COMMUNICATIONS

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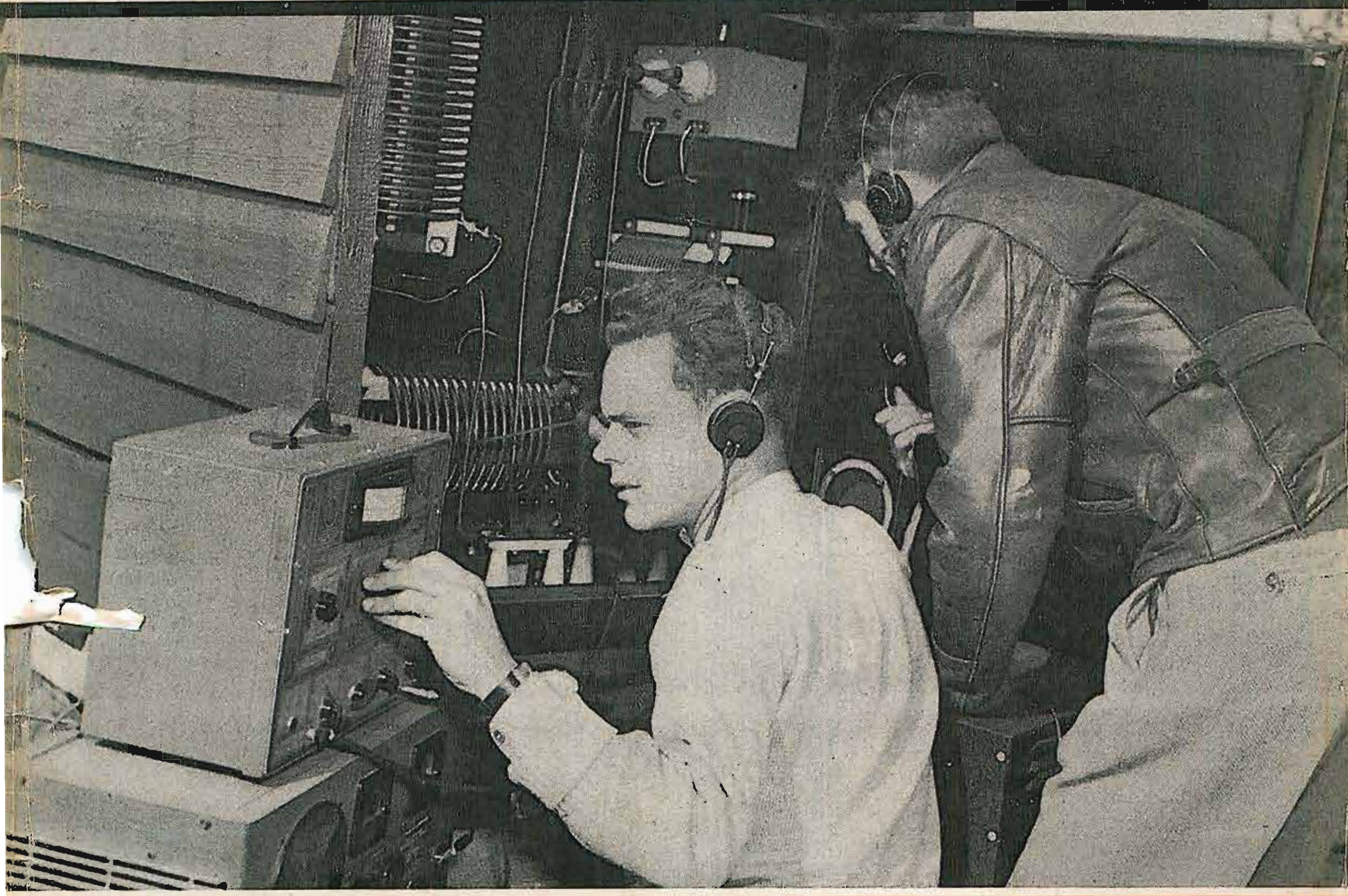


JANUARY

★ TV LENS FACTORS ★ F-M/TV ANTENNA SYSTEMS

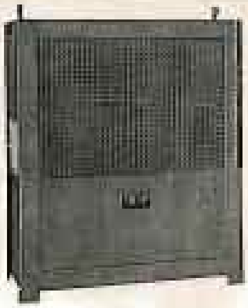
★ H-F 20-KW TRANSMITTER WITH CONTINUOUSLY TUNABLE PLATE CIRCUIT

1948

3-Phase Regulation

MODEL	LOAD RANGE VOLT-AMPERES	*REGULATION ACCURACY
3P15,000	1500-15,000	0.5%
3P30,000	3000-30,000	0.5%
3P45,000	4500-45,000	0.5%

• Harmonic Distortion on above models 3%.
Lower capacities also available.



Extra Heavy Loads

MODEL	LOAD RANGE VOLT-AMPERES	*REGULATION ACCURACY
5,000+	500 - 5,000	0.5%
10,000+	1000-10,000	0.5%
15,000+	1500-15,000	0.5%

General Application

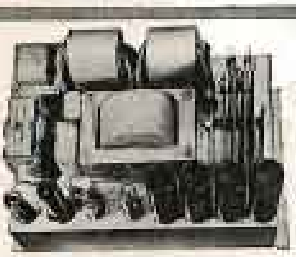
MODEL	LOAD RANGE VOLT-AMPERES	*REGULATION ACCURACY
150	25 - 150	0.5%
250	25 - 250	0.2%
500	50 - 500	0.5%
1000	100-1000	0.2%
2000	200-2000	0.2%

400-800 Cycle Line

INVERTER AND GENERATOR REGULATORS FOR AIRCRAFT.
Single Phase and Three Phase

MODEL	LOAD RANGE VOLT-AMPERES	*REGULATION ACCURACY
D500	50 - 500	0.5%
D1200	120-1200	0.5%
3PD250	25 - 250	0.5%
3PD750	75 - 750	0.5%

Other capacities also available



The NOBATRON Line

Output Voltage DC	Load Range Amps.
6 volts	15-40-100
12 "	15
28 "	10-30
48 "	15
125 "	5-10

• Regulation Accuracy 0.25% from ¼ to full load.

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The First Line of standard electronic AC Voltage Regulators and Nobatrons

GENERAL SPECIFICATIONS:

- Harmonic distortion max. 5% basic, 2% "S" models.
- Input voltage range 95-125; 220-240 volts (—2 models)
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JANUARY, 1948 VOLUME 28 NUMBER 1

COMMUNICATIONS

Including Television Engineering, Radio Engineering, Communication & Broadcast Engineering, The Broadcast Engineer. Registered U. S. Patent Office.

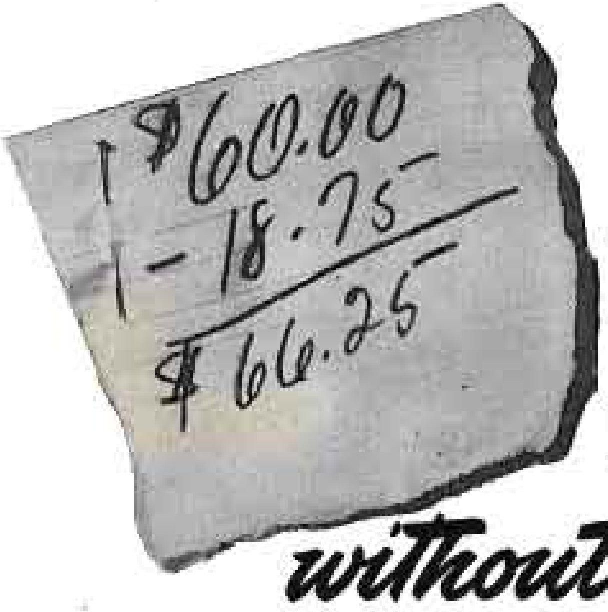
Wellington, New Zealand: Te Aro Book Depot.
Melbourne, Australia: McGill's Agency.

Entered as second-class matter Oct. 1, 1937 at the Post Office at New York, N. Y., under the Act of March 3, 1879. Subscription price: $2.00 per year in the United States of America and Canada; 25 cents per copy. $3.00 per year in foreign countries; 35 cents per copy.

COVER ILLUSTRATION

Raymond C. Watson, Jr., chief engineer of WOOB, Anniston, Alabama and David L. Stanley of the WOOB engineering staff, tuning up an antenna-coupling filter, designed by Andrew, to reject interfering frequencies from the 190' WHMA antenna tower, which is 560' away from the 150' WOOB tower.

Published monthly by Bryan Davis Publishing Co., Inc.
52 Vanderbilt Avenue, New York 17, N. Y. Telephone MUrray Hill 4-0170



How 19,000 companies up take-home pay *without upping payrolls*

Can you deduct $18.75 from $60.00 and get $66.25? ***Yes.*** **And the way you can do it is mighty important to your company—and to the nation!**

You start with $60, representing someone's weekly take-home pay. You deduct $18.75 for the purchase of a U.S. Savings Bond. That leaves $41.25. But $41.25 isn't what the worker takes home. He takes home $41.25 ***plus a $25 Savings Bond.*** **Total (assuming he holds the Bond till maturity):** ***$66.25.***

WHAT 19,000 COMPANIES HAVE LEARNED

In the 19,000 companies that are operating the Payroll Savings Plan for the regular purchase of Savings Bonds, employees have been more contented in their jobs—absenteeism has decreased—even accidents have been fewer!

Those are the "company" benefits the Plan provides, in addition to extra security for individual employees.

But the Plan has other, far-reaching benefits of basic importance to both your business and the national economy...

SPREADING THE NATIONAL DEBT HELPS SECURE YOUR FUTURE

The future of your business is closely dependent upon the future economy of your country. To a major extent, that future depends upon management of the public debt. Distribution of the debt as widely as possible among the people of the nation will result in the greatest good for all.

How that works is clearly and briefly described in the free brochure shown at the right. Request your copy—*today*—from your State Director of the U. S. Treasury Department's Savings Bonds Division.

ACTION BY TOP MANAGEMENT NEEDED

The benefits of regular Bond-buying are as important today as ever—but war-time emotional appeals are gone. Sponsorship of the Payroll Savings Plan by a responsible executive in your company is necessary to keep its benefits *advertised to your employees.*

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The State Director will gladly give you any assistance you wish.

"The National Debt and You,"

a 12-page pocket-size brochure, expresses the views of W. Randolph Burgess, Vice Chairman of the Board of the National City Bank of New York—and of Clarence Francis, Chairman of the Board, General Foods Corporation. Be sure to get your copy from the Treasury Department's State Director, Savings Bonds Division.

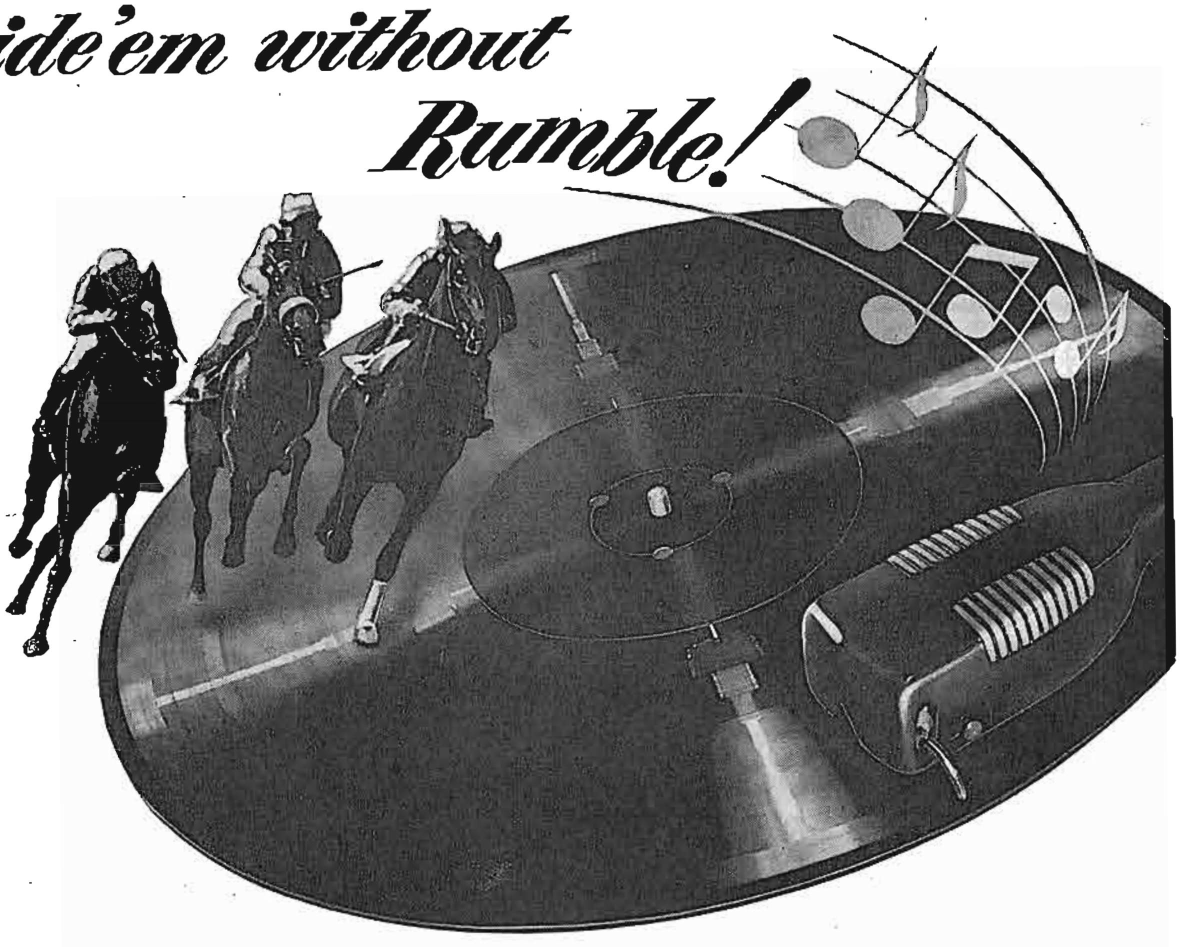
The Treasury Department acknowledges with appreciation the publication of this message by

COMMUNICATIONS

This is an official U.S. Treasury advertisement prepared under the auspices of the Treasury Department and the Advertising Council

PROFESSIONAL PERFORMANCE—that keeps the original sound alive!

Ride'em without Rumble!



—on a turntable free of vibration

The pounding of hooves may be sweet music to the ears of a race jockey. But to a disc jockey—whose program's success depends upon the undistorted high fidelity of his transcriptions—any extraneous mechanical noise leaves his listeners at the starting post. They just won't ride with him!

Fairchild engineers have succeeded in eliminating the last bit of extraneous mechanical noise — in the newly redesigned Unit 524 Transcription Turntable. Turntable noise, rumble and vibration are non-existent because of the unique method of mounting the drive — at the bottom of the cabinet . . . the use of a specially designed rubber coupling to connect the drive and synchronous motor which are spring-mounted and precision-aligned in a single heavy casting . . . the use of sound-stopping mechanical filters on the hollow drive shaft to reduce the transmission of vibration from the drive mechanism to the turntable . . . and the use of a heavy, webbed cast aluminum turntable mount at the top of the cabinet.

In addition to freedom from rumble, Fairchild offers you a wider frequency range and lower distortion content with its Unit 542 Lateral Dynamic Pickup, with a stylus mounting that allows the tip to follow the minute indentations engraved in the groove from 30 to 10,000 cycles and beyond, with a minimum of distortion. Want more details about sound equipment that really keeps the original sound alive? Address: 88-06 Van Wyck Boulevard, Jamaica 1, New York.

Transcription Turntables
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AM FM SOUND EQUIPMENT

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Available in six standard models. -*hp*- 200A and -*hp*- 200B have transformer-coupled output delivering 1 watt into matched load. Primarily designed for audio testing. -*hp*- 200C and -*hp*- 200D have resistance-coupled output and supply constant voltage over wide frequency range. The -*hp*- 202D is a modification of the 200D, extending frequency downward to 2 cps. -*hp*- 200I is a spread-scale oscillator designed for interpolation work and for applications where oscillation frequency must be known with utmost accuracy.

202B LOW FREQUENCY OSCILLATOR

Specially designed for work between ½ cps and 1000 cps. Provides excellent wave form, good stability, split-hair measuring accuracy in the very low frequencies. Ideal for vibration or stability checks on mechanical systems, for testing geophysical, electro-cardiograph or electro-encephalograph equipment, checking response of seismographs, or electrical simulation of mechanical phenomena.

Resistance-Tuned Oscillators ...For Every Measuring Job 1/2 cps to 10 mc!

From A to Z in measuring, there's an -*hp*- resistance-tuned oscillator engineered to fit your exact need. Nine precision oscillators in all...and each bears the famed -*hp*- family characteristics of no zero set, constant output, low distortion, great stability, and decade tuning. Brief data on these -*hp*- oscillators are given here. For complete details, write or wire today!

HEWLETT-PACKARD COMPANY
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201B AUDIO OSCILLATOR

Meets every requirement for speed, accuracy, wave form purity and ease of operation in FM and other fields where high fidelity is most important. Provides 3 watts output into a 600 ohm resistive load. Distortion held to 1% or less, at 3 watts, ½% at 1 watt output. Excels in testing high fidelity amplifiers, speakers, and in comparing frequencies.

650A WIDE-BAND OSCILLATOR

Continuous frequency coverage, 10 cps to 10 mc. Highly stable, versatile. Output flat within 1 db throughout frequency range. Available voltages range from .00003 to 3 v. Other advantages include 94" scale length, 6 to 1 micro-controlled tuning drive, 50 db output attenuator variable in 10 db steps, output voltage divider providing 6 ohm internal impedance (reducing output voltage 100 to 1).

BRIEF SPECIFICATIONS

Instrument	Freq. Range	Output	Distortion	Freq. Response
-hp- 200A	35 cps to 35 kc	1 watt/22.5v	Less than 1%	±1 db to 15 kc
-hp- 200B	20 cps to 20 kc	1 watt/22.5v	Less than 1%	±1 db to 15 kc
-hp- 200C	20 cps to 200 kc	100 mw/10v	Less than 1% to 20 kc	±1 db to 150 kc
-hp- 200D	7 cps to 70 kc	100 mw/10v	Less than 1% 10 cps to 20 kc	±1 db throughout range
-hp- 202D	2 cps to 70 kc	100 mw/10v	Less than 2% 10 cps to 70 kc	±1 db, 7 cps to 70 kc
-hp- 200I	6 cps to 6 kc	100 mw/10v	Less than 1% above 10 cps	±1 db, 4 to 6000 cps
-hp- 202B	½ cps to 1000 cps	100 mw/10v	Less than 1% 1 to 1000 cps	±1 db, 10 to 1000 cps
-hp- 201B	20 to 20,000 cps	3 w/42.5v	Less than 1%	±1 db throughout range
-hp- 650A	10 cps to 10 mc	15 mw/3v	Less than 1% 100 cps to 100 kc	±1 db throughout range

hp laboratory instruments FOR SPEED AND ACCURACY

COMMUNICATIONS

LEWIS WINNER, Editor

JANUARY, 1948

Going Up

A STRIKING INCREASE in operators and stations was revealed in the year-end report of the FCC. As of January 1, 1948, there were 3,834 broadcast stations which included 1962 a-m, 1,010 f-m, 73 tv and 590 remote pickups. Over 120,000 non-broadcasting systems were recorded, including 20,818 aeronautical, 14,254 marine, and over 7,000 public safety and land transportation systems. Over 350,000 licenses were issued to radio operators.

In analyzing the license grants, the FCC reported that 1,522 a-m stations have been licensed to operate, 374 f-m stations are on the air and 17 television stations are now operating. It was reported that a total of 4,130 license authorizations were granted for police, fire and forest protection. And power, transit and petroleum pipe-line facilities received license grants for 1,136 stations. The railroads received 109 licenses and were authorized to operate over 900 transmitters.

