able to make a decision. Presumably the Commission themselves are also disappointed in not being able to reach a decision at this time. Nevertheless, I think their action calling for a considered study of one of three plans at this time is very wise. *I sincerely hope determinations will be made in the very immediate future so as to avoid interference with the prospects of FM sales.*

THE HALLICRAFTERS CO.

W. J. HALLIGAN, *President*

The Commission's delay in determining the final position of FM will have no effect on Hallicrafters plans as our line has included an FM receiver covering all three of the possible alternatives for the past five years.

However, we feel that manufacturers of home radios may be hard pressed to complete their designs if actual production should start with only the 90-day notice promised by the WPB, and we hope that the FCC's test will be completed as soon as possible. The assignment of 13 channels below 300 megacycles to television, and the announced intention of giving FM an 18-megacycle band width and eventual extension to 20 megacycles provides ample room for these services to develop their full usefulness to the public. The final frequency allocations above 25 megacycles will undoubtedly clear the way for many new and valuable applications of the radio art.

CIRCULAR ANTENNAS FOR FM BROADCASTING

Relative Cost Data on Antennas and Towers for FM Stations—Calculated Contours for Mountain-Top Antenna Installations—Part 2

BY M. W. SCHELDORF*

Economic Choice of Antenna & Tower ★ In Part 1, we presented curves indicating the expected coverage for various sizes of circular antennas for normal antenna heights and for standard transmitter sizes. In many cases, the prospective broadcaster will require a supporting lattice tower in order to elevate the antenna system to an efficient height above the ground. For this case, it is possible to present the field intensity information in a form which will bring out the economics of the entire antenna structure.

Quotations were received on seven tower heights, from 100 ft. to 700 ft., and in five combinations corresponding to the loads presented by the five standard sizes of antennas. To the average price of each of these combinations, we added the price of the associated antenna, its self-supporting mast, the transmission lines on the tower, and the price of assembly, so that we had available the average overall price of complete antenna systems. These prices are plotted on Fig. 16.

In order to compare these prices in an effective manner, six sets of curves were next established, Figs. 17 to 22. On each chart for a given transmitter power there are two sets of curves, one for each of the required contour values of 50 and 1,000 microvolts-per-meter. Each curve (one for each antenna size) shows the price of that antenna system corresponding to the distance to the desired contour. The tower heights are marked on each curve by different symbols, in order that the appropriate reference is easily available. The lower limit on a set of curves defines the minimum price at which it is possible to radiate the required fixed intensity at varying distances from the transmitter. The result is that for economic choices, there are certain sizes of antennas and certain tower heights which must be associated, i.e., a small number of bays with the short towers and more bays in regular order with taller towers.

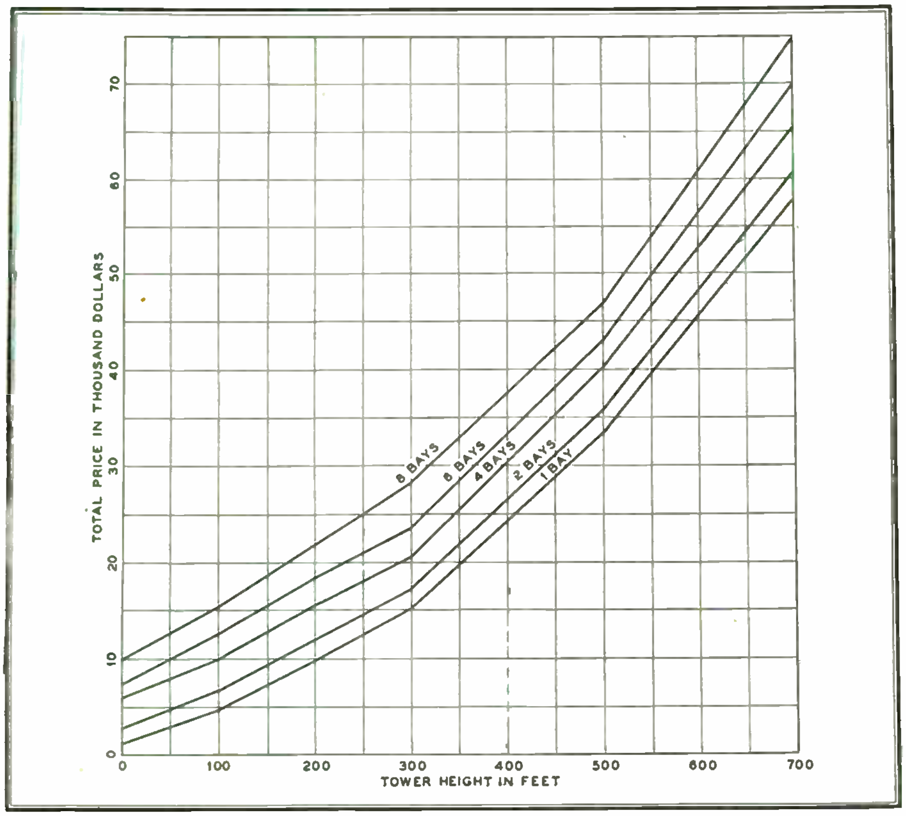


FIG. 16. AVERAGE TOTAL PREWAR PRICE FOR VARIOUS TOWER HEIGHTS, INCLUDING FOUNDATIONS, ERECTION, ASSEMBLY, LIGHTS, AND TRANSMISSION LINES

In order to make available one graphical picture of the whole situation, these limiting minimum curves are plotted on a single graph sheet, Fig. 22. In this illustration we have been able to establish a single set of definite combinations for all the transmitter power values. Note that the single-bay antenna is economical for any tower height up to 116 ft., the two-bay is economical for heights between 68 ft. and 144 ft., the four-bay between 75 ft. and 150 ft., the six-bay between 102 ft. and 216 ft., and the eight-bay for all heights above 161 ft. These combinations will serve to guide the prospective broadcaster in arriving at an economic choice quickly and accurately.

It should be pointed out that although we have used a certain set of price values, there can be a considerable variation in the associated basic tower price without disturbing the relationships, because the tower prices predominate in all cases. That is, the total price may vary considerably for specific cases but the limiting values of tower heights for the different antenna sizes will vary only slightly. In this respect, it should therefore be expected that the price values shown cannot be used except in a relative manner, in making a choice of tower and antenna combination.

Any one can prepare for his own use similar curves covering the distance ranges in which he is interested, based on local prices of the various items. This applies also to any antenna structure for which the necessary field intensity information is available.

Calculated Field Intensity Contours at Extended Heights ★ The curves in Part 1 indicate the expected coverage for various sizes of circular antennas for normal antenna heights and for standard transmitter sizes. In Figs. 17 to 22, this information was collected in another form, together with total antenna structure prices, to show an economical choice of antenna proper and tower height.

However, in many cases in mountainous

* Transmitter Division, Electronics Department, General Electric Company, Schenectady, N. Y.

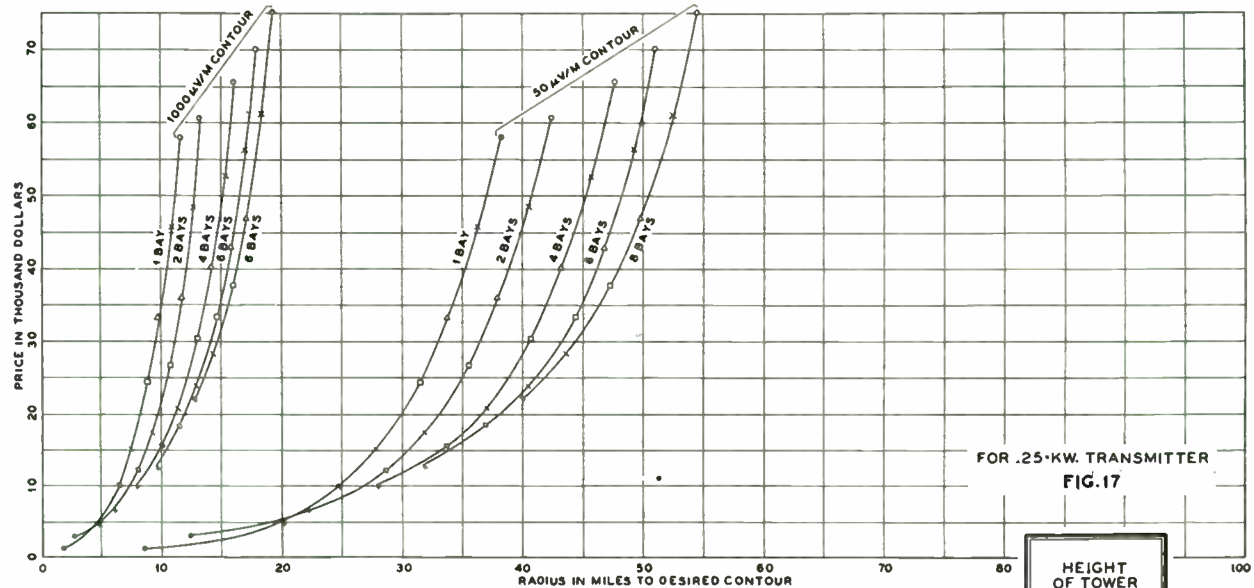


FIG. 17

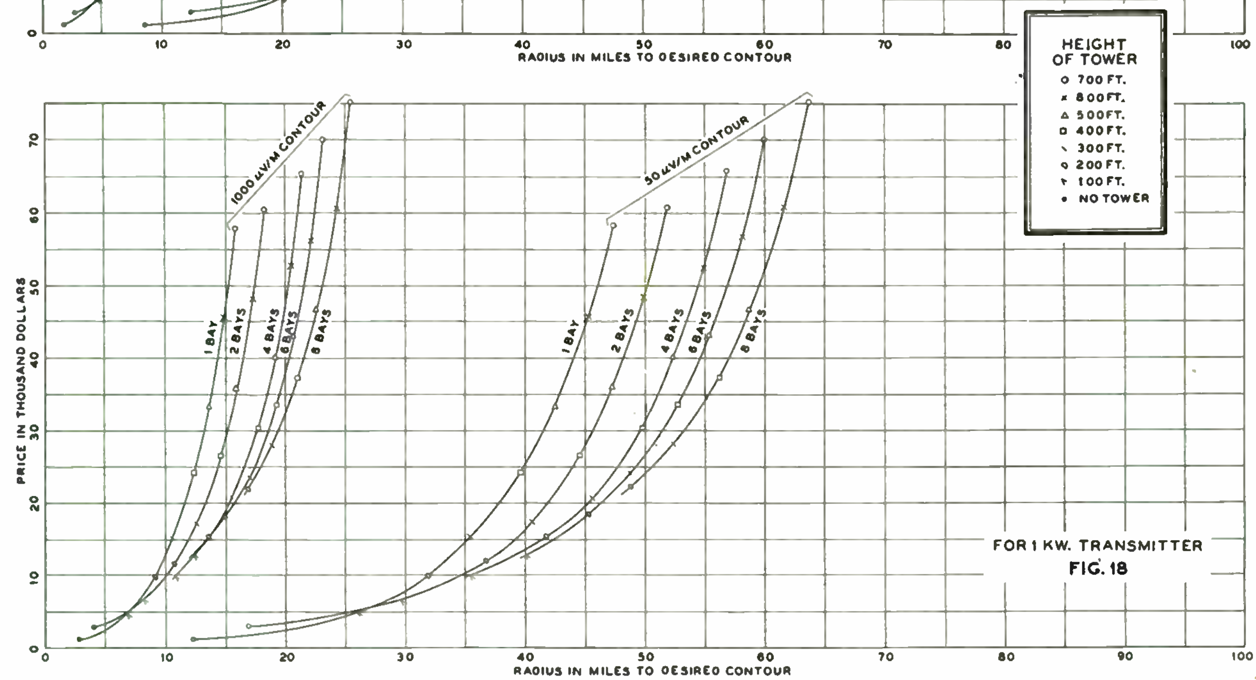


FIG. 18

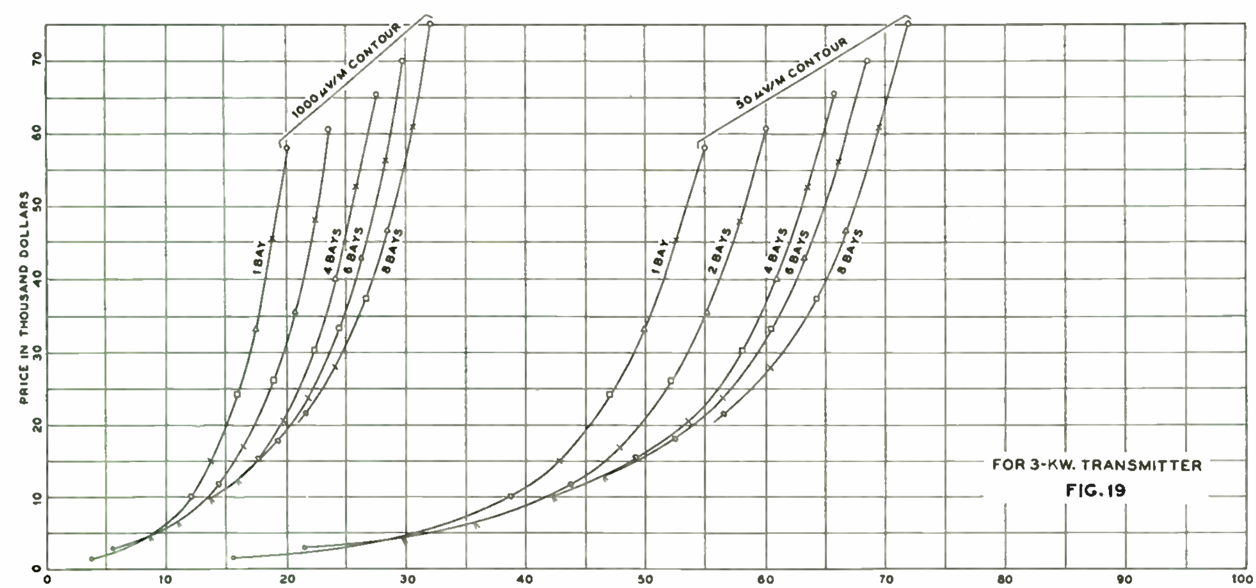
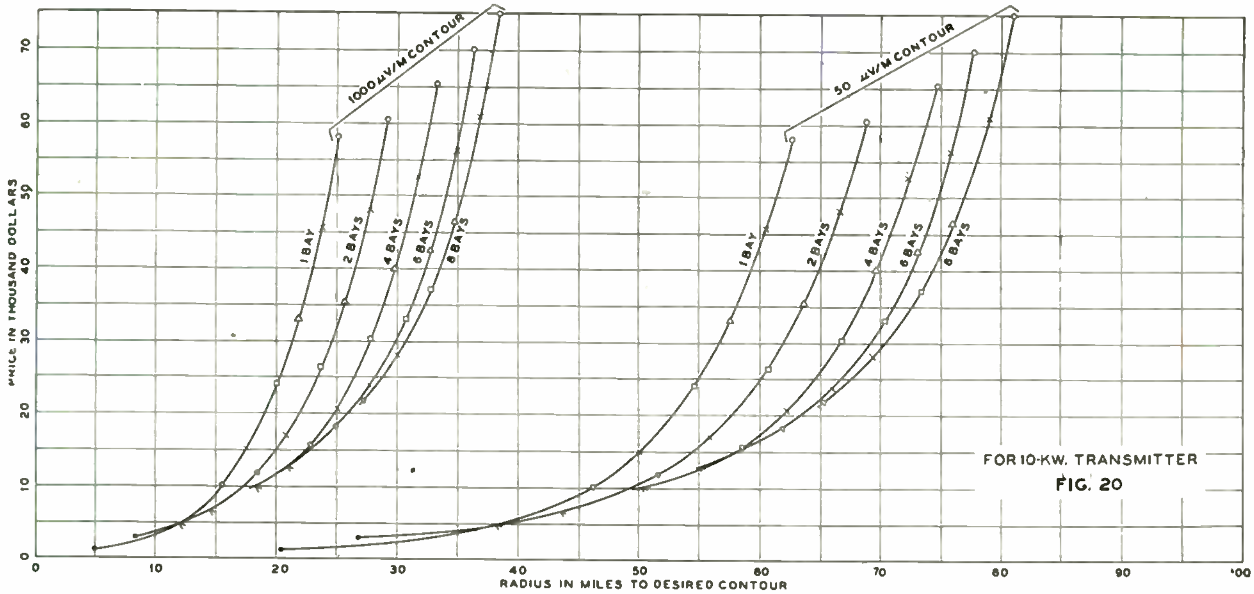
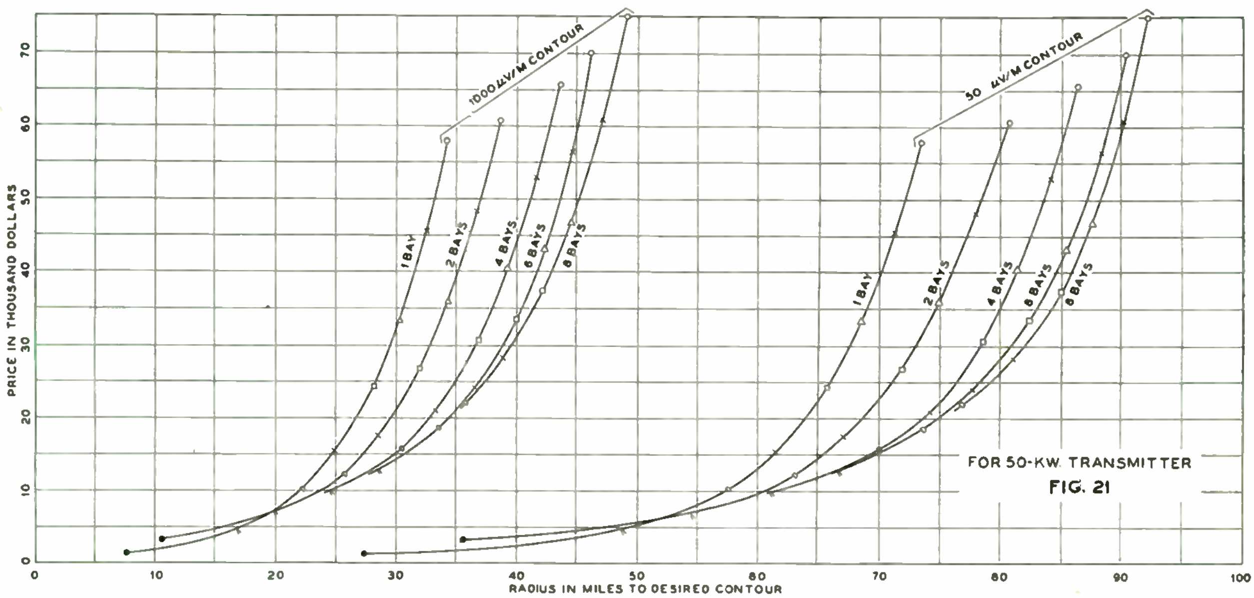
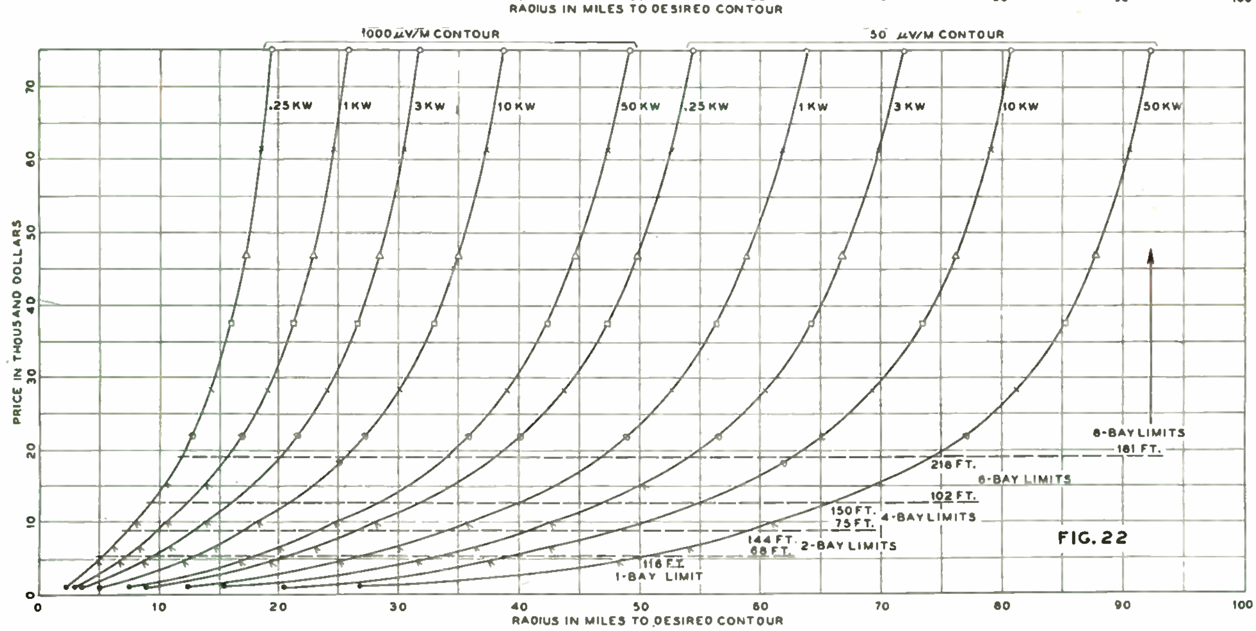


FIG. 19

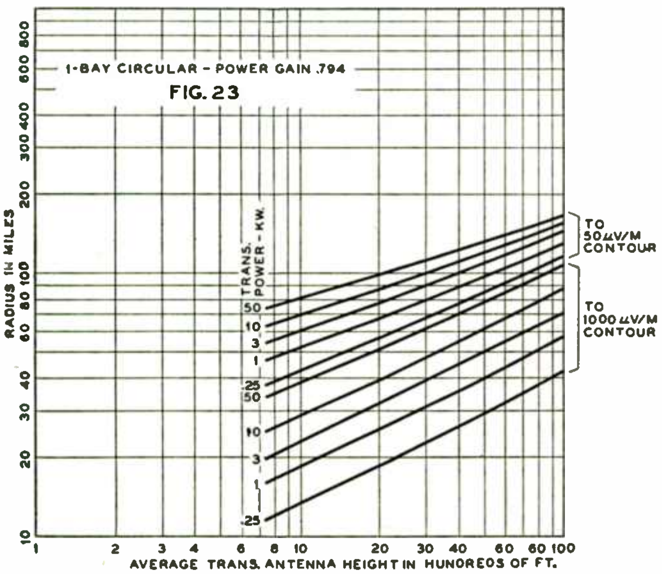
FIGS. 17 TO 19. AVERAGE TOTAL PREWAR TOTAL CIRCULAR ANTENNA PRICE FOR TRANSMITTERS OF .25, 1, & 3 KW.

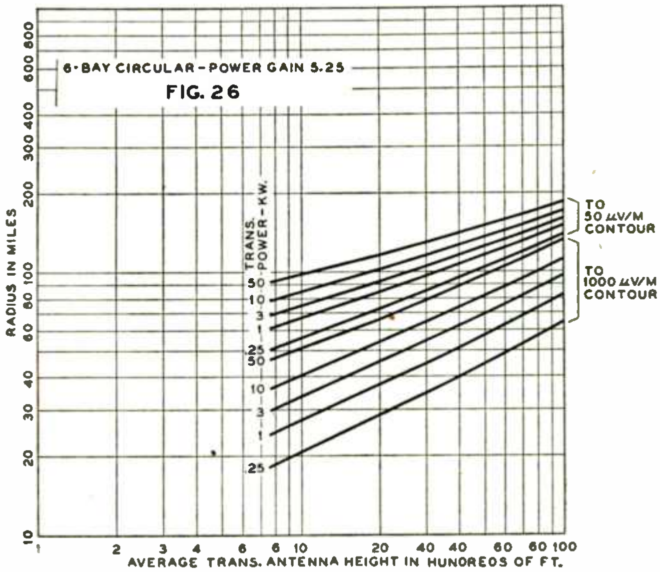


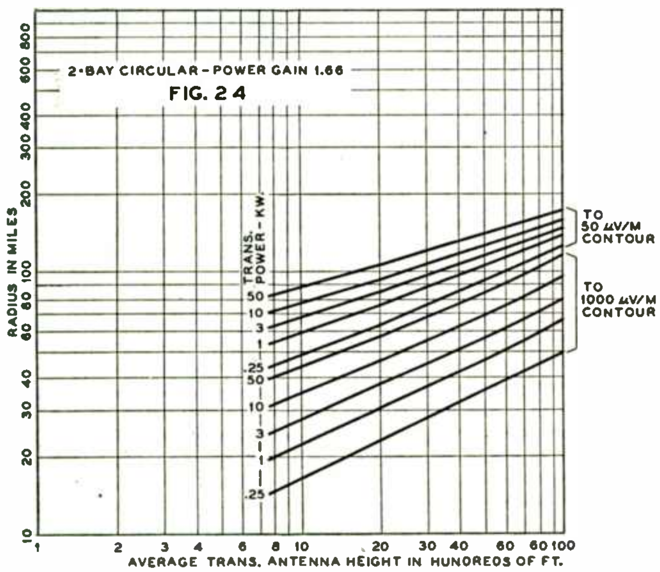


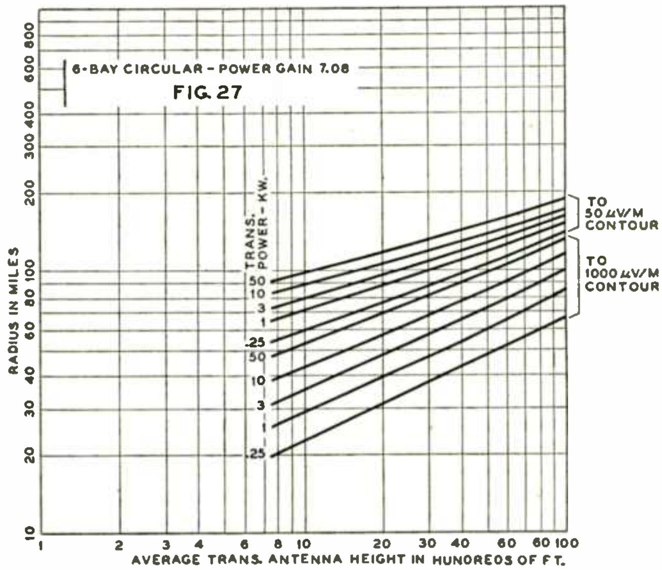


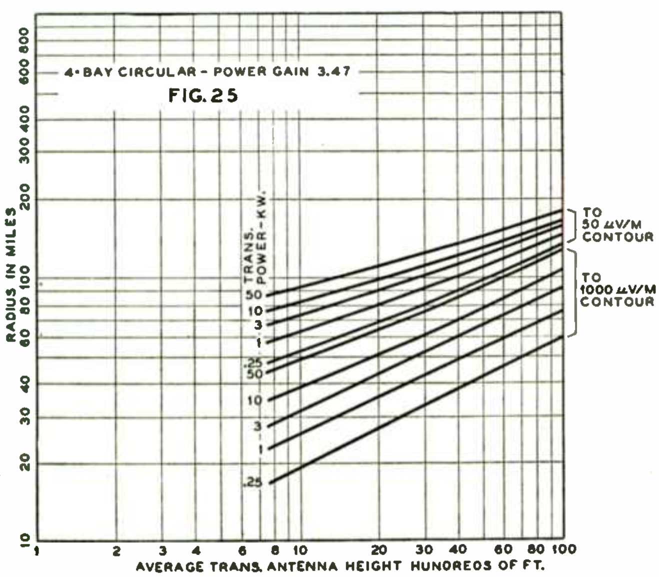
FIGS. 20 AND 21. SIMILAR DATA FOR 10- AND 50-KW. TRANSMITTERS. FIG. 22. OPTIMUM TOTAL CIRCULAR ANTENNA PRICES











FIGS. 23 TO 27. CALCULATED PROPAGATION FOR] CIRCULAR ANTENNAS OF 1 TO 8 BAYS, AND POWER GAIN FACTORS OF .794 TO 7.08

regions, it is convenient to obtain effective antenna heights well above the 800-ft. limit shown on those curves. For the use of prospective broadcasters who are located in these regions, we have extended the coverage curves to effective antenna heights of 10,000 ft. Most of this additional information, Figs. 23 to 27, was secured from the FCC reference,[4] and in the manner described in Part 1. In order to extend the values to 10,000 feet, it was necessary to establish an additional curve on the FCC diagram. This was done, based on the work of Norton.[5] Its de-

(CONCLUDED ON PAGE 83)

[4] "Standards of Good Engineering Practice Concerning High Frequency Broadcast Stations," available from the Federal Communications Commission, Washington, D. C.

[5] "The Calculation of Ground-Wave Field Intensity over a Finitely Conducting Spherical Earth," by K. A. Norton. Proceedings of IRE, Vol. 29, page 623, December, 1941.

LENS SYSTEM FOR PROJECTION TELEVISION

Explaining the Optical Problems of Projection Television, and the Lens System Employed by RCA

BY JOHN P. TAYLOR*

A PREVIEW of postwar television is afforded by the RCA projection-type home television receiver. This receiver, which has recently been demonstrated for various groups in the industry, is a relatively compact console model in which a picture 16 inches x 21⅓ ins. in size is projected on a built-in, translucent screen. Through the use of a new highly-efficient optical system, a picture is produced which has about the same brightness and contrast as that of pre-war, direct viewing tubes — while the size is such as to overcome the one important objection to pre-war television receivers; namely, that "the picture is too small."

The projection set shown on these pages is an experimental model, and obviously has not been styled or otherwise dressed up. However, the general arrangement of the components in this set approximates that which may be expected in post-war production models and, therefore, will serve as a satisfactory example of the principles involved.

There are four features of this set which represent outstanding engineering accomplishments. These are:

1. A simple, but ingenious arrangement which allows a projection system having a "throw" of nearly three feet to be mounted, together with high voltage power supply and other components, in a cabinet only a little larger than many pre-war consoles or phonograph combinations.

2. A new projection-type 5-in. kinescope in which a very bright image is produced by operating with 27,000 volts on the anode and a high beam current.

3. A new type of highly efficient optical system in which an aspherical correcting lens is used in conjunction with a large spherical mirror.

4. A method of manufacturing the aspherical correcting lens at low cost by molding it of clear thermoplastic material.

*Engineering Products, RCA Victor Division, Camden, N. J.

FIG. 2. NEW RCA OPTICAL SYSTEM PRODUCES IMAGE 16 BY 21 INS. FROM 5-IN. TUBE

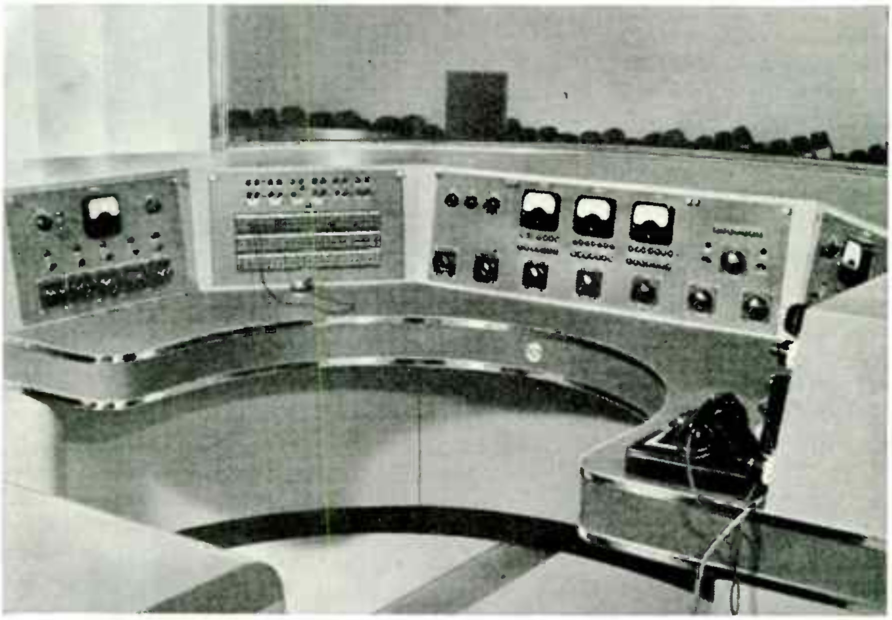
FIG. 1. PREWAR RCA MODEL WITH 12-IN. TUBE PRODUCED AN IMAGE 7 BY 10 INS.

Arrangement of Projection System ★ The projection receiver is a self-contained unit comprising all elements of the system from antenna lead-in to viewing screen. In this respect it differs radically from most of the proposed projection receivers in which the picture is usually intended to be projected onto a wall or screen some distance away.

