electronics

radio, communication, industrial applications of electron tubes . . . engineering and manufacture

Basil Hardgrove

Turnstile at W2XMN
(see contents page)

MARCH
1939

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electronics

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CONTENTS—MARCH, 1939

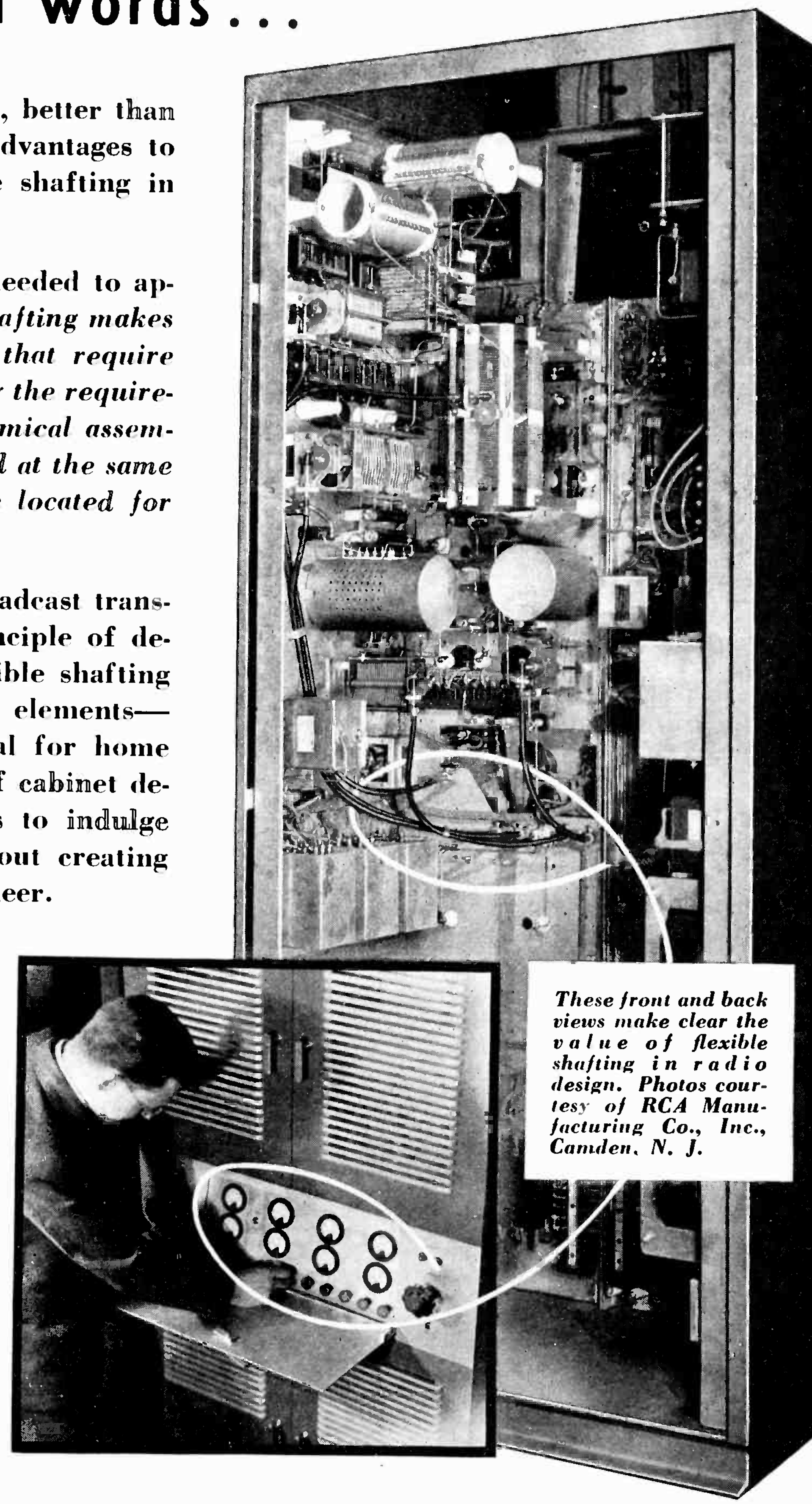
DEPARTMENTS

THIS picture *is* worth more than a thousand words...