Two-way transmitting systems were installed in over 25,000 trucks, buses and taxicabs. Over 30,000 received special licenses to use two-way systems in such activities as lumbering, paper mills, highway activities, ranch services, etc.

In 1948 a 50% increase in station and operator grants is anticipated.

New Broadcast Definitions

STREAMLINED DEFINITIONS of many broadcast terms were adopted at the recent Meeting of Engineers held in Havana, Cuba, during the latter part of 1947.

The definitions approved included *skywave signal*, which was defined as a radiated signal which is reflected back from the ionosphere. A *groundwave signal* was defined as the radiated signal which is propagated close to the surface of the earth and is not reflected back from the ionosphere. Another definition stated that by a 10% (or 50%) skywave field intensity is meant that level of field intensity exceeded by the hourly median field intensities, in some specified interval of calendar time for 10% (or 50%) of the nights of that calendar interval. The hour of the night to which the *hourly median* refers is the hour centered on the instant of time two hours after the latest sunset on the transmission path. Also defined was *frequency tolerance and stability* with the operating frequency of each broadcast station being maintained to within 20 cycles per second of assigned frequency and not varying perceptibly over short periods of time under all conditions of operation. Defining *determination of power*, the engineers stated that power should be determined by taking the product of the square of the current at the point of input to the antenna system and the total resistance at that point.

Provision for the inclusion of the 540-kc band, raising the total channels to 107, was also suggested at the conference. The use of this channel for clear, regional or local purposes will be discussed at the forthcoming Third North American Regional Broadcasting Conference in Canada during August.

On The Development Front

SIMPLIFIED TV RECEIVER designs, featuring 7" electrostatic picture tubes, will soon appear in many models. Circuits will have each of the i-f stages tuned to the same frequency. To achieve broadband response degeneration at r-f will be employed. The use of negative feedback has been found very effective since its behavior is relatively less dependent on the changes in tube characteristics.

Some of the receivers will feature selenium rectifiers in doubler and quadrupler systems. Filaments will be connected up in series, obviating the need for a filament transformer. The only iron core component that will appear in many of these models will be the output transformer to the speaker and filter choke.

The IRE National Convention

THE YEARS'S ENGINEERING EVENT, the IRE National Convention, will feature presentation of over 100 outstanding papers on all phases of broadcasting, commercial communications and industrial electronics. Presented at the Hotel Commodore and Grand Central Palace, March 22nd to 25th, there'll be discussions on f-m, navigation aids, antennas, amplifiers, circuit designs, tube manufacturing, design and engineering, superregeneration, transmission, nuclear studies, components and supersonics, television, measurements, broadcasting and recording, propagation, microwaves and receivers.

Among the f-m papers will be one on an f-m detector tube with instantaneous limiting and single-circuit discriminator, by Robert Adler of Zenith.

Five papers have been scheduled on superregeneration, including a discussion of the linear mode by Herbert A. Glucksman, Watson Labs., and external and internal characteristics of separately quenched superregenerative circuits by Sze-Hou Chang, Watson Labs.

In a session on systems, Donald E. Norgaard, G.E., will analyze the important subject of selective sideband transmission and reception.

Complete details on the program will appear in the February issue.

Definition of An Engineer

FRED SMITH, writer of many COMMUNICATIONS papers, has submitted an interesting bit of comment on the engineer and information.

He says: "A good engineer is often defined as one who may not have remembered every technical detail connected with this work, but who can locate that information quickly when it is required.

"Obviously, it is impossible for everyone to be intimately acquainted with the multitude of innovations and new techniques which appear in all phases of communications. The mountain of journals, bulletins, periodicals and new books which crowd many desks gives mute testimony to the enormity of the task.

"There is, however, a lever by which the engineer can move this mountain of information. That lever is simply a suitable filling system, a master index of the technical data on hand. The idea may sound rather pedantic, but time saved by a good reference system has a dollars and cents value that should appeal to the most practical man."

Sound advice!—L. W.

The Cincinnati Times-Star F-M Station

Above
Antenna at WCTS-FM. A four-section pylon with a gain of four is mounted atop a 446' Blaw-Knox grounded tower providing an effective radiating power of 12.6 kw. Matching stubs are at base, permitting tuning adjustments at ground.

Below
A view of the 3-kw f-m transmitter and associated equipment.

WCTS-FM, Sister Station of 5-Kw A-M WKRC, Now on the Air with a 101.9-Mc F-M Transmitter, with an Effective Radiated Power of 12.6 Kw.

by JOHN B. LEDBETTER

Engineer
WKRC, WCTS-FM

F-M INSTALLATIONS, postponed and delayed in many areas because of reconversion difficulties, parts and material shortages, and strikes in many major industries, have, nevertheless, increased at a striking pace. From 66 stations on the air in January, 1947, f-m has grown until at this writing nearly 300 f-m stations are on the air, some 63 fully licensed and the remainder on *interim* operation. There are 696 more who have received construction permits, while 897 hold conditional grants, and at least 128 are in the process of requesting FCC approval. When these stations have been added to the number already in operation, the ranks of f-m broadcasters will have swelled to nearly 1,800.

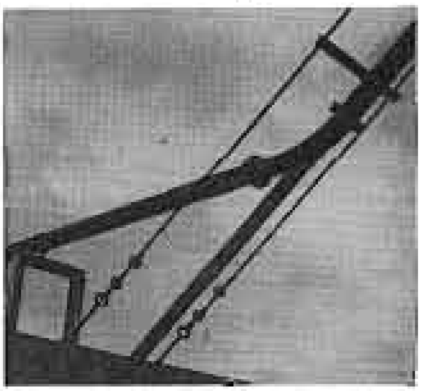
The WCTS/FM Station

After the usual construction difficulties and delays in delivery of equipment, we went on the air on March 17, 1947, with a 3-kw transmitter" and an interim power of 6.2 kw on 96.9 mc. On October 15, we shifted to our new frequency of 101.9 mc. This shift was part of FCC's reallocation plan. Because of tower and transmission-line installation problems, it was necessary to postpone use of a four-section pylon,[1] until a week after the shift to our new frequency.

The Antenna System

The antenna, located on an adjacent hill (one of the highest points in Cincinnati), some 75' above the studio-transmitter location, was mounted atop a 446' grounded tower,[2] making a total height of slightly over 500'. This antenna, with a gain of slightly over four, increased the effective radiation power from 6.2 to 12.6 kw.

The *interim* antenna was an 84' three-bay turnstile. This turnstile, designed and constructed by Hugh LaCrosse, WKRC transmitter engineer, had given a good account of itself during the interim period. One feature, developed by LaCrosse, allowed the matching stubs to be brought to the bottom of the pole instead of being



Above
Reinforced steel cables run from the transmitter to the top of the hill, to which are lashed the transmission line. Transmission line is at left. Conduit at right carries a-c power to eight antenna clearance lights and two 1,000-watt tower beacons.

terminated at the top, so that all tuning adjustments could be made from the ground.

In our transmission-line setup (3⅛" concentric copper lead) it was decided to insert four offset 35° couplers in the line to permit running of the line *up* the hill from the transmitter to tower leg. To permit this installation two specially-reenforced steel cables were run from the transmitter to the top of the hill and the transmission line lashed to these cables.

Transmitter-Studio Building

The transmitter building[4], housing complete radio facilities, was designed by George A. Wilson, chief engineer of WKRC and WCTS. Landscaping transformed the station site from a barren, desolate *rock pile* to a site of beauty.

Due to delays in receiving insulating and other materials the studio has not been completed. It was felt that greater public service would be attained if maximum efforts were expended toward getting the station on the air with its power *first*, then attending to studio and shop matters as soon as materials arrived.

In the announcer's booth which presently occupies part of the regular studio space are an announcer's clock, monitor speaker and microphone.[5a] A two-watt neon bulb placed just below eye level is used for an *open mike* signal.

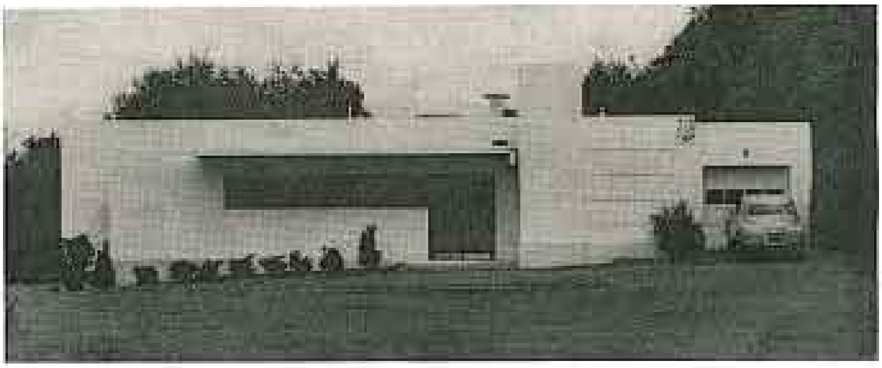
Control Room

The control room is equipped with two turntables,[5] consolette,[6] an audition and monitor cue speaker,[6] a Naval Observatory split-second clock, and a second speaker[6a] for air cue. In the consolette, the *1* and *2* positions are used for microphone channels; positions *3* and *4* are normalled to the two turntables but may be patched out to microphone positions if so desired. The regular attenuators[7] in the *3* and *4* positions have been removed and special attenuators[8] installed.

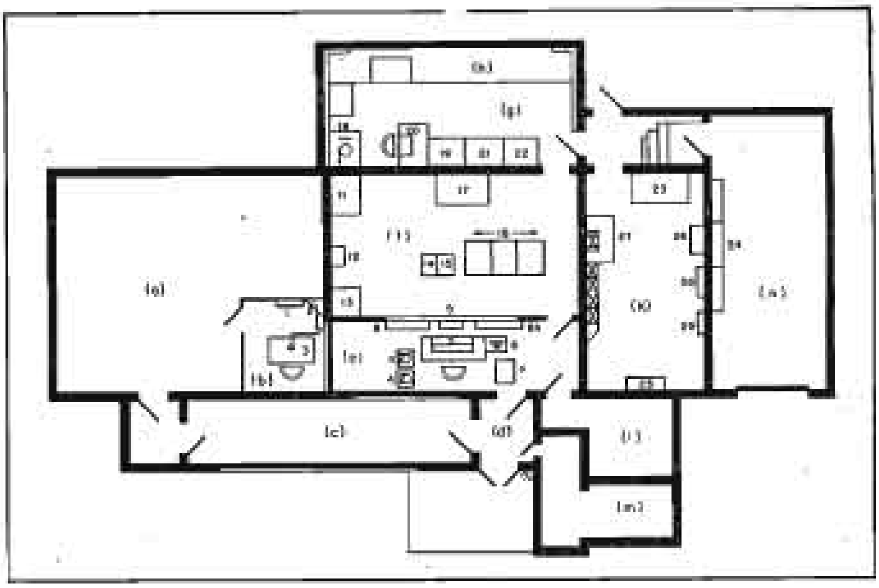
With these new attenuators, the audition amplifier is automatically

(*Continued on page 36*)

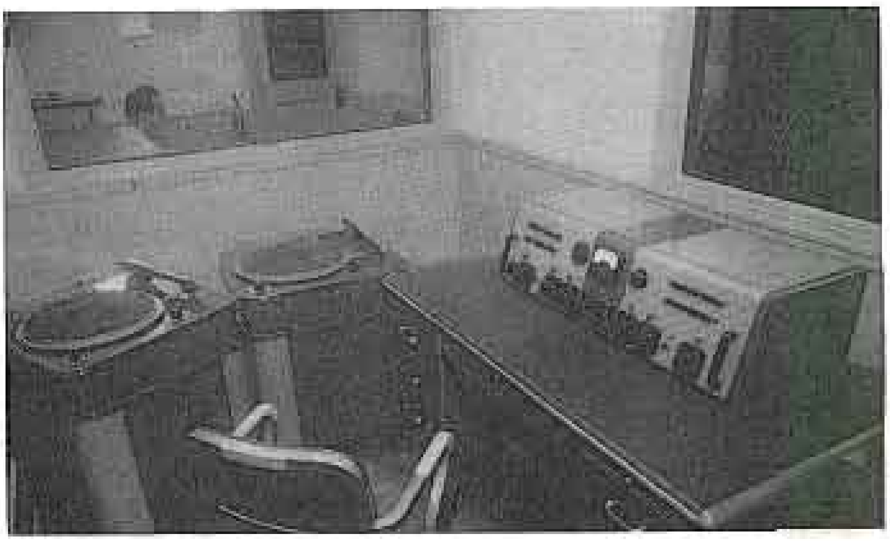
[1a]RCA BTF-3 B.
[2]RCA type BF-14.
[3]Blaw-Knox.
[4]Built by Ferro Concrete Co., Cincinnati.
[5a]RCA 77-D.
[5]RCA 70-C2.
[6]RCA 76-B2.
[6a]Altec-Lansing 600.
[7]Daven RC-102-5.
[8]Daven RCQ-102-5.



Above
Front view of the WCTS-FM building, which is situated on a high hill at 1932 Highland Avenue, Cincinnati, Ohio.



Above
Floor plan of the f-m station of the Cincinnati *Times Star*. Space (*a*) is for a proposed 25' x 21' studio; (*b*) is the announcer's booth; (*c*) outer vestibule; (*d*) entrance; (*e*) control room; (*4*—turntables; *5*—consolette; *6*—combination file cabinet and typewriter desk, which contains transmitter and audio equipment diagrams, etc.; *7*—portable program-record cabinet; *8*—audition and monitor cueing speaker; *8a*—second speaker for air cueing, and *9*—Naval Observatory split second clock); (*f*) transmitter room (*11* and *13* are spare-part storage cabinets, *11* being used for receiving tubes, turntables, overdrive assemblies, attenuators, capacitors and resistors, and *13* being used for spare transmitter tubes and transformers, power resistors, etc.; *12*—power supply for consolette; *14*—equipment rack which contains part of audio equipment; *15*—second audio rack; *16*—3-kw air-cooled transmitter assembly which consists of the power-supply cabinet and control unit, oscillator-modulator and frequency-control unit, and doubler-driver and final-amplifier unit; *17*—portable test equipment dolly which contains a tube tester, vtvm, 'scope, tools, supplies, etc.). In section (*g*) is the program department and record library. Item *18* is a dual-speed high-fidelity playback unit and *19*, *21*, *22*, *23* and *24* are record and transcription files. At *20* is the program director's desk. In space (*h*) we have an equipped workbench for construction work and emergency repair. Telephone and line terminations are housed in room (*k*) with a-c circuit breakers and main boxes at *25*; refrigerated air conditioner is at *26* and wash rooms are at *27*. The section (*n*) is the garage.



Right
Turntable and console used at the station.

International Broadcast H-F Transmitter With Continuously Tunable Plate System

Tuned Circuit of Final Stage of 2.85 to 22.5-Mc Transmitter Is Continuously Tunable from Front Panel. Power Output Is 20-Kw, Carrier, for Telegraph Service and 15-Kw, Carrier, for Phone.

by DAVID A. MILLER

Assistant Chief Engineer
J. H. Bunnell and Company

EASE OF TUNING, one of the most important design considerations, is a particularly vital factor in high-power h-f wide-range transmitter construction, where a minimum of controls and flexibility of operation are extremely advantageous.

With this type of tuning flexibility as a feature consideration, the 20-kw h-f transmitter, shown in Figure 1, was developed, with a plate circuit which is continuously tunable from the front panel over a 2.85 to 22.5-mc range.

The plate tuning circuit is an integral assembly composed of the tube water jacket, tuning coil, tuning capacitor, output coupling coil, bypass and neutralizing capacitors.

Power-Amplifier Circuit

Coupling, shown fixed in Figure 2, at the power-amplifier grid end, can be varied at the exciter end by a control located on the front panel. Both fixed and grid leak bias are employed. The grid tank, balanced with respect to ground in order to obtain the neutralizing voltage, is tuned by varying the inductance. The variable inductors and capacitors in the antenna tuning circuit are used to load, balance and impedance-match the output of the transmitter to the antenna. A pi-section plate supply filter is used.

The plate tuning capacitor varies from 100 to 370 mmfd, the plate tuning inductance from 12 to 0.5 µh, and the loaded Q of the circuit from 10 to 20.

The Inductances

The plate-tuning coil, which is water cooled, is composed of ten and one-quarter turns of ⅜" copper tubing. Of the total turns, eight and one-quarter turns are spaced 1½" between centers, one turn is spaced 1⅝" apart and one turn 2⅜" apart. The closely spaced turns are located at the bottom of the coil and the spacing increases towards the top. The inlet and outlet unions make watertight connections and also make it easy to remove this coil for cleaning, repairs or replacement.

The output coupling coil, with an inductance of 1 µh, is composed of two turns of the same tubing. This coil requires no cooling other than the forced air used to ventilate the entire power amplifier frame. Both plate-tuning coil and output-coupling coil are silver plated.

How these coils are coupled, supported and insulated from each other is shown in Figures 3, 4 and 5. This assembly presented quite a few problems. The support of the coils had to be rigid, strong and capable of holding its spacing under all operating conditions. The proper operation of the shorting spider required that the plate inductance be centered very accurately. Since peak voltage of about 40,000 volts would be encountered in operation, it was necessary in the design to prevent corona, dielectric breakdown, and voltage arc-overs across the surface of the insulation.

For insulation we selected glass-bonded mica, which is strong, machinable, and has excellent insulation characteristics. To achieve rigidity and fixed spacing between turns four grooved bars were made up to hold the plate-tuning coil between them. These bars are supported by four more bars that are securely fastened to the frame at both ends. The output-coupling coil is mounted upon this set of bars and, with the tuning coil and its supports, forms two concentric cylinders. The

[1]J. H. Bunnell model 26-15.

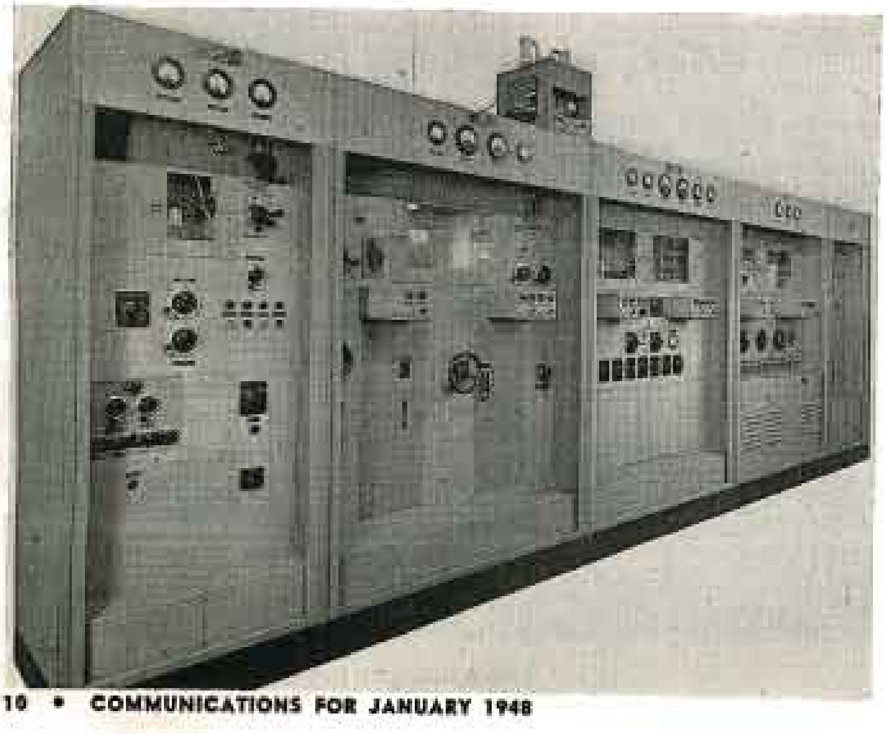


Figure 1
Continuously tunable 2.85 to 22.5-mc transmitter.