The built-in system has many advantages. It is a much less awkward addition in the average living room; it is more convenient to use — doesn't need to be set up again each time the furniture is moved; it can have a fixed focus, eliminating one control and simplifying the optical system; and, for viewing under semi-light conditions, the translucent screen represents a

FM Equipment

One of the studios used interchangeably by FM station WBRL and AM station WJBO. RCA-Type 44-BX Microphones are used in this studio, in the smaller announce-type studio, and in the large, auditorium-type studio.



The specially built RCA control console in the master control room shared by WBRL and WJBO. Individual panels control the output from three studios. Network lines and remotes are controlled from a fourth panel. The push-button selector system in the center panel allows any program to be fed to each of the three output lines (one AM, one FM, one spare or network).

The transmitter room shared by WBRL and WJBO. The 1 KW FM Transmitter is the unit just left of center in this picture. At the far left are racks containing the FM audio input and monitoring units. At the right is the 5 KW AM transmitter. Not shown in this picture are the AM audio and monitoring racks and AM phasing units. All of the equipment in this picture is of RCA manufacture.

Station WBRL uses RCA from Microphone to Antenna

WBRL, the FM station of the Baton Rouge Advocate and State Times, uses RCA equipment throughout. In the studios are RCA 44-BX Microphones; in the control room is a special RCA-built master control console. At the transmitter building are an RCA FM-1-A Transmitter and RCA frequency and modulation monitors. The antenna is an RCA-developed, six-bay, square-loop antenna.

WBRL is a sister station of WJBO, the AM station operated by the Baton Rouge Advocate and State Times. It is interesting to note that WJBO, like hundreds of other AM stations, is also completely RCA equipped. Operators of AM stations know the meaning of "RCA all the way." And they know that in RCA FM equipment they will find the same dependability and the same advanced design features that they have come to expect in RCA AM equipment.

Operators of both AM and FM stations—and station applicants—can make reservations right now for early delivery of RCA postwar broadcast equipment. For information on our Broadcast Equipment Priority Plan, write to Broadcast Equipment Section, Radio Corporation of America, Camden, New Jersey.

RADIO CORPORATION OF AMERICA

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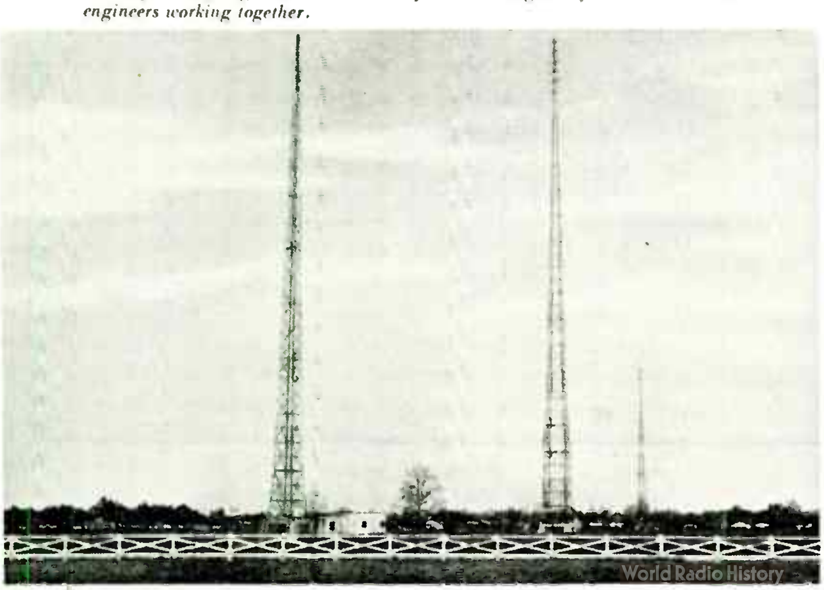
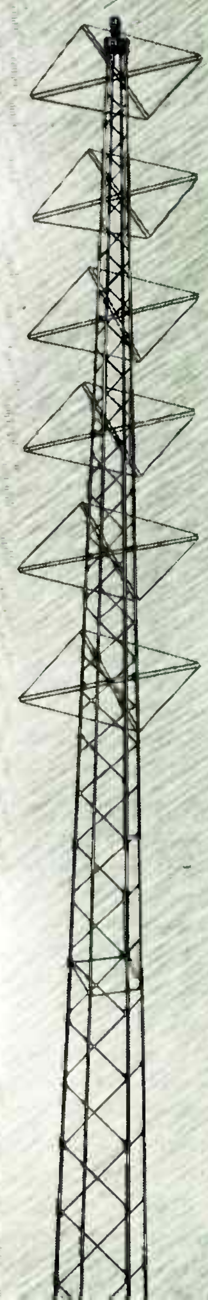
The transmitter plant of WBRL-WJBO. The AM antenna system consists of two 300-ft. and one 500-ft. (center) tower. The FM antenna system is mounted at the top of the latter. It is fed by a concentric transmission line from the transmitter building in the foreground. The entire layout was designed by WBRL and RCA engineers working together.





A close-up of the six-bay FM antenna mounted on top of the 500-ft. AM tower. This antenna consists of square loops mounted around the tower. It was specially designed by RCA engineers to answer a particular mounting problem.

more efficient use of the available image illumination than would a reflective screen.

Getting all the components of this receiver into a single unit, without making that unit unreasonably large, represents more of an achievement than an outward look at the cabinet would indicate. The major problem, of course, was the optical projection system proper. The magnification which can be obtained with a given lens arrangement depends, of course, on the "throw", i.e., distance from lens to screen. For a picture of the size desired, the required distance was about 4½ ft. Obviously, the cabinet couldn't be that deep. The answer was to mount the projection system vertically. To keep this from making the receiver too high, it was necessary to use a reflective system.

In addition to the optical system, it was also necessary to provide space for the receiver chassis, the video deflection circuit chassis, the audio chassis, the high voltage power supply, and the loudspeaker. The first three of these are simply modifications of the standard RCA chassis used in the pre-war TRK-12 Receiver. The development of a stabilized 27,000-volt power supply, in itself something of an engineering achievement, that could be mounted complete on a small chassis made it possible to group the four chassis around the outside cabinet; thus leaving the center free for the projection system. The loudspeaker is mounted in the usual position toward the base of the cabinet.

High-Voltage Projection Kinescope ★ The earliest projection television systems consisted of a standard direct-viewing kinescope plus a lens suitable for projecting an enlarged image on a screen some feet away. The picture projected in this way had very low illumination. There were two reasons: first, the optical systems suitable for use with such a projection system had low light-gathering power, and hence made available only part of the light in the original image. Second, the light thus made available was spread over a much wider area and the average illumination was greatly reduced.

It will be apparent that a successful projection tube must have much higher illumination than a direct-viewing picture tube. For instance, the 16- by 21⅓-in. picture on the new RCA receiver has an overall area a little more than four times that of the 7½- by 10-in. picture on a standard 12-in. viewing tube. If the projection optical system were 100 percent efficient, which, of course, it is not, the total illumination required would be four times as great. Moreover, since the projection tube should preferably be smaller than direct viewing tubes, in order to use small-size lenses, the average illumination or brightness on its face must be even

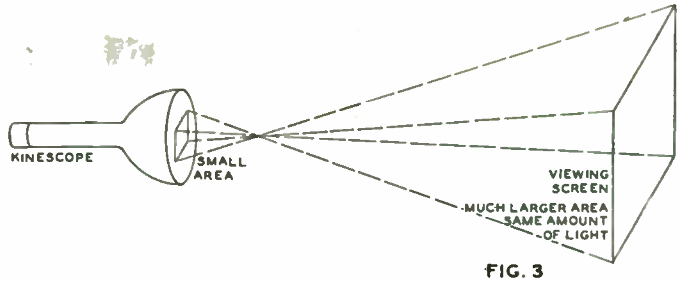


FIG. 3

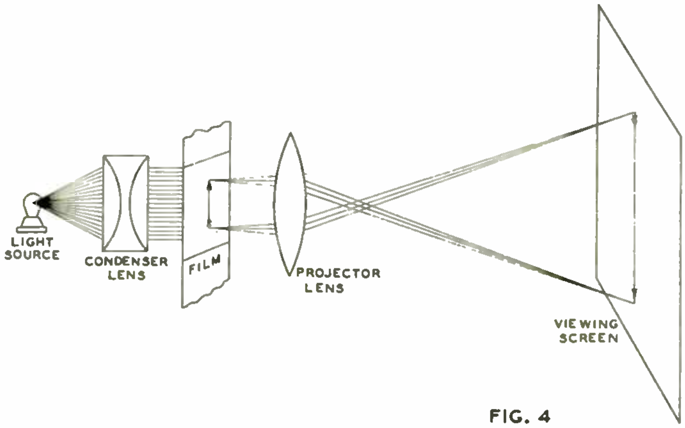


FIG. 4

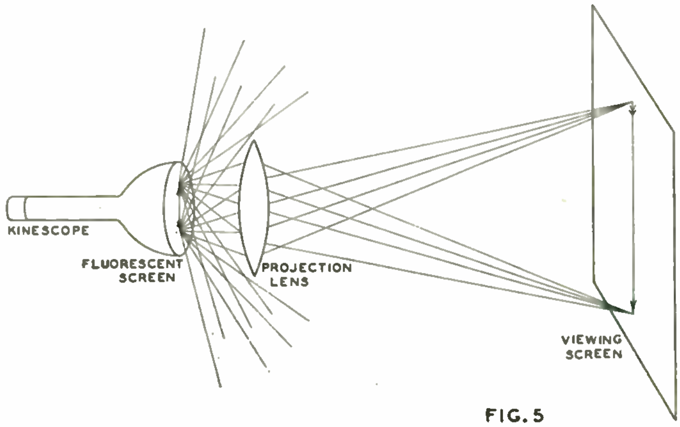


FIG. 5

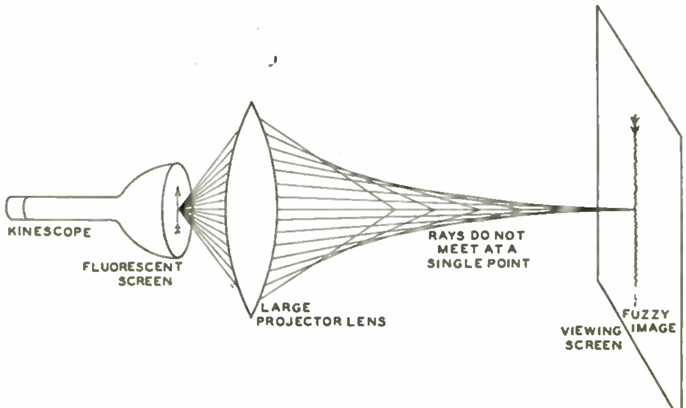


FIG. 6

greater. For example, the 5-in. projection tube, shown at Fig. 9, produces an image about 3 by 4 ins. in size. Thus, in an area approximately one-sixth that of the picture on the 12-in. viewing tube, there must be produced a total illumination four times as great. This means an average illumination, or brightness, some 24 times that of the image on the direct-viewing tube. When the loss in the optical system is taken into consideration these ratios must be even greater.

Increased brightness of the beam spot in a kinescope, and hence of the average illumination, can be obtained by increasing the second anode voltage, thereby causing the electrons in the beam to travel faster, or by increasing the number of electrons in the beam, i.e., the beam current. Both entail difficulties. Increasing the voltage requires greater spacing and better insulation within the tube. Increasing the current requires higher emission cathodes.

RCA engineers have been working on this problem for more than ten years. The new projection tube, now in use, is the result of this long-extended research. This tube operates satisfactorily with 27,000 volts on the anode, approximately four times that of the standard 12-inch viewing tube. It produces an image having an overall illumination about 12 times that of 12-in. pre-war, direct-viewing tubes. Used with the improved optical system described in the following pages, this tube is capable of producing 16- by 21⅓-in. pictures having an average illumination comparable to that of home movies.

How the Optical System Works ★ It would seem on first thought that the projection of television pictures could easily and satisfactorily be accomplished with a simple projection lens system such as that used in motion picture projectors. The first projection receivers were, in fact, so constructed. However, commercially available lenses of the type required have relatively low light-gathering power which means, in effect, that they gather light in from a relatively small angle. As a result, when these lenses are used for television projection, the overall efficiency of the optical system is very poor. The reason for this can best be understood by comparing the arrangement used for television projection with that used in motion picture work.

In a typical motion picture system, Fig. 4, light from a lamp or arc is converged by a condensing lens so that as it strikes the film it consists of a bundle of nearly parallel rays. Nearly all the light which strikes the film passes through except, of course, that part which is stopped by the dark part of the film. Moreover, as the light rays emerge from the far side of

(CONTINUED ON PAGE 53)

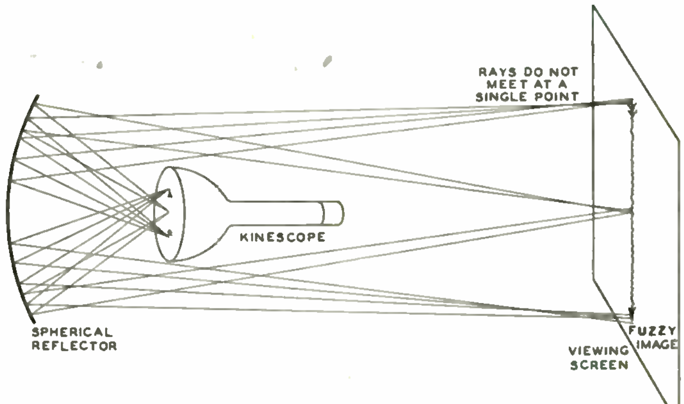


FIG. 7

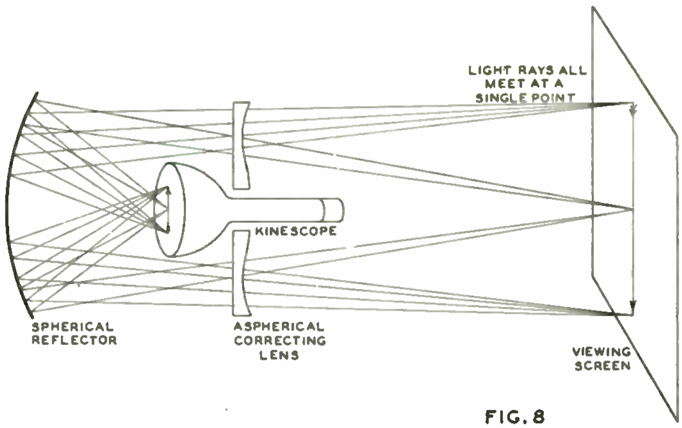


FIG. 8

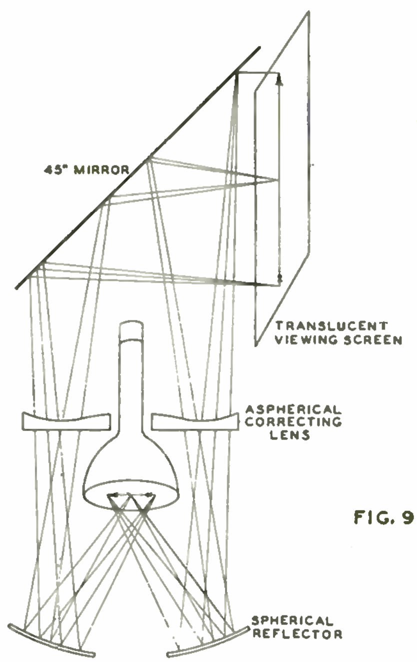


FIG. 9

SUN, EARTH, AND SHORT-WAVE PROPAGATION

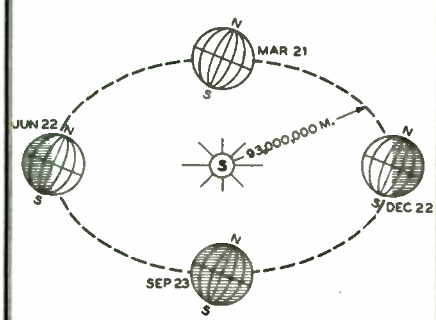
Effects of the Solar System upon Long-Distance, Short-Wave Communications

BY HENRY E. HALLBORG*

SHORT wave communications circuits girdle the earth. They are practical symbols of the effectiveness of skywave transmission. The signals which they radiate bounce between the radio ceiling and the earth, or sea, carrying an ever increasing portion of the world's interchange of intelligence. Their stage is broadly the solar system. Concurrently, they react to changing conditions on the solar surface, and to the relative positions of neighboring planets. We must not overlook the major astronomical and geophysical aspects of the sun and the earth, if we would better understand short wave propagation.

Elementary astronomy shows us four cardinal positions of the earth, namely, winter, spring, summer and fall, in the earth's annual 600-million-mile journey around the sun. These cardinal positions are reproduced in Fig. 1. The earth's orbit is slightly elliptical, having a mean radius of 93 million miles. About January 1st, perihelion, we are 3 million miles closer to the sun than at aphelion, about July 1st. The radio ceiling is therefore most highly ionized in January. This is verified by brief use of abnormally high frequencies over long distances during this month, although the tilt of the earth's axis away from the sun causes shorter and colder days in the northern hemisphere.

* Radio Corporation of America, Camden, N. J. A paper delivered before the Radio Club of America, Columbia University.



THE SOLAR SYSTEM

RELATIVE DISTANCES OF PLANETS FROM THE SUN AND ORBITAL PERIODS OF ROTATION IN REFERENCE TO THE EARTH

PLANET	SOLAR DISTANCE	PERIOD-YRS.
MERCURY	.4	.25
VENUS	.7	.58
EARTH	1.	1.
MARS	1.5	1.94
ASTEROIDS	2 TO 4	5.2 MEAN
JUPITER	5.2	11.8
SATURN	9.5	29.2
URANUS	19.2	85
NEPTUNE	30.1	164
PLUTO	39.6	250

FIG. 1. THE EARTH'S ORBIT AND THE FORMATION OF THE SEASONS

Fig. 1 also contains a tabulation of the distances, and rotational periods, of the principal members of our solar system. The rotational period of Jupiter, our largest planet, is of particular interest in connection with the sun spot cycle, which so intimately affects short wave propagation. Jupiter makes the journey around the sun in 11.8 years. The average length of a sun spot cycle is 11.1 years.

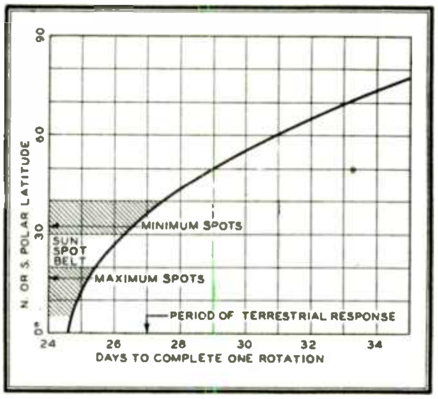


FIG. 2. THE SOLAR ROTATION CYCLE

In an electronic sense the sun is the filament, and the earth the plate, of a vast electronic tube of which the vacuum is supplied by outer space. The sun provides the radiations which energize and sustain our radio roof. The sun is an incandescent gaseous body whose rotational period varies with solar latitude. It completes one rotation in 24.6 days at the equator, and in 35.6 days at solar latitude 80°. New solar surfaces of varying radiative properties are continuously being presented to the earth. The particular solar area that causes the most prolonged variations of the radio roof is the sun spot belt. This is located on the sun, north and south of the solar equator, between latitudes 5° and 40°. Spots on the sun first appear at the higher latitude, and, during the course of the 11-year cycle, work downward toward latitude 5°. The new cycle starts with a rather abrupt recurrence of spots at the higher latitudes. The actual numbers of spots observed are at a maximum around solar latitude 16°. Spots provide a convenient means for measuring the rotational period of the sun. The solar period in terms of measurable effects on terrestrial magnetism is 27 days, which is the accepted solar rotational cycle. Fig. 2 contains a graphical summary of the above mentioned solar data interpolated from Doctor C. G. Abbot's most interesting book "The Sun."

Sun spot areas are the seats of sustained radio roof disturbances which not infrequently last from 3 to 5 days. These disturbed periods are known to radio men as *magnetic blankets*. A more sudden and annoying type of disturbance is the *drop-out*. This may be as completely effective as the opening of a switch, for periods of from 2 to 20 minutes. Drop-outs are caused by sporadic solar eruptions of hydrogen, and the lighter solar gases. Eruptions often precede the formation of a sun spot group. Viewed from the edge of the solar disc both sun spot and flare types of solar activity would appear as prominences. The quiescent, or stable type, may accompany a sun spot area, whereas the eruptive or flare type may occur anywhere on the solar disc. The effect of a flare on the earth, however, is at a maximum when it occurs near the center of the solar disc. Typical solar prominences are shown in Fig. 3. The quiescent type may recur after a 27-day rotational cycle. The flare type has no recurrence cycle.

We now return to earth for our short

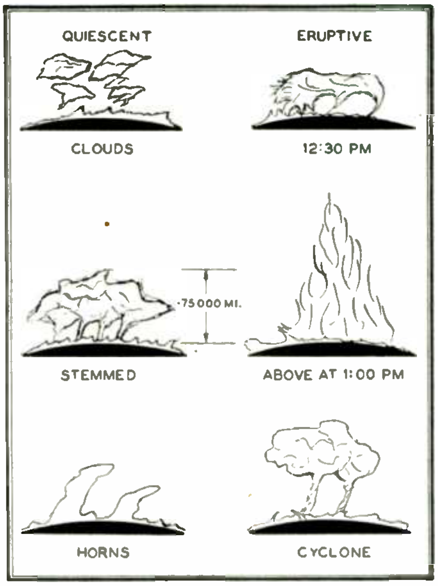


FIG. 3. SIX TYPICAL TYPES OF PROMINENCES AT SUN'S DISC

wave propagation study. Our atmosphere is normally thought of as the air we breathe, having maximum density at the earth's surface. The density drops to the vanishing point at the radio roof, several hundred miles above us. If we could be physically transported upward toward the radio roof a number of unique encircling layers would be encountered. The designations and distinguishing characteristics of these layers are illustrated in Fig. 4.

The first, and lowest, layer to be crossed is the *Troposphere*. It extends upward to a height of about 10 miles. It is the layer of earth-bound weather and human habitation. Within it, winds, clouds and thunderstorms exist, continuously generating, in some part of the globe, radio static. For each mile of our ascent the temperature would be observed to drop 17° F. The barometer at 3 miles altitude would read only one-half that at the earth's surface.

We would then enter a second layer, the *Stratosphere*, extending upward to a height of about 22 miles. The barometer here would read less than 1/10th that at the earth's surface. The thermometer would register − 67° F. This temperature would be found quite constant day and night, for which reason this envelope has also been called, the "isothermal layer."

Above the stratosphere, and extending upward to a height of about 40 miles, we would come upon the *Ozonosphere*. This layer contains free oxygen. It has the life preserving property of absorbing the deadly actinic rays of the sun. In the process of absorption its daytime temperature rises to about 200° F. At night, in the absence of actinic rays, its temperature drops to that of the stratosphere, about − 67° F.

A fourth layer, the *Alto-Troposphere* would be encountered extending above the ozonosphere to a height of about 60 miles. This is a quasi-vacuous region of sporadic radio reflections and absorptions. It may be opportune here to observe that absorption not only involves temperature rise, but also expansions of free gases. Radio absorption screens and blankets are formed by solar radiations which penetrate to the Alto-Troposphere. Sunlight also suffers absorption in this layer. The region consequently undergoes wide temperature and volume changes between day and night. Air density here has dropped to such low values that breakdown of residual gases may be likened to the blue glow in a leaky radio tube. The layer is a dividing zone for sky wave transmission. Long waves are reflected by it. Short waves suffer varying degrees of absorption and penetration depending upon their relative frequencies.

The fifth and last layer to be entered, the *Ionosphere*, extends upward from 60 miles to an indefinite upper height. Here are found free ions, practically a perfect vacuum, and two major stratifications of free ions. The lower stratification, at a mean height of about 75 miles, is the well known Kennelly-Heaviside layer, or E layer. The upper stratification, or F layer, has a mean height of about 200 miles. By virtue of absorption and expansion it separates into two layers, F_1 and F_2, in the daytime. These layers are well known to the radio profession. Daily, seasonal and secular variations of the ionosphere are the subject of periodical publications, notably by the National Bureau of Standards, and the Carnegie Institution.

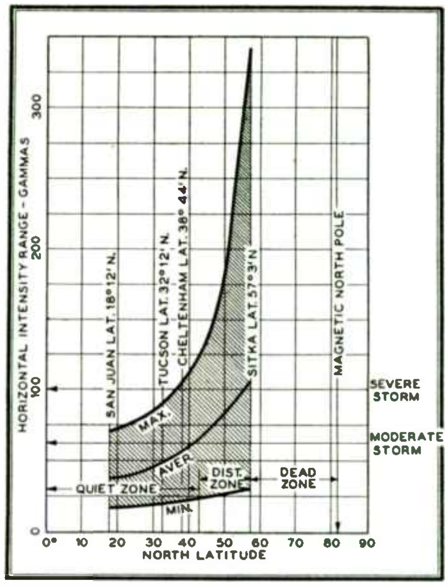


FIG. 6. 1931 VARIATION OF HORIZONTAL INTENSITY RANGE WITH N. LATITUDE

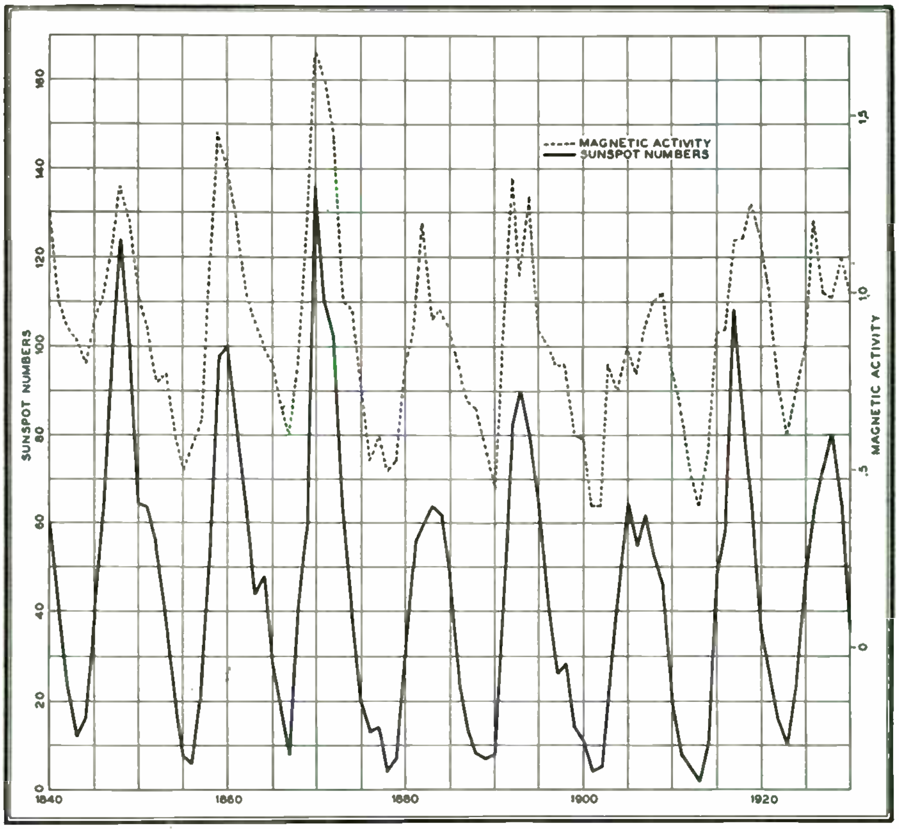


FIG. 5. ANNUAL MEANS OF MAGNETIC ACTIVITY AND RELATIVE SUNSPOT NUMBERS DURING THE PERIOD FROM 1840 TO 1930

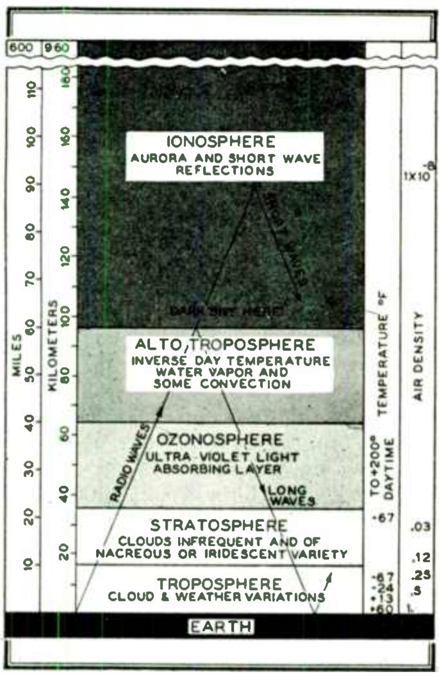


FIG. 4. THE EARTH'S ATMOSPHERIC SHELLS

Dr. J. Bartels of the Carnegie Institution has provided a most interesting century-long correlation between magnetic and solar activity. This covers the period from 1835 to 1930. It is reproduced in Fig. 5 from data originally published in the March, 1932, Journal of Terrestrial Magnetism and Atmospheric Electricity. The long period interrelationship between magnetic activity, and relative sun spot numbers is convincingly indicated by these data.

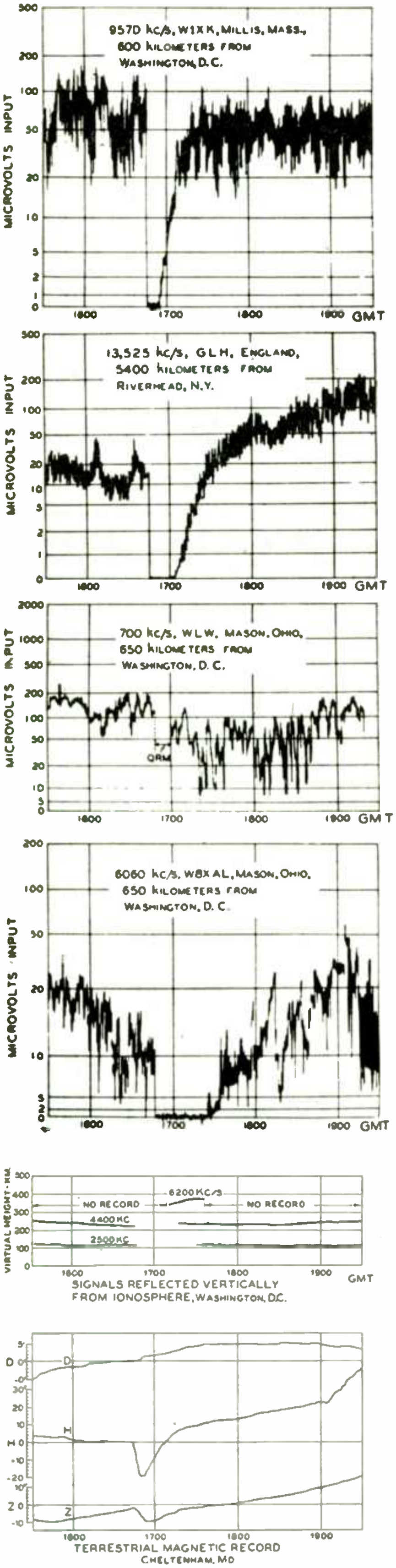


FIG. 8. EFFECTS OF A FLARE TYPE OF DISTURBANCE, AS SHOWN BY RECORDINGS MADE AT THE BUREAU OF STANDARDS, WASHINGTON, D. C., APRIL 8, 1936

Terrestrial magnetic range is normally measured as a difference between maximum and minimum deflections in a unit of time. Terrestrial magnetic range increases sharply with proximity to the earth's magnetic poles. Disturbance on short wave circuits likewise has long been known to increase with proximity to the earth's magnetic poles. A study of this effect was made by the author from terrestrial magnetic data of North American magnetic observatories supplied for the year 1931 by the U. S. Coast and Geodetic Survey. The recorded range values were evaluated to correspond to observed moderate and severe radio circuit disturbances. The results are plotted in Fig. 6. Some uncertainty has always existed as to the exact bearing of the magnetic north pole. At the time these data were plotted the published location was 71° N. The method of applying the radio-magnetic relationship remains valid, however, whatever the actual location of the magnetic pole. An application of the data of Fig. 6 to radio circuits working to and from New York City can be made to Fig. 7, an azimuthal map of the world with New York City as its center. Based upon the curve marked "average" of Fig. 6, "dead" and "disturbed" zones can be laid out on the map. They would picture mean magnetic conditions for the year 1931. The DEAD ZONE would be delineated on Fig. 7 by a radius equal in length to the intersection in Fig. 6 of the severe storm level with the magnetic pole, and with the curve marked AVERAGE. This radius measures about 13° of latitude. Similarly, the DISTURBED ZONE would be defined by the intersection of the moderate storm level with the AVERAGE curve of Fig. 6. If the radius of Fig. 6 had been taken to intersect with the curve marked MAXIMUM instead of to the AVERAGE curve the dead zone would then overlap the disturbed zone on Fig. 7 and the storm period disturbed zone would approach the equator. On the other hand, during quiet conditions, application of the

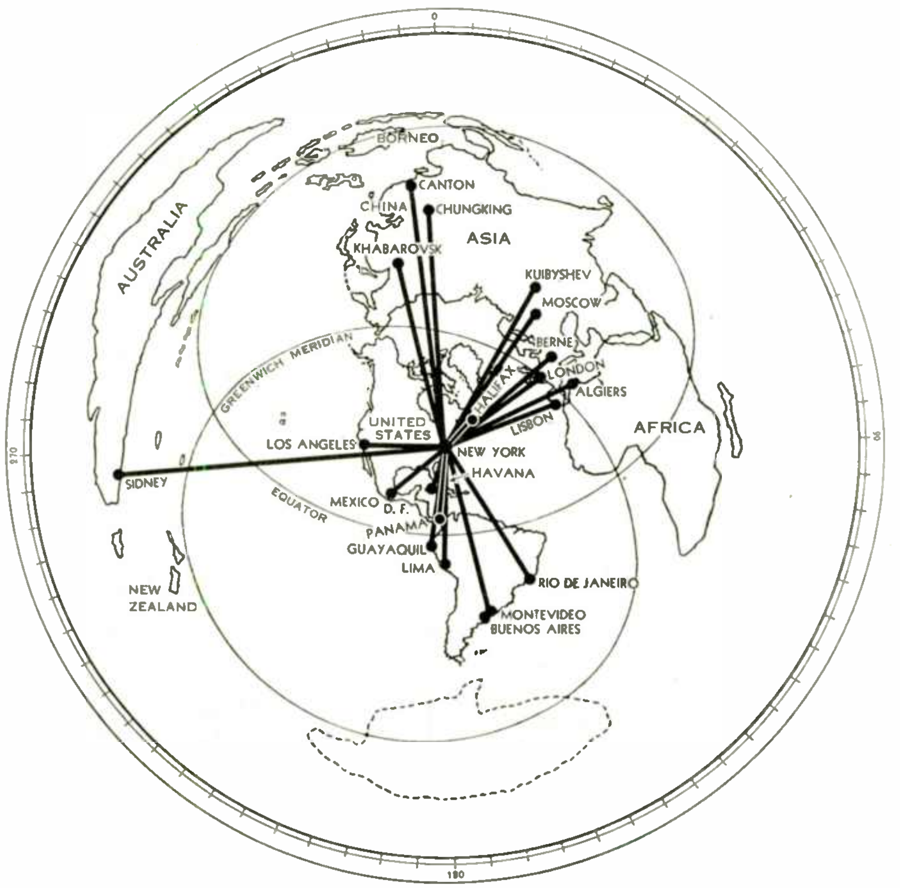


FIG. 7. AZIMUTHAL MAP OF THE WORLD, WITH NEW YORK AS THE CENTER

curve marked MINIMUM of Fig. 6 would produce no intersection with either the moderate or severe storm level, hence no dead zone would exist on quiet days.