THIS one picture drives home, better than any number of words, the advantages to be gained by the use of flexible shafting in home radios.

Only a brief consideration is needed to appreciate how *the use of flexible shafting makes it possible to place all elements that require tuning in positions that best satisfy the requirements of circuit efficiency, economical assembly and servicing convenience, and at the same time, permits tuning knobs to be located for maximum operating convenience.*

While this happens to be a broadcast transmitter, it is obvious that the principle of design—the principle of using flexible shafting instead of direct-connected tuning elements—is as easily applied and as logical for home radios. It opens wide the field of cabinet design because it permits designers to indulge their ingenuity to the limit without creating any difficulties for the radio engineer.



These front and back views make clear the value of flexible shafting in radio design. Photos courtesy of RCA Manufacturing Co., Inc., Camden, N. J.

•

SEND FOR A COPY OF ENGINEERING BULLETIN 38

It gives full information about S. S. WHITE Flexible Shafting, specially developed for remote control, with particular reference to shafting for radios and how to apply it.

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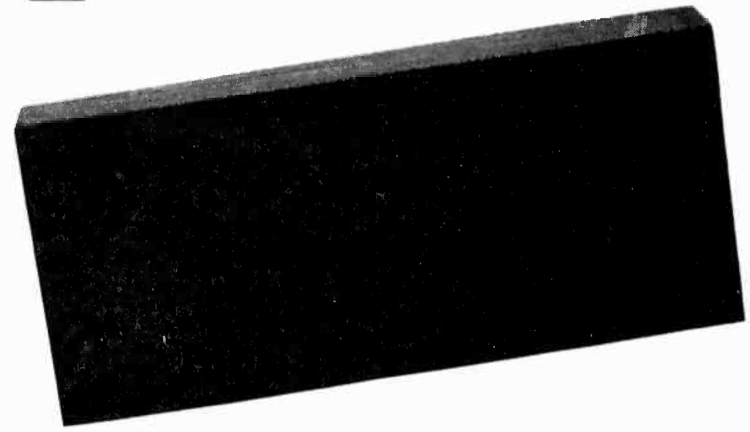
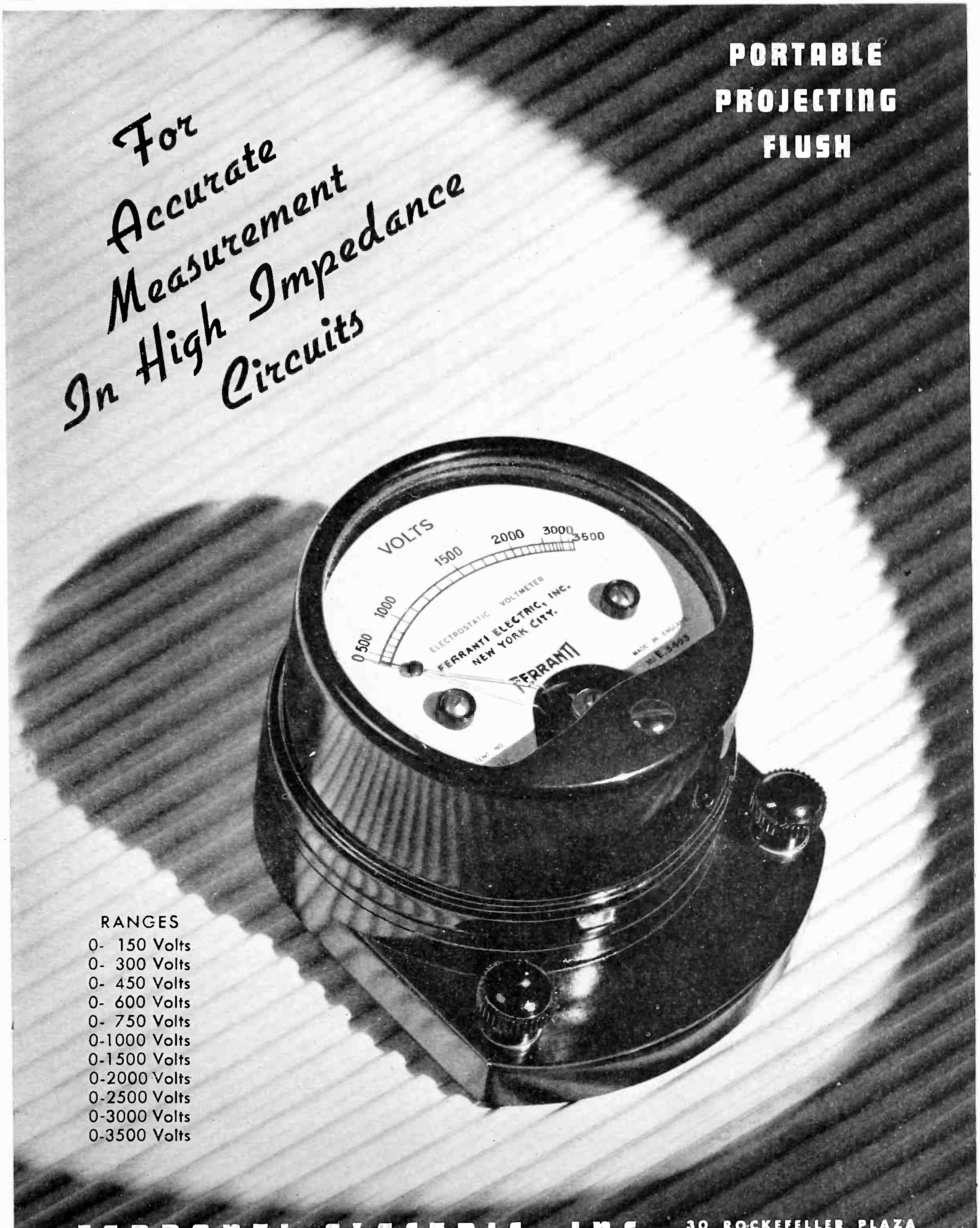
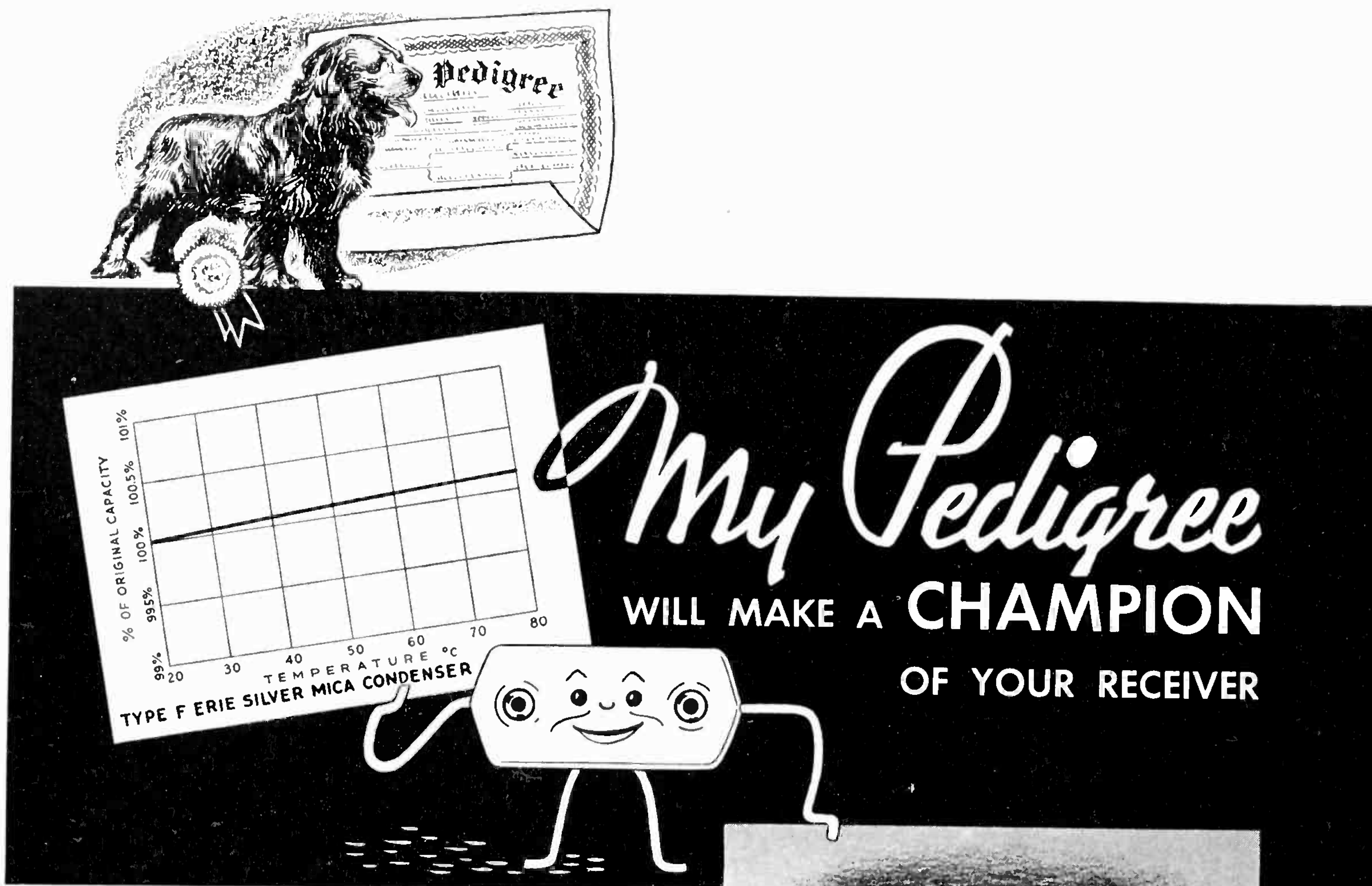