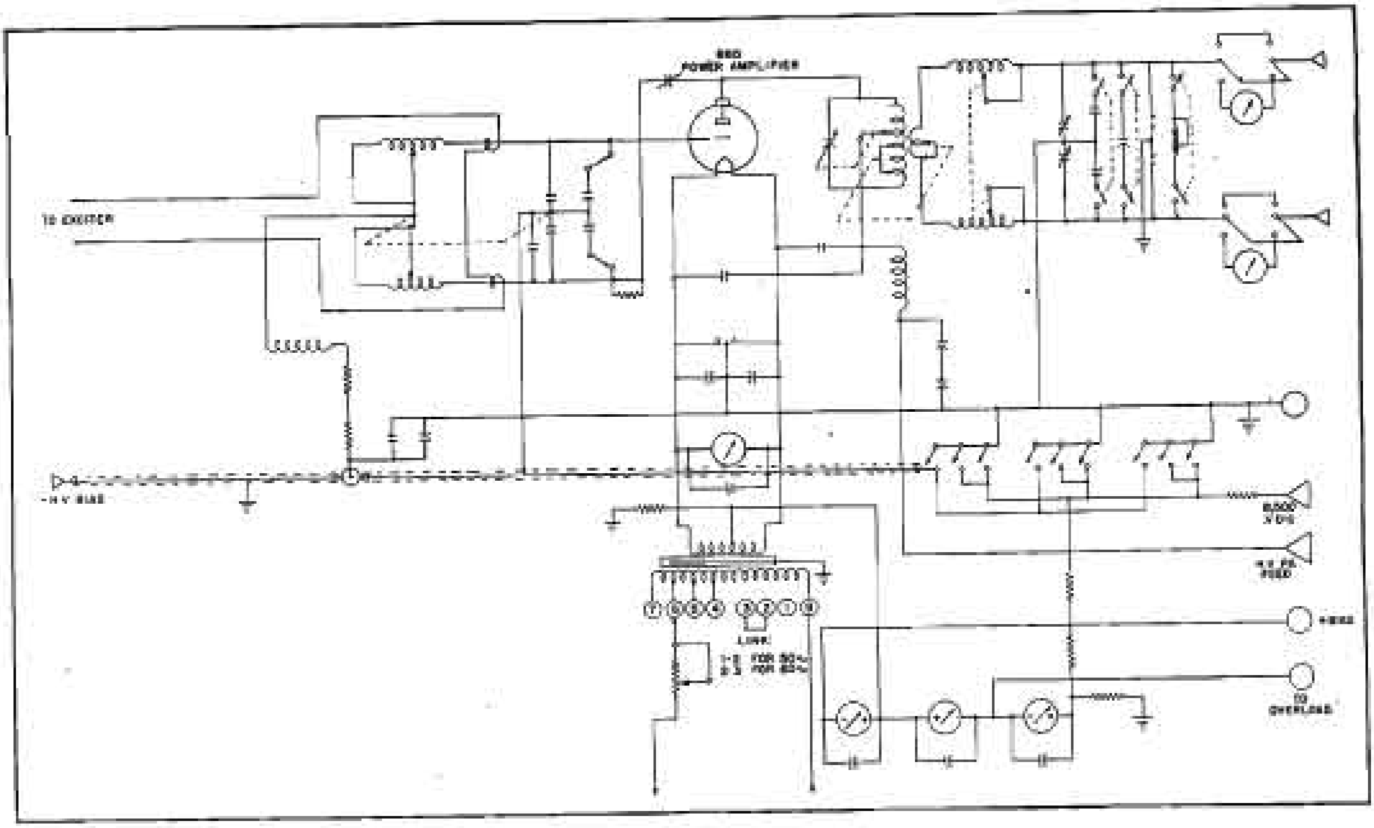


Figure 2
Schematic of the power amplifier. The grid circuit is shown link coupled to the exciter. Although coupling is shown fixed at the p-a grid end it can be varied at the exciter end by a control located on the front panel.

space between the coils is two inches and is controlled by the spacers placed between the two sets of supports. Every section of this assembly can be adjusted to compensate for any differences in parts due to normal production tolerances. Because of this feature, precision settings can be attained with low cost parts. To facilitate replacement, every glass-bonded mica part has an identifying letter and number engraved upon it.

Voltage arc-overs across the surface of the insulation, commonly called *creepage*, presented many construction problems. A conservative *creepage factor* of 5,000 volts per inch was adopted in design to permit operation in service conditions where the ambient humidity might be 95%. The grooved glass-bonded mica bars fulfill this requirement by increasing the surface distance between adjacent turns, between coils and between either coil and the frame.

Water Jacket

The water jacket and its glass-bonded mica supports fit on top of the frame that houses the plate circuit as-

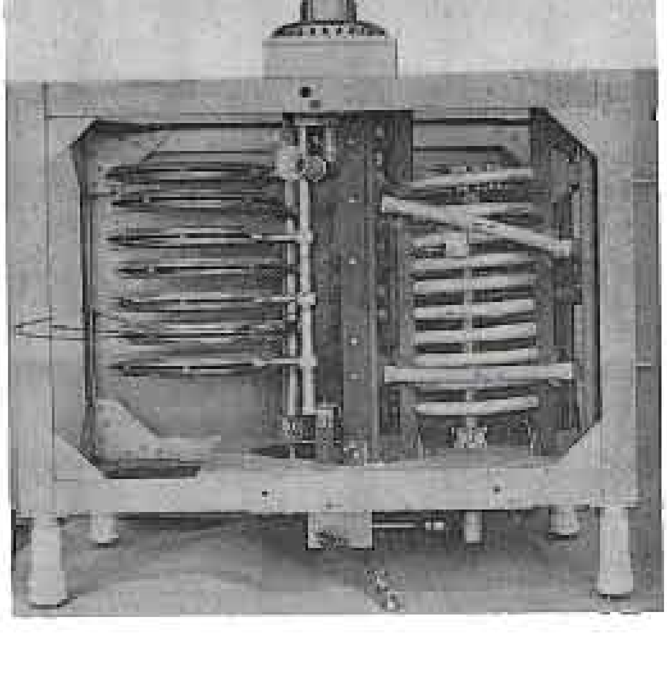


Figure 3
Front view of the plate-tuning system.

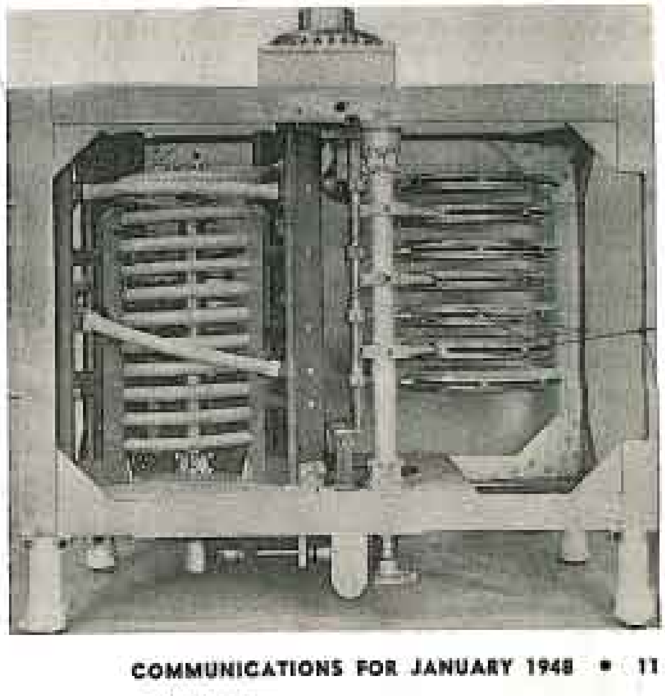


Figure 4
Rear view of the plate tuning system. Incidentally, in both these views the equipment is shown ready for shipment, with the plate coil braced by cord.

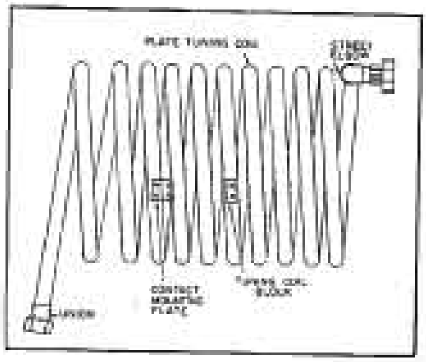
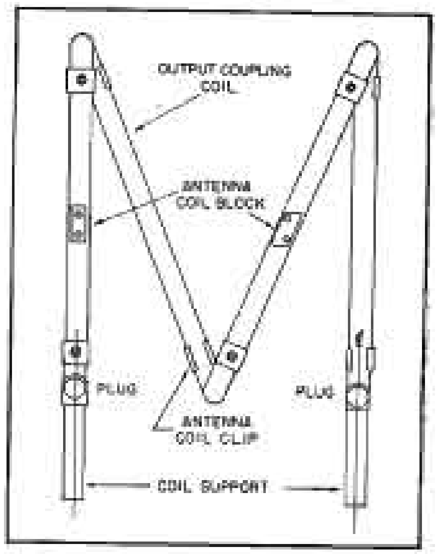


Figure 6
The water-cooled plate tuning coil.

Figure 5
Top view of the plate tuning unit.

Figure 7
The output coupling coil.

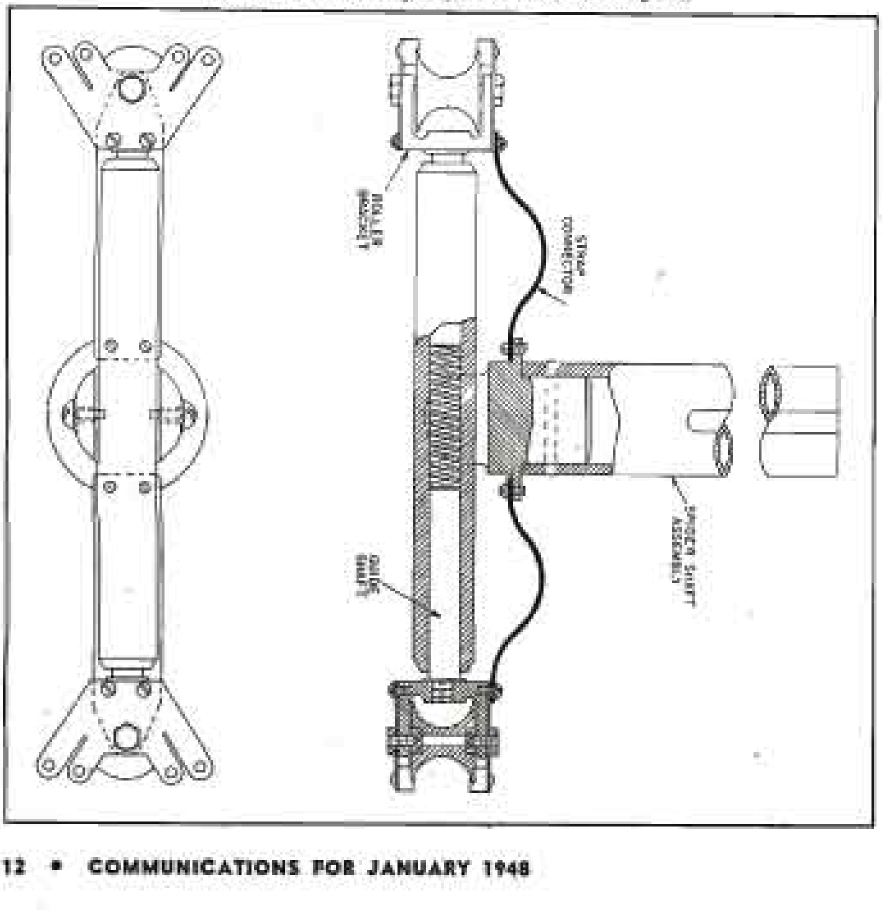


sembly. The union soldered to the inlet pipe of the water jacket provides a removable connection to the plate-tuning coil. The outlet also has a combined union and corona shield which connects it to a Saran pipe which acts as the insulation for the return side of the water system.

The Shorting Spider

The plate-tuning coil shorting spider is shown in Figures 5 and 8. This spider acts as a screw with the spider as a single external thread and the plate-tuning coil as the internal thread. When the large shaft in the center is rotated, the spider climbs up or down the plate-tuning coil, depending upon the direction of the rotation. The shaft, which acts as part of the coil shorting circuit, is raised or lowered by the spider so that it will never be in the unshorted or used portion of the plate-tuning coil.

Figure 8
The plate tuning-coil shorting spider. The spider arms can change their angle to adapt themselves to the changes in spacing or pitch of the plate-tuning coil.



Several interesting features of the spider design appear in Figure 8. It will be noted that the spider arms can change their angle to adapt themselves to the changes in spacing or pitch of the plate-tuning coil. These arms have specially designed rollers at each end. They are made to fit the shape of the coil and are permitted to rotate laterally by their piston arms, allowing the spider to track with the changes in the coil's pitch. These arms press against a common spring that allow the spider arms to lengthen and shorten as the diameter changes with the pitch. To minimize friction, miniature bearings are used in the rollers and roller bearings are used in the center shaft drive.

Spring Contact Assembly

The spring contact assembly has solid silver contacts which make the electrical contact with both the bottom and top surfaces of each turn of the coil. The body of this contact assembly conducts the current around the moving parts of the roller assembly. The strap connectors carry this current around the moving parts of the arm assembly to the center shaft. At the bottom of the shaft is a spring assembly, whose silver contacts conduct the current around the moving parts of the shaft drive and into the frame. By providing these alternate paths for the tank current around the moving parts of the assembly, power losses were reduced to a minimum, sources of heat were prevented, and high efficiency and cool operation were obtained.

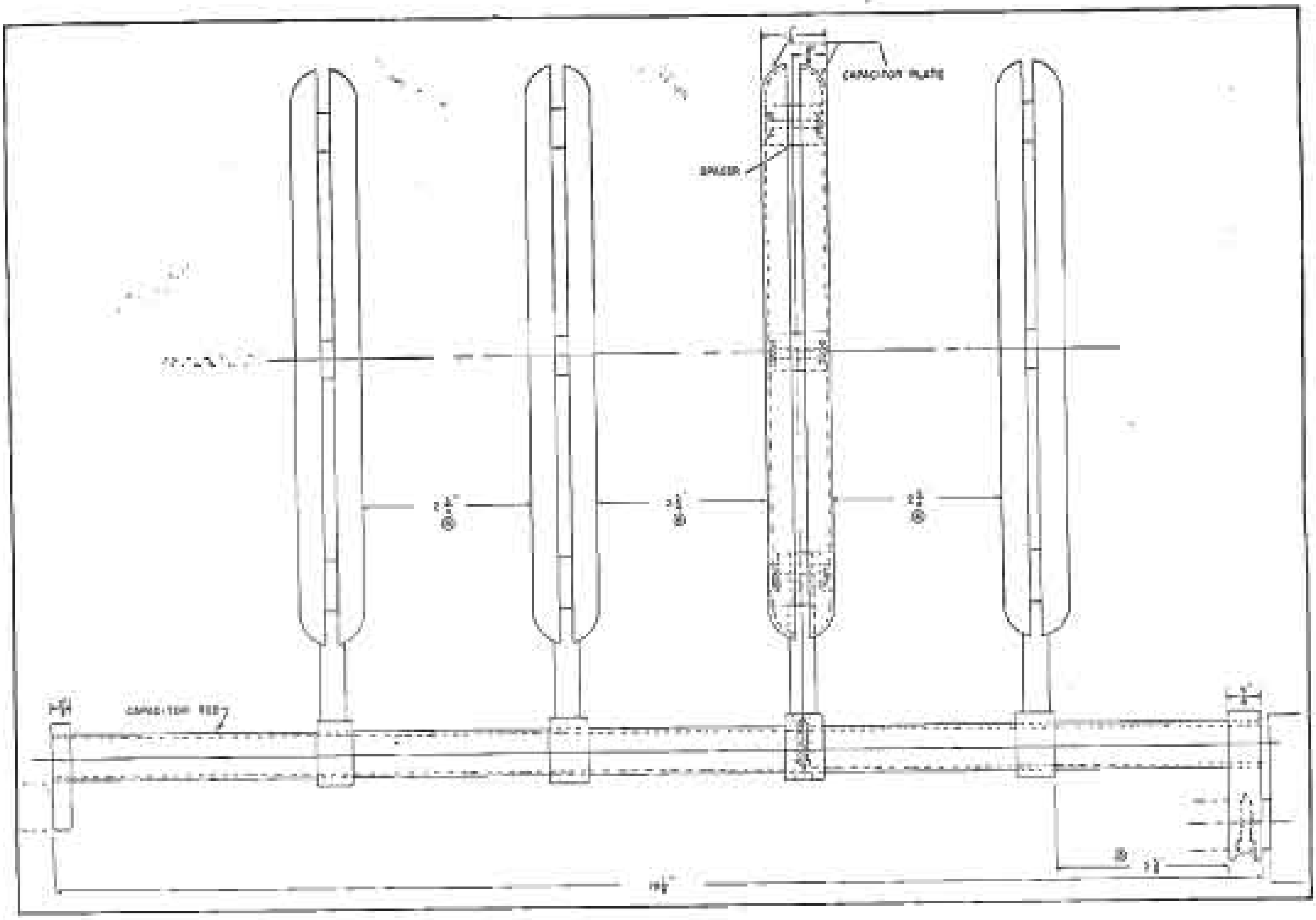
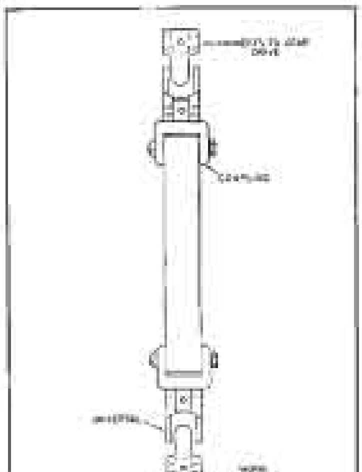


Figure 9
Stator assembly of the variable plate-tuning capacitor which is composed of four plates clamped to a silver-plated brass-supported rod. Distance at A set at assembly of plate-circuit frame.

The Tuning Capacitor

The variable plate-tuning capacitor shown in Figures 3, 4 and 5, and the plate-tuning coil form the plate tank circuit. The stator assembly, shown in Figure 9, is composed of four plates clamped to a silver plated brass support rod. The clamps make the adjustment of the plates or their removal a simple matter. Each plate is composed of two spun aluminum disks placed back to back with aluminum spacers between them. The whole assembly is fastened to the water jacket at the top end and to a horizontal glass-bonded mica bar at the bottom. The rotor assembly has three identical plates fastened in the same manner. This assembly is rotated by a gear drive fastened to a silver-plated brass

(*Continued on page 28*)



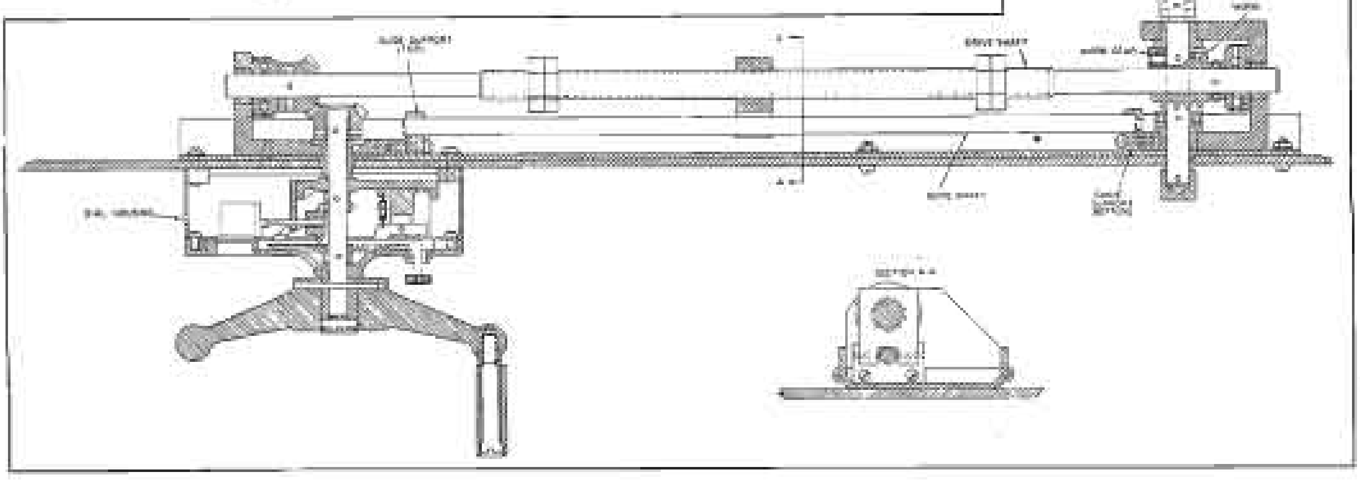


Figure 9a
How the insulating coupling connects to the front panel dial and control is shown in this drawing.