A recording made at the Bureau of Standards, Washington, D. C., on April 8, 1936, and submitted for reproduction provides a graphic illustration of the effects of a flare type of disturbance in producing sudden drop-outs. The recording is reproduced in Fig. 8. Circuits having frequencies of 6.06 mc., 9.57 mc. and 13.525 mc. are seen to cut off promptly at 1640 GMT, and to stage varying degrees of recovery. A broadcast circuit, WLW, of .7 mc. is not affected by the flare, but records QRM during the drop-out interval. At the lower right a recording of the horizontal magnetic intensity trace at Cheltenham shows a steep dip, and gradual recovery, during the drop-out. Reflections by vertical incidence from the ionosphere are seen to cut off at the same instant, namely 1640 GMT, but the higher frequencies are the first to return. This characteristic is also the normal observation over point-to-point circuits. Penetrating radiations from the flare reach the alto-troposphere where they cause ionizations that set up temporary absorption screens in the normal path of the radio wave. The absorbing screen dissipates when the flare subsides, whereupon normal conditions return, since the normal reflecting layers remain unaffected.

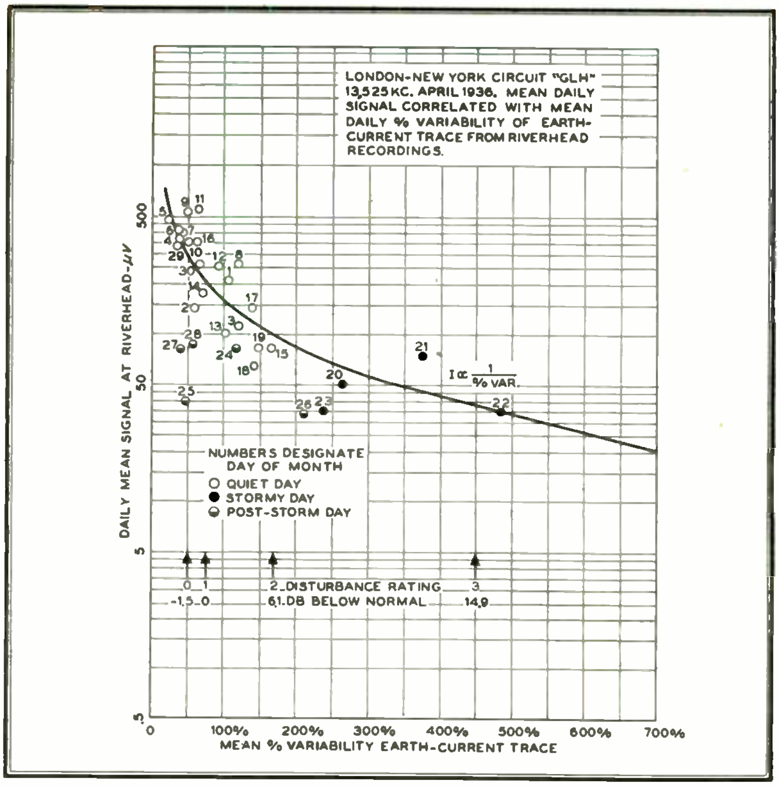


FIG. 10. SIGNAL VERSUS MAGNETIC ACTIVITY, GEOMAGNETIC N. LAT. 59° MEAN

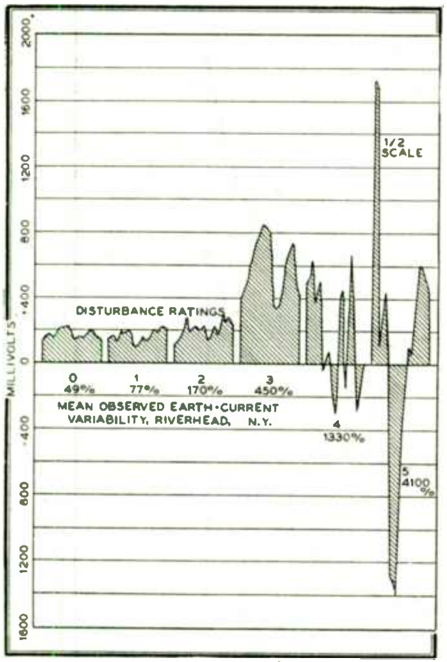


FIG. 9. TRACES CORRESPONDING TO RCAC SCALE OF DISTURBANCE RATINGS

A continuous record of short wave circuit disturbances is maintained on the world wide traffic channels of R.C.A. Communications, Inc. A disturbance rating scale of 0 to 5 is applied to each 8 hour watch. The scale numbers are defined, and evaluated in accordance with the following table:

NUMBER	DISTURBANCE	SIGNAL
0	Unusually Quiet	Unusual Strength
1	Normal Conditions	Strength Normal
2	Slightly Disturbed	Slightly Below Normal
3	Moderately Disturbed	Considerably Below Normal
4	Severely Disturbed	Nearly Out; But Still Audible
5	Complete Drop-out	Inaudible

The circuit disturbance ratings provide a continuous source of radio conditions reference. Plotted in sequences of solar rotations they indirectly chart the ranges of solar activity. They provide means for the prediction of probable propagation conditions during each new solar rotation. An additional source of ionosphere monitoring is maintained by R.C.A. Communications, Inc., in the form of an earth-current recorder at its Receiving Terminal, Riverhead, L. I., N. Y. This consists of a ground loop, 6 miles long, formed by utilization of an abandoned South American long wave antenna in which has been inserted a series resistor, through which induced earth-currents circulate. The voltage drop in this resistor is continuously recorded. The rate of change of earth-current is measured in terms of a variability unit, which expresses rate of change per hour as a percentage of increase of trace length. Typical earth-current traces are reproduced in Fig. 9. They are taken to correspond to mean values of circuit disturbance ratings from the 0 to 5 scale circuit records. Signal strength variation is found to follow quite closely an inverse variability law, which means that doubling of the variability should halve the signal.

The inverse variability law was applied to London Signal "GLH," 13,525 kc., during the disturbed month of April 1936. Mean daily signal strengths from signal recordings were compared to mean daily Riverhead earth-current variabilities during the working hours of the signal. The results are plotted in Fig. 10. Three types of days must be recognized for the proper analysis of the results, namely quiet days, storm days and post storm days. Post storm days are governed by residual ionization and absorption, consequently may be excepted in laying out the variability plot. The solid curve of Fig. 10 is obtained by applying the inverse variability law. The agreement is seen to be close enough to indicate that subnormal signals and earth-current variability are both proportional effects caused by terrestrial magnetic activity.

The amount of radio station power required to combat magnetic conditions has been a matter of speculation. The observed inverse relationship between signal and earth-current variability has provided the means for computing required antenna inputs over a given circuit corresponding to circuit ratings 0 to 5. A plot of computed antenna inputs in kilowatts needed to provide a commercial signal over the North Atlantic on a circuit having a mid point at 60° north geomagnetic latitude is shown in Fig. 11. The kilowatt antenna input required is seen to vary, in round numbers, from ½ kw. for circuit rating 0 to 4000 kw. for circuit rating 5. The 4000-kw. figure means that it is impractical to utilize a high latitude short wave circuit during conditions corresponding to rating 5. The ratio of power required for circuit rating 5 compared to circuit rating 0 is 8000 to 1.

The wide range of power required to produce a commercial signal over a circuit whose mid point geomagnetic latitude is 60° N logically leads to the question, what power ranges will be required over circuits whose mid points are nearer the equator? An answer to this question was obtained by deriving a relationship between earth-current variability and horizontal magnetic intensity ranges at equal latitudes. The derived relationship was then applied to horizontal intensity recordings from all the North American Magnetic Observatories. The results for the year 1939 are shown in Fig. 12. These data provide a direct comparison of power requirements for a circuit whose mid point latitude is 60° N geomagnetic, as compared to a circuit at 30° N geomagnetic. The comparison shows that under

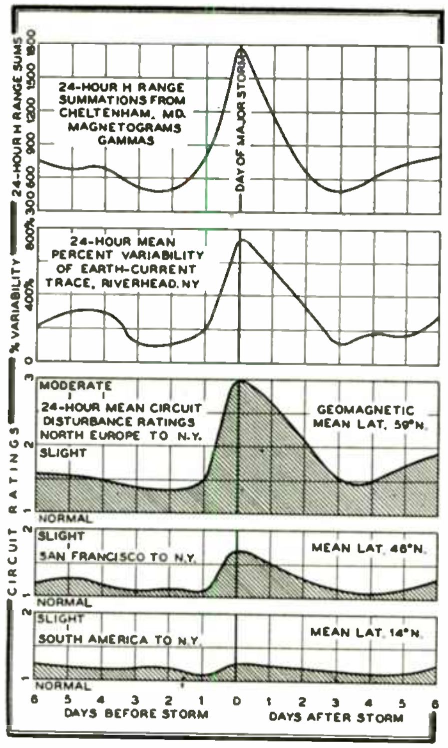


FIG. 13. DATA RECORDED AT RIVERHEAD

are correspondingly 26 to 1, and 2.7 to 1 respectively.

Prevailing circuit conditions 6 days be-

and Cheltenham horizontal magnetic intensity ranges are shown in Fig. 13. The improved operation of low latitude stations is quite evident. Riverhead earth-current variability is lowest two days before the storm day. North Atlantic circuits correspondingly show the lowest disturbance. Nature thus provides a practical warning of the storm to follow, a fact which has not been overlooked by the Operating Staff.

The persistence of residual ionization and absorption on high latitude sky wave circuits has previously been mentioned. This circuit characteristic was studied during the 16 major sun spot passages mentioned in the preceding paragraph. The results for circuits whose mid points have various geomagnetic latitudes are shown in Fig. 14. This figure plots relative lengths of circuit interruptions against the geomagnetic mid point latitudes of the circuits. Circuit interruptions are seen to increase sharply at about 55° N geomagnetic latitude. The New York-London circuit is more disturbed on the 3rd day following a storm, than is the lower latitude New York-San Francisco circuit during the height of the storm. The low latitude New York-Buenos Aires circuit is relatively unaffected.

An example of a most spectacular solar rotation is shown in Fig. 15. It covers the

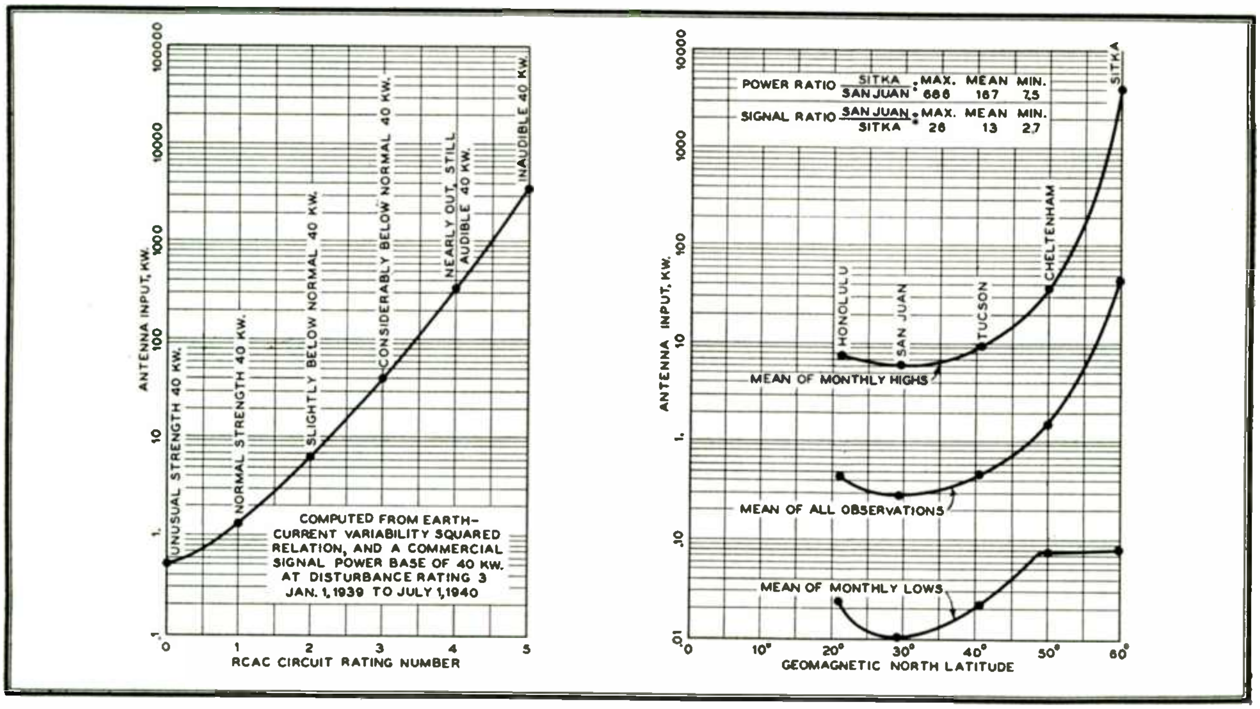
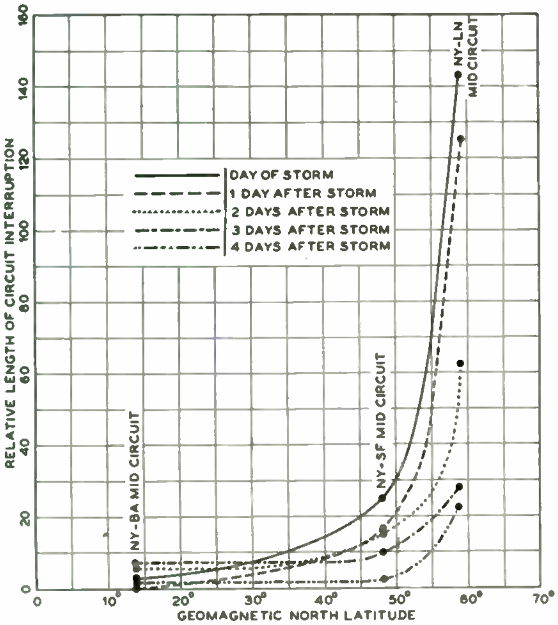


FIG. 11, LEFT. KW. ANTENNA INPUT FOR COMMERCIAL SIGNAL AT VARIOUS RCAC DISTURBANCE RATINGS ON NORTH ATLANTIC, MEAN GEOMAGNETIC LAT. 60° N. FIG. 12, RIGHT. COMPUTED RELATIONSHIP BETWEEN COMMERCIAL SIGNAL, ANTENNA POWER, AND MIDCIRCUIT GEOMAGNETIC LATITUDE. H RANGE DATA FOR THE YEAR 1939

storm conditions 688 times as much power will be required for the high latitude station, and 7.5 times as much under quiet conditions. The signal improvements in field intensity for the low latitude station

fore, during, and 6 days after 16 major sun spot passages of 1939 and 1940 have been studied. A summary of the mean circuit ratings, and the corresponding Riverhead earth-current variability ranges,

period from March 17 to April 12, 1940. This period was outstanding in that it produced two major sun spot barrages, with associated aurora, and cable and radio interruptions for several days, in the



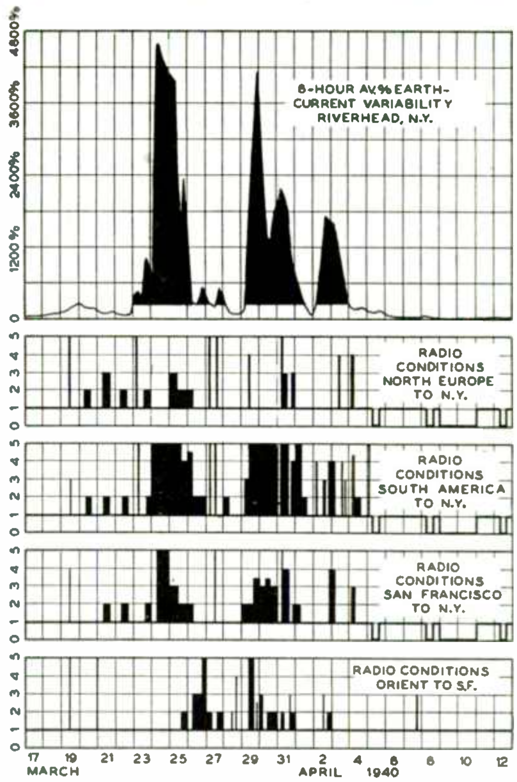


FIG. 14, LEFT. RELATIVE LENGTHS OF CIRCUIT INTERRUPTIONS DURING 16 MAJOR STORMS, 1939-1940.
FIG. 15, RIGHT. SPECTACULAR EXAMPLE OF SOLAR ROTATION OBSERVED MARCH 17 TO APRIL 12, 1940

form of independent storms within 5 days of each other. The measured earth-current variabilities from recordings at Riverhead are plotted in comparison with the reported disturbance ratings on world wide circuits of R.C.A. Communications, Inc., for each day of the solar sequence. The following interesting facts may be observed from a study of the figure. A *flare* type of disturbance strong on all circuits occurred on March 19th, 5 days before the first major disturbance on March 24th, and a second on March 23rd, one day before. A third flare on March 27th preceded by 2 days the second major disturbance of March 29th. Earth-current variabilities of over 4000% were recorded at Riverhead. High frequency outages of several days duration occurred on North Atlantic circuits. South American circuits, on the other hand, showed only moderate disturbances, except for the short period flare type of drop-outs which are normally more intense; but fortunately brief on the equatorial circuits. A period of absolute calm on April 9th and 10th completes the gamut of a most unusual solar rotation.

It is concluded from the evidence herein presented that the sun, the earth and the sky are truly co-actors on the stage of short wave propagation. The moods of the actors on the stage are fortunately calm and serene most of the time. The percentage of disturbances such as above described is well under one per cent per annum. In all fields of endeavor, perfection is quite remote. The remaining one percent may perhaps still be achieved in better understanding of wave propagation.

PROJECTION TELEVISION

(CONTINUED FROM PAGE 47)

the film, they diverge only slightly. Thus, all the light originally falling on the film eventually reaches the screen, except that part stopped by the picture on the film. For comparative purposes, and disregarding losses, such an optical system can be said to have a very high efficiency. This fact, together with the relatively intense illumination, makes for a very satisfactory projection system.

Now, what happens when the same optical system is used to project a television picture is shown by Fig. 5. The only source of light in this case is that in the picture itself. Moreover, this light does not emerge from the fluorescent screen in parallel, or even nearly parallel rays. Rather, since the screen is a perfect diffusing surface, these rays emerge in all directions and only a small part are gathered in and brought to a focus by the lens system. Thus, the overall efficiency of the optical system is very low. Maloff and Epstein have calculated that good, commercially available (f/2) lenses, when used at the magnification typical of home television receivers, will collect and deliver to the screen less than 5% of the light generated.

From the foregoing, it would seem that the obvious answer would be to increase the size of the lens and thereby increase the amount of light it will collect, as in Fig. 6. This, however, brings up another problem: when the rays from a single point source are refracted on different parts of a large spherical lens, they do not all meet accurately at a single focus. Instead, the rays refracted by the outer portions of the lens come to focus nearer to the lens than those that pass through the central portion. This dissimilarity of focus, known technically as "spherical aberration," can be avoided by masking all but the central part of the lens, or "stopping it down," as the photographers say. Doing this, however, cuts down the light-gathering

(CONTINUED ON PAGE 77)

RADIO DESIGNER'S ITEMS

Notes on Methods and Products of Importance to Design Engineers

Amplifier Transformers: A new group of input transformers, known as the 400 series, has been announced by The Langevin Company, Inc., 37 W. 65th Street, New York 23. They are contained in gray enameled cases 1½ ins. in diameter by 2¼ ins. high, and equipped with 10-in. Suprenant color-coded leads. Type 401-A is an input transformer operating from 30/250/600 ohms primary to 30,000 ohms secondary, center-tapped. Type 400-C is a bridging input transformer with a nominal impedance of 600/15,000 ohms to 60,000 ohms secondary. With proper input circuits, the input impedance range is 0/25,000 ohms. Type 402-A is an input transformer of 30/120 ohms primary to 50,000 ohms secondary. Input impedance range is 0/250 ohms. All types have a maximum operating level of +10 VU at .001 milliwatt reference level.

Microphones: Instead of a general catalog for 1945, Universal Microphone Company, Inglewood, Calif., will publish bulletins for distribution to the trade and to jobbers. Two new bulletins, showing 19 different microphones, are now ready.

Milliohmmeter: A 6-scale milliohmmeter, model 673-F, has been added to the line of resistance meters produced by Shallcross Manufacturing Co., Collingdale, Pa. This instrument has a linear scale calibrated for 0–0.5, 1, 5, 10, 50, and 100 ohms, full scale. Separate connections for current and potential are used to minimize the effects of lead and contact resistance when measuring low values. The case carries a single No. 6 dry cell.

Sintered Alnico Magnets: A 20-page brochure on sintered Alnico magnets has been issued by General Electric Company, Schenectady, N. Y. Much valuable data is presented on the manufacturing methods, dies, and tolerances attainable, and on magnetic and mechanical properties of sintered magnets. In addition, there are dimensioned drawings of 76 stock magnet shapes.

Tropicalization: Very interesting data on waxes for the tropicalization of radio and electrical equipment is presented in a pamphlet from Zophar Mills, Inc., 120 26th Street, Brooklyn 32, N. Y. Particular consideration is given to the matter of health hazards resulting from handling waxes containing Pentachlorphenol. Reports of tests made on rabbits showed that such waxes are not likely to give any direct irritative effect when handled by human beings.

Sealed Transformers: A new series of hermetically sealed output transformers is now available from The Acme Electric & Manufacturing Company, Cuba, N. Y. Cases of aluminum, with Pyrex glass terminals and Kovar electrodes are designed to withstand the standard 5-cycle emersion test.

Frequency-Compensated Instruments: Ammeters, voltmeters, and wattmeters of the moving vane and dynamometer types which maintain their accuracy on frequencies from 25 to 3,000 cycles have been developed by Weston Electrical Instrument Company, Newark 5, N. J. They are available in both portable and switchboard types.

Lighthouse Tubes: The first technical data on lighthouse tubes 2C40, 2C43, and GL-559 has been published in a pamphlet from General Electric Company, Schenectady, N. Y. Circuits and performance data, however, are still withheld for military reasons.

FM Tuning: Engineers are greatly relieved over the decision of the FCC to reduce the FM broadcast band to a width of 20 mc., instead of the 30-mc. band first proposed, as this brings the tuning ratio down to a point where it can be covered without a 2-range band switch, and its attendant complications. Moreover, if Alternative No. 1 is finally selected, the reservation of 48 to 50 mc. for facsimile will make this part of the band available temporarily for present FM stations during the period of postwar transition, since prewar sets can cover those channels.

Now, at least, it will be possible to work out the mechanical design of dials and tuning controls for new sets, even though actual calibration must await the FCC's final decision.

VT Frequency Meter: Something new in frequency meters has been developed by J-B-T Instruments, Inc., Chapel Street, New Haven 8, Conn. This instrument combines the standard vibrating-read meter with a multivibrator circuit which divides the incoming frequency by 2, 3, 4, 6, or 9. Thus it is possible to measure frequencies in the 400, 800, 1200, 2400, and 3600-cycle ranges with an accuracy of .25% or better, independent of frequency.

The accuracy is permanent, requiring no subsequent standardization. No protection is required against the accidental application of higher frequencies. Tubes used are two 6N7 multivibrators, a 6N7 input tube, 6J5 buffer, 6V6 amplifier, and a 6X5 rectifier.

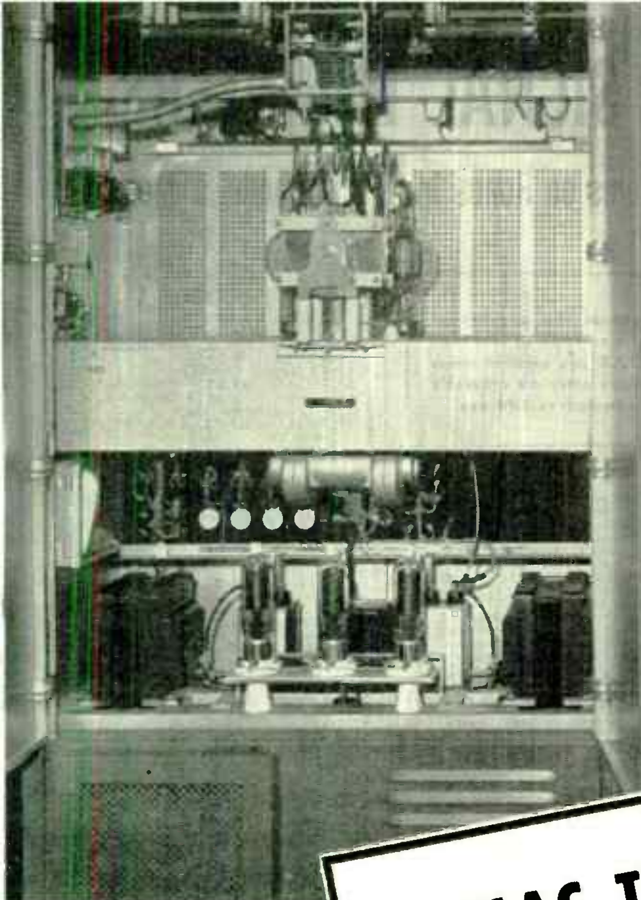
Duplexed Sound & Facsimile: It appears that the first widespread use of facsimile will be in the police services, for it meets an important, unfilled need in recording messages and the transmission of fingerprints and photographs. Discussing the use of facsimile by police services, Lieut. Basil Cutting of the New Hampshire State Police explained that fingerprint and photographic records are kept at the capital city of each state, and that the distribution of such records to municipal police is not practical by mail. Even when specific requests are received from municipal police for fingerprints or photos, much valuable time is lost by transmission through the mails. Thus the use of facsimile will make possible a new degree of coöperation between the state and municipal police.

This introduces a new problem in communications equipment design. The volume of police traffic is too great to hold up speech transmission while the facsimile apparatus is in use. Therefore, separate transmitters and receivers will be required unless a satisfactory method is developed for duplexing these services.

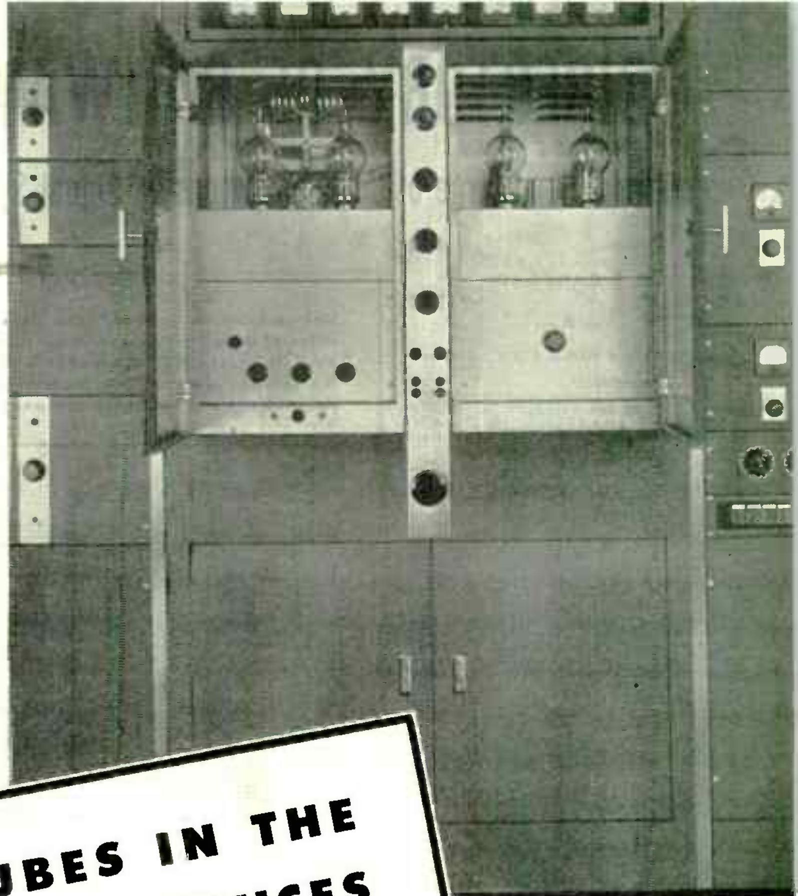
Opinions of the practicability of duplex operation are not in agreement, but the fact is that no one appears to have undertaken the task of perfecting such a system for either police or FM broadcasting. Still, the need for it exists, and it will tap a tremendous market whenever the apparatus is available. In addition, it seems probable that the railroads will be equally interested in duplexed sound and facsimile for confirming verbal orders.

Slide Rule: Because the use of standard slide rules by their engineers called for so frequent reference to mathematical tables, the Standard Transformer Corporation developed a slide rule of its own design which incorporates the 8 tables most commonly used in radio and electrical calculations. Now, this Multi-Slide Rule is being distributed through Stancor jobbers at a price of $1.00, including the carrying case. Orders should not be sent to the Standard Transformer Corporation.

Crystal Mounting: A new low-frequency quartz crystal unit developed by Bliley Electric Company, Erie, Pa., employs a resonant pin assembly to maintain the frequency within narrower limits than has been possible in the past. For frequencies of 70 kc. to 400 kc., the crystal is held between steel pins which are mechanically resonant to the crystal frequency or to a sub-multiple. Thus the damping effect of the mounting upon the crystal is made negligible.