ELECTROSTATIC VOLTMETER





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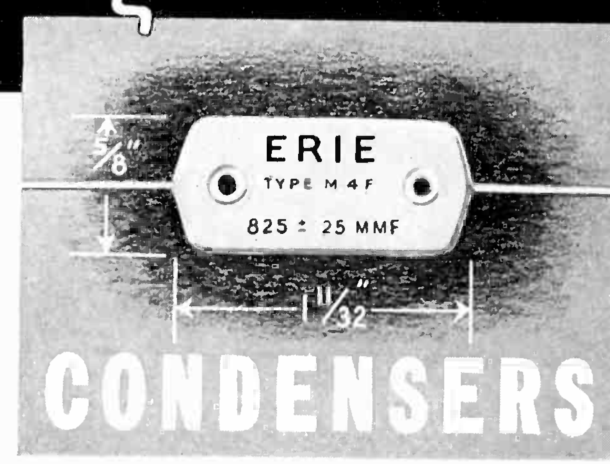

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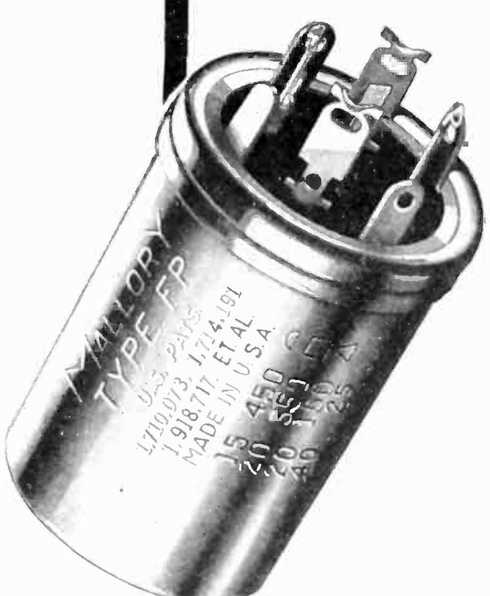