TV Lens Considerations For Image Orthicon Cameras

by LEONARD MAUTNER

Manager, Manufacturing and Engineering Television Transmitter Equipment Division Allen B. DuMont Laboratories, Inc.

THE CHOICE OF LENSES to be used with a tv camera involves factors which are of interest to several types of workers in the field of television. The camera designer is interested since he must know the level of illumination on the sensitive portion of the pickup tube, the necessary motion of the lens relative to the tube for focussing purposes, and the image magnification in terms of the resolution of the system. The producer is concerned with the angular field of view of a given lens from a particular operating position; such information being necessary to plan an adequate coverage of the event to be televised. Finally, the matter naturally is of importance to the television cameraman who needs to evaluate the foregoing factors in addition to judging the depth of field allowable in a given shot.

In general, the choice of lenses for an image orthicon camera is very similar to that used for standard 35-mm motion picture cameras.[1] A large newsreel group has used an assortment of six lenses, ranging from 1" to 12" focal length. However, the chief utility was apparently gained from a 1" lens used for wide angle shots, a 2" all-purpose lens, a 6" semi-telephoto, and a 12" sports telephoto; the latter two providing increased magnification with a smaller field of view. The photosensitive surface of the image orthicon is roughly only 1/16" from the front surface of the tube, so that it is possible to use exceptionally short focal length lenses for wide angle coverage.

Experience at our labs has shown that a usual complement for field operations consists of a 50-mm lens (approximately 2") for general purpose and fairly wide angle coverage; a 135-mm lens (approximately 5¼") for semi-telephoto coverage; and a 20" lens for narrow angle coverage with very large magnification of the scene.

The image orthicon pickup tube offers a variety of television pickups since it readily accommodates such a wide variety of lenses. By contrast, the iconoscope can never be used with less than an approximately 5" to 6" focal length because of its construction; consequently, its angular coverage has always been more restricted than that required by producers. In addition, of course, the high sensitivity of the image orthicon permits relatively smaller apertures to be used with the lenses, so that the depth of field gives tremendous flexibility of coverage for the cameraman.

[1]Popular commercial lens is Kodak Ektar type as used with the Ektra camera.

Summary of Terms Used in Paper

E_{pc} = Photocathode illumination in lumens/foot²
L = Scene luminosity in lumens/foot²
T = Overall transmission factor of lens
f = f/– number of lens
F = Focal length of lens
θ = Angle between optical axis and off-axis ray
ρ = Radius of entrance pupil
d = Diameter of entrance pupil $= 2\rho$
D = Physical diameter of lens
ϕ_h = Horizontal angular field of view
ϕ_v = Vertical angular field of view
X = Width of active portion of photocathode
Y = Height of active portion of photocathode
p_o = Distance from object to lens for optimum focus
p_n = Minimum distance from object to lens for tolerable focus
p_f = Maximum distance from object to lens for tolerable focus
δ = Diameter of tolerable circle of confusion
H = Hyperfocal distance
S = Object distance to first principal plane
S' = Image distance to second principal plane
n = Multiple of F for object distance
k = Multiple of H for object distance
R = Racking distance of lens

Basic Design Formulas

In determining the lens choice, basic optical principles must, of course, be considered. To facilitate this analysis, the following basic design equations[2] relating these factors are offered.

(*A*) For illumination on the photocathode we have

$$E_{pc} = \frac{LT}{4f^2}\cos^4\theta \qquad (1)$$

Where: E_{pc} = photocathode illumination in lumens/sq foot
L = scene luminosity in lumens per sq foot
T = transmission factor of lens
f = f/– number of lens
θ = angle between optical axis and off-axis ray

(*B*) The f/– number of a lens is defined *in general* as

$$f = \frac{F}{2\rho} = \frac{F}{d} \qquad (2)$$

Where: F = focal length
ρ = radius of entrance pupil
d = diameter of entrance pupil

The entrance pupil is the image of the actual limiting stop (aperture) of the lens system formed by all the component lenses preceding it. In actual practice, if the iris is wide open (minimum f/– number) then the value of d is often approximately equal to the diameter of the lens itself. *For this case*

$$f_{min} = \frac{F}{D} \qquad (3)$$

Where: D = lens diameter
and F = focal length of lens

(*C*) The horizontal field of view at infinity focus can be found from the relation

$$\phi_h = 2\tan^{-1}\frac{X}{2F} \qquad (4)$$

[2]These formulas given may be readily applied to all types of pickup tubes.

Where: ϕ_h = horizontal angular field of view

X = width of photocathode

F = focal length of lens

If the vertical field of view is desired, X should be replaced by Y, the height of the photocathode.

(D) Depth of field is the variation in object distance within which adequate focus is obtained, the camera being focused for a given distance.

It can be defined in two ways:

(*1*) As a near and far variation about the optimum object distance, or

(*2*) As a near and far distance measured from the camera lens.

For this case, the latter definition will be used because it results in somewhat simpler mathematics. The equation can be written as

If p_o = optimum object distance

Then p_n, the near distance is

$$p_n = \frac{\dfrac{Fd}{\delta}}{\dfrac{Fd}{\delta\, p_o} + 1} \qquad (5)$$

And p_f, the far distance is

$$p_f = \frac{\dfrac{Fd}{\delta}}{\dfrac{Fd}{\delta\, p_o} - 1} \qquad (6)$$

Where: F = focal length of lens

d = diameter of entrance pupil of lens

δ = diameter of circle of confusion

For television work, a useful diameter of the circle of confusion has been estimated as 1/200 of the height of the picture; this gives a value of δ for the standard 4:3 aspect ratio of

$$\delta = \frac{X}{267} \qquad (7)$$

Where: X = width of mosaic

Then equations (*5*) and (*6*) become

$$p_n = \frac{\dfrac{267\,Fd}{X}}{\dfrac{267\,Fd}{p_o X} + 1} \qquad (8)$$

$$p_f = \frac{\dfrac{267\,Fd}{X}}{\dfrac{267\,Fd}{p_o X} - 1} \qquad (9)$$

But from equation (*4*)

$$\frac{F}{X} = \frac{1}{2}\cot\frac{\phi_h}{2} \qquad (10)$$

Numerical Evaluation of Factors Involved in the Choice of Lenses, Particularly for the Image Orthicon Camera. Graphical Interpretation of Equations Offered to Facilitate Pickup Applications in Field and Studio

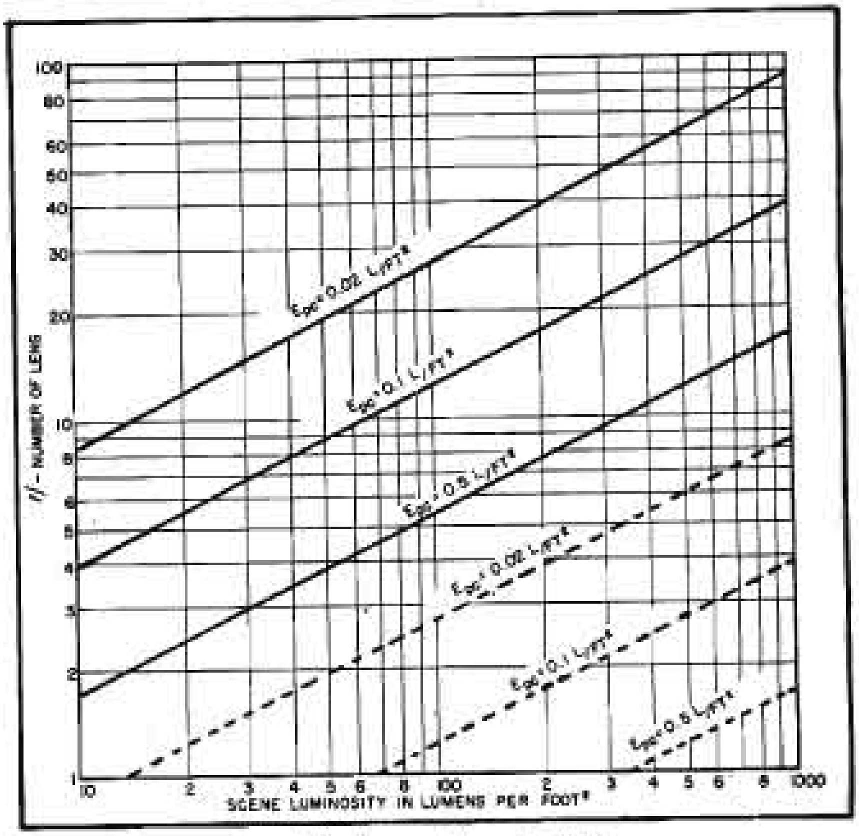
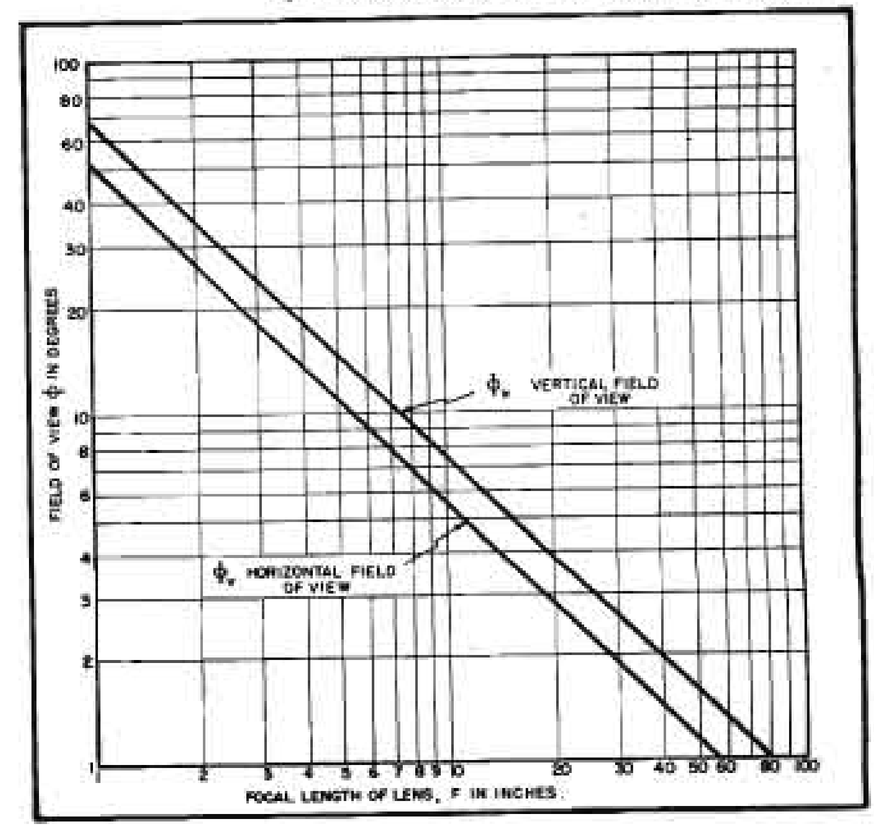


Figure 1 (above). Plot of scene luminosity versus f/- number setting.

Figure 2 (below). Angular field of view versus focal length of lens.



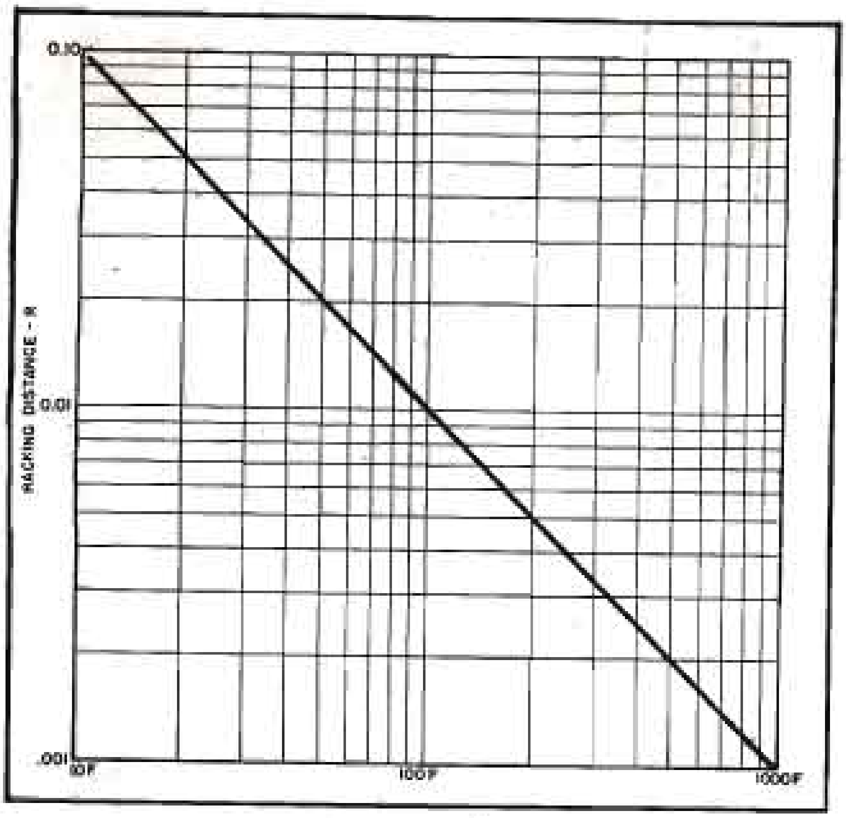


Figure 3
Racking distance R versus nF. Object distance $S = nF$, where n is the number of focal lengths of lens equivalent to the object distance.

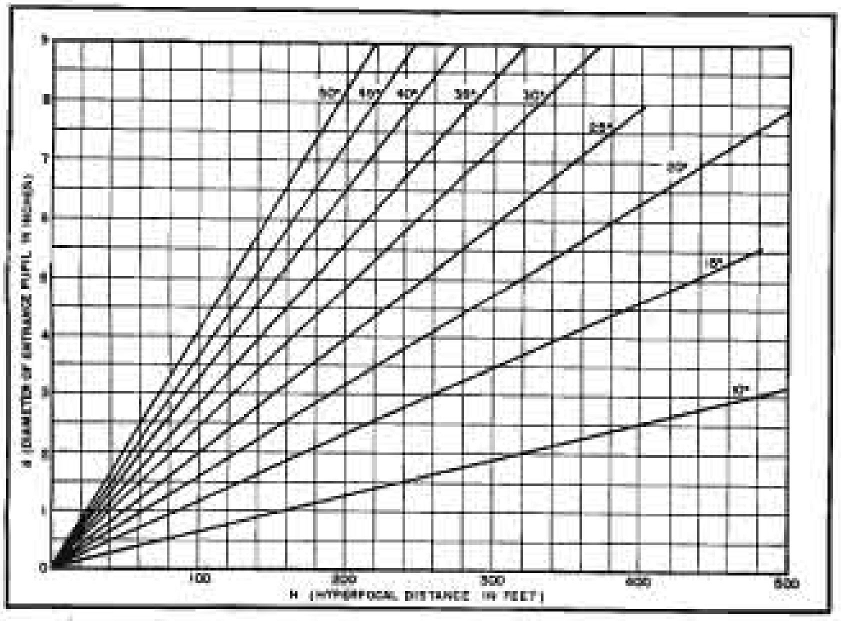
Inserting this in equations (8) and (9), we have

$$p_n = \frac{133\,d\cot\frac{\phi_h}{2}}{\dfrac{133\,d\cot\frac{\phi_h}{2}}{p_o}+1} \qquad (11)$$

$$p_f = \frac{133\,d\cot\frac{\phi_h}{2}}{\dfrac{133\,d\cot\frac{\phi_h}{2}}{p_o}-1} \qquad (12)$$

If we let $p_o \rightarrow \infty$, by focusing the camera at infinity, then p_n becomes

Figure 4
The hyperfocal distance versus the diameter of entrance pupil for a given horizontal field angle. (*Courtesy IRE*).



$$133\,d\cot\frac{\phi_h}{2} = H \qquad (13)$$

This distance is defined as the hyperfocal distance, H. The values of p_n and p_f, in terms of H, are

$$p_n = \frac{H}{\dfrac{H}{p_o}+1} \qquad (14)$$

$$p_f = \frac{H}{\dfrac{H}{p_o}-1} \qquad (15)$$

Thus, if the camera is focused to a distance H, all objects from $H/2$ to ∞ are focused on the mosaic within a circle of confusion of diameter δ, or 1/200 of picture height. In Figure 4 we have a graph of H versus d for various values of ϕ_h. Also, when the lens is focused for a distance H/k, where k is any constant, then the region of good focus extends from $H/(k+1)$ to $H/(k-1)$.

(E) The racking distance for the lens can be calculated from the equation

$$\frac{1}{S}+\frac{1}{S^1}=\frac{1}{F} \qquad (16)$$

Where, S and S^1 are the distances from object to first principal plane and from second principal plane to the image plane respectively. If we let the object distance, S, be equal to $n\,F$, where n is any number, then

$$S^1 = \frac{F}{1-\dfrac{1}{n}} \qquad (17)$$

It is often useful to consider only the variation from F, the focal length. Then we can say

$$R = S^1 - F = \frac{F}{n-1} \qquad (18)$$

The 2P23 Image Orthicon

(A) *Required Scene Luminosity*: The sensitivity of the orthicon is such that about .1 lumen/foot² highlight luminosity on the mosaic gives 5 microamperes of signal output. The minimum noise is .2 microampere, thus a 25:1 signal-noise ratio is available at this level of photocathode illumination.

Using equation (1) from the basic design data, a plot of scene luminosity versus f/– can be made; Figure 1. It is assumed here that a conservative transmission factor for normal lenses is .6 and that the illumination will be

(*Continued on page 28*)

VWOA LIFE MEMBER Jack Poppele offered quite an enthusiastic report on the future of television, during his annual address before the Television Broadcaster's Association, of which he is prexy.

He reported that tv is "skyrocketing at an almost staggering pace."

Transmitter Increase

He pointed out that according to the recently-released FCC annual report there are 15 stations on the air, with 56 construction permits issued and 43 applications still pending.

"Just a year ago," he said, "I stated that six stations were operating, about 45 construction permits had been granted and 25 applications were still pending. Hence, the number of operating stations has nearly trebled during the year (several stations are about to begin operations), the number of applicants for new stations has nearly doubled and many more construction permits were handed out to potential broadcasters.

"On the receiving end of television, the picture is not only one of feverish activity, but by comparison with 1946 seems almost *out of this world.*

"On January 1, 1947, a total of 6,476 postwar receivers had been manufactured and distributed. This represented the total output among RMA-affiliated manufacturers for all of 1946.

"The picture for 1947 was totally different. Production of sets monthly leaped from a mild 5,400 in January to close to 25,000 in October. . . . Total output for 1947 was close to 200,000.

Prospects for '48

"It would appear that television is moving into one of its greatest years. With receiver production sweeping ever upward; with television stations bobbing up everywhere; with network facilities becoming more and more available, 1948 should be a banner year for tv in every way.

VWOA life member J. R. Poppele reading his message on the year's progress in television before members of the TBA, of which he is president. JRP is also chief engineer and vice president of WOR.

Convention Telecasts

"A tremendous stimulant to the acceptance of the tv industry will be the coverage which television will accord the Republican and Democratic National Conventions in Philadelphia next summer. It is no secret that the availability of television network facilities along the eastern seaboard had much to do with the choice of Philadelphia over other sections of the U. S. for both conventions."