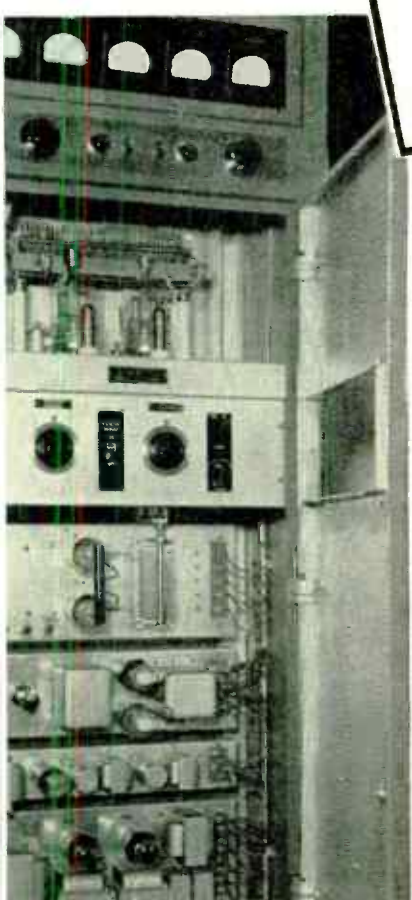


A pair of Eimac 1000-T's give 3 KW output in this Link-built FM transmitter for the emergency services.



500 watt AM police transmitter for 30-40 Mc operation, built by Fred M. Link, using Eimac 250-TH tubes in the final.

Here's a 500 watt supersonic test generator for operation at 1 to 300 kc which uses Eimac 152-T tubes.



EIMAC TUBES IN THE EMERGENCY SERVICES WHERE DEPENDABLE PERFORMANCE COUNTS!

The transmitters shown on this page were developed and built for the emergency services—police, fire and transportation—by Link Radio Corporation of New York City. Recognition such as that enjoyed by the Link organization in this field is built upon sound engineering and the right choice of equipment components. That Eimac tubes occupy the important sockets in these vital transmitters is fitting acknowledgement of their inherently superior performance capabilities. That Fred M. Link specifies Eimac tubes is confirmation of the fact that Eimac tubes are first choice of leading electronic engineers throughout the world.

FOLLOW THE LEADERS TO Eimac TUBES REG. U. S. PAT. OFF.

Get your copy of Electronic Telesis ... the sixty-four page booklet which gives the fundamentals of electronics. This little booklet will help electronic engineers explain the subject to laymen. It's yours for the asking ... no cost or obligation. Available in English and Spanish languages.

EITEL-McCULLOUGH, INC., 1033 San Mateo Ave., San Bruno, Calif.
Plants located at: San Bruno, California and Salt Lake City, Utah
Export Agents: Frazar & Hansen
301 Clay Street, San Francisco 11, California, U. S. A.

DIRECTORY OF RAILWAY SIGNAL ENGINEERS

Officials in Charge of Communications & Signal Systems on Roads in U. S., Canada & Mexico

Unless otherwise noted, each listing shows the number of miles of road operated, and the number and type of locomotives. In most cases, the words RAIL ROAD are omitted from the company name. If no address appears after an official's name, he is located at the company headquarters address.

U. S. RAILROADS

— A —

ABERDEEN & ROCK FISH Aberdeen N C
47 Miles, 5 Steam
J A Bryant General Superintendent
ABILENE & SOUTHERN *See T & P*
AHNAPEE & WESTERN *See G B & W*
AKRON & BARBERTON BELT Barberton Ohio
23 Miles, 6 Steam
C M Potter Superintendent
AKRON CANTON & YOUNGSTOWN 12 E Exchange Akron 8 Ohio
171 Miles, 23 Steam, 1 Diesel
G A Haskins Eng Maint of Way
J V Preto Sig foreman
ALABAMA & VICKSBURG *See Illinois Central*
ALABAMA CENTRAL Jasper Ala
10 Miles, 1 Steam
C A Lee Superintendent
ALABAMA GREAT SOUTHERN *See Southern RR*
ALABAMA TENNESSEE & NORTHERN York Ala
220 Miles, 11 Steam, 2 Gas-Elec, 2 Diesel
G C Nichols General Manager
ALAMEDA BELT LINE Alameda Calif
20 Miles, 3 Oil, 2 Diesel-Elec
L L Davis Superintendent
ALASKA R R Anchorage Alaska
513 Miles, 31 Steam
W L Kinsell Supt Motive Power & Equip
ALBANY & NORTHERN Albany Ga
36 Miles, 5 Steam
J R Hackett General Manager
ALGERS WINSLOW & WESTERN Oakland City Ind
22 Miles, 5 Steam
W H Nichol General Superintendent
ALIQUIPPA & SOUTHERN Aliquippa Pa
44 Miles, 25 Steam
W C Van Blarcom Superintendent
ALLEGHENY & SOUTH SIDE So 10th St & Muriel Pittsburgh Pa
5 Miles, 3 Steam
G A Dietz General Superintendent
ALTON P R Bloomington Ill
959 Miles, 160 Steam, 11 Diesel
H C Sampson Supt Sig & Tele
C Kies Asst Supt Sig
A F Sampson Gen Sig Inspr
ALTON & SOUTHERN Box 270 E St Louis Mo
93 Miles, 18 Steam
W J Nuebling Chief Engineer
Geo H Dauer Signal Supervisor
A L Lenny Superintendent
AMADOR CENTRAL Martell Calif
12 Miles, 3 Oil
H W Loomis General Manager
ANGELINA & NECHES RIVER Keltys Texas
31 Miles, 2 Oil
E L Kurth General Manager
ANN ARBOR R R Decatur Ill
294 Miles, 31 Steam, 1 Diesel-Elec
R J Bellsmith Supt of Tele
APACHE R R McNary Ariz
72 Miles, 2 Oil
W R Fields Master Mechanic
APALACHICOLA NORTHERN Port St Joe Fla
99 Miles, 7 Steam
J L Sharit Superintendent
ARANSAS HARBOR TERM Aransas Pass Tex
7 Miles, 1 Diesel
W A Scrivner Pres
ARCADE & ATTICA Arcade New York
28 Miles, 1 Steam, 1 Diesel
R I Cartwright General Manager
ARKANSAS & LOUISIANA MISSOURI Monroe La
86 Miles, 4 Oil
E S Royster Chief Engineer
ARKANSAS R R Star City Ark
20 Miles, 5 Steam
W R Alsobrook General Manager
AROOSTOOK VALLEY Presque Isle Me
32 Miles, 2 Electric
G B Hallett Manager
ARTEMUS-JELLICO Artemus Ky
14 Miles, 2 Steam
R B Martin General Superintendent
ASHERTON & GULF *See Gulf Coast Lines*
ASHLEY DREW & NORTHERN Crossett Ark
41 Miles, 4 Steam
C L Finch Superintendent
ASPHALT BELT *See Gulf Coast Lines*
ATCHISON TOPEKA & SANTA FE Topeka Kan
13,147 Miles, 12,067 Oil, 159 Diesel-Elec
G K Thomas Signal Engineer
Comprising: Eastern Lines
Western Lines
Coast Lines
Also (Listed Separately)
Gulf Colorado & Santa Fe
Panhandle & Santa Fe
Eastern Lines 2,995 Miles
D W Fuller Signal Engineer Topeka Kan
C B Keers Asst Signal Engineer Topeka Kan
Signal Supervisors:
E H Hahn Newton Kan
F D Hartzell Chillicothe Ill
B R Olin Emporia Kan
E L Salisbury Arkansas City Kan
B F Smith Marceline Mo
Western Lines 3,612 Miles
H A Appleby Signal Eng Amarillo Tex
K Hanson Asst Sig Eng Amarillo Tex
R L Woodling Asst Sig Eng LaJunta Colo
Signal Supervisors:
E F Artman Clovis N M
H L Hutton Las Vegas N M
A N Jackson LaJunta Colo
R C LeHew Dodge City Kan
E H Robinson Amarillo Tex
O T Staley Wellington Kan
Coast Lines 2,500 Miles
E Winans Los Angeles Calif
W F Price Asst Sig Eng Los Angeles Calif.
T A Smith Gen Sig Sup Los Angeles
J N Friedman CTC Eng Los Angeles
Signal Supervisors:
J L Bartlett San Bernardino Calif
J C Bussey Needles Calif
W J Disney Winslow Ariz
W F Douglas Fresno Calif
ATLANTA & ST ANDREWS BAY Dothan Ala
82 Miles, 11 Oil, 5 Diesel-Elec
T L Nichols General Superintendent
ATLANTA & WEST POINT 4 Hunter SE Atlanta 3 Ga
227 Miles, 48 Steam
A T Miller Asst Supt Motive Power
ATLANTA BIRMINGHAM & COAST 26 Cain St NW Atlanta 3 Ga
639 Miles, 61 Steam
C E Brower General Superintendent
W A Spell Chief Engineer
ATLANTIC & CAROLINA Kenansville N C
10 Miles, 2 Steam
J E Jerritt General Manager
ATLANTIC & EAST CAROLINA Kinston N C
96 Miles, 14 Steam, 2 Diesel-Elec
E R Buchan President
ATLANTIC & WESTERN Sanford N C
24 Miles, 3 Steam
E T Usery General Manager
ATLANTIC COAST LINE Wilmington N C
4962 Miles, 237 Steam, 71 Diesel-Elec
F W Brown Vice President Wilmington N C
J S Webb Signal Eng Wilmington N C
S J Davis Act Assistant Engineer Wilmington N C
L White General Superintendent Tele
Signal Supervisors:
W M Adams Rocky Mount N C
O L Chitwood Waycross Ga
J H Lackey Jacksonville Fla
D R Morris Savannah Ga
C H Wiegand Charleston S C

— B —

BALTIMORE & OHIO Baltimore Md
6,144 Miles, 1979 Steam, 9 Electric, 2 Oil, 69 Diesel, 1 Gas
C W Van Horn V Pres (Oper & Maint)
G H Dryden Signal Engineer
Comprising:
New York Terminal Region
Eastern Region
Central Region
Western Region
Also (Listed Separately)
Baltimore & Ohio Chicago Terminal
New York Terminal Region 25 B'way NYC 5 Miles
C M Shriver General Manager
A C Clarke Ch Eng Baltimore Md
C A Salverson Sig Super Staten Is N Y
Eastern Region Baltimore Md
1,975 Miles
F G Hoskins General Manager
F A Baldinger Supt Motive Power
Signal Supervisors:
C R Happ Wheeling W Va
A A Jacobs Baltimore Md
C W Lester Cumberland Md
H W Logsdon Grafton W Va
W L Nethkin Baltimore Md
R T Perrell Cumberland Md
W R Wheat Baltimore Md
Central Region Pittsburgh Pa
2,011 Miles
J D Beltz General Manager
H Rees Supt Motive Power
Signal Supervisors:
J P Buzzerd Pittsburgh Pa
W L Connors Rochester N Y
H H Gault Garrett Ind
J C Hoffman Akron O
T M Walker Connellsville Pa
Western Region Cincinnati Ohio
F B Mitchell General Manager
H J Burkley Supt Motive Power
Signal Supervisors:
G H Cannon Washington Ind
H M Dryden Dayton Ohio
H H Harding Newark Ohio
J W Kunker Cincinnati Ohio
H A Maynard Washington Ind
D W Porterfield Indianapolis Ind
BALTIMORE & OHIO CHICAGO TERMINAL Grand Central Sta Chicago Ill
67 Miles, 16 Steam, 9 Diesel
C M House Supt Motive Power & Equip
J J Clancy Signal Supervisor
BAMBERGER R R Salt Lake City Utah
64 Miles, 9 Electric, 1 Diesel-Elec
J M Bamberger General Manager
BANGOR & AROOSTOOK Bangor Me
596 Miles, 62 Steam
R H MacCready V Pres (Oper)
BARRE & CHELSEA *See Montpelier & Wells River*
BATH & HAMMONDSPORT Hammondsport N Y
8 Miles, 1 Steam
W G Aber Supt of Sig & Comm
BAUXITE & NORTHERN Box 270 E St Louis Ill
7 Miles, 5 Steam
W J Nuebling Ch Eng
BAY POINT & CLAYTON Cowell Calif
9 Miles, 1 Oil
E D Barnett Supt
BAY TERMINAL Toledo Ohio
6 Miles, 1 Steam
H O Cameron Pres & Gen Mgr
BEAUFORT & MOREHEAD Beaufort N C
33 Miles, 2 Steam
A T Leary Gen Mgr
BEAUMONT SOUR LAKE & WESTERN *See Gulf Coast Lines*
BELFAST & MOOSEHEAD LAKE Belfast Me
3 Miles, 3 Steam
W L Bowen Gen Mgr
BELLEFONTE CENTRAL Bellefonte Pa
20 Miles, 3 Steam
G E McClelland V Pres & Gen Mgr
BELT RY CO OF CHICAGO 47 W Polk Chicago
440 Miles, 59 Steam, 9 Diesel
M F Stokes Pres & Gen Mgr
F E Morrow Ch Eng
BENNETTSVILLE & CHERAW Bennettsville N C
23 Miles, 2 Steam
A T Dampier Supt
BENWOOD & WHEELING CONN Wheeling W Va
7 Miles, 4 Steam
F W Kios V Pres
BESSEMER & LAKE ERIE Greenville Pa
214 Miles, 119 Steam, 1 Diesel-Electric
F R Layng Ch Eng
G R Pflasterer Sig Eng
BEVIER & SOUTHERN Bevier Mo
10 Miles, 4 Steam
R Corbin Ch Eng
BIG CREEK & TELOCASET Pondosa Oregon
11 Miles, 1 Steam
T W Collins Pres & Gen Mgr
BIG FOUR *See C C C & St L*
BINGHAM & GARFIELD Magna Utah
33 Miles, 6 Steam, 2 Elec, 4 Diesel-Elec
N E McKinnon Supt
G C Earl Ch Eng
BIRMINGHAM & SOUTH-EASTERN Tallassee Ala
7 Miles, 2 Steam
J H Rainer Gen Mgr
BIRMINGHAM SOUTHERN Fairfield Ala
33 Miles, 16 Diesel-Elec
E W Bean Ch Eng
BLACK MOUNTAIN Erwin Tenn
13 Miles, 1 Steam
L H Phetteplace Gen Mgr
BLUE RIDGE Anderson S C
44 Miles, 3 Steam
J W Smith Supt
BOIS D'ARC & SOUTHERN Texas Bank Bldg Dallas 2 Tex
7 Miles, 2 Gas
E P Gaines Jr Pres & Gen Mgr
BONHOMIE & HATTIESBURG SOUTHERN Hattiesburg Miss
27 Miles, 3 Steam
W O Tatum Exec V Pres
BOSTON & ALBANY Boston Mass
Mileage & Equip included in N Y Central
R J Cullen Supt of Tele & Sig Eng
BOSTON & MAINE Boston Mass
1,819 Miles, 444 Steam, 9 Elec, 35 Diesel
R R Stackpole Supt Tele
J P Muller Eng Sig & Tele
W W Hartzell Field Eng Sig
Signal Supervisors:
L E Norton Dover N H
C P O'Connell Greenfield Mass
A Pennington Boston Mass
A A Wood Concord N H
BOYNE CITY Boyne City Mich
10 Miles, 2 Steam
L H White Gen Mgr
BRIMSTONE R R New River Tenn
13 Miles, 1 Steam
A A Kopp Gen Mgr
BUFFALO CREEK Buffalo N Y
34 Miles, 9 Steam, 4 Diesel-Elec
W M Sporleder Supt
BUFFALO CREEK & GAULEY Dundon Va
19 Miles, 2 Steam
J G Bradley Pres
BUFFALO UNION-CAROLINA Union S C
20 Miles, 3 Steam
L B Woodward Gen Mgr
BURLINGTON MUSCATINE & NORTHWESTERN Cedar Rapids Ia
11 Miles, 2 Steam
R F Knapp Pres & Gen Mgr
BURLINGTON-ROCK ISLAND Houston Texas
228 Miles, 2 Steam
B Bristow Eng
BURLINGTON ROUTE *See C B & Q*
BUSH TERMINAL 107 48th St, Brooklyn N Y
4 Miles, 8 Diesel-Elec
P J Roth V Pres
BUTTE ANACONDA & PACIFIC Anaconda Mont
135 Miles, 3 Steam, 29 Elec
P R Peery Supt Maint Way

— C —

CADIZ R R Cadiz Ky
10 Miles, 2 Steam
W C White Gen Mgr
CALIFORNIA WESTERN & NAVIGATION Ft Bragg Calif
49 Miles, 5 Oil
A T Nelson Gen Mgr
CAMBRIA & INDIANA Colver Pa
35 Miles, 10 Steam
J H Smith Supt
D L Rodgers Eng Maint Way
CAMINO PLACERVILLE & LAKE TAHOE Camino Calif
9 Miles, 2 Oil
S Berry Pres
CAMPBELL'S CREEK Reed W Va
18 Miles, 4 Steam
R Hatfield Gen Mgr
CANTON & CARTHAGE Canton Miss
57 Miles, 1 Steam
C L Freiler Gen Mgr
CANTON R R 300 Water Baltimore Md
35 Miles, 11 Steam
H M Diver Supt
CAPE FEAR R R Fort Bragg N C
32 Miles, 2 Steam, 2 Electric
H H Latham Supt of Sig & Comm
CARBON CO R R Columbia Utah
5 Miles, 2 Diesel-Elec
H R Malaby Gen Mgr
CAROLINA & NORTHWESTERN McPherson Sq Washington D C
113 Miles, 13 Steam
L C Walters Supt of Sig & Comm
H E Johnson Supt Hickory N C
CAROLINA CLINCHFIELD & OHIO *See Clinchfield R R*
CAROLINA CLINCHFIELD & OHIO RY OF SO CAROLINA *See Clinchfield R R*
CAROLINA SOUTHERN Windsor N C
22 Miles, 2 Steam
J H Matthews Gen Mgr
CAROLINA WESTERN Sumter S C
5 Miles, 2 Steam
T H Brice Pres
CARROLLTON R R Carrollton, Ky
9 Miles, 1 Steam
R L Booth V Pres
CASSVILLE & EXETER Cassville Mo
5 Miles, 1 Steam
R Dingler V Pres
CASTLEMAN RIVER 7006 Haze Ave Bywood Upper Darby Pa
13 Miles, 1 Steam
J Hersker Pres & Gen Mgr
CEDAR RAPIDS & IOWA CITY Cedar Rapids Ia
28 Miles, 7 Electric
A R Swem Gen Supt & Ch Eng
CENTRAL CALIFORNIA TRACTION Stockton Calif
53 Miles, 6 Electric
W L White Gen Mgr
CENTRAL INDIANA Indianapolis Ind
52 Miles, 3 Steam
J D Fuchs Supt
CENTRAL OF GEORGIA Savannah Ga
1,816 Miles, 234 Steam, 14 Diesel-Elec
R R Cummins Gen Mgr
E B DeMeritt Sig Eng Macon Ga
R M Hitchcock Super Tele Macon Ga
CENTRAL R R CO OF N J Jersey City 2 N J
657 Miles, 369 Steam, 24 Diesel
E T Moore Gen Mgr
R W Keller Elec Eng
F W Bender Sig Eng
CENTRAL VERMONT *See Canadian Nat'l Ry*
CHARLES CITY WESTERN Charles City Ia
23 Miles, 2 Elec, 1 Diesel-Elec
J F Christiansen V Pres & Gen Mgr
CHARLESTON & WESTERN CAROLINA Wilmington N C
343 Miles, 45 Steam

JENSEN RADIO MANUFACTURING COMPANY, 6601 SOUTH LARAMIE AVENUE, CHICAGO 38, ILLINOIS

SCHEDULE OF DIRECTORIES IN *FM* AND TELEVISION

JANUARY All Police and Emergency Stations in the U. S. A.—includes names of the Radio Supervisors. CLOSING DATE JAN. 5	**FEBRUARY** Radio Products Directory, listing manufacturers of equipment, components, materials, and supplies. CLOSING DATE FEB. 5	**MARCH** FM, AM, and Television Stations in the U. S. A. and Canada—includes general managers, chief engineers. CLOSING DATE MAR. 5	**APRIL** Set and Parts Jobbers, listing general managers & service managers; and Factory Representatives CLOSING DATE APR. 5
MAY Radio Manufacturers in the U. S. A.—includes the names of general managers and chief engineers. CLOSING DATE MAY 5	**JUNE** Railway Signal Engineers on all roads in the United States, Canada and Mexico. CLOSING DATE JUNE 5	**JULY** All Police and Emergency Stations in the U. S. A.—includes names of the Radio Supervisors. CLOSING DATE JULY 5	**AUGUST** Radio Products Directory, listing manufacturers of equipment, components, materials, and supplies. CLOSING DATE AUG. 5
SEPTEMBER FM, AM, and Television Stations in the U. S. A. and Canada—includes general managers, chief engineers. CLOSING DATE SEPT. 5	**OCTOBER** Set and Parts Jobbers, listing general managers & service managers; and Factory Representatives CLOSING DATE OCT. 5	**NOVEMBER** Radio Manufacturers in the U. S. A.—includes the names of general managers and chief engineers. CLOSING DATE NOV. 5	**DECEMBER** Railway Signal Engineers on all roads in the United States, Canada and Mexico. CLOSING DATE DEC. 5

U. S. RAILROADS, Continued

F W Brown Gen Mgr
CHATTAHOOCHEE VALLEY West Point Ga
27 Miles, 3 Steam
R F Lanier Pres
CHESAPEAKE & OHIO Richmond Va
3,073 Miles 895 Steam
A T Lowmaster Exec V Pres
W N Hartman Supt Tele & Sig
D K Roll Super Sig Constr
C E Nauman Gen Super Tele & Telo Maint
H C Land Tele & Telo Eng
Supervisors of Signals:
E T Garrison Clifton Forge Va
H M Johnson Peru Ind
W H Miller Columbus O
C Persinger Covington Ky
R L Thompson Hinton W Va
S R Thompson Huntington W Va
A M Weeks Richmond Va
CHESAPEAKE WESTERN 141 W Bruce St Harrisonburg Va
52 Miles, 5 Steam
J C Black Supt
CHESTNUT RIDGE 160 Front St New York N Y
14 Miles, 3 Steam
L S Holstein Gen Mgr
CHICAGO & EASTERN ILL 332 S Mich Chicago
720 Miles, 152 Steam, 12 Diesel
F G Nicholson Gen Mgr
G P Neal Supt Sig & Tele Danville Ill
Signal Supervisors:
E Folley Danville Ill
E R Lindsey Evansville Ind
G C Seifert Salem Ill
H Duncan Danville Ill
CHICAGO & ILLINOIS MIDLAND Illinois Bldg Springfield Ill
131 Miles, 26 Steam
G W Imgrund Gen Supt
CHICAGO & ILLINOIS WESTERN 135 E 11th Pl Chicago 5 Ill
12 Miles, 4 Steam, 1 Diesel
J L Beven Pres
CHICAGO & NORTHWESTERN 400 W Madison St Chicago 6 Ill
8,077 Miles, 600 Steam, 30 Diesel
S E Noble Supt Tele & Sigs
O S Tomkins Asst Supt Tele & Sigs
M E Moyer Asst Supt Tele & Sigs
Supervisors of Telegraph & Signals:
P O Gladhill Madison Wis
C C Mansfield Boone Ia
H F Mock Chicago Ill
E V Shatwell West Chicago Ill
P A Starck Milwaukee Wis
CHICAGO & WESTERN INDIANA 47 W Polk Chicago 5 Ill
172 Miles, 19 Steam
G M Kelly Sig Super
CHICAGO ATTICA & SOUTHERN Box 169 Attica Ind
63 Miles, 5 Steam
F E Cheak Gen Supt
CHICAGO AURORA & ELGIN Wheaton Ill
112 Miles, 4 Electric
E R Ander Elec Eng
R G Kendall Comm Eng
CHICAGO BURLINGTON & QUINCY 547 W Jackson Chicago 6 Ill
9,024 Miles, 871 Steam, 80 Oil, 4 Gas-Elec, 75 Diesel-Elec
W F Zane Sig Eng Chicago
A L Essman Prin Asst Sig Eng Chicago
L Stueber Asst Sig Eng Lincoln Neb
Lines East of Missouri River 4,556 Mi
O E Ward Supt Motive Power
Signal Supervisors:
C T Bishop Aurora Ill
J H LaChance Ottumwa Ia
W W Swanson Galesburg Ill
F A Tegeler St Joseph Mo
R L Vaughn Harrison & Canal Chicago
Lines West of Missouri River 1004 Mi
Farnam Omaha 8 Neb 4,594 Miles
L Stueber Asst Sig Eng Lincoln Neb
P W Gage Sig Super Lincoln Neb
A M Horn Sig Super McCook Neb
CHICAGO GREAT WESTERN 309 W Jackson Blvd Chicago 6 Ill
1,500 Miles, 156 Steam, 6 Diesel, 2 Gas
S M Golden V Pres
T H Kearton Supt Tele & Sig
G R Holsington Asst Supt Tele
Signal Supervisors:
L D Allison Oelwein Ia
E J Klaas Oelwein Ia
W J O'Neil St Paul Minn
CHICAGO HEIGHTS TERMINAL TRANSFER
332 S Michigan Chicago 4
7 Miles, 3 Steam, 2 Diesel
F G Nicholson V Pres & Gen Mgr
CHICAGO INDIANAPOLIS & LOUISVILLE Lafayette Ind
541 Miles, 85 Steam, 4 Diesel-Elec
A Anderson Asst Ch Oper Off & Ch Eng
E G Stradling Supt Tele & Sig
E E Ireland Sig Super
CHICAGO JUNCTION *See Chicago River & Ind*
CHICAGO KALAMAZOO & SAGINAW *See Michigan Central*
CHICAGO MILWAUKEE ST PAUL & PACIFIC Union Station Chicago 6 Ill
10,411 Miles, 1008 Steam, 52 Elec, 82 Oil, 74 Diesel
J T Gillick Ch Oper Off
L B Porter Supt Tele & Sig
Eastern Lines 7,346 Miles
O N Harstad Gen Mgr Chicago Ill
J P Kaysen Asst Supt Sig Milwaukee Wis
E J Muckerheide Tele & Telo Eng Milwaukee Wis
J A Henry Super Tele & Sig Milwaukee Wis
Supervisors of Telegraph & Signals:
A F Alexander Minneapolis Minn
E D Barton Mason City Ia
R S Bentley Terre Haute Ind
F W Bornitzke Milwaukee Wis
G C Downing Milwaukee Wis
R C Dueland Ottumwa Ia
H J Dunn Minneapolis Minn
J F McConahay Milwaukee Wis
M H Schmidt Marion Ia
W H Stevens Savanna Ill
Western Lines 30,065 Miles
L W Smith Supt Tele & Sig Seattle Wash
Telegraph & Signal Supervisors:
E P Allen Tacoma Wash
R M Lloyd St Maries Idaho
C O McPherson Miles City Mont
E T McPherson Butte Mont
CHICAGO NORTH SHORE & MILWAUKEE 72 W Adams Chicago
297.8 Miles, 8 Electric
R G Kendall Comm Eng
W G Fitzgerald Sig Sup Highwood Ill
CHICAGO RIVER & INDIANA La-Salle St Sta Chicago 5 Ill
228 Miles, 35 Steam, 12 Diesel
W L Houghton Supt Equip Chicago
S L Van Akin Supt Tele Detroit Mich
CHICAGO ROCK ISLAND & PACIFIC LaSalle St Station Chicago 5 Ill
7,751 Miles, 722 Steam, 116 Diesel,
C R Swenson Sig Eng Chicago
E A Dahl Electronic Eng
C M Duffy Asst Sig Eng El Reno Okla
C E Hartvig Asst Sig Eng Chicago Ill
C O Ellis Supt Tele Chicago Ill
G E Byram Tele & Telo Super Kansas City
Signal Supervisors:
E L Bartholomew Liberal Kan
B F Beasley Des Moines Ia
C Hattery Fairbury Neb
F E Kinney Cedar Rapids Ia
H B McCallum Rock Island Ill
L E Nordholm Trenton Mo
F H Rich El Reno Okla
J P Zahnen Blue Island Ill
CHICAGO ST PAUL MINNEAPOLIS & OMAHA 400 W Madison Chicago 6
1,617 Miles, 234 Steam, 8 Diesel
S E Noble Supt Tele & Sig Chicago
O S Tomkins Asst Supt Tele & Sig Chicago
F W Bieler Gen Sig Super St Paul Minn
CHICAGO SHORT LINE South Chicago Ill
29 Miles, 6 Steam, 3 Diesel-Elec
A E Feeley Gen Mgr
CHICAGO SOUTH SHORE & SOUTH BEND Michigan City Ind
77 Miles, 16 Electric
C H Jones V Pres & Gen Mgr
CHICAGO TERRE HAUTE & SOUTHEASTERN *See Chicago Milwaukee St Paul & Pacific*
CHICAGO WEST PULLMAN & SOUTHERN West Pullman Ill
31 Miles, 11 Steam
W J Wheaton Maint of Way Eng
CINCINNATI BURNSIDE & CUMBERLAND RIVER *See Southern Railway System*
CINCINNATI NEW ORLEANS & TEXAS PACIFIC *See Southern Railway System*
CITY OF PRINEVILLE Prineville Ore
18 Miles, 3 Oil
C W Woodruff Mgr
CLARENDON & PITTSFORD Proctor Vt
18 Miles, 3 Steam
H A Collin Master Mech
CLARION RIVER Ridgway Pa
11 Miles, 1 Steam
R E Cartwright V Pres
CLEVELAND CINCINNATI CHICAGO & ST LOUIS Indianapolis Ind
Mileage & Equip included in New York Central
J J Corcoran Sig Eng Cleveland Ohio
B J Schwendt Asst Sig Eng Cincinnati O
C D Cronk Asst Sig Eng Cleveland O
C E Baxter Supt Tele Detroit Mich
Signal Supervisors:
R H Burkett Bellefontain Ohio
L Clark Indianapolis Ind
C W Hummel Mattoon Ill
W V Moak Springfield Ohio
CLINCHFIELD R R Erwin Tenn
302 Miles, 76 Steam
Comprising: Carolina Clinchfield & Ohio Carolina Clinchfield & Ohio of S C
L H Phetteplace Gen Mgr
COLORADO & SO EASTERN Delagua Colo
18 Miles, 2 Steam
A McNew Supt
COLORADO & SOUTHERN Denver Colo
748 Miles, 64 Steam, 9 Oil, 1 Diesel
A E Parnell Supt Tele & Sig
COLORADO & WYOMING 1755 Glenarm Pl Denver Colo
114 Miles, 21 Steam
W Wire V Pres
COLORADO RAILROAD INC Pueblo Colo
33 Miles, 1 Gas-Elec
I MacDaniel Sec & Treas
COLUMBIA & COWLITZ Tacoma Wash
8 Miles, 1 Oil
C H Ingram V Pres
COLUMBIA NEWBERRY & LAURENS Columbia S C
75 Miles, 6 Steam
J P Taylor Pres & Gen Mgr
COLUMBUS & GREENVILLE Columbus Miss
168 Miles, 28 Steam
I H Atkins Supt Tele
CONDON KINZUA & SOUTHERN Kinzua Oregon
24 Miles, 1 Oil
C C Coleman Supt
CONEMAUGH & BLACK LICK Johnstown Pa
48 Miles, 27 Steam
R F Campbell V Pres & Gen Supt
COPPER RANGE 89 Broad St Boston Mass
101 Miles, 9 Steam
P F Beaudin V Pres
CORNWALL R R Bethlehem Pa
36 Miles, 9 Steam
P A Trageser V Pres
COTTON BELT ROUTE *See St Louis Southwestern*
COUDERSPORT & PORT ALLEGANY Coudersport Pa
33 Miles, 3 Steam
W F Du Bois Pres
COWLITZ CHEHALIS & CASCADE Seattle Wash
32 Miles, 3 Oil
J N Davis Pres
CRAIG MOUNTAIN Winchester Idaho
6 Miles, 1 Steam
R Hansen Gen Supt
CUMBERLAND & MANCHESTER *See Louisville & Nashville*
CUMBERLAND & PENNSYLVANIA Cumberland Md
50 Miles, 11 Steam
W Claus Gen Mgr
CUYAHOGA VALLEY 3341 Jennings Rd Cleveland Ohio
14 Miles, 9 Steam
W M Lorenz Pres & Gen Mgr