- Substantially lower prices per unit.
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- Less labor in assembling to chassis.
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- Materially reduce rejects in assembly lines and in the field.
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- Greater uniformity, eliminates the need for other parts to stabilize circuit performance.
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ELECTRONICS

MARCH 1939

KEITH HENNEY
Editor

Crosstalk

▶ **PHOTO TECHNIQUE** . . . On a recent Crosstalk page we sent up a trial balloon. The question was asked whether a department devoted to photography should be included in *Electronics*. While the results have not been overwhelming, numerous *Electronics*' subscribers felt that such an addition to the present paper would be useful.

One reader, however, felt that other *Electronics*' readers had other hobbies, and that if we tried to cover them all we would ultimately be in the class of certain mechanical magazines (we won't name them), which publish nothing about practically everything.

The balloon was part of a piece of research to determine the possiblities of a technical journal of photography. The research has been most encouraging, and with no more fanfare, we beg to announce *Photo Technique*, a McGraw-Hill magazine to be ready in May which will deal with all technical matters of making and using photographic materials. It will aim to cover X-ray, aerial, color, medical, industrial, commercial and other phases of the photographic art. The book will be good looking (we hope) but emphasis will be on technique rather than art; it will be about the same size as *Electronics*, and will cost the reader $5 per year.

Until he is tossed off by centrifugal force, or something, your editor will act as editor of *Photo Technique;* Mr. Dudley will be Managing Editor of the new publication, Mr. Fink assuming more direct charge of *Electronics.*

It would be delightful to find among the readers, and contributors, of *Photo Technique* many of the friends of *Electronics.*

▶ **AMATEUR STUFF** . . . Mr. J. E. Blackburn, Jr., is boss of all McGraw-Hill circulation activities (nearly 400 people employed, handling 3 million mailings per month, and having a quarter of a million chances of making a mistake per day, with 420,000 paid subscribers to service). Recently he was handed an ARRL radiogram which said "haven't you forgotten something?" It was sent from St. Sgt. T. Biggs, Regt'l Radio Sgt — USARMYHQBTRY77TH FA Marfa Texas (that's the way his circulation department card reads); via amateur radio, picked up by W2OQ relayed to W2KMS who works for a stamp company in the McGraw-Hill Building. W2KMS delivered it in person to Mr. Blackburn, who wondered what it was all about.

Checking into our records he found that Sgt. T. Biggs had subscribed to *Electronics*, paying the second of two installments on Jan. 12, and expecting a premium which had not arrived when he sent the radio Jan. 23. On this date, a new batch of premium books arrived, and before the radio had been delivered, Sgt. Biggs' book was in the mail.

Amateur radio always crashes through!

▶ **DIATHERMY** . . . Certain omissions in our report of the radio-diathermy meeting on this page in February appear to give wrong impressions. The meeting was voluntary and was called by the Council of Physical Therapy of the American Medical Association. As pointed out by a manufacturer of diathermy apparatus, "the demonstration at the meeting showing interference by electro-medical equipment was achieved through the use of specifically planted diathermic equipment, quite carefully tuned to the demonstration equipment. The actual location of the diathermy equipment and the pickup equipment was geographically placed to make the demonstration as vivid as possible."