Programming

Discussing programming, Jack said that it has and is constantly becoming better.

"If the nth degree of perfection is still lacking in some presentations, it should be remembered that radio, motion pictures and the theatre passed through various stages of growing pains before high accolades were accorded the various and sundry presentations. The label of mediocrity which some critics have been prone to attach to all television programming is certainly unfair to those individuals who, to date, have done an admirable job with only a minimum of funds and a paucity of facilities. Television programming will, of course, grow much better; it certainly is greatly improved over previous years.

TV and Economics

"Ours is an industry that grows day by day. Whenever a new station opens in an area not presently serviced, it also opens the doorway to greater prosperity for many other enterprises related to television.

"Television has brought to viewers the greatest sports and news events of the day; it has taken millions of people right into the White House where they have been seated next to the President of the United States as he addressed them and others in the nation. Television is the great common denominator. Seeing is believing and having faith in our fellow man is democracy in action."

VWOA Annual Meeting

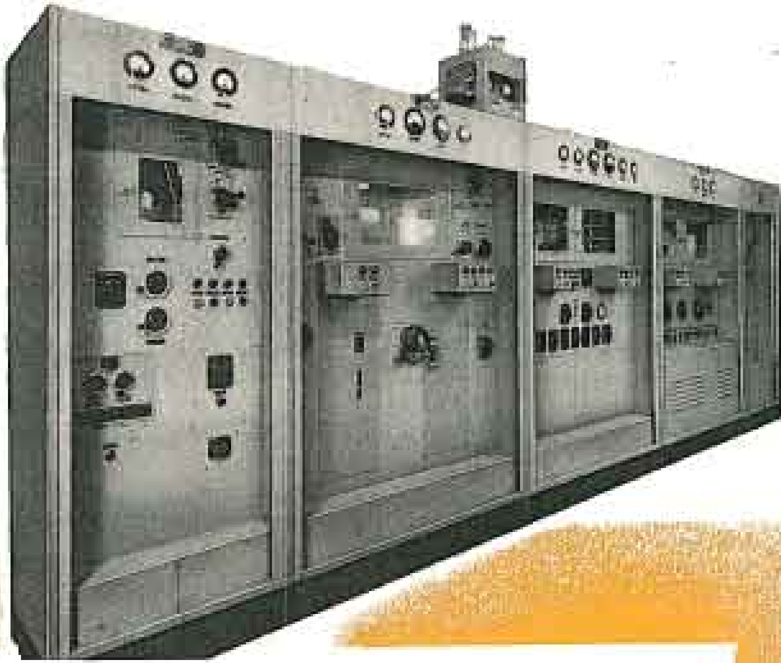
THE ANNUAL MEETING of the Veteran Wireless Operators Association was held in the Marine Room of the Fireplace Inn, New York City, January 15.

Ballots for the election of officers and directors for 1948 were counted. W. J. McGonigle was reelected president. A. J. Costigan and Haraden Pratt were elected first and second vice presidents, respectively. William C. Simon was reelected secretary and H. T. Hayden was elected assistant secretary. C. D. Guthrie was elected to the treasury post.

On the new board of directors are W. C. Simon, George H. Clark, A. J. Costigan, C. D. Guthrie, W. J. McGonigle, J. R. Poppele, Fred Muller and Haraden Pratt.

Plans for the twenty-third anniversary dinner-cruise to be held at the Hotel Astor on February 28 were also discussed. Details will be mailed to members.

20 KW Transmitter with CONTINUOUS TUNING FROM THE FRONT PANEL



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- **CONTINUOUS TUNING.** Continuously tunable from the front panel over its entire frequency range of 2.85 to 22.5 mc. Tuning circuits simple to operate.
- **MAXIMUM OPERATING CONTINUITY.** Recycling overload relays insure against loss of operating time due to temporary overloads. Control circuits fulfill rigid broadcast requirements.
- **COOL OPERATION.** By electrically short circuiting sources of resistance from moving parts, heat and power loss are reduced considerably.
- **SAFE OPERATION.** Automatic-safety grounding switches used on all cabinet doors and housing openings. All operating controls are grounded. Interlocked control circuits.
- **EASY TO MAINTAIN AND SERVICE.** Components are readily accessible and individually removable for replacement and repair.

Continuous Tuning Plate Circuit

- Frequency changes can be made in a few seconds.
- Alternate paths for current around moving parts of circuit provide high efficiency and cool operation.
- Glass-bonded mica assembly supports inductances by holding coils rigid—permits precision adjustment of coil relationship.
- All parts removable and easily accessible to operating personnel.

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F-M and TV TRANSMISSION LINE Installation Problems

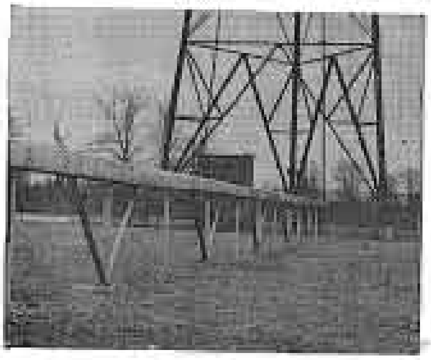


Figure 15
General view of an f-m/a-m horizontal isolator installed at WBNS-WELD.

Part II of Discussion of Materials, Components, Accessories and Methods Used in Installation of Coaxial Transmission Lines from Transmitter to Antenna. Assortment Includes Special Gas Barriers, Inner Conductors and Line Supports, Elbows, Mounting Fittings, Clamp Connectors, Flanges, Reducers, Pressure Controls, Isolators, etc.

by J. S. BROWN

Assistant Chief Engineer
Andrew Company

IN THE INITIAL installment[1] appeared a discussion of the installation of the insulated section on the tower which is effected by the use of insulated mounting clamps and support brackets. These supports are designed to apply stresses to the porcelain insulators so that the porcelain is always in compression.

It was pointed out that when the insulated section of line is installed on the ground, it may be done in several ways. The simplest is merely to mount the f-m line on standoff insulators for the proper distance away from the tower base. This method has the disadvantage that the line, forming one conductor of an unshielded, unbalanced transmission line section, will radiate at the a-m frequency, which will distort the a-m radiation pattern. Furthermore, this radiation is very difficult to control, making adjustment of direction arrays very difficult. Usual practice is to stimulate a coaxial line section, in which the f-m line forms the inner conductor. The outer conductor may be either a wire cage or a metallic hood enclosing the f-m line.

Photographs of such an installation, made at WBNS-WELD, Columbus, O., are shown in Figures 15, 16, and 17. This particular installation accommodates two 3⅛" lines. Figure 15 shows a general view of the *bazooka*. Figure 16, showing one section of cover removed, illustrates the type of construction. The transmission lines are supported on a stair channel by standoff insulators. The hood is formed of 1/16" thick aluminum sheet, and is attached to the stair channel by means that allow easy removal for maintenance. The view shows an expansion joint in one of the lines. Figure 17 shows the tower end of the isolator.

Expansion of the line and enclosure must be taken into consideration, so the lines are supported so that they may slide. The line is rigidly anchored at the shorted end of the section, and again at the tower end, with an expansion joint in the middle of the run.

The insulated section, either when mounted on the tower or on the ground, is often made slightly less

[1]COMMUNICATIONS; November, 1947

Figure 16
One section of cover removed to show construction of f-m/a-m isolator.

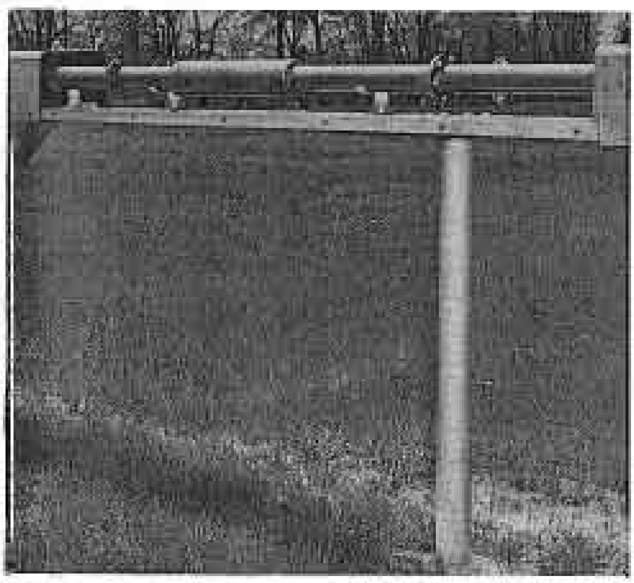
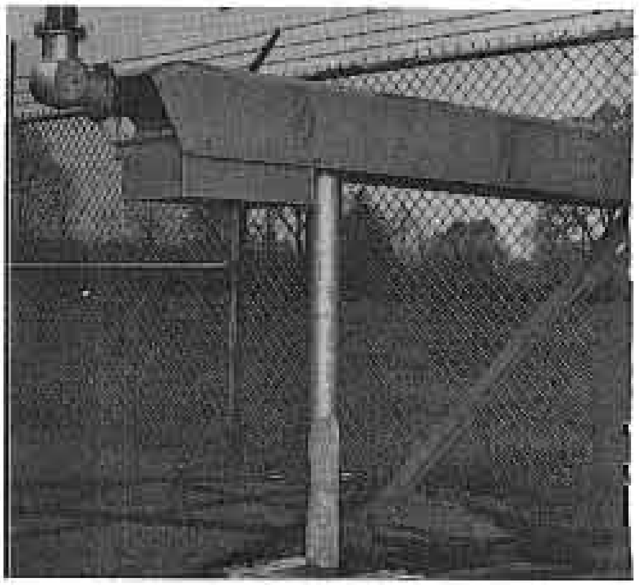


Figure 17
Tower end of section of f-m/a-m isolator. Note compensated right angle junction box.



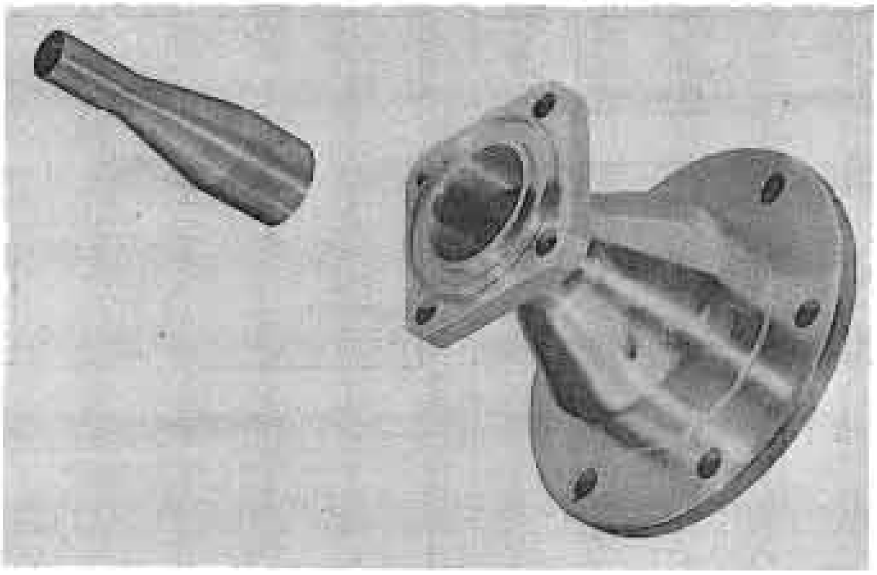


Figure 18 (above)
Clamp connector, for use when 20' section of line must be cut in the field.

Figure 19 (left)
Reducer, 3⅛" to 1⅝". Note sliding flange on small end.

Figure 20 (below)
Gas barrier (sectioned) for installation between two standard flanges.

than a quarter-wave long, and a variable capacitor is connected across the open end of the line for use in making the final adjustment. In Figure 17, the housing directly beneath the end of the hood contains a variable capacitor used for this purpose.

Many miscellaneous fittings are required to meet the requirements of a complete installation. When a 20' section of line must be cut in the field, it is necessary to provide a solderless fitting that will take the place of the flange that was cut off. Such a device, called a clamp connector, is illustrated in Figure 18.

Reducers are sometimes required, when it is necessary to join lines of different sizes. This occurs often at the transmitter output. A particular installation may require a transmission line of larger size than that of the output stub on the transmitter, because of transmission line efficiency requirements. The reducer, shown in Figure 19, is intended to connect 3⅛" and 1⅝" lines together.

In order to pressurize the line, gas-tight end terminals must be used. Two types may be used. Figure 20 shows one, more properly called a gas barrier, intended for installation in a line where minimum reflections are desired. Special attention has been given to maintaining electrical continuity. A second type of end terminal is shown in Figure 21. This terminal is designed for outdoor use, for such applications as connections to antennas.

Provision must be made for introducing the dry air or nitrogen with which the lines are pressurized. This is, of course, usually made at the transmitter end of the line. It is also necessary to provide a means of opening the line at the far end, in order to *bleed* the line. By this means any moisture that may enter the line may be removed by allowing dry air to blow through the line and evaporate the moisture.

The foregoing has been an attempt to describe standard lines and fittings. Special assemblies and accessories galore are required for specific installations, as might be expected when the multiplicity of various field conditions is considered. Some of the *specials* are required only once—others prove to be of great utility and become standard items.

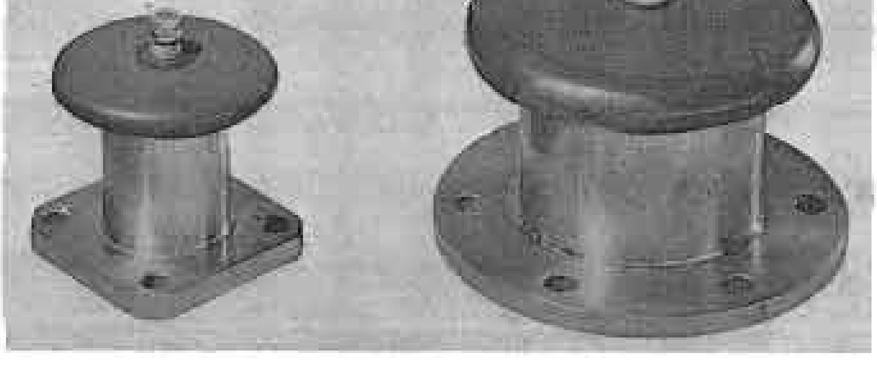
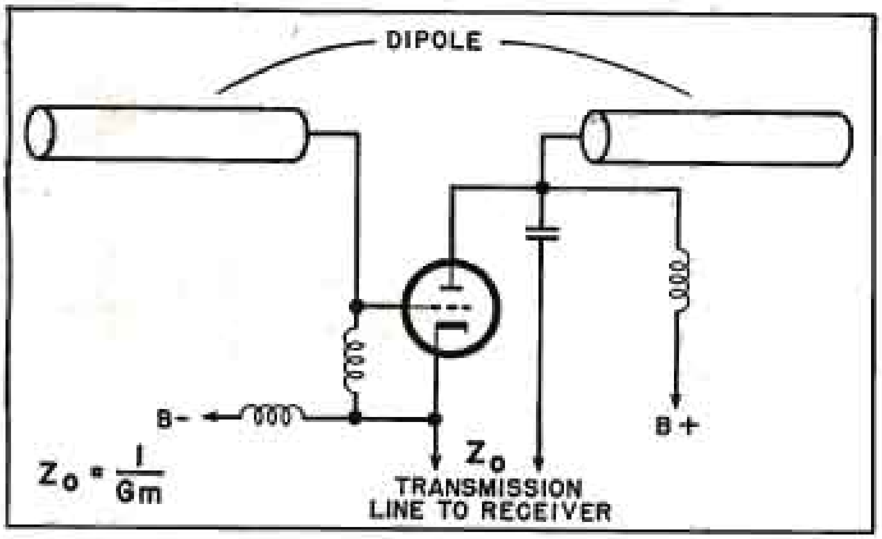


Figure 21 (left)
End terminals for outdoor use.

Figure 22 (below)
Gas inlet fitting, to be installed between standard line flanges.



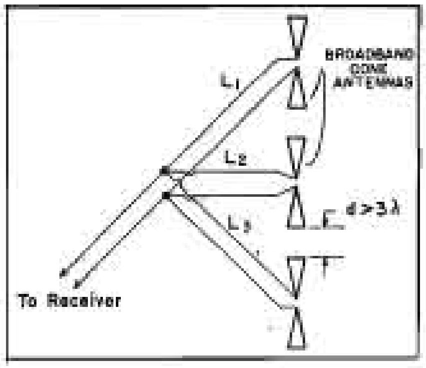


Figure 1 (above)
Array of conical elements. $L_1 = L_2 + n\lambda$ and $L_3 = L_2 + k\lambda$, where n and k are integers which will give broadside array, but to work over a wide band $n = k = 0$ is necessary.

Figure 2 (left)
Simplified circuit of the cathode-follower dipole.

Cathode-Follower TV-Antenna System

Antenna Array Operates in the 44 to 88-Mc and 175 to 216-Mc Bands, with a Standing-Wave Ratio on Transmission Line Always Less Than 2:1 and with a Gain at All Frequencies.

by E. G. HILLS

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There has long existed the need for an antenna that will receive from the same direction over a wide band (several octaves) of frequencies with a limited beam width. This need has become more pronounced with the accelerated advance in television use in the 44 to 88 and 175 to 216-mc bands.

As the frequency of operation of a directive antenna is changed, the two most important properties of the antenna to change are: (*1*) Its beam of radiation or reception changes in beam width, direction and various side lobes appear and disappear; (*2*) its input impedance changes.

Certain antennas such as the non-resonant wire antenna,[1] the non-resonant *V* antenna,[2] the rhombic,[3] and various antennas built up of conical elements, have impedances that remain substantially constant over several octaves of frequency. In all of these antennas, a variation of frequency of over one octave causes the beam to change direction or broaden. Although a conical antenna may have gain over wider ranges, it is not very considerable. Other antennas such as horns, or radiators feeding into parabolic reflectors, can be built to have good gain in a given direction but suffer from input impedance variations as the frequency is changed much over an octave.

It would, of course, be possible to build up an array of double cone antennas, as illustrated in Figure 1, to operate say as a broadside array if the spacings of the individual elements were great enough that mutual impedances between the elements would not alter the phases or amplitudes of the cone currents appreciably. This spacing would have to be of the order of three wavelengths[4] at the lowest operating frequency of the array and, as the gain of an array of given length goes down rather rapidly as the spacings between elements is increased, the efficiency of use of the space occupied by the array would be very low. Another factor enters the picture when considering the use of conical elements. For a double cone to be of substantially constant input impedance its overall length must be of the order of a half wavelength at the lowest operating frequency. As the frequency is increased, the action of the double cone antenna is something of a compromise between that of a long wire antenna and the biconical horn antenna. Its beam tends to broaden and split into separate lobes which radiate in directions which move farther from the normal to the axis of the cone as frequency is increased. Since the radiation pattern of a transmitting array, or the reception pattern of a receiving array, may be considered to be the products of the patterns of one of the array elements, and the pattern of the same array made up of isotropic radiating or receiving elements[5] the reception from the broadside array would be low at the frequency at which the double cone elements had nulls in their patterns in the desired direction of reception. This, of course, could be remedied, if the desired impedance characteristic could still be obtained, by tilting the axes of the two conical elements making up each dipole with respect to each other.

[1]Harold H. Beverage, C. W. Rice, Ed. W. Kellogg, *The Wave Antenna—A New Highly Directive Antenna*, Trans. AIEE, Vol. 42, p. 215; 1923.
[2]P. S. Carter, C. W. Hansell, N. E. Lindenblad, *Development of Directive Transmitting Antennas by RCA Communications, Inc.*, Proc. IRE, p. 1773; Oct., 1931.
[3]E. Bruce, A. C. Beck, L. R. Lowery, *Horizontal Rhombic Antennas*, Proc. IRE, p. 24; Jan., 1935.
[4]P. S. Carter, *Circuit Relations in Radiating Systems and Applications to Antenna Problems*, Proc. IRE, p. 1004; June, 1932.
[5]S. A. Schelkunoff, *A Mathematical Theory of Linear Arrays*, Bell System Technical Journal; Jan., 1943.