— D —

DALLAS TERMINAL R R & UNION DEPOT CO
See St Louis Southwestern
DANSVILLE & MOUNT MORRIS Dansville N. Y.
9 Miles, 2 Steam
F A Hart V Pres & Gen Mgr
DANVILLE & WESTERN Danville Va
82 Miles, 5 Steam
W J O'Pry Supt
DARDANELLE & RUSSELLVILLE Dardanelle Ark
7 Miles, 3 Steam
A P Rudowsky V Pres
DAVENPORT ROCK ISLAND & NORTHWESTERN Davenport Ia
48 Miles, 10 Steam
F S Weisbrook Gen Mgr
DE KALB & WESTERN De Kalb Miss
12 Miles, 2 Steam
E H Jones Pres
DELAWARE & HUDSON Albany N Y
848 Miles, 355 Steam, 5 Oil, 1 Diesel-Elec
S H Rice Sig Eng & Supt Tele
J A Vallee Super Sig Constr
Signal Supervisors:
C M Acker Albany N Y
B H Richards Oneonta N Y
T R Robson Carbondale Pa
DELAWARE LACKAWANNA & WESTERN 140 Cedar New York City
1604 Miles, 370 Steam, 141 Motor cars, 33 Diesel-Elec
G J Ray V Pres New York City
A Reilly Sig Eng Hoboken N J
C L Thomas Telo Eng Hoboken N J
Signal Supervisors:
G E Goeppert Buffalo N Y
J R Heisler Scranton Pa
I K Johnson Hoboken N J
DELRAY CONNECTING 7501 W Jefferson Ave Detroit 32 Mich
28 Miles, 6 Steam
G J Mobley Pres
DELTA VALLEY & SOUTHERN Wilson Ark
18 Miles, 2 Steam
E D Bryan V Pres & Gen Mgr
DENVER & INTERMOUNTAIN Denver Colo
56 Miles, 6 Electric
H Detrick Supt Equip
DENVER & RIO GRANDE WESTERN Rio Grande Bldg Denver Colo
2,405 Miles, 321 Steam, 41 Diesel-Elec
W W Pulham Supt Denver Colo
B W Molis Sig Eng Denver Colo
O H Brown Sig Constr Eng Denver Colo
J Ayer Sig Super Provo Utah
C R Homberg Sig Super Pueblo Colo
B C Eaton Sig Super Grand Jct Colo
DENVER & SALT LAKE Denver Nat'l Bldg Denver Colo
231 Miles, 39 Steam
W H Sagstetter Asst to Pres
S J Wirz Supt Tele
DEQUEEN & EASTERN DeQueen Ark
36 Miles, 1 Oil
J C Leeper V Pres
DES MOINES & CENTRAL IOWA 114 11th St Des Moines Ia
75 Miles, 7 Elec
H A Benjamin Pres & Gen Mgr
DES MOINES UNION Decatur Ill
40 Miles, 5 Steam
R J Bellsmith Supt of Tele
DETROIT & MACKINAC Tawas City Mich
242 Miles, 18 Steam, 1 Gas
C A Pinkerton Pres & Gen Mgr
DETROIT & TOLEDO SHORE LINE Monroe Mich
59 Miles, 25 Steam
O H Sessions Eng Maint of Way
DETROIT CARO & SANDUSKY Caro Mich
44 Miles, 4 Steam
J W MacLachlan Gen Mgr
DETROIT TERMINAL 14517 Woodward Ave Detroit Mich
18 Miles, 28 Steam
D G Cohan Gen Mgr
DETROIT TOLEDO & IRONTON 4921 Calhoun Ave Dearborn Mich
464 Miles, 49 Steam 2 Diesel
W G Clinton Supt Sig & Comm
P L Forbes Supt Tele & Telo
DONIPHAN KENSETT & SEARCY *See Mo Pac R R*
DONORA SOUTHERN Donora Pa
16 Miles, 1 Steam
F E Van Woert V Pres & Gen Supt
DULUTH & IRON RANGE *See Duluth Missabe & Iron Range*
DULUTH & NORTHEASTERN Cloquet Minn
12 Miles, 5 Steam
G E Nichols V Pres & Gen Mgr
DULUTH MISSABE & IRON RANGE Duluth Minn
545 Miles, 139 Steam
A L Ledin Supt
DULUTH SOUTH SHORE & ATLANTIC Minneapolis Minn
535 Miles, 32 Steam
R C Wickizer Supt Tele 509 W Roosevelt Rd Chicago Ill
DURHAM & SOUTHERN Durham N C
59 Miles, 4 Steam
M D Clark Supt

— E —

EAST BROAD TOP Rockhill Furnace Pa
70 Miles, 9 Steam
C D Jones V Pres (Oper)
EAST CAROLINA Farmville N C
25 Miles, 1 Steam
W H Newell Gen Mgr
EAST ERIE COMMERCIAL Erie Pa
12 Miles, 4 Diesel-Elec
J H Huntt Pres & Gen Mgr
EAST JERSEY R R & TERM Bayonne N J
4 Miles, 4 Diesel
J A Gillespie Supt

EAST JORDAN & SOUTHERN East Jordan Mich
22 Miles, 1 Steam, 1 Gas
H P Porter Pres & Gen Mgr

EASTLAND WICHITA FALLS & GULF Eastland Texas
28 Miles, 2 Oil
C J Rhodes V Pres Gen Supt

EAST ST LOUIS JUNCTION Nat'l Stock Yards Chicago Ill
36 Miles, 8 Steam
G L Schiele Supt

EAST TENNESSEE & WESTERN NORTH CAROLINA Johnson City Tenn
34 Miles, 6 Steam
W H Blackwell V Pres & Gen Mgr

EAST WASHINGTON Seat Pleasant Md
3 Miles, 2 Steam
J M Rector Pres & Gen Mgr

EDGEMOOR & MANETTA Edgmoor S C
3 Miles, 1 Steam
R A Willis Gen Mgr

EL DORADO & WESSON El Dorado Ark
10 Miles, 3 Oil
H D Reynolds Pres

ELGIN JOLIET & EASTERN Joliet Ill
392 Miles, 174 Steam, 63 Diesel-Elec
T M Milligan Gen Supt
F C Stuart Sig Eng
F W Furnas Asst Sig Eng

ERIE R R Midland Bldg Cleveland O
2,377 Miles, 761 Steam, 12 Diesel-Elec, 1 Gas-Elec
W S Storms Sig Eng
J P Kreiter Act Supt Tele & Telo
G D Poole Tele & Telo Eng
Eastern District 1,171 Miles
R C Randall Gen Mgr Jersey City N J
Signal Supervisors:
R C Galleher Hornell N Y
M J Menzie (Asst) Binghamton N Y
S D Richardson (Asst) Paterson N J
J H Storms Paterson N J
A C Turner Buffalo N Y
Western District 1,206 Miles
A E Kriesien Gen Mgr Youngstown O
Signal Supervisors:
O G Carey Marion O
C L Castor Youngstown O
E F Champlin Huntington Ind
A E Young Salamanca N Y
F Youngwerth (Asst) Youngstown O

ERIE & MICHIGAN RY & NAVIGATION Alabaster Mich
11 Miles, 1 Steam
A A Bigelow Gen Supt

ESCANABA & LAKE SUPERIOR Wells Mich
95 Miles, 5 Steam
G W Brown Supt

ETNA & MONTROSE Etna Pa
1 Mile, 3 Stream
M J Strueber Supt

EVANSVILLE & OHIO VALLEY Evansville Ind
14 Miles, 1 Elec
W R Hickrod Gen Mgr

EVANSVILLE SUBURBAN & NEWBURGH Evansville Ind
25 Miles, 3 Steam
C H Hendricks V Pres & Gen Mgr

— F —

FAIRPORT PAINESVILLE & EASTERN Painesville Ohio
20 Miles, 8 Steam
L L Dixon Pres & Gen Mgr

FEATHER RIVER Feather Falls Calif
30 Miles, 5 Steam
C J Everett Supt of Sig & Comm

FEDERAL VALLEY *See N Y Central*

FERNWOOD COLUMBIA & GULF Fernwood Miss
44 Miles, 3 Steam
P H Enochs Supt of Sig & Comm

FLEMINGSBURG & NORTHERN Flemingsburg Ky
7 Miles, 1 Gas-Elec
G Faulkner Gen Mgr

FLINT RIVER & NORTH EASTERN Moultrie Ga
23 Miles, 3 Steam
F R Pidcock Gen Mgr

FLORIDA EAST COAST St Augustine Fla
682 Miles, 102 Oil, 6 Diesel-Elec
W A Hoffman Supt Tele & Sig
C U Jellison Telo & Tele Insp

FONDA JOHNSTOWN & GLOVERSVILLE Gloversville N Y
20 Miles, 4 Steam
J Zimmer Pres

FORDYCE & PRINCETON Fordyce Ark
9 Miles, 2 Oil
B A Mayhew V Pres & Gen Mgr

FORE RIVER Bethlehem Pa
7 Miles, 6 Steam
P A Trageser V Pres

FT DODGE DES MOINES & SOUTHERN Boone Ia
150 Miles, 12 Elec
C H Crooks Pres & Gen Mgr

FORT MYERS SOUTHERN *See Atlantic Coast Line*

FT SMITH SUBIACO & ROCK ISLAND Paris Ark
15 Miles, 1 Steam
B A Brown Gen Mgr

FT WORTH & DENVER CITY 307 W 6th St Fort Worth Texas
804 Miles, 58 Oil, 4 Diesel-Elec
W F Zane Sig Eng Chicago Ill
H H Hasselbacher Gen Supt Tele Chicago
A E Parnell Supt Tele Denver Colo

FORTH WORTH BELT *See Texas & Pacific*

FRANKFORT & CINCINNATI Frankfort Ky
41 Miles, 5 Steam
J M Perkins Pres & Gen Mgr

— G —

GAINESVILLE MIDLAND Gainesville Ga
74 Miles, 5 Steam
F W Webb Supt

GALESBURG & GREAT EASTERN Bank Bldg Indianapolis Ind
10 Miles, 2 Steam
R H Sherwood Pres

GALVESTON HOUSTON & HENDERSON Galveston Texas
50 Miles, 7 Oil
N E Smith Supt Sig & Comm

GALVESTON WHARVES Galveston Texas
51 Miles, 7 Steam
R E Fristoe Ch Eng

GARDEN CITY WESTERN Garden City Kan
14 Miles, 1 Oil
J Stewart Pres & Gen Mgr

GENESEE & WYOMING Scranton Pa
15 Miles, 5 Steam
H C Finch V Pres & Gen Mgr

GEORGIA & FLORIDA Augusta Ga
408 Miles, 32 Steam
Chas McDiamid Supt Sig & Comm

GEORGIA NORTHERN Moultrie Ga
68 Miles, 6 Steam
C W Pidcock Pres & Gen Mgr

GEORGIA R R 4 Hunter St Atlanta Ga
329 Miles, 53 Steam
C A Wickersham Gen Mgr

GEORGIA SOUTHERN & FLORIDA *See Southern Railway System*

GRAFTON & UPTON Hopedale Mass
15 Miles, 2 Elec
A D Johnson Gen Mgr

GRAHAM COUNTY Oil City Pa
12 Miles, 1 Steam
J B Veach Pres

GRASSE RIVER Conifer N Y
16 Miles, 2 Steam
W C Sykes Pres

GRAYSONIA NASHVILLE & ASHDOWN Nashville Ark
27 Miles, 3 Steam
J W Dawson Gen Sup & Ch Eng

GREAT NORTHERN St Paul Minn
8,372 Miles, 423 Steam, 386 Oil, 12 Elec 66 Diesel-Elec, 31 Gas-Elec Motor Cars, 2 Diesel-Elec Motor Cars
H E Brashares Supt Sig
P G Seaholm Asst Supt Sig
R C Thayer Supt Tele St Paul Minn
S J Bowers Asst Supt Tele Spokane Wash
Signal Supervisors:
J P Melby Seattle Wash
H Ottoson Minneapolis Minn

GREAT WESTERN P O Box 5308 Terminal Annex Denver Colo
84 Miles, 9 Steam
D J Roach V Pres

GREENBAY & WESTERN Green Bay Wis
234 Miles, 12 Steam, 1 Diesel-Elec
H E McGee Pres

GREENVILLE & NORTHERN Greenville S C
19 Miles, 2 Steam
F G Hamblen V Pres & Gen Mgr

GULF & SHIP ISLAND *See Ill Central*

GULF COAST LINES Comprising:
Asherton & Gulf
Asphalt Belt
Beaumont Sour Lake & Western
Houston & Brazos Valley
New Iberia & Northern
New Orleans Texas & Mexico
Orange & Northwestern
Rio Grande City
St Louis Brownsville & Mexico
San Antonio Southern
San Antonio Uvalde & Gulf
San Benito & Rio Grande Valley
Sugar Land
1,734 Miles, 5 Steam, 93 Oil, 2 Elec, 7 Diesel
L S Werthmuller Sig Eng St Louis Mo
H L Robertson Asst Sig Eng Houston
W Rogers Supt Tele St Louis Mo
R H Richter Asst Supt Tele Houston Tex

GULF COLORADO & SANTA FE Galveston Texas
2,098 Miles, Equip incl in A T & S F
V O Smeltzer Sig Eng
W L Talevich Asst Sig Eng
J L L Lee Tele Mgr
Signal Supervisors:
W E Benson Temple Tex
G T Leonard Ft Worth Tex
P H Yarbrough Galveston Tex

GULF MOBILE & OHIO Mobile Ala
1,963 Miles, 160 Steam, 13 Diesel
K P Goodwin Supt Telo Tele & Sig
G D McDonald Super Telo Tele & Sig
J M Wuerpel Super Sig

— H —

HAMLIN & NORTHWESTERN Vernon Texas
11 Miles, 1 Oil
H U Jackson Pres & Gen Mgr

HAMPTON & BRANCHVILLE Hampton S C
49 Miles, 4 Steam
E O Lightsey V Pres

HANNIBAL CONNECTING Northampton Pa
4 Miles, 3 Steam
A F Tidabock Pres

HARBOR BELT LINE San Pedro Calif
118 Miles, 16 Oil
L L Laughlin Gen Mgr

HARRIMAN & NORTHEASTERN *See So Ry System*

HARTWELL R R Anderson S C
10 Miles, 1 Steam
C Quin V Pres

HELENA SOUTHWESTERN West Helena Ark
287 Miles, 4 Steam
F W Schatz Gen Mgr

HIGH POINT-THOMASVILLE & DENTON High Point N C
34 Miles, 5 Steam
O A Kirkman Exec V Pres & Gen Mgr

HILLSBORO & NORTH EASTERN Hillsboro Wis
6 Miles, 1 Gas
J A Cesnik Pres & Gen Mgr

HOBOKEN MANUFACTURERS R R Hoboken N J
11 Miles, 3 Diesel-Elec, 1 Gas
A R Macgowan Supt

HOOPPOLE YORKTOWN & TAMPICO Hooppole Ill
12 Miles, 1 Steam
A R Mathis Gen Mgr

HOOSAC TUNNEL & WILMINGTON Readsboro Vt
12 Miles, 2 Steam
J A Long Gen Supt

HOUSTON & BRAZOS VALLEY *See Gulf Coast Lines*

HOUSTON BELT & TERMINAL Union Sta Bldg Houston Texas
26 Miles, 7 Oil, 1 Diesel
G M Leach Gen Mgr

HUNTINGDON & BROAD TOP MOUNTAIN Saxton Pa
74 Miles, 9 Steam
F E Steele Supt

HUTCHINSON & NORTHERN Hutchinson Kan
6 Miles, 2 Elec
S B Horrell Gen Supt

— I —

ILLINOIS CENTRAL SYSTEM 135 E 11th Place Chicago 5 Ill
10,819 Miles, 1370 Steam, 37 Diesel, 140 Motor Cars, 140 Trailer
Comprising:
Alabama & Vicksburg
Gulf & Ship Island
Illinois Central
Vicksburg Shreveport & Pacific
Yazoo & Mississippi Valley
W M Vanderslus Gen Supt Tele & Sig
H G Morgan Sig Eng
R C Bingham Asst to Sig Eng
J M Trissal Elec Eng Fixed Property
P B Burley Electronics Eng
G K Phillis Asst Supt Tele
J C Ramage Super Telo & Tele Equip
G R Stewart Telo & Tele Eng
D C Walker Asst Supt Tele Rm 411 Grand Central Sta Memphis Tenn
C H Edney Super Telo & Tele Equip 411 Grand Central Sta Memphis Tenn
A L Stahl Telo & Tele Eng Memphis Tenn
District Foremen Telegraph:
L P Anderson Chicago Ill
L H Carlyle Memphis Tenn
D Davis Carbondale Ill
J C Doyle Champaign Ill
J A Holliday Jackson Miss
B R Peck Waterloo Ia
L R Willingham Fulton Ky

ILLINOIS NORTHERN 180 N Michigan Chicago
28 Miles, 9 Steam
W J Wheaton Maint of Way Eng

ILLINOIS TERMINAL Springfield Ill
456 Miles, 22 Steam
John Leisenring Supt of Sig & Comm

INDIANA HARBOR BELT Detroit Mich
628 Miles, 116 Steam
S L Van Akin Supt Tele
C E Rowe Sig Super Englewood Ill
W L Murphy Asst Sig Super Englewood Ill

INDIANA NORTHERN 533 S Chapin St South Bend Ind
4 Miles, 2 Steam
G R Lanphere V Pres

INDIANA SERVICE CORP 2101 Spy Run Fort Wayne Ind
18 Miles, 2 Elec
E A Luhman Gen Mgr

INDIANAPOLIS UNION Union Station Chicago
16 Miles, 11 Steam
J M Symes Pres

INTERNATIONAL-GREAT NORTHERN Houston Tex
1,155 Miles, 103 Oil, 10 Diesel
H L Robertson Act Asst Eng Sig
R H Richter Asst Supt Tele
L S Werthmuller Sig Eng St Louis Mo
W Rogers Supt Tele St Louis Mo

INTERNATIONAL R R 43 Court St Buffalo N Y
121 Miles, 3 Elec
B J Yungbluth Pres & Gen Mgr

INTERSTATE R R Andover Va
55 Miles, 13 Steam
H A Ramsey V Pres

IOWA TRANSFER Des Moines 9 Ia
3 Miles, 1 Elec
F C Hubbell Pres

— J —

JACKSONVILLE TERMINAL Jacksonville Fla
51 Miles, 11 Steam, 2 Oil
J L Wilkes Pres & Gen Mgr

JAMESTOWN WESTFIELD & NORTHWESTERN Jamestown N Y
33 Miles, 2 Elec
M P Gross V Pres & Gen Mgr

JAY STREET CONNECTING 71 Water St N Y C
5 Miles, 1 Gas
C K Woodbridge Pres

JOHNSTOWN & STONY CREEK Johnstown Pa
3 Miles, 3 Steam
C M Kimmel Pres

— K —

KANAWHA CENTRAL Charleston W Va
5 Miles, 1 Steam
H H Fletcher Gen Mgr

KANSAS & MISSOURI 1711 Minn Ave Kansas City Mo
6 Miles, 2 Elec
W H Cummins Sec

KANSAS CITY CONNECTING Livestock Exch Bldg Kansas City Mo
12 Miles, 1 Steam
J C Cash Pres

KANSAS CITY KAW VALLEY Bonner Springs Kan
42 Miles, 2 Elec
J E Hubbel Supt

KANSAS CITY PUBLIC SERVICE 728 Delaware Kansas City 13 Mo
200 Miles, 2 Elec
N Grover V Pres

KANSAS CITY SOUTHERN 114 W 11th St Kansas City Mo
1713 Miles, 189 Steam, 14 Diesel
E F Salisbury Supt Sig & Comm
C F Grundy Sig Eng
A H Ryden Supt Tele

KANSAS CITY TERMINAL Union Station Kansas City Mo
170 Miles, 13 Steam, 10 Diesel
F J Ackerman Ch Eng

KANSAS OKLAHOMA & GULF *See Midland Valley*

KELLEY'S CREEK & NORTHWESTERN Ward W Va
7 Miles, 3 Steam
L Ridenour Mgr

KELLY'S CREEK Mammouth W Va
7 Miles, 1 Steam
W F Wolfe Supt

KENTUCKY & INDIANA TERMINAL 2910 No Western Pkway Louisville 12 Ky
125 Miles, 30 Steam
C W Ashby Pres & Gen Mgr

KEWAUNEE GREEN BAY & WESTERN
35 Miles, 6 Steam, 1 Diesel-Elec
For officials see G B & W R R

KLICKITAT LOG & LUMBER Klickitat Wash
20 Miles, 2 Oil
W H Rathert Supt

— L —

LACKAWANNA & WYOMING VALLEY Scranton Pa
24 Miles, 3 Elec
P J Murphy Pres & Gen Mgr

LACKAWANNA R R *See Del Lack & West'n*

LAKE CHAMPLAIN & MORIAH Port Henry N Y
7 Miles, 1 Diesel-Elec
A K McClellan Gen Mgr

LAKE ERIE & FT WAYNE Decatur Ill
5 Miles, 1 Diesel
R J Bellsmith Supt of Tele

LAKE ERIE & EASTERN *See P & L E R R*

LAKE ERIE FRANKLIN & CLARION Clarion Pa
16 Miles, 5 Steam
L L Marshall Gen Supt

LAKELAND R R Lakeland Ga
10 Miles, 1 Steam
C Bradford Gen Mgr

LAKE PROVIDENCE TEXARKANA & WESTERN Memphis Tenn
2 Miles, 1 Steam
R W Dickinson V Pres & Supt

LAKESIDE & MARBLEHEAD Marblehead Ohio
11 Miles, 4 Steam
O F Gardner Mgr

LAKE SUPERIOR & ISPEMING Marquette Mich
156 Miles, 32 Steam
A Syverson V Pres & Gen Mgr

LAKE SUPERIOR TERMINAL & TRANSFER Superior Wis
25 Miles, 13 Steam
L M Elmslie Supt

LAKE TERMINAL Grant Bldg Pittsburgh Pa
40 Miles, 17 Steam
J M Morris Pres & Gen Mgr

LANCASTER & CHESTER Lancaster S C
29 Miles, 4 Steam
A P McLure Pres & Gen Mgr

LAONA & NORTHERN Laona Wis
14 Miles, 3 Steam
R M Connor V Pres

LARAMIE NORTH PARK & WESTERN Laramie Wyo
111 Miles, 4 Steam
F C McEntee Gen Supt

LA SALLE & BUREAU COUNTY La Salle Ill
13 Miles, 1 Steam, 1 Gas-Elec
J B McCaffrey Gen Mgr

LAURINBURG & SOUTHERN Laurinburg N C
30 Miles, 3 Steam
G Y Jones Mgr & Supt

LEHIGH & HUDSON RIVER Warwick N Y
96 Miles, 20 Steam
A Shaw Pres & Gen Mgr

LEHIGH & NEW ENGLAND Bethlehem Pa
190 Miles, 44 Steam
J E Hackman Super Tele & Sig

LEHIGH VALLEY Bethlehem Pa
1,260 Miles, 352 Steam, 51 Diesel-Elec, 5 Gas-Elec
J F Yerger Supt Tele & Sig
J A Niedeck Asst Supt Tele & Sig
Supervisors of Tele & Sig:
C L Ditchendorf Buffalo N Y
A Frank Wilkes-Barre Pa
T P Heitzman Jersey City N Y

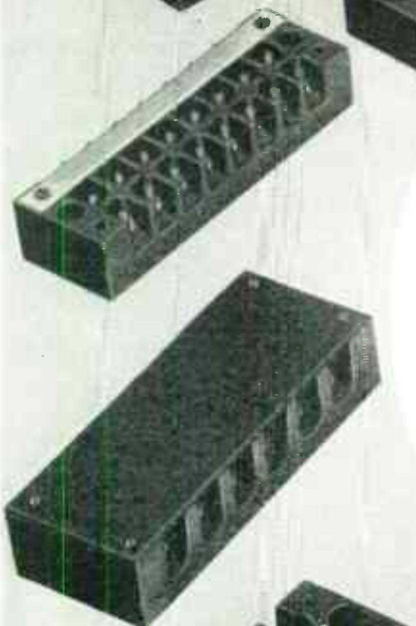
LEWISTON & YOUNGSTOWN FRONTIER Youngstown N Y
6 Miles, 1 Diesel
J Van Kill Supt of Sig & Comm

LIGONIER VALLEY Ligonier Pa
16 Miles, 4 Steam
J P Gochnour Jr Gen Mgr

LITCHFIELD & MADISON Edwardsville Ill
51 Miles, 7 Steam, 1 Diesel-Elec
H N Huntsman Chief Engineer

LIVE OAK PERRY & GULF Foley Fla
59 Miles, 4 Steam
J H Kansinger V Pres & Gen Mgr

LONG ISLAND R R Penn Station New York N Y
374 Miles, 88 Steam, 35 Elec, 3 Diesel
J S Gensheimer Supt Tele & Sig
S B Higginbottom Asst Eng Tele & Sig
G H White Super Tele & Sig Jamaica N Y
E J Kelly Asst Super Tele & Sig Jamaica N Y



NEW *Catalog* AVAILABLE
ON BURKE TERMINAL BLOCKS

If your problem is control circuit design, layout, or installation, you will want this new informative bulletin on Burke Molded Bakelite Terminal Blocks. The Bulletin contains actual size cross sectional illustrations showing detail construction features, with dimension and prices on all types and sizes.

Burke Terminal Blocks provide a simple method of identifying, sectionalizing and terminating intricate control circuit wiring—a few of the typical applications are listed below. Prompt deliveries are being made.

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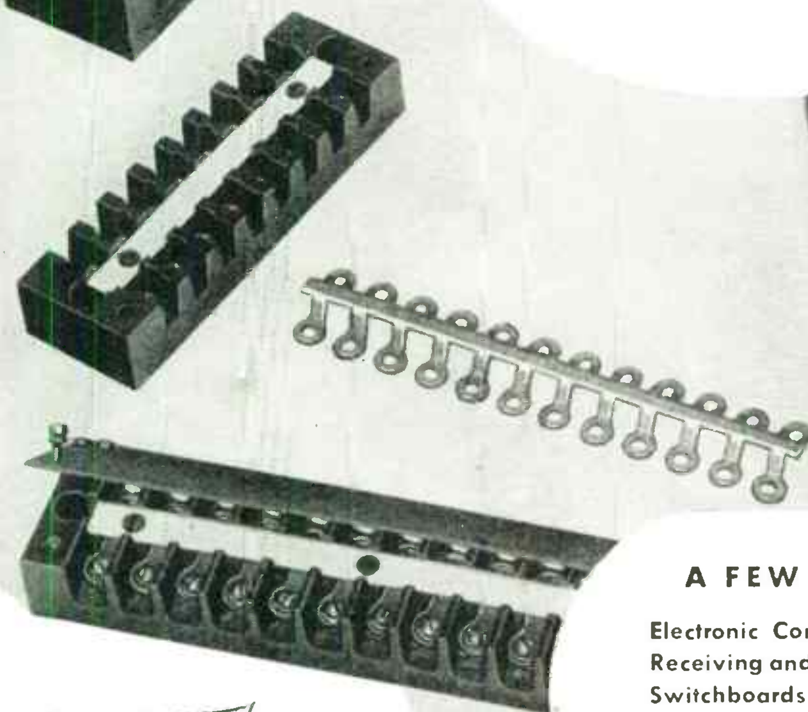


A FEW *Typical* USES

Electronic Control Systems • Radar Equipment • Radio Receiving and Transmitting Sets • Telephone and Telegraph Switchboards • Load Dispatching Signal Systems • Fire and Police Signal Systems • Traffic Signal Systems Machine Tool Control • Voltage Regulator Equipment Switchboards of all kinds • Automatic Welding Control Induction Heating Control

MOTORS 1 TO 1500 H. P. • GENERATORS 1 TO 1000 K. W.

BURKE A. C. & D. C. Motors & Generators

BURKE ELECTRIC COMPANY, ERIE, PENNSYLVANIA • *Since 1891*

H L Ralnear Asst Super Tele & Sig Jamaica N Y

LONGVIEW PORTLAND & NORTHERN Longview Wash
7 Miles, 4 Oil, 1 Diesel-Elec
R F Morse Gen Mgr

LORAIN & SOUTHERN Guildhall Bldg Cleveland Ohio
6 Miles, 1 Steam
E T Ripley Pres

LORAIN & WEST VIRGINIA *See W & L E Ry*

LOS ANGELES JUNCTION 4814 Loma Vista Los Angeles Calif
33 Miles, 1 Oil, 2 Diesels
H G Erickson Ch Eng

LOUISIANA & ARKANSAS Kansas City Mo
854 Miles, 64 Oil, 2 Diesel
F H Hooper Gen Mgr

LOUISIANA & NORTH WEST Homer La
99 Miles, 5 Steam
L S Rand Gen Supt

LOUISIANA & PINE BLUFF Shreveport La
3 Miles, 5 Oil
E A Frost Pres

LOUISIANA SOUTHERN New Orleans La
15 Miles, 2 Oil, 1 Diesel-Elec
D W McDow V Pres & Gen Mgr

LOUISVILLE & NASHVILLE 908 W B'way Louisville 1 Ky
4,745 Miles, 908 Steam, 33 Diesel-Elec
W H Stilwell Sig Eng
P P Ash Asst Sig Eng
M R Williams Sig Super Train Control
Signal Supervisors:
R C Austin Knoxville Tenn
W C Baker Mobile Ala
F Hacker Latonia Ky
G H Hume Ravenna Ky
C E Pinkston Nashville Tenn
W G Ray Birmingham Ala
E H Welsh Louisville Ky
E S Williams Evansville Ind

LOUISVILLE NEW ALBANY & CORYDON Corydon Ind
8 Miles, 2 Steam
W F Buchanan V Pres & Gen Mgr

LOWVILLE & BEAVER RIVER Lowville N Y
11 Miles, 2 Steam
F L Parker Pres

— M —

McCLOUD RIVER R R McCloud Calif
61 Miles, 14 Steam
P N Myers V Pres & Gen Mgr

McKEESPORT CONN Grant Bldg Pittsburgh Pa
15 Miles, 10 Steam
J M Morris Pres & Gen Mgr

MACON DUBLIN & SAVANNAH Macon Ga
92 Miles, 8 Steam
F C Cheney V Pres

MAGMA ARIZONA 14 Wall St New York N Y
28 Miles, 2 Oil
E G Dentzer V Pres & Gen Mgr

MAINE CENTRAL 222-242 St John Portland Me
964 Miles, 130 Steam, 5 Diesel
J P Muller Sig Eng Boston Mass
F E Avery Sig Super Portland Me
J M Scott Asst Sig Super Bangor Me
S Sullivan Asst Sig Super Portland Me

MANCHESTER & ONEIDA Manchester Ia
9 Miles, 2 Steam
C J Hockaday V Pres

MANISTEE & NORTHEASTERN Manistee Mich
112 Miles, 6 Steam
J G Johnson Gen Mgr

MANISTIQUE & LAKE SUPERIOR Decatur Ill
41 Miles, 3 Steam
R J Bellsmith Supt of Tele

MANITOU & PIKES PEAK Colorado Springs Colo
10 Miles, 4 Steam, 1 Diesel-Elec, 1 Gas
J A Carruthers V Pres & Gen Mgr

MANSFIELD RY & TRANS Shreveport La
3 Miles, 2 Oil
R G Dowell Supt

MANUFACTURERS R R 2297 S Broadway St Louis Mo
37 Miles, 8 Diesel-Elec
A E Wright Pres & Gen Mgr

MARCELLUS & OTISCO LAKE Marcellus N Y
3 Miles, 1 Steam
A V Smith Pres

MARIANNA & BLOUNTSTOWN Blountstown Fla
29 Miles, 3 Steam
O O Miller Pres & Gen Mgr

MARINETTE TOMAHAWK & WESTERN Tomahawk Wis
24 Miles, 3 Steam
J A Fremon Exec V Pres

MARION & EASTERN *See Missouri Pacific*

MARSHALL ELYSIAN FIELDS & SOUTHEASTERN 111 E Rusk St Marshall Tex
2 Miles, 1 Gas
W K Furth V Pres & Gen Mgr

MARYLAND & PENNA Mt Royal Sta Baltimore Md
81 Miles, 11 Steam
C Adler Jr Sig Eng

MASON CITY & CLEAR LAKE Mason City Ia
10 Miles, 3 Elec
C E Strickland Pres & Gen Mgr

MASSENA TERMINAL Massena N Y
2 Miles, 3 Diesel
A J Hanmer V Pres

MERIDIAN & BIGBEE RIVER Meridian Miss
51 Miles, 4 Steam
J C Floyd

MICHIGAN CENTRAL Michigan Central Term Bldg Detroit Mich
Mileage & Equip included in N Y C System
C E Baxter Supt Tele
J J Corcoran Sig Eng Cleveland O
C D Cronk Asst Sig Eng Cleveland O
Signal Supervisors:
H D Albright Jackson Mich
F M Brown St Thomas Ont
V J Humphrey Detroit Mich
T G Inwood Englewood Ill

MIDDLE CREEK 231 S LaSalle St Chicago Ill
6 Miles, 2 Steam
L S Voltz Pres

MIDDLE FORK Ellamore W Va
13 Miles, 2 Steam
H W Kelly Gen Mgr

MIDDLETOWN & UNIONVILLE Middletown N Y
15 Miles, 1 Steam
L F Zieres

MIDLAND CONTINENTAL Jamestown N D
73 Miles, 2 Steam, 1 Diesel-Elec
C W Cockrell Gen Mgr