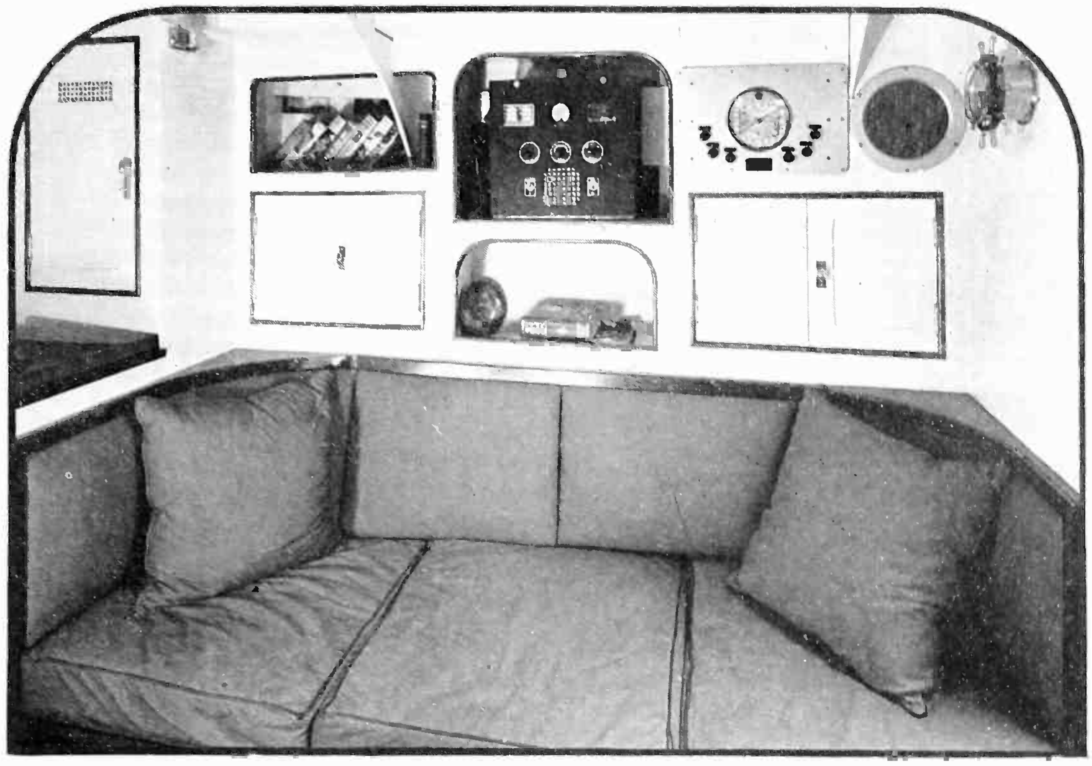
Furthermore, it was pointed out to the assembly that "whereas the planted demonstration equipment showed evidence of disturbance during the period of the demonstration there were probably several hundred diathermic units in actual clinical use in doctors' offices and hospitals within a radius of five miles of the pickup equipment and not to the slightest degree was there any evidence in the demonstration to show that these hundreds of pieces of equipment in actual usage were creating any disturbance."

Electronics has no axe to grind, no brief to offer. Both communication and medical uses of radio frequencies are essential services; neither must be allowed to prevent the other's complete realization of its possibilities.

▶ **44-50 Mc** . . . Two young engineers got together by phone recently, one working for a very large organization experimenting with television; the other from a smaller group working with television and on the air from midnight to 9 AM. Said engineer from big company, "I hear you are transmitting on *our* wavelength." Said engineer from small company, "what do you mean, your wavelength. You mean *our* wavelength."

▶ **STOP PRESS** . . . A special meeting of the Radio Club of America will be held on March 23 in Room 301 Pupin Physics Building, Columbia University, New York City at 7:30 P.M. Two papers on the subject of frequency modulation will be given, followed by a demonstration given by Major E. H. Armstrong. The papers will be by I. R. Weir and G. W. Fyler and J. A. Worcester of the General Electric Co. We suggest you read Mr. Fink's report on the subject in this issue, and then cram yourself into Room 310 early on March 23.