Array Band with Limitations

Before going into the reasons for operation of the array to be described, it will be useful to examine the operation of a conventional array of dipoles as the frequency of operation is changed. Let us assume a broadside array of elements carrying equal currents, in which the different elements are fed from a common transmission line junction through trans-

Figure 3
Cathode-follower dipole for the television bands.

mission lines, the lengths of which differ by integral multiples of a wavelength. Since the voltages at the ends of these transmission lines would all be in phase if the lines were terminated in identical loads it is necessary (except for the case of 90° lines) that the elements all present the same complex impedances to their respective lines, when connected to these lines, in order that equal, in-phase, currents flow in the elements. In order that the element impedances be equal when arranged in the array, the elements must, of course, be in general different from each other, because if they had identical impedances, when isolated from the other elements, the mutual impedances between the elements when placed in the array would alter the element input impedances, so that they would not be identical.

As the frequency of operation of the array is changed, the electrical lengths of the various transmission lines change such that they no longer differ by integral multiples of wavelengths. Even if at a new frequency the dipole input impedances were still identical, their currents would have changed relatively because of this change in relative electrical lengths of the transmission lines, with resulting deterioration of the array reception pattern.

The radiator input impedances, however, do change as a result of two effects with resulting aggravation of the radiator current non-uniformity. One effect is that the impedances of the radiators if isolated change, in general, with frequency and the other is that the mutual impedances between the radiators when placed in the array change with frequency.

To summarize the reasons for deterioration of an array's operation with frequency change, one has (*1*) change of electrical lengths of radiator feed transmission lines, (*2*) change in element feed point impedances when isolated from other elements, (*3*) change in mutual impedances between radiators when placed in an array, and (*4*) change in number of wavelengths in physical spacings of the array elements.

The effects of the first and fourth type of changes can be overcome together, not only for a broadside array but for an end-fire or any other type of array, in which the signals received from the various elements are added together in phase at the various transmission line junctions as is often the case in high gain arrays. This can be done by making the total electrical length of the composite path (through free space and transmission line) that the signal must travel from the distant transmitting source to the output terminals of the array, the same regardless of which element, with its corresponding transmission line, the signal is considered as traveling. For the case of a broadside array, this would merely mean the making of all of the transmission lines from the array terminals to each element in the array of equal electrical length. By this is meant signal length, not phase length, as the phase lengths could be equal at any one frequency if different transmission lines differed in length by integral multiples of full wavelengths, while the distances a signal would actually travel in the different lines would be unequal.

The above choice of transmission line lengths insures that the signals from the various elements will reach the receiver all in phase at all frequencies, but does not insure that any transmission line section, that may be used in the capacity of a transformer, will operate regardless of frequency. This will not be the case, so the array must be designed using no transmission lines as transformers for impedance matching. Instead elements of the proper impedances must be used in various parts of the array and the lines leading to them must be matched to the elements. This is because the only transmission line acting as a transformer, that has the same transformation ratio regardless of frequency, is one having a 1:1 ratio at all frequencies, or, in other words, a matched line.

The second type of change, that of the isolated element feed point impedance changing with frequency, has been overcome in any of the broad-band antennas in use at present, such as those using conical elements. It has also been overcome in the *cathode-follower antenna* system, which will be analyzed in this paper.

The third change, that of the mutual impedances between elements of an array changing with frequency, can be minimized in its effect by placing the elements so far apart in space that the mutuals existing between them are negligible. This, as was mentioned earlier, causes the array to be very wasteful of space. A second method is that of reducing the currents flowing in the various elements to such low amplitudes that

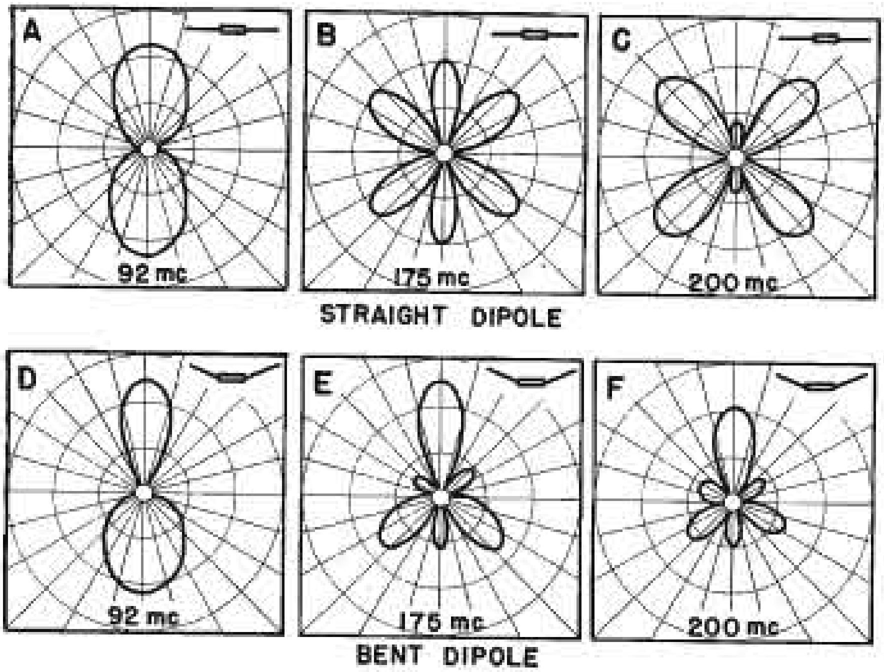


Figure 4 (left, center)
Cathode-follower dipole reception patterns.

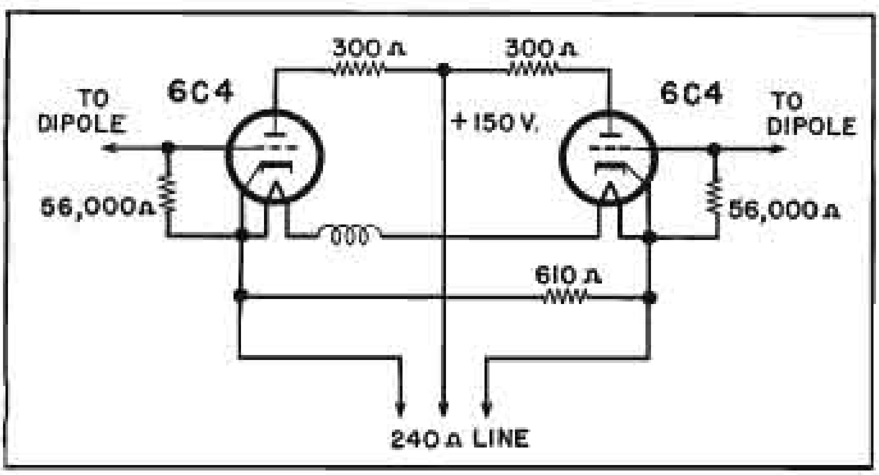


Figure 5 (left)
Balanced cathode-follower circuit.

there is no appreciable voltage induced in an element by current flowing in another element, compared to the voltage induced in the element by the incident wave being received. This reduction of current flow can be accomplished by terminating the receiving element in an impedance much greater than its feed-point impedance. This has the undesirable effect, of course, of reducing the efficiency of power transmission from the receiving element to its transmission line, a point which will be considered in another portion of this article. This element current reduction is, however, accomplished in the cathode-follower dipole.

Cathode-Follower Antenna

Figure 2 illustrates a dipole feeding directly into a cathode follower of such mutual conductance that the cathode-follower output impedance matches the transmission line leading from the dipole. Disregarding small stray capacitances, the output impedance of such a cathode-follower is independent of frequency, and also independent of the impedance of the generator driving it. The transmission line in the figure will then be matched regardless of what the dipole impedance does as frequency is changed. Since the input impedance of a cathode-follower can be extremely high, compared to ordinary dipole feed-point impedances, as long as transit time loading does not enter the picture, the current flow in the dipole of Figure 2 is very low for all frequencies for which the dipole length is appreciably less than a full wavelength. This is true because the dipole is essentially open-circuited when the cathode-follower is inserted in its center. Because of this low dipole current, the third type of change previously mentioned, mutual impedance change, does not cause a deterioration of the directivity pattern of an array made up of cathode-follower antenna elements. As the cathode-follower does not load the dipole efficiently, the dipole open-circuit voltage is applied to the cathode-follower grid, giving approximately twice the voltage input to the cathode-follower that would be applied to it if its input impedance matched the dipole internal impedance. Since the voltage output of a dipole increases as the square root of its radiation resistance, folding the dipole doubles the voltage applied to the cathode-follower.

In Figure 3 appears a view of a cathode-follower dipole in which two folded dipoles were essentially connected in parallel to the input of a cathode-follower which is enclosed in the center portion of the dipole. The two dipoles were adjusted for the high and low television bands, respectively.

Figure 4 (*a*, *b* and *c*) shows the reception patterns taken with the dipole of Figure 3, in which the two halves of the dipole were colinear. Parts *d*, *e* and *f* of the figure show the reception patterns taken with the two halves of the dipole bent so that they make angles of 130° with each other. This was necessary in order that the dipole receive from the same direction at all frequencies of interest.

Cathode-Follower Circuit

In the circuit, Figure 5, two cathode-followers are used in a push-pull arrange-

(*Continued on page 30*)

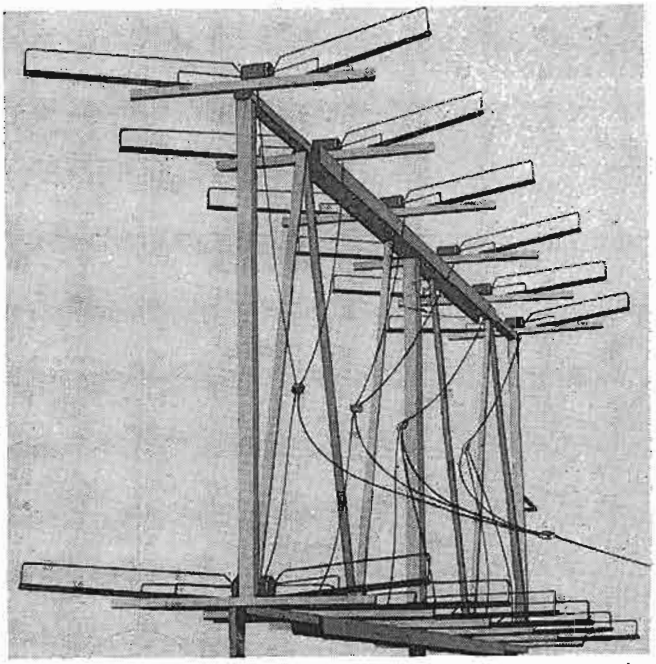


Figure 6
A 12-dipole array.

Figure 7
Gain and standing-wave ratio of a cathode-follower antenna.

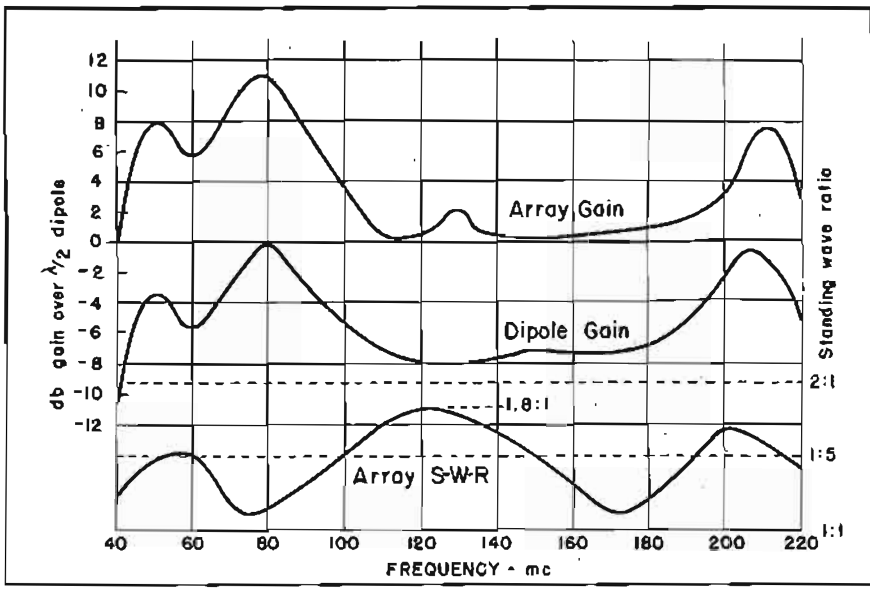
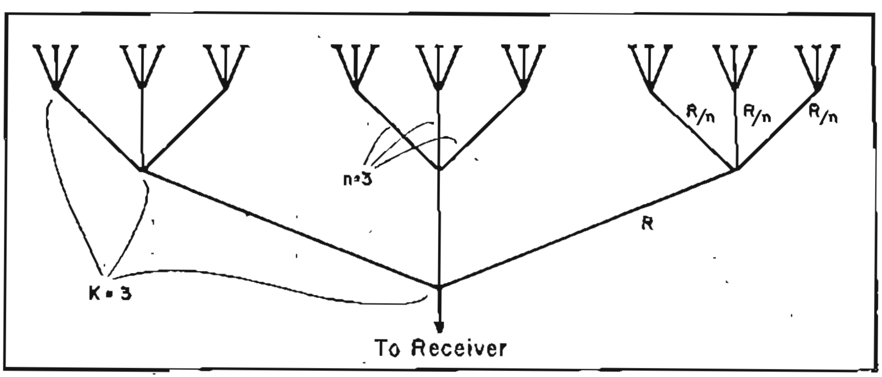


Figure 8
Transmission line network (m = the dipole total of 27). K = the number of junctions from an element to the receiver, n = the number of lines converging per junction, and $m = n^k$ = total number of dipoles in array. The signal-noise ratio in db = 10 $\log_{10} m$.



Tube Engineering

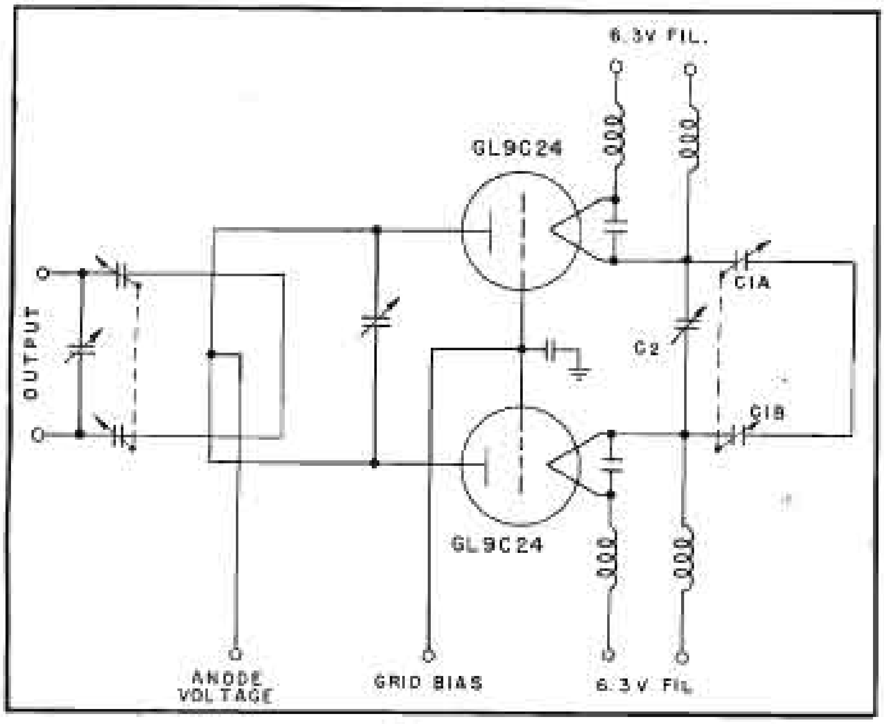


Figure 1
Typical grounded-grid amplifier circuit for the GL-9C24.

V-H-F Tube Design

Two TYPES OF V-H-F tubes, with quite a few unusual features, have been announced recently. One, the GL-9C24,* especially designed for use as a high-power grounded-grid amplifier, features an introverted anode and the ring-seal design. Inside the tube a conical flange connects the grid ring to the grid basket. This flange provides a long plate-to-filament capacity (less than 0.6 mmfd) and, as a result, no neutralizing is necessary up to 100 mc.

In Figure 1 appears a typical output circuit using the tubes. No *swamping* or grid-loading resistor is required, loading being controlled by adjustment of the ratio of anode and filament variable capacitors.

These tubes are being used in pairs in tv transmitters, providing 5-kw peak power in the linear class *B* output stage.

The tube is water-cooled by eight gallons per minute through the anode and one quart per minute through the filament. The glass seals are air cooled.

The 5618

Another v-h-f tube, a filament-type miniature pentode (5618**), developed particularly for mobile and emergency communications, has a maximum plate dissipation of 5 watts and can be operated with full input to 100 mc.

The filament is of the mid-tapped coated type which can be operated on either 6 or 3 volts, within an operating range of ±10%, and is said to be ready for operation in less than one second after power is turned on.

The 5618 can be used as an a-f power amplifier and modulator (class A_1), r-f power amplifier and oscillator (class *C* telegraphy) and r-f power amplifier (class *C* f-m telephony), as well as a frequency multiplier.

Filament Arrangements

In class A_1 use, the d-c plate voltage is 300, d-c grid (No. *2* screen) voltage is 125 and grid No. 2 input is two watts, while the plate dissipation is 5 watts. These are maximum ratings (absolute value) for intermittent and commercial amateur service. In this application, either series or parallel filament arrangements can be used. With either filament arrangement, the d-c plate voltage is 250, d-c grid (No. *3*) voltage is zero, d-c grid (No. *2*) voltage is 75, d-c grid (No. 1 control-grid) voltage is −8 and the peak a-f (grid No. *1* to grid No. 1) voltage is 8.

The maximum signal power output with the series-filament arrangement is 1.2 watts. With the parallel arrangement it is 1.4 watts. The effective load resistance (plate-to-plate) is 12,000 ohms.

When the tube is used as an r-f power amplifier and oscillator[1], 300 volts can be used on the plate at either 40 or 80 mc. The useful power output in this arrangement at 40 mc is 5 watts and at 80 mc, 4.5 watts.

Plate voltage of the 5618 when used as a doubler or tripler to 80 mc is also 300. The useful power output of the tube when it used as a doubler is 3½

Table 1
Preferred types of c-r and camera tubes.

Screen Size (Inches)	Kinescopes: Directly Viewed	Kinescopes: Projection	'Scope Types: P1 Screen	Camera Types	Monoscope
2			2BP1	5527	
3			3KP1	2P23	
				5655	
5		5TP4	5UP1		2F21
7	7DP4				
	7JP4				
8				1850-A	
10	10BP4				

*G. E.
**RCA.
[1]Key-down conditions without amplitude modulation. Modulation essentially negative may be used if the positive peak of the a-f envelope does not exceed 115% of the carrier conditions.

Design and Application Notes on 5-Kw TV Tube, V-H-F Miniature Power Pentode and Image Orthicon for Studio and Field.

watts, and 2.7 watts for tripler operation.

Approximate driving power for the 5618, in doubler or tripler application, is .75 watt.

Camera Tubes

An image orthicon, particularly designed for studio use and other applications employing artificial illumination, is now available. The tube, type 5655*** differs from the 2P23 in that its photocathode has practically no infrared sensitivity, its resolution is somewhat better and its signal-to-noise ratio has been improved about twice. Since the photocathode does not respond to infrared, colors are portrayed with more satisfactory gradation under a suitable combination of fluorescent and incandescent illumination. It does not, however, cover as wide a light range as the 2P23.

***RCA.

Relatively small in size like the 2P23, the 5655 can be used in comparatively light-weight portable television cameras.

The 5655 is not directly interchangeable with the 2P23.