MIDLAND VALLEY Muskogee Okla
334 Miles, 13 Steam
E M Tanner Gen Supt

MILSTEAD R R La Grange Ga
3 Miles, 1 Steam
J H Daughdrill V Pres

MINNEAPOLIS & ST LOUIS Northwestern Bank Bldg Minneapolis Minn
1,409 Miles, 89 Steam, 11 Gas-Elec, 12 Diesels
C S Weatherill Chief Engineer
G S Lovering Asst Ch Eng & Supt T & S

MINNEAPOLIS ANOKA & CUYUNA RANGE Fridley Minn
5 Miles, 2 Elec
J B Hawley Pres

MINNEAPOLIS EASTERN Minneapolis Minn
4 Miles, 1 Steam
P J Tomlinson Supt

MINNEAPOLIS NORTHFIELD & SOUTHERN Pence Bldg Minneapolis Minn
77 Miles, 10 Steam, 1 Diesel-Elec
J R Branley Gen Mgr

MINNEAPOLIS ST PAUL & SAULT STE MARIE Soo Line Bldg Minneapolis Minn
4,277 Miles, 275 Steam, 9 Diesel-Elec
J R Smith Supt Tele & Sig
B F McGowan Asst Sig Eng
R C Wickizer Supt Tele (Chicago Dist)

MINNESOTA DAKOTA & WESTERN International Falls Minn
22 Miles, 6 Steam
W La Du Gen Supt

MINNESOTA TRANSFER 2071 Univ Ave St Paul Minn
140 Miles, 13 Steam, 6 Diesel
H McCarthy Gen Supt

MINNESOTA WESTERN Minneapolis Minn
115 Miles, 1 Diesel
J R Branley Gen Mgr

MISSISSIPPI & ALABAMA Leakesville Miss
17 Miles, 2 Steam
O T Brown Supt of Sig & Comm

MISSISSIPPI & SKUNA VALLEY Box 391 Memphis Tenn
21 Miles, 1 Steam
R Y Duquesnay V Pres & Gen Mgr

MISSISSIPPI CENTRAL Hattiesburg Miss
158 Miles, 12 Steam
L F Faulkner V Pres & Gen Mgr

MISSISSIPPI EXPORT Moss Point Miss
44 Miles, 2 Diesel-Elec
W M Dutton V Pres & Gen Mgr

MISSISSIPPIAN R R Amory Miss
24 Miles, 2 Steam
E L Puckett Pres & Mgr

MISSOURI & ARKANSAS Harrison Ark
365 Miles, 20 Steam
J R Tucker Gen Mgr

MISSOURI & ILLINOIS BRIDGE & BELT Alton Ill
3 Miles, 1 Steam
A A Lampert Supt

MISSOURI-ILLINOIS *See Mo Pac R R*

MISSOURI-KANSAS-TEXAS Dallas Texas
1,798 Miles, 29 Steam, 244 Oil
J A Johnson Supt Tele & Sig Denison Tex
R R Wood Sr Sig Super Denison Tex
R O Johnson Tele & Sig Super Denison Tex
R A Mosse Sig Super Parsons Kan
W G Pluto Sig Super Parsons Kan

MISSOURI-KANSAS-TEXAS R R CO of TEXAS Katy Bldg
1,350 Miles, 37 Oil
J A Johnson Supt Tele & Sig Denison Tex
R R Wood Sr Sig Super Denison Tex
W H Dutton Sig Super Denison Tex
R O Johnson Tele & Sig Super Denison Tex
L F Garrison Sig Super Waco Tex

MISSOURI PACIFIC LINES *Officials & mileage below. Comprising:*
Doniphan Kensett & Searcy
Gulf Coast Lines
International-Great Northern
Marion & Eastern
Missouri-Illinois
Missouri Pacific
Natchez & Louisiana Ry Transfer Co
Natchez & Southern
St Joseph Belt
Union Ry Co (Memphis)
Union Terminal Ry (St Joseph Mo)

MISSOURI PACIFIC R R Mo Pac Bldg St Louis Mo
7,139 Miles, 714 Steam, 213 Oil, 47 Diesel-Elec
L S Werthmuller Sig Eng
A T Hunot Asst Sig Eng
W Rogers Supt Tele
R A Hendrie Asst Supt Tele
C H Dietrich Gen Super Tele
F K Garlock Tele Eng
W Chunn Tele Eng
O J Surron Super Tele Kansas City Mo
P F McKinney Super Tele Little Rock Ark
Signal Supervisors:
W N Barnes Atchison Kan
C Brady Coffeyville Kan
J W Chowning Monroe La
E M Kempe Dodson Mo
N S Lynch Kansas City Mo
R R Ragland De Soto Mo
Spillman Nevada Mo
O R Thurston Little Rock Ark
L D Woods (Asst) Little Rock Ark
J L Marcum 3001 Chouteau Ave St Louis Mo

MOBILE & GULF Fayette Ala
34 Miles, 2 Steam
R E Loper Gen Mgr

MODESTO & EMPIRE TRACTION Modesto Calif
5 Miles, 4 Oil
G K Beard V Pres & Mgr

MONONGAHELA CONNECTING 311 Ross St Pittsburgh Pa
38 Miles, 22 Steam, 10 Diesel
W E Cox V Pres & Supt

MONONGAHELA RY CO Penn Sta Pittsburgh Pa
171 Miles, 53 Steam
C M Yohe V Pres

MONONGAHELA WEST PENN PUBLIC SERVICE Parkersburg W Va
97 Miles, 3 Elec
J R Robinson Supt Maint of Way

MONSON R R Monson Me
8 Miles, 2 Gas, 2 Steam
P A Jackson Supt

MONTANA WESTERN Valier Mont
20 Miles, 1 Steam
C E Atwood Supt of Sig & Comm

MONTANA WYOMING & SOUTHERN Belfry Mont
34 Miles, 3 Steam
W H Bunney Pres & Gen Mgr

MONTOUR R R Coraopolis Pa
51 Miles, 22 Steam
W H Hamilton Gen Supt

MONTPELIER & WELLS RIVER Montpelier Vt
20 Miles, 8 Steam
H L Skeels Pres

MOORE CENTRAL Asheboro N C
10 Miles, 1 Steam, 2 Gas
A Ross Sec

MOREHEAD & NORTH FORK Clearfield Ky
4 Miles, 2 Steam
M C Crosley Pres & Gen Mgr

MORRISTOWN & ERIE Whippany N J
11 Miles, 3 Steam
M Jensen V Pres

MOSCOW CAMDEN & SAN AUGUSTINE Camden Tex
7 Miles, 2 Oil
S F Adams Gen Supt

MOSHASSUCK VALLEY Saylesville R I
5 Miles, 2 Steam
D C Paton Gen Supt

MOUNT HOOD Hood River Ore
22 Miles, 1 Steam
L Kostol Gen Supt

MUNCIE & WESTERN 1410 E 12th St Muncie Ind
5 Miles, 1 Gas, 1 Gas-Elec
V G Krauskopf Supt

MURFREESBORO — NASHVILLE Murfreesboro Ark
15 Miles, 1 Steam, 1 Oil
J L Ledbetter

— N —

NACOGDOCHES & SOUTHEASTERN Nacogdoches Tex
42 Miles, 1 Oil
H W Whited V Pres & Gen Mgr

NACOZARI R R El Paso Texas
77 Miles, 1 Oil
H S Fairbank V Pres

NARRAGANSETT PIER Peace Dale R I
8 Miles, 2 Gas
J A Monahan Sec

NASHVILLE CHATTANOOGA & ST LOUIS 930 B'dway Nashville 3 Tenn
1,072 Miles, 205 Steam, 16 Diesel-Elec
E W Anderson Sig & Tele Eng
L W Oliphant Super Sig Constr
C R Stuart Super Tele Maint & Constr

NATCHEZ & SOUTHERN Natchez Miss *See Mo Pac R R*
3 Miles, 1 Steam

NATCHEZ URANIA & RUSTON Urania La
7 Miles, 1 Oil
Q T Hardtner Pres & Gen Mgr

NELSON & ALBEMARLE Schuyler Va
14 Miles, 2 Steam
C C Rothwell V Pres & Gen Mgr

NEVADA COPPER BELT Mason Nevada
29 Miles, 2 Oil
L G Ellis Supt

NEVADA NORTHERN East Ely Nevada
165 Miles, 7 Steam
H J Beem Gen Mgr

NEWBURGH & SO SHORE 8143 B'dway Cleveland 5 Ohio
5 Miles, 9 Steam, 12 Diesel
F A Gideon Pres & Gen Mgr

NEW HAVEN & DUNBAR Dunbar Pa
6 Miles, 1 Steam
P Friedley Pres

NEW IBERIA & NORTHERN *See Gulf Coast Lines*

NEW JERSEY INDIANA & ILLINOIS Ry Exch Bldg St Louis Mo
12 Miles, 1 Steam
N B Pitcairn Pres

NEW ORLEANS & LOWER COAST New Orleans La
60 Miles, 5 Steam
G C Stohlman V Pres

NEW ORLEANS & NORTHEASTERN *See Southern Railway System*

NEW ORLEANS PUBLIC BELT Municipal Bldg New Orleans La
128 Miles, 3 Steam, 10 Oil, 6 Diesel-Elec
E J Garland Gen Mgr

NEW ORLEANS TERMINAL *See Southern Ry System*

NEW ORLEANS TEXAS & MEXICO *See Gulf Coast Lines*

NEW YORK CENTRAL SYSTEM 466 Lexington Av New York N Y
10,534 Miles, 3,190 Steam, 144 Elec, 168 Diesel-Elec
W A Jackson Gen Supt Tele & Telo
J L Niesse Asst to Gen Supt Tele & Telo
Comprising:
Boston & Albany
Chicago Junction
Chicago River & Indiana
Cleve Cin Chic & St Louis
Indiana Harbor Belt
Michigan Central
New York Central
Peoria & Eastern
Pittsburgh & Lake Erie
Buffalo & East
C E Baxter Supt of Tele Detroit Mich
R B Elsworth Sig Eng Albany N Y
West of Buffalo
C E Baxter Supt of Tele Detroit Mich
J J Corcoran Sig Eng Cleveland O

NEW YORK CHICAGO & ST LOUIS Term Tower Cleveland 1 Ohio
1,688 Miles, 351 Steam
S G Raber Supt Tele & Sig
F H Schultize Asst Supt Tele
H G Stiebeling Asst Sig Supt
A L Shepard Sig Office Eng
Nickel Plate District
Signal Supervisors:
J Saunders (Asst) Ft Wayne Ind
E Schroff Ft Wayne Ind
H M Van Osinski Conneaut Ohio
C R Myers (Asst) Conneaut Ohio
Lake Erie & Western District
C Mettlin Sig Super Frankfort Ind
H V Gillette Asst Sig Super Frankfort Ind
Clover Leaf District
C Mettlen Sig Super Frankfort Ind
H V Gillette Asst Sig Super Frankfort Ind

NEW YORK DOCK 44 Whitehall St New York N Y
11 Miles, 2 Steam, 4 Oil
G E Fenniman V Pres

NEW YORK NEW HAVEN & HARTFORD New Haven Conn
1,838 Miles, 496 Steam, 127 Elec, 113 Diesel, 1 Gas
R E Taylor Sig Eng
W A Ford Gen Sig Super
C R Somers Off Eng
T P Flavell Asst Off Eng
Signal Supervisors:
O F Dorward New Haven Conn
O Frantzen Boston Mass
A Schwartz Hartford Conn
E W Shea Providence R I

NEW YORK ONTARIO & WESTERN 330 W 42nd St New York N Y
546 Miles, 87 Steam, 5 Diesel
H H Shannon Sig Eng Middletown N Y

NEW YORK SUSQUEHANNA & WESTERN North Hawthorne N J
129 Miles, 20 Steam, 2 Gas, 8 Diesel
W I McAlpine Sig Super

NEZPERCE & IDAHO Nezperce Idaho
14 Miles, 1 Steam
H C Kendall Pres & Gen Mgr

NIAGARA JUNCTION Niagara Falls N Y
33 Miles, 9 Elec
T P Redding Gen Supt

NICKEL PLATE ROAD *See N Y C System*

NORFOLK & PORTSMOUTH BELT LINE Norfolk Va
27 Miles, 23 Steam
H L White V Pres & Gen Mgr

NORFOLK & WESTERN Roanoke Va
2,127 Miles, 562 Steam, 16 Elec
J A Beoddy Supt Tele & Sig
J L George Asst Supt Tele
A B Armistead Asst Supt Sig
A R Clark Super Tele & Tele
J O Trump Gen For Tele & Sig
I H East Asst Gen For Tele & Sig

NORFOLK SOUTHERN Norfolk Va
728 Miles, 51 Steam
C A Riggan Super Tele Telo & Sig

NORTHAMPTON & BATH Northampton Pa
12 Miles, 3 Oil-Elec
A F Tidabock Pres

NORTHEAST OKLAHOMA Miami Okla
41 Miles, 6 Diesel
E C Mackey Supt Sig & Comm

NORTHERN OHIO *See Akron Canton & Youngst'n*

NORTHERN PACIFIC St Paul Minn
10,249 Miles, 834 Steam, 43 Diesel
S W Law Sig Eng
F L Steinbright Supt Tele
R B Johnson Asst Supt Tele
C W Harding Asst Supt Tele Seattle Wash
Supervisors of Signals:
F L Eukes Livingston Mont
T C Hanson Tacoma Wash
A G Nutting St Paul Minn

NORTHERN PACIFIC TERMINAL CO OF OREGON Union Sta Portland Oregon
79 Miles, 14 Oil, 8 Diesel
H D Mudgett Mgr

NORTH LA & GULF Hodge La
25 Miles, 3 Oil
J S Hunt Pres

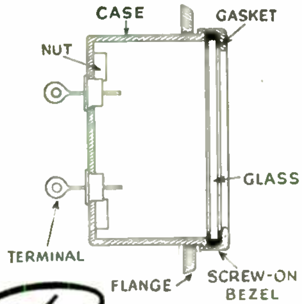
NORTHWESTERN PACIFIC 65 Market St San Francisco Calif
331 Miles, 36 Oil
D J Russell Pres

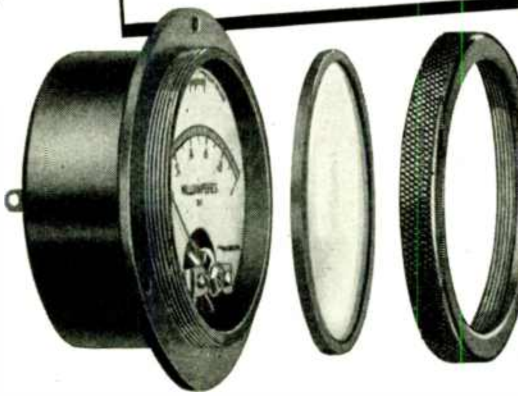
NORWOOD & ST LAWRENCE Norfolk N Y
18 Miles, 3 Steam
E W Beaty Supt

— O —

OAKLAND TERMINAL 114 Sansome St San Francisco Calif
14 Miles, 2 Elec, 2 Diesel
G E Duffy V Pres

Introducing the NEW TRIPLETT LINE of HERMETICALLY SEALED INSTRUMENTS





All the features of standard instruments retained. Withstand submersion tests at 30 feet. Comply with thermal shock, pressure and vibration tests. Resistant to corrosion. Conform to S.C. No. 71-3159 and A.W.S. C-39.2-1944 specifications. 1½", 2½" and 3½" metal cases with 1/16" thick walls, in standard ranges. D.C. moving coil, A.C. moving iron and thermocouple types. Write for circular.

STANDARDS ARE SET BY TRIPLETT

Precision first ...to last

Triplett

ELECTRICAL INSTRUMENT CO. BLUFFTON, OHIO

Make Plans Now... *for the coming* PLASTIC ERA

Consult ROGAN

Here at Rogan, seasoned engineers are ready and willing to assist you in determining your post-war *plastic* requirements. Whether your peacetime products are to include electronic equipment, electrical appliances, stoves or what have you, the Rogan Organization will gladly provide cost-free advice on all phases of plastic production.

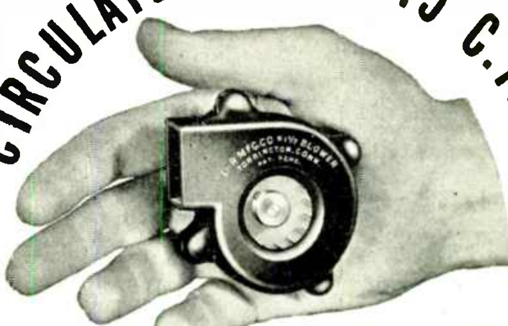
Send Us Your Specifications Today!

ROGAN BROTHERS

Compression Molders and Branders of Plastics

2000 So. Michigan Avenue **CHICAGO, ILLINOIS**

CIRCULATE AIR AT 15 C.F.M.



Only 2½" of space needed

WEIGHT: 2 oz. • CAPACITY: 15 C. F. M. at 8000 R. P. M. • CONSTRUCTION: Housing of high impact phenolic plastic • Wheel is turbo-type cadmium-plated steel SIZE: 2 5/8" long x 61/64" wide x 2 1/2" high

The blower illustrated, No. 1½, is one of many blower models manufactured by the L-R Manufacturing Company. These blowers were designed to outperform many larger and heavier types formerly in use. Where size and weight are factors these blowers with their minimum size and maximum output are the answer to cooling problems presented by electronic tubes or circuit components in such applications as air-borne communication units as well as in many industrial applications.

L-R MANUFACTURING COMPANY • DIVISION OF

The RIPLEY Company

21 NEW LITCHFIELD STREET
TORRINGTON, CONNECTICUT

OHIO & MORENCI Springfield Ohio
22 Miles, 4 Steam
W G Bell V Pres & Gen Mgr
OHIO CENTRAL LINES *See New York Central*
OHIO PUBLIC SERVICE Hanna Bldg Cleveland Ohio
45 Miles, 2 Elec
T O Kennedy Pres & Gen Mgr
OKLAHOMA R R 1206 Exch Ave Oklahoma City
142 Miles, 7 Elec
N Barrett V Pres
OKMULGEE NORTHERN Okmulgee Okla
10 Miles, 2 Oil
D H Corbell Mgr
OMAHA LINCOLN & BEATRICE 895 North St Lincoln Nebraska
10 Miles, 2 Elec
M Freshman V Pres & Gen Mgr
ONEIDA & WESTERN Hinsdale Ill
38 Miles, 3 Steam
M S Healy Pres
ORANGE & NO WESTERN *See Gulf Coast Lines*
OREGON & NORTHWESTERN Hines Oregon
51 Miles, 2 Oil
E T F Wohlenberg V Pres & Gen Mgr
OREGON ELECTRIC R R *See SP & S*
OREGON PACIFIC & EASTERN Cottage Grove Oregon
20 Miles, 2 Steam
R P Boyce Gen Mgr
OREGON TRUNK R R *See SP & S*
OSAGE R R Lep Okla P. O. Webb City
18 Miles, 1 Steam
L P Groves Mgr
OUACHITA & NORTH-WESTERN Clarks La
10 Miles, 1 Oil
W L McDermott Supt

— P —

PACIFIC COAST R R 811 S Alaska Way Seattle Wash
43 Miles, 5 Steam
G W Mertens Pres & Gen Mgr
PACIFIC ELECTRIC 208 E 6th St Los Angeles Calif
891 Miles, 50 Elec, 6 Oil
E C Johnson Chief Engineer
PANAMA R R Balboa Heights, C Z
98 Miles, 25 Steam, 5 Diesel
A C Garlington Electrical Engineer
PANHANDLE & SANTA FE Amarillo Tex
1,888 Miles *See A T & S F R R*
PARIS & MT PLEASANT Paris Texas
51 Miles, 4 Oil
R W Wortham Pres
PATAPSCO & BACK RIVERS Bethlehem Pa
67 Miles, 15 Steam, 19 Diesel
P A Trageser V Pres
PEARL RIVER VALLEY Picayune Miss
5 Miles, 2 Steam
A H Knight Sec
PECOS VALLEY SOUTHERN
40 Miles, 1 Oil
See T & P R R
PENINSULA TERMINAL Union Stock Yds North Portland Ore
4 Miles, 2 Oil
H H Burdick Pres
PENNSYLVANIA & ATLANTIC New Egypt N J
25 Miles, 1 Steam
F Johnson Gen Mgr
PENNSYLVANIA R R Broad St Sta Bldg 1617 Penn Blvd Phila Pa
9,767 Miles, 4,369 Steam, 286 Elec, 3 Gas, 18 Diesel
W R Triem Gen Supt Tele
W M Post Sig Eng
New York Zone
698 Mi (inc L I R R)
J S Gensheimer Supt Tele & Sig
Supervisors of Tele & Sig:
S F Schmidhamer Jersey City N J
G H White Jamaica N Y
Eastern Region Penn Sta 30th St Phila
3,011 Miles
J I Kirsch Supt Tele & Sig
J C Patterson Asst Supt Tele & Sig
Supervisors of Tele & Sig:
T R Adams Williamsport Pa
F L Chatten Harrisburg Pa
E T Hammer Sunbury Pa
P J Irvin Baltimore Md
F G Mayer Harrington Del
W C Miller Baltimore Md
W D Stewart Altoona Pa
W G Trost Philadelphia Pa
D R Vought Camden N J
Central Region Penn Sta Pittsburgh Pa
3,354 Miles
A M Crawford Supt Tele & Sig
B F Dickinson Eng Tele & Sig
T E Binyon Eng Telo & Tele
Supervisors of Tele & Sig:
E G Baumann Pittsburgh Pa
G L Black Cleveland Ohio
C Darrah Pittsburgh Pa
C W Henricks Pittsburgh Pa
W A Jones Erie Pa
C Myers Pittsburgh Pa
G W Spangler Pittsburgh Pa
C M Weaver New Castle Pa
O M Willard Buffalo N Y
Western Region Union Sta Chicago Ill
R F Raughley Supt Tele & Sig
W G Salmonson Eng Tele & Sig
Supervisors of Telegraph & Signals:
H T Fleisher Ft Wayne Ind
G C Godshall Toledo O
R E Harlow Terre Haute Ind
C P Huth Cincinnati O
P W Iba Indianapolis, Ind
S J King Columbus O
G H Leford Chicago Ill
D L Moore Logansport Ind
C P Woodson Grand Rapids Mich
PENNSYLVANIA-READING SEA-SHORE LINES Camden N J
405 Miles, 23 Steam
S F Schmidhamer Super Tele & Sig

PEORIA & EASTERN Indianapolis Ind
202 Miles, 42 Steam
W Davis Gen Mgr
PEORIA & PEKIN UNION Springfield Ill
158 Miles, 16 Steam, 4 Diesel
W C Hurst V Pres
PERE MARQUETTE Gen Motors Bldg Detroit 2
1949 Miles, 286 Steam, 6 Diesel
H C Lorenzen Supt Tele & Sig
M F Anderson Asst Sig Eng
PETALUMA & SANTA ROSA Petaluma Calif
38 Miles, 6 Elec
W B Isaacs Eng Maint of Way
PHILADELPHIA BETHLEHEM & NEW ENGLAND Bethleham Pa
55 Miles, 8 Steam, 20 Diesel
D M Petty Pres
PICKENS R R Pickens S C
9 Miles, 1 Steam
T J Mitchell Gen Mgr
PIEDMONT & NORTHERN Charlotte N C
130 Miles, 17 Elec
F H Cothran Pres
PIONEER & FAYETTE Pioneer O
5 Miles, 1 Steam
E S Snyder Pres
PITTSBURGH & LAKE ERIE P & L E Term Bldg Pittsburgh Pa
233 Miles, 266 Steam
E F Brown Sig-Elec Eng
Signal Supervisors:
W A Dean Pittsburgh Pa
H P McKenery McKeesport Pa
F K Mitchell Beaver Pa
PITTSBURGH & OHIO VALLEY Neville Island Pa
8 Miles, 4 Steam
C G Gibson Supt
PITTSBURG & SHAWMUT Kittanning Pa
97 Miles, 16 Steam
W W Morrison V Pres & Gen Mgr
PITTSBURGH & WEST VIRGINIA Wabash Bldg Pittsburgh Pa
136 Miles, 33 Steam
A I Derr V Pres
PITTSBURGH CHARTIERS & YOUGHIOGHENY Penn Station Pittsburgh Pa
19 Miles, 10 Steam
N W McCallum Chief Engineer
PITTSBURG COUNTY McAlester Okla
25 Miles, 2 Elec
M M Schene V Pres & Gen Mgr
PITTSBURGH LISBON & WESTERN Youngstown O
22 Miles, 5 Steam
G C Harper Pres
PITTSBURG SHAWMUT & NORTHERN St Marys Pa
190 Miles, 15 Steam
P B McBride Gen Mgr
PORT ANGELES WESTERN Port Angeles Wash
62 Miles, 3 Oil
H LeGear Supt & Mgr
PORT EVERGLADES BELTLINE Ft Lauderdale Fla
12 Miles, 4 Diesel-Elec
F J Stewart Chief Engineer
PORT HURON & DETROIT Port Huron Mich
20 Miles, 4 Steam
W N Boyd Supt
PORTLAND ELECTRIC POWER 1605 S E Water Av Portland Ore
37 Miles, 12 Elec
B Rossiter Chief Engineer
PORTLAND TERMINAL *See Maine Central R R*
PRATTSBURGH R R Prattsburgh N Y
12 Miles, 2 Steam
S B Merritt Mgr
PRESCOTT & NO WESTERN Prescott Ark
33 Miles, 3 Oil
J R Bemis Pres
PRESTON R R Crellin Md
12 Miles, 3 Steam
J W Kendall V Pres
PULLMAN R R 707 E 111th St Chicago Ill
31 Miles, 3 Steam, 2 Diesel
N Kunst Pres

— Q —

QUANAH ACME & PACIFIC Quanah Tex
122 Miles, 7 Oil
A F Sommer V Pres & Gen Mgr
QUINCY R R Quincy Calif
6 Miles, 2 Oil
L H Thayer Supt

— R —

RAHWAY VALLEY Kenilworth N J
15 Miles, 3 Steam
G A Clark President
RAPID CITY BLACK HILLS & WESTERN Rapid City S D
34 Miles, 5 Oil
J P Nye Gen Mgr
RARITAN RIVER R R South Amboy N J
21 Miles, 8 Steam
H Fliskov Mgr
READER R R Shreveport La
23 Miles, 3 Oil
B McCullough Gen Mgr
READING COMPANY Reading Term Phila 7 Pa
1,374 Miles, 631 Steam, 58 Diesel
S R Negley Elec Eng
J W Moorehouse Elec Super
E W Reich Sig Eng Reading Pa
Supervisors of Signals:
T G Phillips Philadelphia Pa
E L Rogers Reading Pa
L B Sinclair Tamaqua Pa
RED RIVER & GULF Long Leaf La
62 Miles, 2 Oil
H A White Gen Mgr

RICHMOND FREDERICKSBURG & POTOMAC Fredericksburg Va
118 Miles, 110 Steam
W K Saunders Super Sig
RIO GRANDE & EAGLE PASS Laredo Texas
21 Miles, 2 Steam, 1 Gas
R W Davis Pres
RIO GRANDE CITY *See Gulf Coast Lines*
RIO GRANDE SOUTHERN Durango Colo
174 Miles, 6 Steam
C W Graebing Gen Mgr
RIVER TERMINAL R R 3100 E 45th St Cleveland Ohio
22 Miles, 16 Steam, 3 Diesel
B Ladley Gen Mgr
ROARING FORK Blackwood Va
15 Miles, 1 Steam
L J Huettle Chief Engineer
ROCKDALE SANDOW & SOUTHERN Rockdale Tex
6 Miles, 2 Steam
J M Weed Gen Mgr
ROCKINGHAM R R Rockingham N C
22 Miles, 2 Steam
W H Newell Gen Mgr
ROCK ISLAND SOUTHERN Rock Island Ill
58 Miles, 2 Steam, 2 Elec
L R Walsh Pres
ROCK PORT LANGDON & NORTHERN Rock Port Mo
6 Miles, 2 Steam
P Hedgpeth Supt Sig & Comm
ROSCOE, SNYDER & PACIFIC Roscoe Tex
32 Miles, 3 Oil
R O Dobbins Vice President
RUTLAND R R Rutland Vt
408 Miles, 60 Steam
A T Danver Ch Eng
W O Cutler Supt Tele

— S —

ST JOHNSBURY & LAKE CHAMPLAIN Montpelier Vt
96 Miles, 9 Steam
A G Emery Gen Supt
ST JOHNS RIVER TERMINAL *See Southern R R*
ST JOSEPH BELT Mo Pac Bldg St Joseph Mo
19 Miles, 1 Diesel
R E Hastings V Pres & Gen Mgr
ST JOSEPH TERMINAL 803 S 4th St St Joseph Mo
11 Miles, 3 Steam
C H Drew Supt
ST LOUIS & BELLEVILLE ELECTRIC 7 Collinsville Ave E St Louis Mo
18 Miles, 2 Elec
T G Dyer Supt
ST LOUIS & O'FALLON 2927 S B'dway St Louis Mo
19 Miles 2 Steam
H Marsh Chief Engineer
ST LOUIS & OHIO RIVER *See Alton & So R R*
16 Miles, 1 Steam
ST LOUIS & TROY Hannibal Mo
5 Miles, 1 Steam
W C Ramsay Pres & Gen Mgr
ST LOUIS BROWNSVILLE & MEXICO *See Gulf Coast Lines*
ST LOUIS-SAN FRANCISCO Springfield Mo
4,647 Miles, 601 Steam, 28 Diesel
R W Troth Sig Eng
R E Testerman Asst Sig Eng
S L Uhr Tulsa Okla
G F Linster Supt Tele
C I Garton Supvr C T C
Signal Supervisors:
H Barron Springfield Mo
G J Drummon Springfield Mo
P W Davis Jasper Ala
F C Harper Cape Girardeau Mo
E Shannon Memphis Tenn
ST LOUIS SAN FRANCISCO & TEXAS Springfield Mo
154 Miles
F G Jonah Chief Engineer
ST LOUIS SOUTHWESTERN Cotton Belt Bldg St Louis Mo
1,617 Miles, 32 Steam, 178 Oil, 7 Diesel
Comprising:
St Louis South Western
St Louis South Western R R Co of Texas
F W Green Ch Oper Off
R M Stone Supt Tele Tyler Texas
ST MARYS R R St Marys Ga
11 Miles, 4 Steam
W T Scarboro Gen Agt
SABINE & NECHES VALLEY Deweyville Tex
14 Miles, 1 Oil
C C Cary Pres
SACRAMENTO NORTHERN Sacramento 14 Calif
275 Miles, 23 Elec
C B Bruner Chief Engineer
SALT LAKE & UTAH 107 W South Temple Salt Lake City Utah
76 Miles, 6 Elec
W J Browne Supt of Sig & Comm
SALT LAKE GARFIELD & WESTERN 22 E 1st So Salt Lake City Utah
17 Miles, 6 Elec
H A Snow Pres
SAN ANTONIO UVALDE & GULF *See Gulf Coast Lines*
SAN BENITO & RIO GRANDE VALLEY *See Gulf Coast Lines*
SAN DIEGO & ARIZONA EASTERN 65 Market San Francisco Calif
140 Miles, 13 Oil
A W Flanagan Supt Tele
SAND SPRINGS Sand Springs Okla
32 Miles, 4 Elec
C O Nuckolls Chief Engineer
SAN FRANCISCO & NAPA VALLEY Napa Calif
7 Miles, 3 Diesel
C E Brown V Pres & Gen Mgr
SAN LUIS VALLEY SOUTHERN Denver Nat Bldg Denver 2 Colo
32 Miles, 2 Steam
G T Kearns V Pres & Mgr