THE 70 foot yawl, Wakiva, owned by Harkness Edwards, puts out to sea from East Hampton equipped with 15 watt Western Electric radio telephone coastal harbor communication equipment. The backstay also serves as an antenna



Salon of the Wakiva with 15 watt two way marine radio telephone occupying a convenient niche

Radiophone Service for Small Ships

Yachts and tugs may now communicate with land telephones, call the Coast Guard in case of emergency, or use intership communication with coastal harbor radio telephone equipment

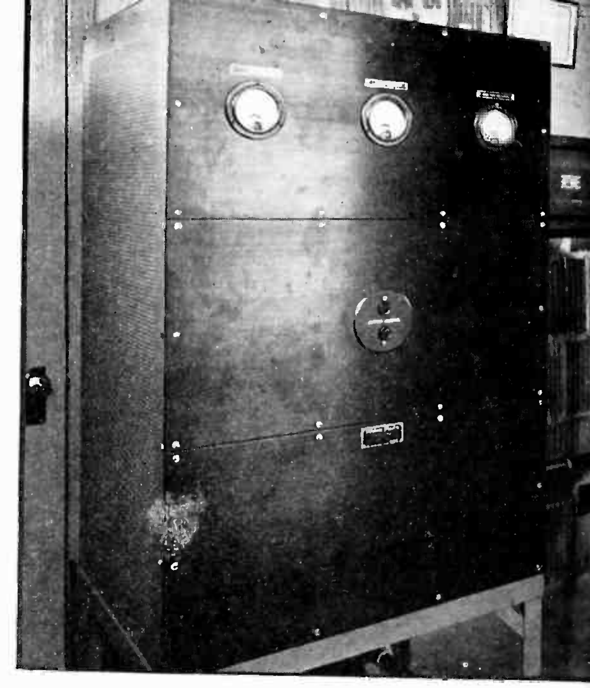
By BEVERLY DUDLEY
Associate Editor

MARINE radio telephone service for small boats is one of the newer branches of communication which, although small, has made rapid progress within the past few years. More than 1,000 yachts, tugs, motor boats, and similar small vessels are equipped with radio telephone apparatus which permits communication between radio equipped vessels, with the Coast Guard, and also connects with the land wire telephone services for dispatching or general telephone communication. In the latter instance, local, long distance or foreign calls may be completed through the nearest land telephone office equipped with coastal radio facilities.

Communication is carried on in the communication range between 2,000 kc and 3,000 kc although in a few exceptional cases higher frequencies have been employed. The transmitting and receiving equipment installed aboard small ships has been designed to result in the utmost simplicity of operation so that technically trained personnel is not required. While a ship station license is required for the installation, and the operator must have a third class operator's license, both of these are sufficiently easy to obtain so that no person who is seriously interested in equipping his boat with radiophone facilities need be barred because of license restrictions. The operator's license examination does not include a test of knowledge of the radio telegraph code, but does require that the applicant be able to operate the equipment installed on the ship and that he be familiar with the rules and regulations affecting radio communication services.

Service was first inaugurated in July 1934 for ships operating in the vicinity of Boston Harbor. The service has since been extended to the entire Atlantic Coast, the Gulf of Mexico, and Pacific Coast, and a large part of the Great Lakes region. The table shows the location of terminal offices, transmitters, and receivers, as well as the frequencies on which communication is carried at the present time. In addition to these stations now operating and under construction, applications are on file with the Federal Communications Commission or the erection of new stations at other points, most of them on the Great Lakes. While several of the existing and proposed stations are operated by individuals or radio, communications, or independent telephone companies, most of these coastal harbor stations are operated by the Bell Telephone System, and all coastal harbor radio stations connect directly with the land telephone lines.

Several types of service are available to boats equipped with radiophone apparatus. Suitably equipped vessels may communicate between themselves on 2738 kc which is designated primarily for intership communication. In the case of bona fide emergency at sea, the assistance of Coast Guard boats may be requested



by transmitting on the Coast Guard frequency of 2670 kc. Neither of these services ordinarily requires the use of any land wire facilities.

The third type of service which is available, makes more or less extensive use of the wire telephone facilities of the Bell System, and two types of service are available. These are known as the ordinary coastal harbor radio telephone service, and the dispatching service. The first of these is used primarily by privately owned boats, whereas the dispatching service is employed quite extensively by fleets of tugs, and small cargo vessels. For such services, the coastal harbor land stations usually operate on frequencies between 2500 and 2750 kc whereas the marine stations operate on frequencies between approximately 2100 and 2210 kc.