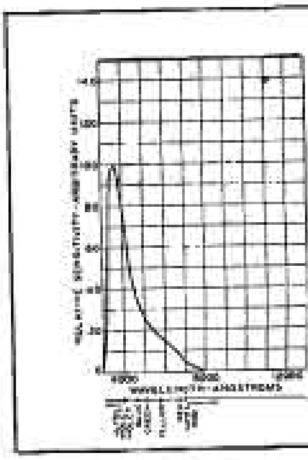


Figure 2

Spectral sensitivity characteristics of the 5655, for equal values of radiant flux at all wavelengths.

Preferred Tubes

A list of preferred types of tubes, including power amplifiers and oscillators and cathode-ray and camera tubes, has been announced****. These listings, shown in tables *1* and *2*, cover pentodes, beam types, tetrodes and triodes, and picture, 'scope and camera tubes and monoscopes.

****Prepared by the tube department of RCA.

Table 2

Preferred types of amplifiers and oscillators.

Type	Class	Maximum Input Power vs. Frequency — *Values shown are class C telegraphy ratings for continuous commercial service*												
		1.6	7.5	15	25	50	75	110	150	200	250	300	600 mc	
802	Pentode	25	25	25	25	20	16	...	...	...	...	...	...	watts
2E26	Beam	30	30	30	30	30	30	30	25	...	...	...	...	watts
832-A*	Beam	36	36	36	36	36	36	36	36	36	32	...	...	watts
2E24	Beam	40**	40**	40**	40**	40**	40**	40**	33**	...	...	...	...	watts
807	Beam	60	60	60	60	60	50	40	...	...	...	...	...	watts
815*	Beam	60	60	60	60	60	60	60	55	40	...	...	...	watts
8025-A	Triode	75	75	75	75	75	75	75	75	75	75	75	75	watts
829-B*	Beam	120	120	120	120	120	120	120	120	120	105	...	...	watts
826	Triode	125	125	125	125	125	125	125	125	125	125	100	...	watts
812	Triode	155	155	155	155	155	125	...	...	...	...	...	...	watts
811	Triode	155	155	155	155	155	125	...	...	...	...	...	...	watts
828	Pentode	200	200	200	200	160	130	...	...	...	...	...	...	watts
8005	Triode	240	240	240	240	195	...	...	...	...	...	...	...	watts
5588	Triode	250	250	250	250	250	250	250	250	250	250	250	250	watts
813	Beam	360	360	360	360	300	...	...	...	...	...	...	...	watts
8000	Triode	500	500	500	500	400	300	...	...	...	...	...	...	watts
4-125A/4D21	Tetrode	500	500	500	500	500	500	500	500	425	335	...	...	watts
6C24	Triode	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	...	...	...	...	kw
833-A	Triode	1.8	1.8	1.8	1.75	1.5	1.2	...	...	...	...	...	...	kw
7C24	Triode	5	5	5	5	5	5	5	...	...	...	...	...	kw
8D21*	Tetrode	10	10	10	10	10	10	10	10	10	10	10	...	kw
889R-A	Triode	16	16	16	16	12	9.6	...	...	...	...	...	...	kw
889-A	Triode	16	16	16	16	16	14	11	8	...	...	...	...	kw
892-R	Triode	18	13.5	10.5	...	...	...	...	...	...	...	...	...	kw
892	Triode	30	22.5	17	...	...	...	...	...	...	...	...	...	kw
9C25	Triode	40	40	40	40	25	25	25	...	...	...	...	...	kw
9C27	Triode	40	40	40	40	25	25	25	...	...	...	...	...	kw
5592	Triode	50	50	50	50	50	44	...	...	...	...	...	...	kw
9C22	Triode	100	91	80	70	...	...	...	...	...	...	...	...	kw
9C21	Triode	150	150	150	105	...	...	...	...	...	...	...	...	kw

*Twin type. Input values per tube for push-pull operation.
**ICAS rating. This type is recommended only for applications of a high intermittent nature.

H-F Broadcast Transmitter

(Continued from page 13)

capacitor rod. Here, too, we used the silver spring contact assembly to carry the tank current around the moving parts.

Figures 3 and 4 which show the assembly ready for packing do not show the actual relation between capacitance and inductance. In actual operation the capacitor is closed when the spider is at the bottom of the coil and does not short any portion of it. When the spider is all the way up, shorting ten turns of the coil, the capacitor is completely unmeshed.

Test Results

By providing alternate paths for current around the moving parts of the assembly, overall efficiencies of about 70% were obtained during tests. After operation for several hours, it was possible to turn the transmitter off and touch any part of the circuit. The temperature rise over the ambient in this portion of the amplifier was 5° C.

Tuning tests also proved that rigid support of the coils and their low temperature prevented detuning after hours of continuous operation.

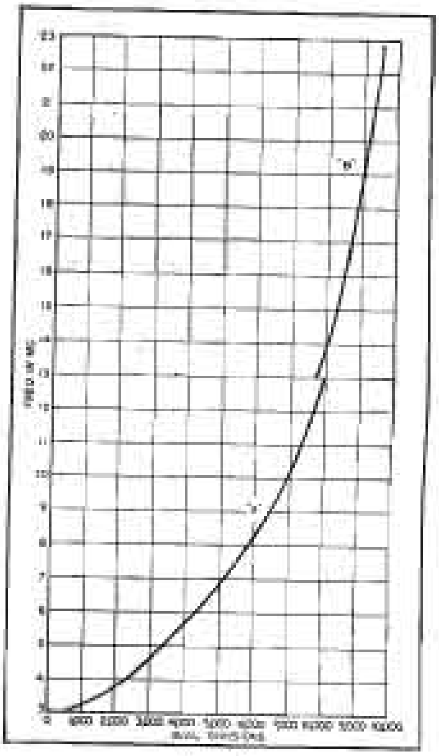


Figure 10
Tuning chart of the plate circuit. With coil switch *C* out, curve *A* prevails, and with the coil switch in, we have curve *B*. This coil switch is composed of two shorting bars mounted on glass bonded mica supports. Its purpose is to short circuit three turns in the plate tuning coil and one turn in the output coupling coil.

TV Lenses

(Continued from page 16)

calculated for the center of the photocathode; i.e. $\theta = 0°$.

(B) Angle of View: The angle of view at infinity focus will be solely a function of focal length, for a given width of mosaic. Thus for the 2P23 the angular field of view we have the plot of Figure 2. The width of mosaic assumed is 1.28", height .96" to give a maximum diagonal of 1.6". For convenience, the angular field of view ϕ_h and ϕ_v are given for horizontal and vertical fields, respectively.

(C) Racking Distance: To aid in camera design the mechanical movement of the lens must be known. From equation *(18)* it can be seen that for an object at infinity, *n* is infinite and the racking distance *R* is zero. As the object comes closer, *n* decreases and *R* increases; thus for fixed mosaic position the lens travels towards the object as the object approaches from infinity. In Figure 3 the variation of *R* as a function of *n* is given.

If it is not required to have the object closer than 10F, then the lens need never be racked more than .1F.

(D) Depth of Field: Depth of field is a figure which cannot be readily graphed for the 2P23 as a particular case, because of the large number of

(Continued on page 29)

parameters involved. Analysis of a typical case follows, using the graph of H versus d, as shown in Figure 4.

Typical Example

Analyzing a typical case, we will use a lens with an

$$F = 6''$$
$$f_{min} = 2.7$$

From the basic design and 2P23 data the following results can be obtained:

(*a*) From Figure 1 we find that this lens will provide satisfactory operation (i.e., $E_{pc} = 0.1$ l/ft²) for values of scene luminosity from about 3 lumens per foot² at f/2.7 to about 1,000 lumens per foot² at f/39. This easily covers the range of outdoor illumination levels for ordinary use.

(*b*) From Figure 2 we find that a field of view of 9° vertical by 12° horizontal will be obtained.

(*c*) From Figure 3 we see that a racking distance of .6" will be required to cover object distances from infinity to 5'. If we are permitted a total of lens movement of 1", a near distance of 3.2' can be tolerated. At 3' the horizontal field (corresponding to 12°) is only 10.5'.

(*d*) To use Figure 4 we must calculate d, based upon the f/- number. Using equation (2)

f/-	d	H
2.7	2.22"	280'
10	0.6"	70'

The value of H corresponding to a above can be found from Figure 4, and the angle of view of 12°. The depth of field for these two aperture settings can then be tabulated for specific object distances:

	S = Obj. distance	P_n	P_f
f/2.7	∞	140'	∞
	100'	74'	156'
	50'	42.5'	61'
	10'	9.65'	10.4'
f/10	∞	35'	∞
	100'	35'	∞
	50'	29.2'	175'
	10'	8.75'	11.7'

If the object distance exceeds the hyperfocal distance, then the camera may be focused for the hyperfocal distance with acceptable results; any other focus distance between H and infinity will result in no improvement in focus inasmuch as the resultant circle of confusion will always be within the allowable limit.

References

[1]Devore and Iams, *Some Factors Affecting Choice of Lenses for Television Cameras*, Proc. of IRE, August, 1940.

[2]Hardy & Perrin, *The Prin. of Optics*, McGraw-Hill.

[3]Henney & Dudley, *Handbook of Photography*.

[4]P. Moon, *Scientific Basis of Illuminating Engineering*, McGraw-Hill.

Cathode-Follower

(Continued from page 25)

ment so that a balanced dipole could be used to feed a balanced transmission line. This dipole was used with a balanced three-wire 240-ohm transmission line. Filament voltage for the two tubes was fed up the two outer wires through r-f chokes and the plate voltage was fed up the center wire. Two 300-ohm resistors, in the plate circuits of the two tubes, were used to decrease the effect of the plate-cathode capacitances of the tubes. Without these resistors the series combination of the plate-cathode capacitances would shunt the transmission line and keep the line from being terminated properly. The effect of these resistances on the effective mutual conductance of the tubes was negligible, as they had the effect of increasing the tube-plate resistances by very small percentages. The standing-wave ratio on the transmission line steadily increased from 1.1:1 at 40 mc to 1.7:1 at 220 mc. Figure 7 shows a curve of the gain of this dipole over a 290-ohm folded dipole cut for each frequency measured.

Twelve Element Array

Figure 6 shows a view of a 12-element array of the dipoles just described. This array occupied a space of 8' x 8' x 20'.

The dipoles were divided into four groups of three each, with the dipoles of each group connected in parallel at the junctions of their transmission lines to 75-ohm transmission lines. These four 75-ohm transmission lines were connected in series to the junction of the main 300-ohm transmission line to the receiver. The gain and standing-wave ratio on the 300-ohm transmission line for the twelve-dipole array also appears in Figure 7. It can be seen that there is very little gain in the 120-mc region. This is probably due to two factors; one, the individual dipoles had very low gain at this frequency, and two, the input admittances of the cathode-followers began to be appreciable at these frequencies causing dipole loading with the result that the mutual impedances between dipoles began to throw off the phases of the various dipole signals. This second effect probably accounts for the fact that the gain in the high television band was not as high as might have been expected from the gains of the individual dipoles.

Noise

The introduction of vacuum tubes into the antenna introduces a source of noise not present in antennas made up entirely of passive elements. Let us assume an antenna of 72-ohms radiation resistance, of negligible loss resistance, and of narrow beam-width, made up entirely of passive elements. If this antenna were pointed toward the sky in a direction from which little celestial radiation emanated, very little noise voltage would appear at the terminals of the 72-ohm antenna. It would thus appear to be a 72-ohm resistor at an extremely low temperature, so far as thermal noise was concerned. On the other hand, if the hypothetical antenna were pointed at the side of a mountain, the soil of which had a resistance of 377 ohms per square, an amount of the thermal noise being radiated by the mountain would be received by the antenna. Accordingly the noise voltage available at the terminals of the antenna would then indicate that the antenna was a 72-ohm resistance at the temperature of the mountain.

In addition to the above type of noise, the cathode-follower antenna has the noise generated in the tubes themselves. It can be shown that this tube noise decreases relative to the signal, so that the signal-to-noise ratio increases as the number of cathode-follower antennas in the array is increased, provided the array is of the type in which the signal energies are all fed together in phase at the various transmission-line junctions.

In Figure 8 a transmission-line network connecting 27 dipoles of an array to the main receiver transmission line is shown. In the figure the lines directly from the dipoles are shown divided into nine groups of three lines each, with these nine groups further divided into three subgroups of three each. Obviously the division could have been made in many other manners. In any network, such as shown in the figure, where n is the number of lines converging at any one junction into a single line, and where k is the number of junctions through which energy must pass on, going from a dipole to the receiver, the total number of dipoles in the array will be $n^k = m$. Since noise energy, which is random in phase and frequency, upon reaching any junction not only goes down the main feeder into which the various lines connect, but also goes back up some of the other lines, only a part of the noise energy originating in a dipole reaches the receiver. This is not true of a received signal, since signals from the various dipoles are connected together in phase at the various junctions and the total signal energy reaching the receiver is the sum of the signal energies from the various dipoles. In addition to this difference between signal and noise energies there is another effect that increases the signal-to-noise ratio. The noise energy coming down a dipole feed line to a junction finds that the junction does not match the dipole feed line, while there appears to be a match so far as the signal is concerned. This is true because there are identical in-phase signals coming down the other transmission lines feeding into the junction which effectively modify the mismatch that would otherwise exist and does exist for the random noise signal.

As an example of the above, let us consider the case of n lines of impedance R/n feeding into a main transmission line of impedance, R, with a series connection. Looking from the main transmission line into the junction there appears to be a match. Looking from any one of the n dipole feed lines into the junction there appears to be a mismatch. The impedance seen from any feed line is $(n-1)R/n + R$. The standing-wave ratio on the feed line due to this mismatch would

then be $\frac{(n-1)R/n + R}{R/n} = 2n - 1$.

The transmission coefficient corresponding to this mismatch is

$$\frac{4\,SWR}{(SWR+1)^2} = \frac{2n-1}{n^2} \qquad (1)$$

for noise.

For unit noise energy actually being transmitted into the junction from a feed line, the energy going down the main line to the receiver is the ratio of the main

(Continued on page 32)

(Continued from page 31)

line resistance to the total resistance seen by the feed line or

$$\frac{R}{(n-1)\,R/n + R} = \frac{n}{2n-1} \qquad (2)$$

For unit noise energy leaving a dipole the amount of energy going down the main line at the first junction is then the product of (1) and (2), or 1/n. The total noise energy from n dipoles is then n times this or unity. The above process repeats itself for each of the k junctions, so that the total noise energy reaching the receiver is for unit noise energy from each dipole, $1^k = 1$. Since the signal energies reach each junction in phase for unit signal energy, from each of the $n^k = m$ dipoles in the whole array, the total signal energy reaching the receiver will simply be m. The signal-to-noise ratio for the antenna is then

$$SNR = 10 \log_{10} m \text{ db} \qquad (3)$$

over what it would be with a single dipole so far as tube noise is concerned. Since k does not appear in the final expression it does not matter in what manner the m dipoles are interconnected, so long as the signal energies converging at any junction be equal and in phase, and so long as the dipole feed transmission line impedances be equal and of such values that a match is seen when looking from the main line back up into the particular junction.

Of course, noise reduction due to the antenna not receiving from directions of high-noise intensity will be the same for the array of cathode-follower dipoles as for any other array of the same reception pattern. Improvement in signal-noise ratio, due to the signal from a high gain cathode-follower array overriding noise generated in the receiver, will also be the same as for any other type of array of equal gain.

Conclusions

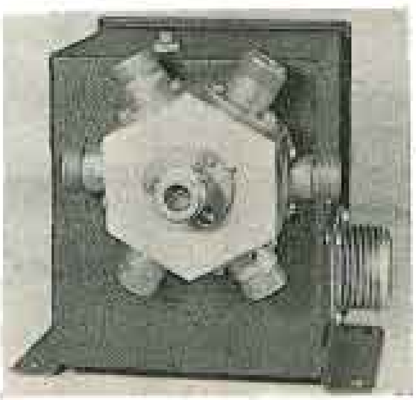
The cathode-follower antenna system for receiving shows enough promise, so that further development might make it into a useful antenna for use over wide-frequency ranges. Of course it will only be usable for receiving since the tubes will not pass power in both directions. The big drawback with both the dipole and the c-f array is that the gain is not what might be desired. The low gain of the dipole comes from two sources. One is that the tube mutual conductance should be as large as the transmission line admittance, if a considerable voltage loss in the cathode-follower is to be avoided by the elimination of a cathode resistor for impedance matching, and the other is that specially in the high television band, transit time effects and interelectrode capacitance cause dipole loading, so that the dipole open-circuit voltage is not applied to the cathode-follower input. This tube loading causes the mutual impedances between dipoles in an array of cathode-follower dipoles to adversely effect the array operation over a band of frequencies. The desirable tube for this application is the same tube that is desired for many r-f applications, namely a tube of high mutual conductance and low interelectrode capacitances and low input conductance. Probably improved cathode-follower antennas could be built with the use of lighthouse tubes. The antenna will always have the disadvantage of requiring power from some source to operate its tubes.

The Industry Offers

DESIGNERS FOR INDUSTRY COAXIAL SWITCHES

Coaxial switches which are said to feature low standing-wave ratio and high adjacent-channel rejection ratio have been announced by Designers For Industry, Inc., 2915 Detroit Avenue, Cleveland 13, Ohio.

Three types are available: Type C, vswr less than 1.25:1 to 6,000 mc, less than 1.8:1 to 10,000 mc, single circuit, two position (spdt) for use with RG-8/U cable; type D, automatic—switch rotated to positive position by remote selector, single circuit, six position, for use with RG-8/U cable; and type Y, for applications where power handling is a factor, single circuit, two position, for use with RG-17/U cable.



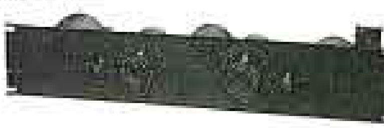
CINEMA ENGINEERING PROGRAM EQUALIZER

A program equalizer, type 4031-B, featuring 12 db equalization at 100 cycles and 3, 5 and 10 kc in calibrated and detented two db steps has been announced by the Cinema Engineering Co., 1510 West Verdugo Ave., Burbank, Calif.

High and low frequency attenuation up to 16 db in two db steps is accomplished by turning the same controls in a counter clockwise rotation past the center point.

A constant K circuit is said to maintain the level and eliminate wave distortion over the entire range.

Equalizer is said to provide over 1460 curve combinations.



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AIRBORNE INSTRUMENTS POLAR RECORDER

A polar recorder, type 116, has been announced by Airborne Instruments Laboratory, Inc., Mineola, N. Y. Originally designed to plot aircraft antenna radiation patterns, the recorder charts voltage on either a linear or a logarithmic scale as radial distance against angular position.

Offers a permanent ink record (reproducible) and rapid writing speed coupled with low pen overshoot. Can be provided in either portable or rackmounted form.

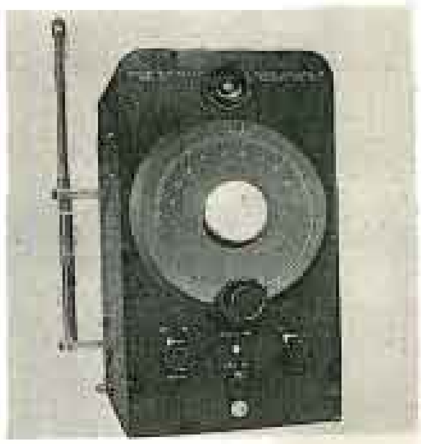
BROWNING FREQUENCY METER

A frequency meter, model S-7, designed for measurements in the 72-76 and 152-162 mc band has been announced by Browning Laboratories, Inc., Winchester, Mass. Meter features accuracy, in either band, of .005%, or .0025% where minor precautions are taken.

A whip antenna mounted at the side of the cabinet furnishes coupling to the transmitter and may be telescoped to form a carrying handle.

Available in single or two specified frequencies in either or both bands.