SANTA FE SYSTEM *Comprising:*
Atchison Topeka & Santa Fe
Gulf Colorado & Santa Fe
Panhandle & Santa Fe
SANTA MARIA VALLEY 6381 Hollywood Blvd Los Angeles Calif
23 Miles 6 Oil
J M Davis Mgr
SAVANNAH & ATLANTA Savannah Ga
145 Miles, 13 Steam
J A MacLeod Chief Engineer
SEABOARD AIR LINE Norfolk Va
4,179 Miles 552 Steam, 1 Oil, 44 Diesel
J R DePriest Supt Tele & Sig
SIERRA R R Jamestown Calif
57 Miles, 5 Oil
J E Taylor V Pres & Gen Mgr
SIOUX CITY TERMINAL Sioux City Ia
18 Miles, 4 Steam
J T Flynn Supt
SKANEATELES SHORT LINE Skaneateles N Y
5 Miles, 2 Steam
A H Holder Gen Mgr
SMOKY MOUNTAIN R R Sevierville Tenn
30 Miles, 3 Steam
M Kesselman Gen Mgr
SOUTH BROOKLYN R R 250 Hudson New York N Y
9 Miles, 3 Elec
P E Pfeifer Gen Supt
SOUTH BUFFALO Bethlehem Pa
87 Miles, 21 Steam, 18 Diesel
H M Dalziel Chief Engineer
SOUTH GEORGIA Quitman Ga
77 Miles 3 Steam
S S Rountree Pres
SOUTH OMAHA TERMINAL So Omaha Neb
32 Miles, 8 Steam
J V Erixon Chief Engineer
SOUTH SHORE R R Jackson La
28 Miles, 3 Steam
H H Holloway Gen Supt
SOUTHERN R R SYSTEM McPherson Sq Washington D C
7,735 Miles, 1,558 Steam, 54 Diesel
Comprising:
Alabama Gt Southern
Cincinnati Burnside & Cumberland River
Cincinnati New Orleans & Texas Pacific
Georgia Southern & Florida
Harriman & Northeastern
New Orleans & Northeastern
New Orleans Terminal
St Johns River Terminal
Southern R R
L C Walters Asst to V Pres (Sig)
P E Snead Asst Eng Sig & Elec
J A Jones Asst to V Pres (Comm)
D Ruff Tele & Telo Eng
A H Johnson Supt T & T Cincinnati O
J R Smith Supt T & T Charlotte N C
Eastern Lines Charlotte N C
2,989 Miles
T N Charles Sig & Elec Supt
J R Smith Supt Tele & Telo
J W Sutton Super Tele & Telo
Signal Supervisors:
W O Junker Spartanburg S C
P S Scharf Greensboro N C
R T Sewell Greenville S C
L E Walke Orange Va
W H Wiley Columbia S C
Central Lines Knoxville Tenn
2,463 Miles
T N Charles Sig & Elec Supt Charlotte N C
H A Hudson Sig & Elec Supt Cincinnati O
Signal Supervisors:
J W Cole Macon Ga
C E Colvin Knoxville Tenn
C A Hinds Rome Ga
R T Hinds Atlanta Ga
C L Kale Asheville N C
F W Long Sheffield Ala
Western Lines Cincinnati O
2,283 Miles
H A Hudson Sig & Elec Supt
A H Johnson Supt Tele & Telo
N O Keller Super Tele & Telo
Signal Supervisors:
C B Behnke Slidell La
M Brock Lexington Ky
W C Brown Birmingham Ala
A N Goodson Tuscaloosa Ala
J L Linn Birmingham Ala
J Waller Chattanooga Tenn
A W Wilson Somerset Ky
SOUTHERN INDIANA R R Speed Ind
5 Miles, 3 Elec
G L Harmon Gen Supt
SOUTHERN IOWA R R Centerville Ia
32 Miles, 3 Elec
E L Shutts Pres
SOUTHERN NEW YORK 225 B'dway New York City
3 Miles, 3 Steam
M P Gross V Pres & Gen Mgr
SOUTHERN PACIFIC SYSTEM *Comprising:*
Southern Pacific Co — Pacific Lines
Southern Pacific Lines — Tex & La
Texas & New Orleans R R
SOUTHERN PACIFIC CO — Pacific Lines
65 Market St San Francisco Calif
8,263 Miles, 39 Steam, 1,486 Oil, 104 Diesel
R D Moore Sig Eng
A W Flanagan Supt Tele
W R Birt Asst Supt Tele
A E DeMattei Asst Supt Tele
R E Steere Asst Supt Tele
Signal Supervisors:
T Armstrong San Francisco Calif
S L Baxter Sacramento Calif
P A Bliss Los Angeles Calif
O A Burton Bakersfield Calif
L V Cutsforth Portland Ore
T L Gordon West Oakland Calif
J H Hickey Dunsmuir Calif
W J Jenne El Paso Tex
A C Krout Tucson Ariz
D C Miller Ogden Utah
SOUTHERN PACIFIC LINES (Texas & New Orleans R R) So Pac Bldg Houston Tex
4,340 Miles, 467 Oil, 8 Diesel, 1 Gas

U. S. RAILROADS, Continued

R W Meek Sig Eng
M O Scobee Supt Tele
Signal Supervisors:
D W Rosenzweig Lafayette La
W R Smylie Houston Tex
N C Tubbs Ennis Tex
P V Wright San Antonio Tex
SOUTHERN PACIFIC OF MEXICO 65 Market San Francisco Calif
1,331 Miles, 88 Oil
W B Barker Chief Engineer Guadalajara Mexico D F Mex
SPOKANE COEUR D'ALENE & PALOUSE *See Great Northern*
SPOKANE INTERNATIONAL Spokane 1 Wash
150 Miles, 14 Steam
D R Waite Gen Supt
J B Williams Div Eng
C J Sinnitt Asst Supt
SPOKANE PORTLAND & SEATTLE Portland Ore
962 Miles, 85 Oil, 16 Elec, 14 Diesel
Comprising:
Oregon Elec
Oregon Trunk
United Rys
A J Witchel Ch Eng
D I Clough Elec Supt
SPRINGFIELD & SOUTHWESTERN Springfield Ill
8 Miles, 2 Steam
T A Cahee Supt
SPRINGFIELD TERMINAL Springfield Vt
7 Miles, 3 Elec
W G Bell Gen Mgr
SPRINGFIELD TERMINAL (of Illinois) Springfield Ill
5 Miles, 2 Steam
G Willis Chief Engineer
STATE BELT R R Foot of Battery St San Francisco Calif
58 Miles, 7 Steam, 4 Diesel
F G White
STATEN ISLAND RAPID TRANSIT St George S I N Y
23 Miles, 4 Steam
C A Salverson Super Sig Tele & Telo
STEELTON & HIGHSPIRE Bethlehem Pa
35 Miles, 9 Steam, 5 Diesel
H M Dalziel Chief Engineer
STOCKTON TERM & EASTERN Stockton Calif
22 Miles, 1 Oil
F E Odell Supt
STRASBURG R R Strasburg Pa
4 Miles, 1 Gas
J E Homsher Pres
SUGAR LAND R R *See Gulf Coast Lines*
SUMPTER VALLEY R R Baker Oregon
62 Miles, 3 Steam, 1 Diesel
J F Carpenter Asst Gen Mgr
SUMPTER & CHOCTAW Bellamy Ala
23 Miles, 2 Steam
W T Haynie V Pres & Gen Mgr
SUNCOOK VALLEY Concord N H
29 Miles, 1 Steam
E J Stapleton Gen Mgr
SUNSET R R *See A T & S F R R*
SYLVANIA CENTRAL Savannah Ga
15 Miles, 1 Steam
R R Cummins Pres

— T —

TALLULAH FALLS Cornelia Ga
58 Miles, 4 Steam
H L Brewer Gen Mgr
TAMA & TOLEDO Toledo Ia
4 Miles, 1 Diesel
D V Wells Supt
TAMPA SOUTHERN *See Atlantic Coast Line*
TAVERES & GULF Taveres Fla
38 Miles, 1 Steam
W H Edmunds Supt
TENNESSEE & NORTH CAROLINA Hayesville N C
25 Miles, 3 Steam
R E Crawford
TENNESSEE ALABAMA & GEORGIA Chattanooga Tenn
95 Miles, 7 Steam
W A Forrester Chief Engineer
TENNESSEE CENTRAL Amer Trust Bldg Nashville Tenn
287 Miles, 34 Steam, 2 Diesel
H R Manby Chief Engineer
TENNESSEE R R Oneida Tenn
65 Miles, 6 Steam
S A Blair Gen Mgr
TERMINAL R R ASSOC OF ST LOUIS Union Sta St Louis Mo
367 Miles, 101 Steam, 48 Diesel
A P Hix Sig Eng
E A Wunder Supt Tele & Telo
H Austill Ch Eng
TERMINAL RAILWAY ALABAMA STATE DOCKS Mobile Ala
41 Miles, 5 Steam
C U Irvine Supt
TEXAS & NEW ORLEANS *See S P Lines*
TEXAS & PACIFIC Tex & Pac Bldg Dallas Tex
1,884 Miles, 289 Oil
E P Weatherby Sig Eng
F W Burkholder Sig Super Ft Worth Tex
C C Whitehead Sig Super Ft Worth Tex
G E Thompson Sig Super Alexandria La
TEXAS CITY TERMINAL Texas City Tex
42 Miles, 1 Gas, 4 Oil
H J Mikeska Pres & Gen Mgr
TEXAS ELECTRIC R R CO 216 Interurban Bldg Dallas Tex
174 Miles
G H Peters Supt of Power
TEXAS-MEXICAN R R Laredo Tex
161 Miles, 6 Oil, 6 Diesel
R R Fenner Gen Mgr
TEXAS OKLAHOMA & EASTERN Dierks Bldg Kansas City Mo
40 Miles, 1 Oil
J C Leeper V Pres & Ch Eng

TEXAS PACIFIC-MISSOURI PACIFIC TERMINAL R R OF NEW ORLEANS St Louis Mo
94 Miles 2 Oil, 2 Diesel
L W Baldwin Pres
TEXAS SOUTH-EASTERN Diboll Tex
21 Miles, 1 Oil
H G Temple Pres & Gen Mgr
TIDEWATER SOUTHERN Modesto Calif
65 Miles, 2 Oil, 2 Elec
R T Kearney Supt
TOLEDO ANGOLA & WESTERN Lock Box 858 Toledo Ohio
10 Miles, 1 Steam
R E Minogue Supt
TOLEDO PEORIA & WESTERN Peoria Ill
239 Miles, 16 Steam
I H Hultgren Supt Tele & Sig
TOLEDO TERMINAL Toledo Ohio
88 Miles, 20 Steam
A B Newell Pres & Gen Mgr
TONOPAH & GOLDFIELD Tonopah Nev
100 Miles, 6 Oil
E Peterson Super Tele
TOOELE VALLEY Tooele Utah
9 Miles, 4 Steam
T E Tate Supt
TORONTO HAMILTON & BUFFALO 230 Pk Ave New York City
111 Miles, 23 Steam, 1 Gas
J G Stonehouse Sig Super Hamilton Ont
TREMONT & GULF Winnfield La
97 Miles, 1 Steam, 5 Oil
T W Fatherson Gen Supt
TRONA R R Trona Calif
31 Miles, 3 Oil
J L Robinson Gen Mgr
TUCKASEEGEE & SOUTH EASTERN E La Porte N C
12 Miles, 1 Steam
Mrs J Keys Pres & Gen Mgr
TUCSON CORNELIA & GILA BEND Ajo Ariz
44 Miles, 1 Oil
LM Barker Gen Mrg
TUSKEGEE R R Tuskegee Ala
6 Miles, 2 Steam
W Runnette Gen Mgr
TWIN BRANCH R R Mishawaka Ind
3 Miles, 2 Elec
O K Fay Gen Supt
TWIN CITY R R Chehalis Wash
2 Miles, 1 Elec
G M Brown Gen Mgr

— U —

UNADILLA VALLEY New Berlin N Y
49 Miles, 4 Steam
L L Schomo Supt Motive Power
UNION ELECTRIC Coffeyville Kan
86 Miles, 6 Elec
L L Francis Pres & Gen Mgr
UNION FREIGHT R R New Haven Conn
2 Miles, 4 Steam
J F Doolan Oper Asst
UNION PACIFIC R R 1416 Dodge Omaha Neb
9,782 Miles, 974 Steam, 534 Oil, 73 Diesel
L D Dickinson Gen Sig Eng
T W Hays Asst Gen Sig Eng
Eastern District Omaha Neb
3,827 Miles
D C Bettison Sig Eng
Signal Supervisors:
E H Bullock Omaha Nebr
M P Dalbey Cheyenne Wyo
E C Grant Denver Colo
G A Ziehlke Kansas City Mo
South-Central District Union Pac Bldg Salt Lake City Utah
3,743 Miles
R B McArdle Sig Eng
Signal Supervisors:
B P Manear Las Vegas Nev
R V Moisbee Salt Lake City Utah
F A Purdy Pocatello Idaho
A R White Los Angeles Calif
Northwestern District Pittock Block Portland Ore
2,212 Miles
R C Charlton Sig Super Albina Ore
C A Larson Sig Super Spokane Wash
UNION R R East Pittsburgh Pa
45 Miles, 124 Steam, 18 Diesel
E Bouchet Supt Sig
UNION RAILROAD OF OREGON P O Box 1202 Portland Ore
5 Miles, 1 Gas
R Woodbury Pres & Gen Mgr
UNION RY CO (Memphis) Memphis Tenn
104 Miles, 13 Steam
W E Lamb Pres
UNION TERMINAL Dallas Tex
16 Miles, 1 Oil
M L Buckner V Pres & Gen Mgr
UNION TERMINAL RY (St Joseph Mo) Mo Pac Bldg St Joseph Mo
25 Miles, 3 Steam, 1 Diesel
R E Hastings Pres & Gen Mgr
UNITED RAILWAYS *See S P & S*
UPPER MERION & PLYMOUTH Conshohocken Pa
12 Miles, 10 Steam, 3 Diesel
H P Ross V Pres
UTAH IDAHO CENTRAL Ogden Utah
94 Miles, 7 Elec
W J Browne Supt Power & Equip
UTAH R R Newhouse Bldg Salt Lake City Utah
111 Miles, 13 Steam
G S Anderson Pres & Gen Mgr

— V —

VALLEY & SILETZ Hoskins Ore
41 Miles, 4 Oil
F W A Cox Supt
VENTURA CO R R Oxnard Calif
11 Miles, 3 Oil
J W Rooney V Pres & Gen Mgr
VERDE TUNNEL & SMELTER Clarkdale Ariz
11 Miles, 2 Oil
J B Pullen V Pres

VICKSBURG SHREVEPORT & PACIFIC *See Illinois Central System*
VIRGINIA & CAROLINA SOUTHERN Lumberton N C
53 Miles, 6 Steam
J Q Beckwith V Pres
VIRGINIA & TRUCKEE Carson City Nev
46 Miles, 5 Oil
G T Salzman Ch Eng
VIRGINIA BLUE RIDGE Massies Mill Va
16 Miles, 4 Steam
T A Fry V Pres
VIRGINIAN R R Princeton W Va
657 Miles, 106 Steam, 12 Diesel
A R Kyle Supt Tele & Sig
E Lockhart Asst Supt Tele & Sig
VISALIA ELECTRIC Exeter Calif
39 Miles, 1 Elec, 1 Gas
R T Jackson Mgr

— W —

WABASH R R Decatur Ill
2394 Miles, 384 Steam, 17 Diesel
G A Rodger Signal Eng
R J Bellsmith Supt Tele
WACO BEAUMONT TRINITY & SABINE Trinity Tex
41 Miles, 2 Oil
T B Legett Gen Mgr
WALLA WALLA VALLEY Walla Walla Wash
24 Miles, 5 Elec
J E Martin Gen Mgr
WARE SHOALS Ware Shoals S C
5 Miles, 1 Steam
C P Gordon Sec
WARREN & OUACHITA VALLEY Warren Ark
16 Miles, 1 Steam
W R Warner Gen Mgr
WARRENTON & SALINE RIVER Warren Ark
16 Miles, 3 Steam
J C Anthoni V Pres & Gen Mgr
WARRENTON R R Warrenton N C
3 Miles, 1 Steam
J Rodgers Supt
WASHINGTON & OLD DOMINION Arlington Va
52 Miles, 3 Diesel
G C Baggett V Pres & Gen Mgr
WASHINGTON & VANDEMERE *See Atlantic Coast Line*
WASHINGTON IDAHO & MONTANA Potlatch Idaho
50 Miles, 4 Oil
W J Gamble Asst Gen Mgr
WATERLOO CEDAR FALLS & NORTHERN Waterloo Ia
128 Miles, 10 Elec
T E Rust Chief Engineer
WATERVILLE R R Waterville Wash
5 Miles, 1 Steam
W V Friel Gen Mgr
WEATHERFORD MINERAL WELLS & NORTH WESTERN Weatherford Tex
31 Miles, 1 Oil
M Y Anderson V Pres
WESTERN ALLEGHENY Kaylor Pa
21 Miles, 4 Steam
C L Correy Gen Mgr
WESTERN MARYLAND RAILWAY Hagerstown Md
720 Miles, 212 Steam, 18 Diesel
K L Muse Sig & Telo Eng
E C Shreve Eng Maint of Way Hillen Sta Baltimore Md
J A Abbott Supt Hagerstown Md
J M Miller Supt Cumberland Md
WESTERN PACIFIC 526 Mission St San Francisco 5 Calif
1,195 Miles, 152 Oil, 25 Diesel-Elec, 17 Steam
H W Dunn Signal Engineer
J P Quigley Supt Tele
WEST PITTSTON-EXETER Scranton Pa
3 Miles, 3 Steam
C H McKnight Supt & Ch Eng
WEST VIRGINIA NORTHERN Kingwood W Va
11 Miles, 4 Steam
G Reith Gen Mgr
WHEELING & LAKE ERIE Brewster Ohio
999 Miles, 154 Steam, 4 Diesel
E A Hamilton Elec Eng
WHITE SULPHUR SPGS & YELLOWSTONE PARK White Sulphur Spgs Mont
23 Miles, 1 Steam
G A Wetherell Supt
WICHITA FALLS & SOUTHERN Wichita Falls Tex
169 Miles, 9 Oil
J D Sullivan Gen Mgr
WILLAMINA & GRAND RONDE Longview Wash
8 Miles, 2 Steam
H B Robertson V Pres
WINCHESTER & WESTERN Winchester Va
18 Miles, 1 Steam
D H Sencindiver Pres
WINFIELD R R Butler Pa
13 Miles, 2 Steam
F C McKee Pres
WINIFREDE R R Charleston W VA
10 Miles, 1 Steam
A R Yarborough Traf Mgr
WINONA R R Warsaw Ind
58 Miles, 1 Propane, 1 Propane-Elec
B R Ritter Gen Supt
WINSTON-SALEM SOUTHBOUND Wilmington N C
89 Miles, 8 Steam
Lowell White Cen Supt Tele
WOOD RIVER BRANCH Hope Valley R I
6 Miles, 1 Gas
R R Rawlings Eng
WRIGHTSVILLE & TENNVILLE Dublin Ga
36 Miles, 3 Steam
B H Lord Pres & Gen Mgr
WYANDOTTE SOUTHERN Wyandotte Mich
6 Miles, 3 Steam
W D LeBar Gen Supt

WYANDOTTE TERMINAL Wyandotte Mich
9 Miles, 5 Steam, 1 Diesel
E Edson Pres
WYOMING R R Buffalo Wyoming
28 Miles, 3 Steam
C C Palmer Supt Tele & Comm

— Y —

YAKIMA VALLEY TRANSPORTATION Yakima Wash
34 Miles, 3 Elec
LeGrand Young V Pres & Supt
YAKUTAT & SOUTHERN Hamlin St & Fairview Av Seattle Wash
15 Miles, 1 Diesel
G V Graham Pres & Gen Mgr
YAZOO & MISSISSIPPI VALLEY *See Illinois Central System*
YORK UTILITIES Sanford Me
2 Miles, 2 Elec
W M B Lord V Pres & Gen Mgr
YOSEMITE VALLEY Merced Calif
78 Miles, 8 Steam
L A Foster Gen Mgr
YOUNGSTOWN & NORTHERN Youngstown Ohio
5 Miles, 7 Steam, 7 Diesel
F H Pilgrim Gen Supt
YOUNGSTOWN & SUBURBAN Youngstown Ohio
19 Miles, 3 Elec
G C Harper Pres
YREKA WESTERN Yreka Calif
8 Miles, 2 Oil
O F Guerin Supt
YUMA VALLEY Yuma Ariz
43 Miles, 1 Oil
C B Elliott Supt

CANADIAN RAILROADS

ALGOMA CENTRAL & HUDSON BAY Sault Ste Marie Ont
332 Miles, 27 Steam
R S McCormich Gen Supt & Ch Eng
ALMA & JONQUIERES Lake St John Que
11 Miles, 3 Steam
T J Butler Mgr
BRITISH COLUMBIA ELEC Vancouver B C
213 Miles, 11 Elec
J B Mouat Supt
BRITISH COLUMBIA YUKON
BRITISH YUKON NAVIGATION
BRITISH YUKON R R
See White Pass & Yukon
CANADA & GULF TERMINAL Mont Joli Que
38 Miles, 5 Steam
T J Fouhy Gen Supt
CANADIAN NATIONAL Montreal Que
23,198 Miles, 2,380 Stm, 84 Oil, 33 Elec, 35 Diesel *Comprising:*
Canadian Government
Canadian Northern
Central Vt (*Mileage shown separately*)
Duluth Winnipeg & Pacific
Duluth Rainy Lake & Winnipeg
Grand Trunk Pacific
Grand Trunk R R
Gr Trunk Western (*Mileage also shown separately*)
Niagara St Catharines & Toronto (*Mileage also shown separately*)
N B Walton Exec V Pres (Oper)
Atlantic Region 3,076 Miles
H L Black Sig Eng Moncton N B
Central Region 7,506 Miles
C H Tillett Sig Eng Toronto Ont
Western Region 11,533 Miles
L A Guthrie Sig Eng Winnipeg Man
CENTRAL VERMONT
422 Miles, 62 Steam
R D Garner Gen Mgr St Albans Vt
DULUTH WINNIPEG & PACIFIC — DULUTH RAINY LAKE & WINNIPEG
173 Miles
W C Owens Gen Mgr Winnipeg Man
GRAND TRUNK WESTERN
1,026 Miles
W L Dayton Sig Eng Detroit Mich
J B McGregor Supt Tele Battle Creek Mich
NIAGARA ST CATHARINES & TORONTO Toronto Ont
57 Miles
J F Pringle V Pres & Gen Mgr
CANADIAN NORTHERN *See Canadian National*
CANADIAN PACIFIC 204 Hospital St Montreal
17,038 Miles, 1,700 Steam, 15 Diesel
W D Nell Gen Mgr Comm
E S Taylor Sig Eng Rm 337 Union Sta Toronto Ont
L A W East Ch Eng Comm 204 Hospital Montreal Que
C R Hodgdon Sig Eng Winnipeg Man
New Brunswick Dist 842 Miles
C H Cameron Sig Super St John N B
Quebec Dist 1,658 Miles
E S Beckstead Sig Super Montreal Que
Ontario Dist 1,423 Miles
R I Beckstead Sig Super Toronto Ont
Algoma Dist 1,223 Miles
E S McCracken Gen Mgr North Bay Ont
Manitoba Dist 2,516 Miles
J I MacKay Gen Supt Winnipeg Man
Saskatchewan Dist 3,626 Miles
H C Taylor Gen Supt Moose Jaw Sask
Alberta Dist 3,103 Miles
A Davies Sig Super Calgary Alta
British Columbia Dist 1,987 Miles
A Davies Sig Super Calgary Alta
CENTRAL VERMONT R R *See Canadian Nat'l*
CUMBERLAND R R Springhill N S
32 Miles, 6 Steam
D A McMillan Supt
DOMINION ATLANTIC R R Kentville N S
304 Miles, 23 Steam
J J Richardson Eng

CANADIAN RAILROADS
Continued

ESQUIMALT & NANAIMO R R Victoria B C
209 Miles, 25 Oil
C D Mackintosh Asst Supt & Div Eng

GREATER WINNIPEG WATER DIST St Boniface Man
97 Miles, 4 Steam, 1 Diesel, 1 Elec
H Shand Eng 185 King St Winnipeg
H DeCuyper Gen Foreman 202 Notre Dame St Boniface
G McFadden Gen Supt Greater Winnipeg
Water Dist St Boniface Man

LAKE ERIE & NORTHERN Preston Ont
51 Miles, 6 Steam
D A McMillan Supt

LONDON & PORT STANLEY London Ont
55 Miles, 3 Elec, 10 Motor Cars
E V Buchanan Mgr

MARITIME COAL R R & POWER Amherst N S
15 Miles, 4 Steam
N T Avard Gen Mgr

MIDLAND R R CO OF MANITOBA 175 E 4th St Paul 1 Minn
6 Miles, 2 Steam
C M Nye Ch Eng

MONTREAL & SOUTHERN COUNTIES Toronto Ont
54 Miles, 2 Elec
E B Walker Gen Supt

MORISSEY FERNIE & MICHEL Fernie B C
5 Miles, 2 Steam
H P Wilson Pres & Gen Mgr

NAPIERVILLE JUNCTION 1010 St Catherine W Montreal Que
28 Miles, 2 Steam
J H Nuelle Pres

NEWFOUNDLAND R R St Johns N F
738 Miles, 45 Steam
D G Ross Ch Eng Maint of Way

NIAGARA ST CATHARINES & TORONTO *See Canadian Nat R R*

NORTHERN ALBERTA Edmonton Alta
923 Miles, 16 Steam
J M MacArthur Gen Mgr

OSHAWA R R Toronto Ont
22 Miles, 6 Elec
J F Pringle V Pres & Gen Mgr

PACIFIC & ARCTIC R R & NAVIGATION *See White Pass & Yukon Route*

PACIFIC GREAT EASTERN R R Squamish B C
347 Miles, 10 Steam
J A Quick Supt

QUEBEC RAILWAY LIGHT & POWER Quebec Que
33 Miles, 7 Steam
E D Gray-Donald Ch Eng

QUEBEC CENTRAL R R Sherbrooke Que
362 Miles, 18 Steam
F H Hibbard Ch Eng

ROBERVAL & SAGUENAY Sun Life Bldg Montreal Que
38 Miles, 6 Stm, 3 Elec
W C Duncan Mng Director

SYDNEY & LOUISBURG Sydney N S
120 Miles, 26 Steam
W S Wilson Ch Eng

TEMISCOUATA R R Riviere du Loup Que
113 Miles, 7 Steam
T N Walsh Supt Sig & Comm

TEMISKAMING & NORTHERN ONTARIO R R COMMISSION North Bay Ont
574 Miles, 51 Stm, 1 Diesel
G M Simpson Supt Tele & Telo

THOUSAND ISLANDS R R Toronto Ont
5 Miles, 1 Gas-Elec
J F Pringle V Pres & Gen Mgr

TORONTO HAMILTON & BUFFALO Hamilton Ont
111 Miles, 23 Steam, 1 Gas-Elec
J G Stonehouse Sig Super

WHITE PASS & YUKON Skagway Alaska
110 Miles, 9 Steam
Comprising: British Columbia Yukon
British Yukon
British Yukon Navigation
Pac & Arctic R R & Navigation
V I Hahn Supt

MEXICAN RAILROADS

CAMARGO & WESTERN Calle Bolivar No 21 Mexico City Mex
20 Miles, 1 Gas
G S McLaughlin Ch Eng

CANANEA CONSOLIDATED COPPER Cananea Sonora Mex
32 Miles, 9 Oil
A Mendelsohn Gen Mgr

CHIHUAHUA MINERAL Chihuahua Chih Mex
9 Miles, 1 Steam, 3 Oil
M O'Reilly Gen Mgr

COAHUILA & ZACATECAS Coahuila Mex
103 Miles, 11 Steam
J Morales Supt

EL ORO MINING & R R CO E Oro Mex
9 Miles, 3 Steam
G M Wasteneys Gen Mgr

FERROCARRIL INDUSTRIAL EL POTOSI Y CHIH Chihuahua Mex
14 Miles, 7 Elec
L Obregon Ch Elec

FERROCARRILES NACIONALES DE MEXICO
See National Rys of Mexico

FERROCARRILES UNIDOS DE YUCATAN S A
See United R R's of Yucatan

FERROCARRIL MEXICANO DEL NORTH *See Mexican Northern*

FERROCARRIL SUD PACIFICO DE MEXICO
See Southern Pacific R R Co of Mex

MEXICAN NORTHERN Ave 16 Sept 26 Mexico City Mex
88 Miles, 8 Steam
J M Delgado Mgr

MEXICAN PACIFIC Sinaloa Mex
25 Miles, 3 Steam
W P Griggs Gen Mgr

MEXICAN R R Co Ltd Plazuela Buena Vista Mexico City Mex
434 Miles, 60 Oil, 12 Diesel
L P Castro Res Eng

MEXICO NORTH-WESTERN R R Ciudad Juarez, Chih., Mex
476 Miles, 2 Steam, 24 Oil
F J Clark V Pres (Oper)

MINATITLAN AL CARMEN Minatitlan Ver., Mex
9 Miles, 5 Oil
J J Nettel Flores Ch Eng

NATIONAL R R OF MEXICO Mexico City Mex
8,384 Miles, 1019 Steam *Comprising:*
National Rys of Mexico
Interoceanic Ry of Mexico
Tehuantepec National Ry
Veracruz to Alvarado Ry
A Ortiz Gen Mgr Mexico City
B E Arias Supt Tele & Elec Mexico City

POTOSI & RIO VERDE San Luis Potosi S L Potosi Mexico
41 Miles, 3 Oil
R M Leech Supt

SOUTHERN PACIFIC OF MEXICO Guadalajara Mexico
1,331 Miles, 88 Oil
A M Fernandez Gen Mgr

TOLUCA & ZITACUARO Mexico City Mex
40 Miles, 3 Steam
J Zermeno Pres & Gen Mgr

UNITED R R's OF YUCATAN Merida Yucatan Mex
564 Miles, 58 Steam
M Mier y Teran Mgr

VERACRUZ TO ALVARADO *See National Rys of Mexico*

VERACRUZ TERMINAL Mexico D F Mex
32 Miles, 10 Oil
J D W Helmes Gen Mgr

WESTERN RY OF MEXICO Culiacan Sinaloa Mex
38 Miles, 4 Steam
L V Valdes Mgr

OWI *uses* RAYTHEON *tubes* IN UNIQUE MOBILE RECORDER

● This "traveling recording studio" of the Office of War Information has *everything* for making recorded pickups for broadcasting on international short wave. Such important equipment must be the finest that science can provide, so Raytheon High-Fidelity Tubes are used to assure the highest quality reception.

Wherever they are employed, Raytheon Tubes live up to their reputation for fine performance. That is why they are first choice among electronic engineers planning post-war products . . . and first choice among radio service-dealers who are building soundly for the future.

There's a real promise of greater profits and greater customer-satisfaction for service-dealers who feature Raytheon Tubes. And there's a revolutionary Raytheon merchandising program planned, too . . . to help you be more successful than ever before.

Switch to Raytheon Tubes *now!*

Increased turnover and profits, plus easier stock control, are benefits which you may enjoy as a result of the Raytheon standardized tube type program, which is part of our continued planning for the future.

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"MEET YOUR NAVY"
Every Saturday Night
AMERICAN BROADCASTING CO.
Coast to Coast
181 Stations

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All Four Divisions Have Been Awarded Army-Navy "E" With Stars

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High Fidelity
ELECTRONIC AND RADIO TUBES

DEVOTED TO RESEARCH AND THE MANUFACTURE OF TUBES FOR THE NEW ERA OF ELECTRONICS

THE "FLYING UTE" CUTS 3 HOURS FROM AVERAGE RUNNING TIME

DENVER, COLO.—Using Motorola Radio 118 Mgc. equipment for vocal communications between locomotive and caboose, the "Flying Ute," crack freight of the Denver and Rio Grande Western, cut three hours off the average running time between Denver and Salt Lake City, it was announced today after a trial run.

with Motorola F-M 2-WAY RADIO-TELEPHONE SYSTEM

The efficiency, economy and safety provided by Motorola F-M two-way radiotelephone were demonstrated again—with spectacular results! On a test run over the rugged, mountainous route between Denver and Salt Lake City, "The Flying Ute," fast Diesel freight, carried 65 cars of explosives and other vital war materials.

The 570 mile run included 50 tunnels, but clear and intelligible communications between engine and caboose were maintained throughout most of the route.

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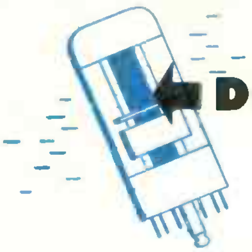


DEEP IN THE HEART OF EVERY TUBE...

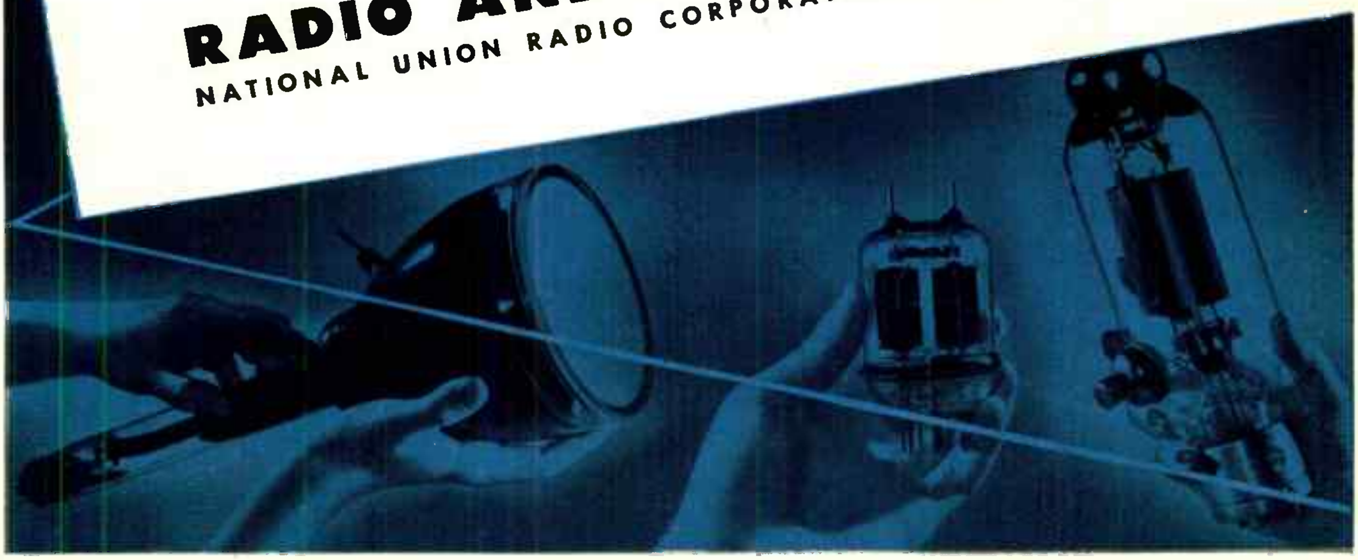
THE HEART of every radio and electron tube is its *cathode*. And National Union electronic engineers are in many ways the heart specialists of the tube world.

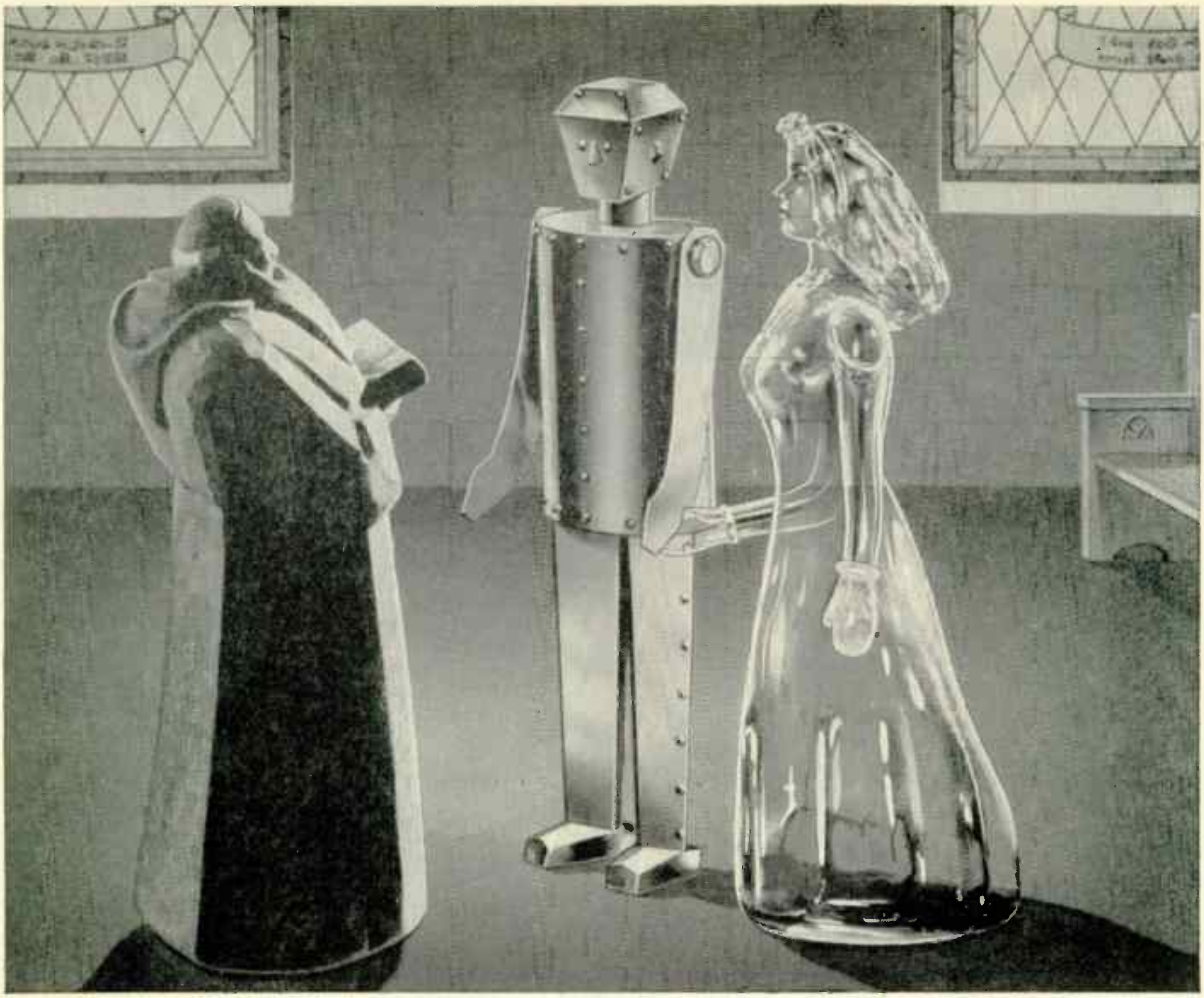
They have developed high-emission cathode coatings for a wide variety of tube types. They have perfected improved methods of controlling the torrent of electrons that is emitted by every *good* cathode. And, of course, they have their own ways of determining that a cathode *is* good. For example, microscopic magnifications up to 2500X enable N. U. scientists to tell at once that a cathode coating of millions of minute crystals, has the desired density and texture.

As the cathode is the heart of the tube, so the tube is the heart of radio, communications and industrial electronic equipment. And the day is coming when N. U. research, N. U. mass-producing facilities, and N. U. "know how" with the elusive electron will aid in speeding the return of many peacetime products to our homes and industries.

NATIONAL UNION RADIO AND ELECTRON TUBES

NATIONAL UNION RADIO CORPORATION · NEWARK 2, N. J.





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Things are different now. *Corning's* metallizing process weds glass and metal with a bond that lasts like an old-fashioned marriage. Through heat and cold . . . under severe conditions of stress and strain, they stick together in a lasting union.

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TELEVISION—sign and symbol of the age to come—is one of the wonders that specially designed cable transmission makes practical. For the quality and fidelity of the transmitted image depend largely on how well the cables are engineered and manufactured, from tiny cables in the broadcasting mechanism itself to the great coaxial cables linking city with city, making possible the television networks of the future.

Thus the "wireless age" as it develops will actually need more wires—and more complicated cables—to achieve its realization! And in the solution of these problems, new and more complicated cables will be required.

Today, we will undertake to engineer and manufacture the radio and audio cable requirements of any government agency or private concern in war work. Moreover, we look forward to solving many of the most difficult cable tasks in peacetime — as we have in wartime. The same laboratories, the same Yankee ingenuity that have helped to whip many of the difficulties involved in the communications requirements of our Army and Navy are prepared to function for industry — whatever the problems of today and tomorrow.

Why ANKOSEAL *solves cable problems*

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

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—In peacetime makers of the famous Noma Lights—the greatest name in decorative lighting. Now, manufacturers of fixed mica dielectric capacitors and other radio, radar and electronic equipment.

PROJECTION TELEVISION

(CONTINUED FROM PAGE 53)

power again, so that the net amount gained by going to a larger lens is relatively small.

In the actual arrangement of the optical system for a home receiver, a reflective system is used as shown in Fig. 7. The main lens in this arrangement consists of a bowl-shaped spherical reflector some 12 ins. in diameter. When the fluorescent screen of the projection kinescope is placed at a point between the principal focus and the center of curvature, an enlarged image is projected on the screen. The tube itself blocks off a small part of the reflected rays, but does not affect the image, just as reducing the aperture on a camera reduces the light, but does not affect the size of the picture. Unfortunately, a reflector such as shown here — if of large size, introduces "spherical aberration" with the result that the image is not sharply focused.

In order to correct this "spherical aberration," an aspherical correcting lens is arranged as shown in Fig. 8. A hole is cut out of its center so that it can fit over the neck of the tube. By locating this lens at the center of curvature of the reflector, a minimum of shaping is required. The reflector itself is polished glass with an aluminized surface. The center part of this mirror is masked (actually, it is cut away) since most of the light reflected by this part is blocked by the tube. Masking prevents reduction in contrast which would be caused by the light it would otherwise reflect on the face of the tube. So efficient is this arrangement that the overall system has an efficiency of approximately 30% equivalent to an aperture of f/.9. This is 6 to 8 times better than direct-projection optical systems.

The final step in the development of the projection optical system is shown in Fig. 9. In order to get the whole system into a cabinet of relatively shallow depth, the main axis of the system is arranged vertically. The projection kinescope tube points downward. The image, projected downward from the tube, is reflected straight up by the spherical reflector, passes through the correcting lens, strikes a 45° mirror near the top of the cabinet, and is projected forward onto the translucent screen in the front of the receiver. Some added advantage is gained here since a translucent screen can be made to have a higher efficiency than a diffusive, reflective screen. The picture on this screen actually has a brightness in the highlights of approximately 8 foot-lamberts, which is about the same as that in good motion picture projection and somewhat better than that of home movies.

The largest issue of *FM* AND TELEVISION ever published will be the special Emergency Radio number for July. In addition to feature articles on communications equipment for emergency services, this issue will contain our 4th semi-annual Directory of Emergency Radio Stations. This is an exclusive feature of *FM* AND TELEVISION.

WHAT'S NEW THIS MONTH

(CONTINUED FROM PAGE 4)

war. It is estimated conservatively that this will exceed ¼ billion dollars per year, and it may reach twice that figure.

However, that is far from enough. To maintain postwar radio employment, radio manufacturers must have at least 1 billion dollars in annual sales of home radio sets and broadcast station equipment. *And this production must start just as soon as there are substantial cancellations of military contracts!*

Production of broadcast receivers and transmitters must be started in step with military cancellations 1) to give continued employment to the largest possible number of factory workers and 2) to provide jobs in distribution, sale, service, and operation to radio-trained men released from the Armed Forces and those laid off by radio manufacturers. To do this, manufacturers must start *now* to design postwar equipment, and to initiate production plans.

But today, this is impossible — not because there is inadequate engineering talent available at this time, but because manufacturers do not know the frequencies on which FM broadcast transmitters and receivers are to operate. Any statement from Government officials that manufacturers do not have engineering man-hours for this purpose is either a deliberate misstatement of fact for "morale" purposes, or is made in ignorance of true conditions.

Not until the FCC settles the frequency assignments for 44 to 108 mc. can any constructive planning be done to prevent postwar radio unemployment. But the FCC hasn't settled these assignments, and makes no promise of doing so until some time after "the coming summer."

Sets Without FM ★ Of course, new sets could be made with only AM circuits until such time as FM broadcast frequencies have been determined. Why not? There is a very good reason why not.

Before Pearl Harbor, the public had a foretaste of FM quality, with the result that there was a greater demand for fine receivers, retailing at $175 to $350 than manufacturers could supply. Moreover, the introduction of FM-AM sets and phonograph combinations resulted in shrinking the demand for AM sets into the lowest brackets, from $9.95 to $19.95.

During the four years that home radios have not been produced, continuous publicity has been given to the superiority of FM over AM, supported by official statements from FCC such as its promise that it will be "a service which will not be simply a new and improved broadcast service, but the finest aural broadcast service which is attainable under the present state of the radio art."

Thus during the period when an enor-

(CONTINUED ON PAGE 79)

WHAT'S NEW THIS MONTH

(CONTINUED FROM PAGE 78)

mous replacement market has been built up for radio receivers, the public has been educated to think of new sets in terms of FM, with the result that any demand for plain AM models will be limited to the cheapest types, to serve until the genuine postwar designs afford both FM and AM reception.

What Has Gone Wrong ★ In order to determine what corrective measures must be taken, it is necessary to have a clear picture of conditions as they exist now:

In 1943, James Lawrence Fly, then FCC chairman, proposed the formation of RTPB so that technical problems affecting frequency allocations could be ironed out well in advance of the war's end. Had that been done, every one concerned could have carried on his war job, civilian or military, with the assurance that plans were being made for reasonably smooth conversion from war to peace.

Mr. Fly's intentions were excellent, but Mr. Fly was a lawyer, not a business man, and he failed to realize that engineers are men of opinions rather than decisions. Thus, when the RTPB FM Panel did arrive at a delayed recommendation as to FM broadcast frequencies, FCC's Dr. Wheeler and his student Norton slyly introduced a counter-proposal all their own, based on information which had been withheld from RTPB.

Eventually, their conclusions on tropospheric interference were shown to be in error, but then, oblivious of their obligations to the public by whom their wages are paid, they continued to maintain that FM frequencies must be changed radically, and fortified their position with fresh arguments concerning Sporadic E interference. In this stand they have been discredited again, but they had sufficient supporters among anti-FM broadcasters that their smoke-screen beclouded the issue in the minds of the Commissioners.

As a result, the Commissioners, when they announced the final frequency allocations from 25 mc. to 30,000 mc. on May 17th, side-stepped the issue by proposing three alternative arrangements for the band from 44 to 108 mc.

This Doesn't Make Sense ★ Here is the official explanation given by the FCC for failing to meet the issue on FM broadcast frequencies: "The reason for not making a final decision at the time (May 17th) was that the Commission felt that further measurements were desirable before making a final allocation for FM. In this connection the Commission pointed out that its decision not to make a final allocation for FM at this time would not in any way hamper the future development of that service because the Commission has received advice from the War Production

(CONTINUED ON PAGE 81)

BEAT FREQUENCY GENERATOR

Type 140-A

A dependable test instrument

An accurate signal source capable of supplying a wide range of frequencies and voltages.

Frequency Range 20 C.P.S. to 5 MC.
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COMPLETE MANUFACTURERS FROM START TO FINISH

WHAT'S NEW THIS MONTH

(CONTINUED FROM PAGE 79)

Board that the radio industry will not resume production of new AM, FM, and television transmitters or receivers 'in 1945 or even in the first part of 1946 unless Japan capitulates. This is not to say that a small quantity of receivers and possibly a few transmitters may not be made available. However, this will have little or no effect on the future expansion of AM, FM, and television services.' The War Production Board has also advised the Commission that in event there is any change in its prediction, it will give 90 days advance notice."

The radio manufacturers would like to know the name of the individual at WPB who had the presumption to make such a statement to the FCC. If there is anyone who can give the Commissioners 90 days notice of conditions in the Pacific war that will result in releasing civilian radio production, he doesn't belong in WPB. He should be military advisor to General Marshall.

As for any assurance from the WPB that there will be time enough to complete significant FM tests and to design new equipment before civilian production can be resumed — the truth is that WPB merely functions under the orders of our military high command, to which it is responsible. It does not issue contracts. It cannot influence their cancellation. When aircraft contracts totalling 4 billion dollars, an amount equal to the total production of radio and radar equipment for this year, were cancelled recently, WPB had no more advance notice than the manufacturers who received the cancellations.

Actually, the "advice" received from WPB is so cockeyed that the FCC never should have published it, except as a horrible example of the extent to which Government agencies can fail to recognize their limitations and the nature of their responsibilities.

The Commissioners should have recognized this. The Commissioners must realize that the permission implied by WPB to build "a small quantity of receivers and possibly a few transmitters" — not to sell but merely for laboratory tests — is all that manufacturers need to formulate their plans for civilian production and postwar employment. But how can they design or build or plan anything until FM frequencies have been allocated?

It's a Matter of Jobs ★ In proposing to delay FM broadcast assignments pending further tests during the summer, the Commissioners fail to see the need for an immediate decision. It has nothing to do with "the comparatively small present investment in transmitting equipment and receivers," nor with "the short-range advantage to be obtained by manufac-

(CONTINUED ON PAGE 83)

WHAT'S NEW THIS MONTH

(CONTINUED FROM PAGE 81)

turers." It's a matter of jobs, — jobs for radio workers whose financial independence requires continuous employment, and for returning veterans who will judge the management of this country during their absence by the availability of employment.

Even the engineers who have been invited to serve under Chief Engineer Adair on the joint committee to make FM tests this summer are outspoken in saying that while some interesting data may be obtained, little will be added to present knowledge already available to the FCC, and that more useful ends would be served by spending the same amount of time on the design of postwar transmitters and receivers.

No, the problem confronting the Commissioners is not one of further assaying the propagiaton advantages of proposals 1, 2, and 3. It is a matter of choosing between risking the responsibility for denying employment to civilian radio workers and returned veterans, or deciding NOW between the propagation advantages of the three bands proposed for FM broadcasting.

Certainly, this choice should not be difficult to make, and the opinions of the Commissioners should be unanimous.

CIRCULAR ANTENNAS

(CONTINUED FROM PAGE 42)

pendability was accepted on the basis that we were able to verify the other curves by the same method.

While the curves themselves are completely reliable, one must be cautioned in the use of the value of effective height that applies for transmission from mountain tops. Unless the path of the earth-reflected rays from the transmitting antenna are several wavelengths above the terrain from the transmitter location to the level terrain at the service area, it will not be found appropriate to use for the effective height the entire height above the level terrain. In other words, at least a short tower must be used even on a mountain top to gain the full advantage that this natural height offers.

A most interesting brochure on magnesium and its uses has been issued by the Magnesium Division of The Dow Chemical Company. Die castings of this metal were employed extensively in German radio equipment, but magnesium is almost a stranger to our radio industry. However, in addition to great weight advantage over steel, it has many properties which lend themselves to production economies in stamping and machining. Information can be obtained from Dow offices at 30 Rockefeller Plaza, New York 20; Field Building, Chicago 3; and 634 S. Spring Street, Los Angeles 14.

SEND FOR THIS

RESISTOR DATA

For the convenience of designers of products requiring resistors, Ward Leonard offers this new Resistor Handbook. It describes in detail the full line of wire-wound resistors giving complete information on mountings, enclosures, terminals and resistance values. Write for your copy today.

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WARD LEONARD

RELAYS • RESISTORS • RHEOSTATS

Electric control (WL) devices since 1892.

WARD LEONARD ELECTRIC COMPANY, 30 SOUTH ST., MOUNT VERNON, N. Y.

• They were mighty tough before Pearl Harbor, and they are now still tougher, these Type "05" Aerovox oil-filled Xmitting capacitors, because of their service on many fighting fronts. You'll have these heavy-duty capacitors available for your bigger and better "ham" rigs or electronic assemblies just as soon as Uncle Sam releases them for your use. Remember Aerovox "05" Hyvols.

Convenient, moderate-priced, oil-filled capacitors.

Reinforced round metal can. Hyvol impregnant and fill.

600 to 3000 volt D.C.W. ratings. Capacitance ratings from 1.0 to 4.0 depending on voltage.

Immersion-proof terminals with "double rubber bakelite," porcelain pillar insulator, lug and locking nuts.

Adjustable mounting ring for upright or inverted mounting.

• Ask your jobber about these Aerovox "05" Hyvols now available on suitable priorities, but generally available after V-day.

AEROVOX Capacitors
INDIVIDUALLY TESTED

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Here's an opportunity to join one of America's largest manufacturers of electronic and communications equipment.

Radio
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Work in connection with the manufacture of a wide variety of new and advanced types of communications equipment and special electronic products.

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• Also: C. A. L.
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Applicants must comply with WMC regulations

SPOT NEWS NOTES

(CONTINUED FROM PAGE 28)

estimate is issued, probably late in June, monthly production figures will be considerably under $200,000,000.

Dr. Leroy D. Weld: Professor of physics at Coe College, Iowa, has joined the Turner Company, microphone manufacturers, as director of research, heading a program of military and postwar product development.

Correction: Last month, it was stated in this Department that the I.B.M. Radiotype machine operates at 150 words per minute. Mr. A. C. Holt, assistant general manager of I.B.M.'s Radiotype division, advises that the rated speed of this equipment is 100 words per minute. This error came about through confusion with the 150-word speed of I.B.M. electric typewriters, on order for our editorial office.

Murray G. Crosby: Research engineer at RCA for the past 20 years, has joined the consulting firm of the Paul Godley Company at Upper Montclair, N. J. Widely known for his work on the reactance-tube method of frequency modulation, he will specialize on point-to-point, airborne, and multiplex communications and FM problems, relay and satellite stations, television, and facsimile.

WPB Contradiction: While someone at WPB was assuring the FCC Commissioners that they would be given a 90-day advance notice of any new prediction concerning the resumption of civilian radio manufacture, and that, therefore, no embarrassment would be caused the radio industry by postponing the assignment of FM broadcast frequencies, a bulletin was issued under WPB Chairman Krug's name warning that: "Army and Navy war production schedules are currently being lowered and contracts terminated. Such a major withdrawal of Government purchases from the market poses a major problem."

Chairman Krug continues with this quotation from the 3rd Annual Report of the Senate Committee Investigating the National Defense Program: "If the home economy is permitted to weaken and lose the resiliency necessary for quick and successful conversion to peacetime occupations, it will not be able to provide employment for soldiers and war workers when they are released from their present tasks. Should unemployment and business depression gain headway before the major task of readjustment has even begun, the difficulties of reemployment will be much greater."

This bulletin lists the various present job classifications and the number employed in each. The classifications are then grouped to show which will or will

(CONCLUDED ON PAGE 86)

SPOT NEWS NOTES

(CONTINUED FROM PAGE 85)

not be affected by military contract cutbacks. Under the heading "Jobs Most Likely to Be Affected by Cutbacks" is the item

Ordnance & Signal Equipment
1,800,000 workers

Yet, in spite of this warning and the information from the assistant director of the WPB Radio & Radar Division that the outlook on military production beyond the next four months is "uncertain," someone in WPB advised the FCC that nothing would be lost by spending the summer on FM propagation tests, thereby postponing indefinitely the allocation of FM broadcast frequencies upon which depend the initiation of plans necessary to assure employment to factory workers and veterans after the Pacific War reaches its concluding phase.

25 Years' Growth: When RCA was organized in 1919, it began operations with 457 employees. That number has been increased during the war to 38,000, of which 51% are women. Gross business during the first year was $2,000,000, compared to the 1944 volume of $326,000,000. Net profit, after taxes, for the 25-year period totalled $123,000,000, from which $80,000,000 have been paid in cash dividends. Of the $40,211,000 gross profit in 1944, the sum of $29,948,000 will be paid in taxes, leaving $10,263,000 available for dividends to stockholders.

It is interesting to note that RCA has never sold stock or bonds to the public. Most of the stock outstanding was issued in payment for manufacturing plants, communications properties, patent rights, or assets acquired from other companies.

RCA's unfilled orders on April 1st, 1945 totalled approximately $180,000,000 compared with $300,000,000 on April 1st, 1944. This is a decrease of about 40%.

D. D. Jones: For the past six years a member of the engineering department at CBS, has been appointed assistant chief engineer of Tech Laboratories, 337 Central Avenue, Jersey City 7, N. J.

Draft Deferment: No more certifications of radio and radar workers as essential employees for draft purposes will be issued by WPB, the Army, or the Navy.

Timothy E. Shea: Formerly chief engineer of the Electrical Research Products division of Western Electric, and for the past four years director of research for the Columbia University Division of War Research under NDRC, has been appointed superintendent in charge of manufacturing at Western Electric's vacuum tube shop in New York City.

ENGINEERING SALES

(CONTINUED FROM PAGE 8)

RCA: Has appointed Modern Radio Supply Company, San Antonio, Texas, as distributor of tubes, test equipment, replacement parts, and sound equipment. This firm, headed by Walter R. Retzloff, operates branches at Corpus Christi and Harlingen.

Sonora: Seven hundred dealers, assembled at Hotel Pennsylvania, were promised that Sonora is ready for civilian production. To overcome expected shortage of cabinets and components, Sonora has acquired the Sterling Wood Manufacturing Company and the Electronic Parts Manufacturing Company.

Westinghouse: Has appointed the following men as managers of Westinghouse Supply Companies: Charles R. Lee at New Orleans; C. M. Reynolds at Corpus Christi; and L. J. Clay at San Antonio. B. A. Rowan has been named radio sales manager for the northern district, with headquarters at the Westinghouse Supply Company, Milwaukee.

Lear: New Factory representatives are Ernie Camos for the St. Louis area; Frank Russell for the Baltimore, Washington, Philadelphia area; William R. Connors for the Denver and Rocky Mountain area; Allen Dunlap for the State of Ohio. Added distributors are Wood Distributing Company, Little Rock, and Approved Appliance Company, Indianapolis.

Stromberg-Carlson: Padgett Distributing Company, 409 Bullington Street, Dallas, will handle the S-C line in 88 counties adjacent to Dallas and Fort Worth, and in 4 parishes comprising the Shreveport area.

Stewart-Warner: Philadelphia Distributors, Philadelphia, will handle the S-W radio line in eastern Pennsylvania, southern Jersey, and northern Delaware. Company is headed by Al Hughes and Harry Ellis.

New Zealand: Radio Corporation of New Zealand, 80 Courtenay Place, Wellington C3, the Hytron distributor in that country, is interested in receiving catalogs and prices on small components suitable for midget receivers and hearing aids.

Lear: E. B. Latham & Company will handle Lear home radios in Greater New York, including Westchester, Nassau, and Suffolk counties. Latham was an early and very successful distributor of radio sets. Before the war, however, the Company turned down offers from several manufacturers to take on some excellent lines.

Westinghouse: L. E. Septer, former assistant sales manager of Kenrad's replacement tube division, has returned to Westinghouse as manager of replacement tube sales for the home radio division. He will make his headquarters at Sunbury, Pa.

"CQ..." we'll hear it again-SOON

Who Said The "Ham" Is Finished?

THERE have been rumors to the effect that the radio Amateurs were going to be denied their old frequency bands, and given new bands of such high frequency as to be useless for medium and long distance communication.

Some rumors say "Remember the last War? We are going to get the same treatment this time!"

Now, we don't believe the "Hams" should be denied their rightful place on the air in bands suitable for communication beyond the horizon——and further, we do not believe that our Government would want to see those privileges denied.

Are not the "Hams" fighting on many battlefronts, working in war factories and laboratories for a New World wherein the individual will be able to live and enjoy his hobbies, his church and other personal freedoms which go to make up a healthy, happy world?

It is well-known among Government officials whose task it was to build our great war-time communications system that from the rank and file of amateurs came executives, instructors and thousands of engineers and operators. Without this nucleus of experienced men, it would no doubt have taken a much longer time to reach the present high degree of perfection in the communications branch of our fighting forces.

In every emergency Amateurs have proved their ability and willingness to come to the aid of their Country——who would be so unjust as to want to deny them their small place in the radio spectrum? We do not believe these rumors that the "Ham" will be denied his privileges, we believe rather that those who speak so much of justice coming out of this war will see to it that the Amateur receives his just reward.

The entire radio industry knows well, and appreciates the many contributions "Hams" have made for the advancement of high frequency radio communications, and surely they too can be counted on to assist the "Ham" in regaining his privileges when the right time comes.

HAMMARLUND MANUFACTURING CO., Inc.
160 West 34th Street, New York 1, N. Y.

THIS AD APPEARED IN MARCH, 1944

THE HAM IS COMING BACK... STRONGER THAN EVER

WE never lost faith in the friends of amateur radio. We believe progress up to this very moment indicates that Hams have many friends in high places. Of course, there is a lot of romance to Ham radio, but the place won by the Ham in the hearts and minds of important people is the result of a very practical demonstration of real worth—real American ability.

We wish to openly express our sincere appreciation for the wisdom of those whose job it was to guide amateur radio through these troubled times. And those who have given Hams a just portion of the spectrum are to be commended for their farsightedness.

American amateurs can be thankful they live in a country where ability receives its just reward.

LLOYD A. HAMMARLUND, President

HAMMARLUND MFG. CO., INC., 460 W. 34th ST., NEW YORK 1, N. Y.

Reading and Writing and F.M.

FM STATION WNYE

***Owner and Licensee* — Board of Education, City of New York**

Frequency: 42.1 megacycles • Input to final amplifier: 1.67 KW • Antenna output: 1 KW • Type of transmitter: REL S18 DL

Station WNYE has been in successful operation since 1941. REL equipment played an important part in the installation of this educational station.

REL

Schools and colleges are rapidly recognizing the value of FM broadcasting as an effective channel for extending their daily work into millions of homes.

REL, pioneers in FM educational broadcasting, have developed transmitting equipment for FM broadcasting to the highest degree of efficiency. Proof of the excellence and reliability of REL equipment is contained in the operating records of many FM stations of 1 KW, 3 KW, 10 KW and 50 KW power.

When planning for FM transmission, go *first* to REL!

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PIONEER MANUFACTURERS OF FM TRANSMITTERS EMPLOYING ARMSTRONG PHASE-SHIFT MODULATION

RADIO ENGINEERING LABS., INC.

Long Island City, N. Y.

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CONCORD, N. H.

The TOUGHEST *Emergency Radio* PROVING GROUNDS

NEW YORK
METROPOLITAN AREA

Here — in addition to hundreds of other tough areas throughout the country, *Link* units excel in:

ENGINEERING • DESIGN
PERFORMANCE • QUALITY

GUARDING THIS AREA

95 % Plus IS *Link* EQUIPMENT

BY *Preferred* CHOICE—
in this most important seaport and gateway of the world . . .

Link Radio Users in Metropolitan Area

New Jersey
Allenhurst
Asbury Park
Atlantic Highlands
Avon
Bakelite Corporation
Belmar
Bergen County Police and Prosecutor
Bergenfield Police and Fire
Bloomfield Police and Fire
Bogota
Boonton
Bradley Beach
Brielle
Budd Lake
Butler
Caldwell Township
Carlstadt
Cedar Grove Police and Fire
Clifton Police and Fire
Cresskill
Denville
Dover Police and Fire
East Orange Fire
East Paterson
Eatontown
Edgewater Police and Fire
Emerson
Englewood Cliffs
Englishtown
Fair Haven
Fairlawn
Fairview
Fairville
Garfield Police and Fire
Glen Rock
Hackensack Police, Fire and Water
Haledon
Harrison Fire
Hasbrouck Heights
Haworth
Hawthorne
Hayden Chemical Company
Hillside
Ho-Ho-Kus
Interlaken
Keansburg
Keyport
Leonia
Little Falls Police and Fire
Little Silver
Long Branch
Lyndhurst
Madison Township
Manasquan
Matawan Boro
Matawan Township
Maywood
Middletown Township
Millburn
Monmouth Beach
Montclair
Mountville
Neptune City
Neptune Township
New Jersey Motor Vehicle
New Jersey State Police
New Milford
North Arlington
North Bergen Police and Fire
North Haledon
Ocean Grove
Oceanport
Ocean Township
Oradell
Paramus
Palisades Interstate Park
Passaic
Paterson
Perth Amboy
Piscataway Township
Point Pleasant Beach
Pompton Lakes
Princeton
Princeton Township
Prospect Park
Raritan Township
Red Bank
Ridgefield Park
Ridgewood Police and Water
River Edge
Roselle
Roselle Park
Rumson
Rutherford
Saddle River
Sayreville
Sea Bright
Sea Girt
Shrewsbury Boro
South Amboy
South Belmar
Spring Lake
Spring Lake Heights
Springfield
Tenafly
Teaneck Police and Fire
Totowa Boro
Union
Union Beach
Verona
Wall Township
Wanaque
Wayne Township
West New York
West Paterson
West Long Branch
West Point Pleasant
Westwood
Woodbridge
Woodridge
Wycoff
Port Authority
Bayonne Bridge
George Washington Bridge
Outer Bridge
New York
Babylon
East Hampton
Federal Communications Commission
Floral Park
Grumman Aircraft
Hastings
Huntington
Islip
Lake Success
Lloyds Harbor
Lynbrook
Nassau County Police and Fire Marshal
New York Central
New York City Police and Fire
New York State Police
Oyster Bay Cove
Patchogue
Riverhead
Rockville Centre
Shelter Island
Smithtown
Southampton
Southold
Suffolk County Sheriff
Republic Aircraft
Teterboro
Connecticut
Bethel Police, Fire and Public Works
Bloomfield Police, Fire and Public Works
Bridgeport Police and Fire
Connecticut State Police
Danbury Police and Fire
Darien Police, Fire and Public Works
East Haven Police, Fire and Public Works
Enfield Police, Fire and Public Works
Greenwich Police, Fire and Public Works
Hamden Police, Fire and Public Works
New Haven Police and Fire
Norwalk Police and Fire
Norwich Police and Fire
Stamford Police and Fire
Torrington Police and Fire
Waterbury Police and Fire
Watertown Police and Fire
Woodbridge Police and Fire
Pratt & Whitney
Connecticut Light and Power Company

ENGINEER • MANUFACTURER

Fred M. Link

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PREFERRED *FM* RADIO COMMUNICATION EQUIPMENT

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