(Continued on page 34)



The Industry Offers

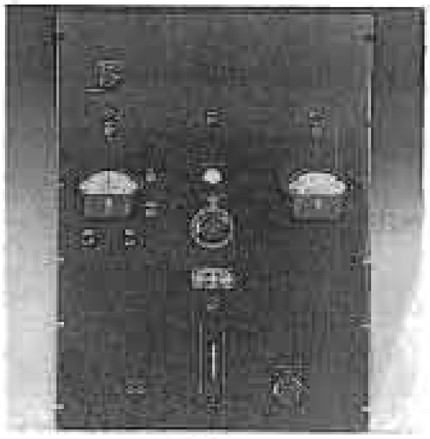
(Continued from page 33)

G-R F-M MONITOR

An f-m monitor type 1170-A, which provides a continuous indication of center frequency, meter indication of percentage modulation, positive, negative, or peak-to-peak, and a lamp indication of peaks in excess of a predetermined percentage, has been announced by General Radio Company, 275 Massachusetts Avenue, Cambridge 39, Mass.

Stability of center-frequency indication is comparable with that obtained on a-m monitors in the standard broadcast band, so that no calibration checks need be made during the operating day, hence a remote indicator can be used at the transmitter engineer's desk.

The monitor uses a counter type discriminator which permits the use of a low intermediate frequency. Two audio output systems are provided, one for measuring distortion and noise with the type 1932-A distortion and noise meter, and the other for audio monitoring. Inherent distortion is said to be less than 0.2% and distortions as low as 0.1% can be measured. Noise level is said to be at least 75 db below 100% modulation.



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DUMONT HI-Q CAPACITORS

A high-Q capacitor, which is said to have a leakage resistance of better than ¼ million megohms and a power factor of .01% has been developed by Dumont Electric Corp., 34 Hubert Street, New York.

Available in capacity ranges from 5 to 100,000 mmfd in 300 to 10,000-volt ranges.

• • •

TRIPLETT ILLUMINATED-DIAL SIGNAL GENERATOR

A signal generator, model 3432, with an illuminated dial, and five fundamental ranges of 100 kc to 40 mc and two harmonic ranges directly calibrated from 36 to 120 mc, has been announced by The Triplett Electrical Instrument Co., Bluffton, Ohio.

Circuit selector provides for internally modulated signal (variable 0 to 100% at 400 cycles). Variable amplitude of external modulation 40 to 15,000 cycles; unmodulated signal or variable audio 0-10 volts at 400 cycles.

• • •

PRD SLOTTED SECTION AND PROBE

Slotted section and probe combinations, featuring friction-driven probe carriages supported by spring-loaded ball bearings have been announced by the Polytechnic Research and Development Co., Inc., 66 Court St., Brooklyn, N. Y. Bearings roll in precision-ground grooved runways made from hardened tool steel.

Slotted sections and all units of PRD microwave test equipment line are available in all the sizes of waveguide and coaxial line in common use for frequency bands between 1000 and 40,000 mc.

• • •

KEPCO LAB MULTIPLE POWER SUPPLY

A power supply which contains two continuously-variable B supplies delivering from 0 to 350 volts at currents up to 120 ma, one variable C supply delivering from −50 to +50 volts at 5 ma, and one heater supply for 6.3 volts at 5 amperes, has been developed by the Kepco Laboratories, Inc., 142-48 Roosevelt Avenue, Flushing, N.Y.

Two 6Y6 control tubes are used in B circuit. Ripple voltage is said to be less than 5 millivolts.

News Briefs

PERSONALS

J. K. Poff, has been named general sales-service engineer for manufacturer as well as jobber divisions of the Astatic Corporation, Conneaut, Ohio.

Allan W. Parkes, Jr. is now head of the field engineering and sales department of the Aircraft Radio Corporation, Boonton, N. J.

V. W. Palen, formerly with North American Philips Co., is now handling publicity for N.Y.U. College of Engineering, 180th Street & University Avenue, New York 53, N. Y.

Neal McNaughton, former chief of the allocation section in the FCC engineering department's broadcast division, has joined the staff of NAB, as assistant director of the engineering department.

Henry L. Dabrowsky, former G.E. development engineer, has been named technical supervisor of television for WATV, Newark, N. J.

Edward H. Reeves is now technical supervisor of f-m operations for WAAT-FM, Newark, N. J.

Thomas E. Howard has become chief engineer of KSD and KSD-TV, the St. Louis Post-Dispatch radio and television stations.

Howard succeeds **Robert L. Coe,** who has become manager of the New York Daily News television stations.

R. P. Almy has resigned as assistant general sales manager of the radio division of Sylvania Electric Products Inc., and acquired part-ownership in the Dixie Radio Supply Company of Columbia, S. C., where he has become vice president and assistant general manager.

Melville Eastham, chief engineer, and **Arthur E. Thiessen,** vice president of the General Radio Company, recently received certificates of commendation from the Navy Department, Bureau of Ships, for their contributions to the successful prosecution of the war.

H. Ward Zimmer, former vice president in charge of the radio tube division, Sylvania Electric Products, Inc., has been appointed vice president in charge of manufacturing operations for all company divisions.

INDUSTRY ACTIVITIES

Commercial operator license renewal applications must now be filed prior to the date of expiration. FCC states that operators should not wait until their licenses are about to expire before applying for renewal, provided service requirements are met. Applications may be filed at any time within the last year of the license term.

This procedure marks the end of the series of FCC orders which were prompted by the war emergency, and intended primarily to assist commercial operators who, because of wartime conditions, did not have actual possession of their licenses, could not ascertain their expiration dates, or for other reasons beyond their control found it difficult or impossible to file timely renewal applications.

Wire Recording Corp. of America, 1331 Halsey Street, Brooklyn, N. Y., have taken over the assets and manufacturing facilities of St. George Recording Equipment Company of New York City. J. J. Sullivan is president of the newly formed corporation. Robert J. Marshall is chief engineer.

An electronic research 57-acre development, to be known as Sylvania Center, will be built at Bayside, L. I., N. Y. Ground was broken recently at the site by Walter E. Poor, chairman of the board of Sylvania Electric Products, Inc.

Activities at the center will be under the direction of Dr. Bennett S. Ellefson. The initial building, which will house physics labs, will cover over 28½ acres of the site facing Long Island Sound.

The sales operations of Fred M. Link and the manufacturing functions of Link Radio Corporation have been combined under Link Radio Corporation, 125 W. 17 Street, N. Y. City.

LITERATURE

The Haydon Manufacturing Co., a subsidiary of General Time Instruments Corp., East Elm Street, Torrington, Conn., has released a 16-page catalog on synchronous timing motors, clock movements and timing devices. Catalog has photos, profile drawings, shaft drawings and listings of the speeds, voltages, frequencies, shaft sizes, etc.

Catalog may be obtained by writing E. B. Hamlin.

Cornell-Dubilier Electric Corp., South Plainfield, New Jersey, have released a 24-page catalog, No. 200.

Illustrated with detail drawings as well as halftones of more than 30 different classes of capacitors.

Electro-Voice, Buchanan, Mich., have published a bulletin, No. 138, on the E-V 805 contact pick-up microphone for stringed instruments.

Dayton Aircraft Products, Inc., 342 Xenia Avenue, Dayton 10, Ohio, have released an eight-page booklet on the reduction of precipitation static in aircraft radio.

Booklet details causes of precipitation static and describes the methods developed by the U. S. Air Forces during the war for greatly reducing this static. The methods now used consist of metal and ceramic antenna fittings, which in conjunction with polyethylene wire, insulate the antenna system against corona discharge. These fittings are made to be used on marker beacon, compass sense and receiving and transmitting antennas.

Ward Leonard Electric Company, Mount Vernon, N. Y., have announced publication of a catalog D-30, which describes and illustrates stock units in resistors, rheostats, and radio amateur relays.

Catalog may be procured by writing to Radio and Electronic Distributor Division, Ward Leonard Electric Company, 53 W. Jackson Blvd., Chicago 4, Illinois.

The Meletron Corp., 950 North Highland Avenue, Los Angeles 38, California, have released a four-page bulletin describing George A. Sturbird microphone booms and stands, which feature air-valve control, centerless and anodized tubings, ball bearings casters, etc.

Times-Star F-M

(*Continued from page 9*)

switched into the circuit for setup use whenever the gain controls are turned to the normally-off or *infinity* position. This feature saves much time in cueing records and transcriptions, especially in *tight spots* where several short *spot* announcements are run close together.

Two types of playback heads are used; one[9] for the reproduction of shellac-base records, and the other[10] for high-quality plastics. Both sets of playback arms are bridged so that switching is not necessary in changeovers; only the proper filter step need be selected.

We also use two portable program record cabinets, mounted on rubber wheels and lined with felt. Records and transcriptions are arranged according to program times by the program department and wheeled into the operator's reach. These cabinets make a very compact and time-saving arrangement for recording operations.

The Transmitter Room

The transmitter room includes two metal spare parts storage cabinets.

Mounted on the wall between these two cabinets and away from all a-c and r-f circuits, is a power supply unit[11] for the consolette. In an equipment rack are some of the audio equipment.

Here are, from top to bottom: (*1*) A spare vu meter and attenuator. This meter is normalled across the transmitter input but can be patched into any other circuit or used to check the levels of incoming remote programs. (*2*) Noise suppressor.[12] This unit has proved very satisfactory in reducing record scratch and groove noise. A remote gate circuit control has been mounted on the consolette so that proper suppression levels may be selected instantly at the control desk for different types of records and for noisy transcriptions, or taken out entirely for voice and high-quality pressings. This control was installed in the space originally occupied by the consolette meter switch; the switch was remounted inside the consolette and is easily accessible from the top for meter readings. (*3*) Limiting amplifier.[13] (*4*) Variable line equalizer.[14] This equalizer is permanently connected across a remote line from the *Cincinnati Times-Star* news room and equalized to 15

[9]Pickering.
[10]RCA.
[11]RCA MI-11301-B.
[12]Technical Instrument Corp. 910-AB.
[13]RCA 86-A1.

kc. (5) Jack strip 1 which contains jacks normalled to four pre-amplifiers (contained in the consolette), two turntables, the noise suppressor, consolette output, preemphasis coil, limiting amplifier, a 20-db fixed pad, and the transmitter input. The preemphasis filter circuit is of the constant-impedance, balanced, *bridged-T* type and is designed for preemphasis attenuation of audio frequencies. A 5-db minimum loss is attained at 15 kc, with an approximate 26-db maximum loss below 500 cps. The frequency response gives a maximum equalization of approximately 20 db between the high and low frequencies. (6) Jack strip 2, which is normalled to a high-fidelity line (15 kc) line from WKRC, four multiple jacks, a special news room line, and six remote positions. These positions appear at the consolette on positions 5 and 6. Remote programs are checked in by pressing the appropriate remote button on either mixer position and throwing the mixer key to *Audition*. The spare vu meter may then be patched into the circuit to determine the remote levels and to calculate the approximate amount of line equalization to be used for that particular setup. Most remote terminations have been tested and checked in prior to air time with equalization settings noted for future reference. However, many special events or one-time pickups arise during the course of air time and can be satisfactorily equalized by the above method. (7) Another jack strip which contains input, output, bridging and multiple jacks for program and monitor amplifiers and terminations for transmitter and consolette telephones. There are 14 spare jacks in this strip. (8) A spare variable line equalizer[14] for use on remote lines or wherever needed. (9) Program amplifier.[15] (10) An a-c control switch and indicator lamp. (11) Coil bank, including three 500-ohm isolation coils, one spare 20-db fixed attenuator, and a preemphasis filter[16] and fixed attenuator.

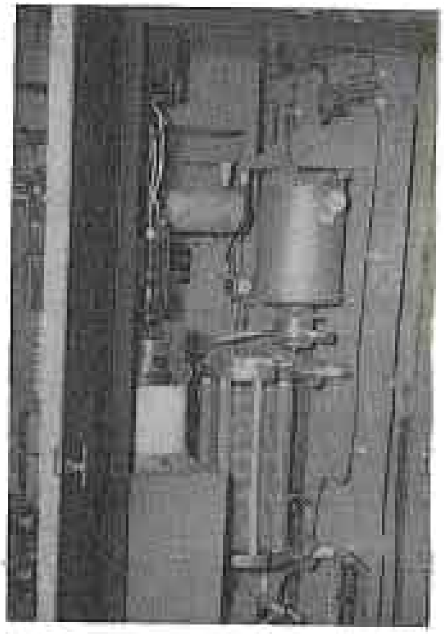
On another rack are additional audio equipment, from top to bottom: (1) Plate current meter for program and monitor amplifiers. (2) Frequency monitor.[17] (3) and (4) Beat-frequency oscillator[18] and distortion and noise meter.[19] (6) Spare program amplifier.[20] (7) Monitor amplifier.[21] Remote gain control for this monitor

(Continued on page 39)

[14]RCA 10B-1A.
[15]RCA BA-3B.
[16]RCA MI-4926.
[17]G.E. BM-1-A.
[18]RCA.
[19]G.R.
[20]RCA BA-4C.

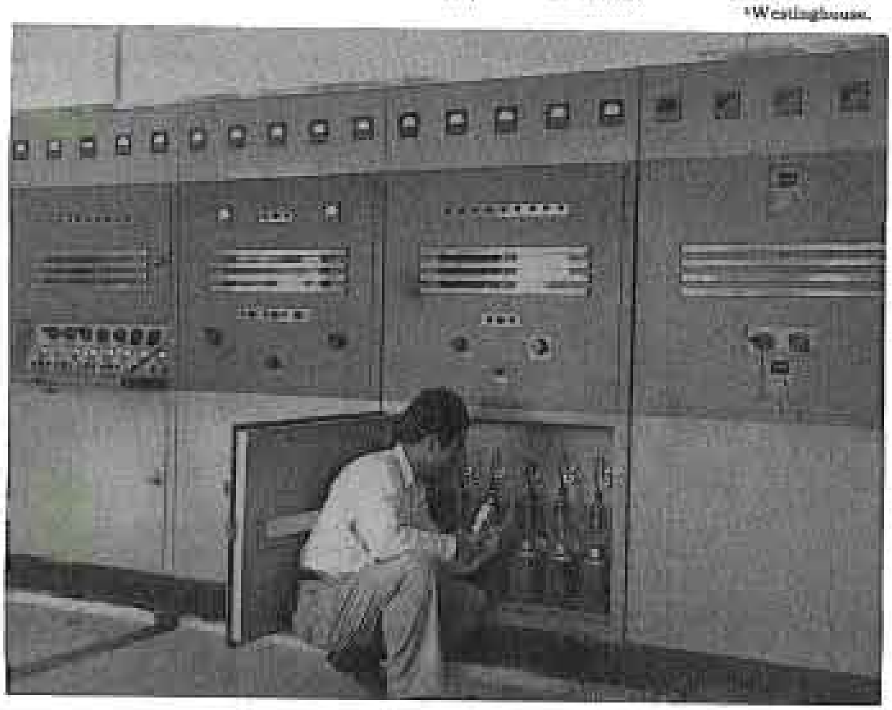
10-Kw A-M Installation In Puerto Rico

Above, view of WIBS building in San Juan, Puerto Rico, which houses 10 kw a-m transmitter[1], operating on 740 kc. The building is located seven air miles from downtown San Juan. A two-tower directional antenna array is used to provide a cardioid pattern; full 10-kw power is used for day and night service. Below, Carlos Rafael Mercado, WIBS engineer, inserting a rectifier tube in the main rectifier power supply of the transmitter.

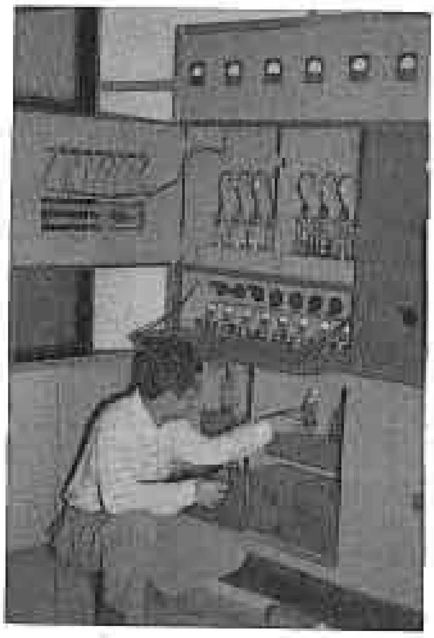


Above, close-up view of the modulator.

[1]Westinghouse.



Below, engineer Mercado inserting a tube in the exciter section of the transmitter.



WHEN YOU CHANGE YOUR ADDRESS

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Times-Star F-M

(Continued from page 37)

is located on the extreme lower left-hand corner of the consolette, in the space originally used for the monitor phone jack. (*8*) An a-c control switch and indicator lamp. This switch controls a-c power to all equipment in this rack except the crystal heater circuit in the frequency monitor. A special power supply[9] is available for this monitor. A special a-c line is connected from the power circuit to the transmitter crystal heater supply source so that all heaters are always on. Space is also provided on this rack for installation of a transmission-line monitor.[10]

All equipment is readily accessible for servicing. As an aid to locating potential sources of trouble, a 50-watt 115-volt lamp bulb has been mounted in the back of each transmitter unit so that all parts are fully illuminated. Heat from the bulbs is not sufficient to affect inside temperatures. A thermometer has been placed inside each unit so that constant watch may be maintained over each stage. Often a small rise in temperature, accompanied by a change or fluctuation in plate or grid current, is sufficient warning of impending trouble, which may then be corrected before it actually happens. Fans have been installed in the top of each audio rack so that air circulation will be improved.

One of our most useful maintenance aids is a portable test equipment dolly, in which are a tube tester, vacuum-tube voltmeter, 'scope, tools and supplies, etc.

A large section of the wall behind the transmitter units is covered with a framed blueprint of the complete transmitter and control circuits. This diagram is large enough to read across the room and has been a valuable asset in maintenance and trouble-shooting.

For network operation we plan to install soon a special relay receiver.

[9] G.E. 4BP2A1.
[10] RCA MI-28155

SEVEN-TOWER DIRECTIONAL ARRAY

Seven tower directional-array system of WREX, Duluth, Minnesota. Six towers are used during the night, and the seventh tower with two night-pattern towers make up a three-element array for daytime coverage. *(Courtesy Blaw-Knox)*

ADVERTISERS IN THIS ISSUE

COMMUNICATIONS INDEX

JANUARY, 1948

for **FM** COVERAGE and PERFORMANCE

you can't beat Federal's
COMPLETE "ONE-PACKAGE" STATION

A broadcast station that's FM by Federal all the way—from microphone to antenna—offers *three exclusive features* that assure maximum coverage at minimum operating cost, and maximum performance with minimum maintenance expense.

1. FEDERAL'S SQUARE-LOOP ANTENNA!

The coverage of an FM station depends *primarily* on the effective strength of the radiated signal. And Federal's 8-Element, Square-Loop Antenna gives an effective radiated power *more than 8 times* the transmitter rating. Actual installations have repeatedly *proved* its ability to give outstanding coverage—and to withstand high winds and heavy icing loads.

2. FEDERAL'S HIGH-FIDELITY TRANSMITTER!

All Federal FM transmitters feature the exclusive "Frequematic*" modulator — for outstanding fidelity and performance. Maintains center-frequency stability within 0.001% — reduces signal-to-noise ratio to 5600-to-1 — uses simple all-electronic circuits with standard receiver tubes — easy to align, simple to maintain.

3. FEDERAL ENGINEERING ALL THE WAY!

Complete FM by Federal means FM at its best, with all components precision engineered to work together. Transmitter console, studio console, transcription units, power supplies — everything from microphone to antenna—designed and coordinated for maximum over-all performance and economy.

When planning your new FM station, remember these exclusive advantages. And if you want to get on the air *fast*, Federal can now make your complete installation in record time! For further information, write to Federal, Dept. B610.

*Trade Mark

With this Federal 8-Element Square-Loop Antenna, now on the air at Station WMRC-FM, Greenville, South Carolina, listeners more than 200 miles away—including cities in 6 different states—report excellent reception. Lower photo shows WMRC's transmitter room, with Federal 10-Kw transmitter, console, monitor speaker and power supply.

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An IT&T Associate

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100 KINGSLAND ROAD, CLIFTON, NEW JERSEY

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