In the ordinary class of service, the ship station calls the land station by picking up the handset which, in most equipment, starts up the transmitter. The ship operator must, of course, ascertain that he is transmitting on the frequency to which the nearest land receiver is tuned, as given in the table. When the telephone operator comes in, the ship operator gives the name and location of his ship, and asks for his call in the usual manner. If proper credit has been established with the telephone company, the call —either local or long distance—is put through in the usual manner. In some cases a technical operator picks up the ship call initially, but in new installations, automatic equipment connects the ship operator directly with the telephone operator placing the call. The charge for this service is based upon a zoning schedule which depends upon the amount of land wire equipment brought into operation. The charge is $1.50 for the first three minutes within the first zone (approximately 150 miles or less from the coastal station) and $3.00 outside of this zone. These rates apply to local calls only, and if long distance calls are made, the usual long distance charge is added to that for local coastal harbor radio telephone service. The ship owner receives a 33% rebate on coastal harbor charges for his labor in operating the ship apparatus. Consequently, if a man operates his own equipment the total cost to him for local calls is $1.00 or $2.00 depending upon the zone in which he is in when making the call.

In the case of dispatching service, ship operators can communicate only with a single land telephone which is reserved for ship use. This land telephone is usually located at the central office of the company operating a fleet of vessels, and because the dispatching phone is always available for ship calls and less likely to be busy when ship calls are made than normal telephones used in routine business service, the rates for dispatching service are somewhat less than those for general ship-to-shore communication. In dispatching service, the installations may be made in such a way that the central or dispatching office can call any desired ship by means of selective ringing features incorporated in the ship's receiver, or can call all ships at once in a general broadcast. The selective ringing feature is usually the more desirable since it permits greater freedom to the ship personnel and does not require close attention of the ship operator which the broadcast system requires.

Quite naturally the distance over which ships can communicate depends upon the time of day during which calls are made, the power of the ship's transmitter, and the excellence and effectiveness of the ship's installation. Ship transmitters are commonly made with rated power outputs of 5, 15, and 50 watts, whereas the shore station transmitters are usually rated at 400 watts. The fact that there are often several receiving stations for each shore transmitter extends the useful range of the ship stations and assures reliable service along practically all of the coastline of the United States.

Equipment for installation on ships is available from a number of concerns, among whom may be listed:

Bendix Aviation Corp., South Bend, Ind.

Collins Radio Co., 11 W. 42nd St., New York, N. Y.

A. Dahlstrom, Los Angeles, Calif.

General Specialties Co., Rialto Bldg., San Francisco, Calif.

The Hallicrafters, Inc., 2611 S. Indiana Ave., Chicago, Ill.

Harvey Radio Laboratories, 25 Thorndike St., Cambridge, Mass.

Jefferson-Travis Radio Mfg. Corp., 198 Milburn Ave., Baldwin, N. Y.

Lorain County Radio Corp., Lorain, Ohio.

Marinephone, Inc., 123 Liberty St., New York, N. Y.

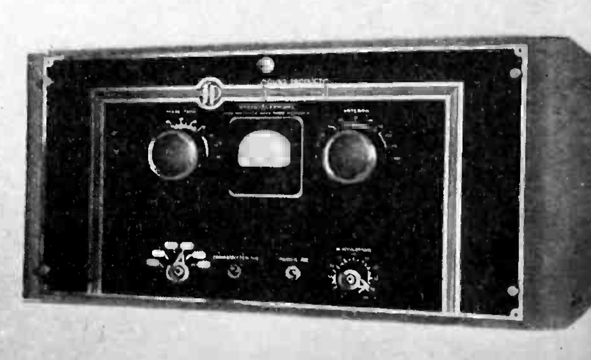
Marine Radio Service, Inc., Los Angeles, Calif.

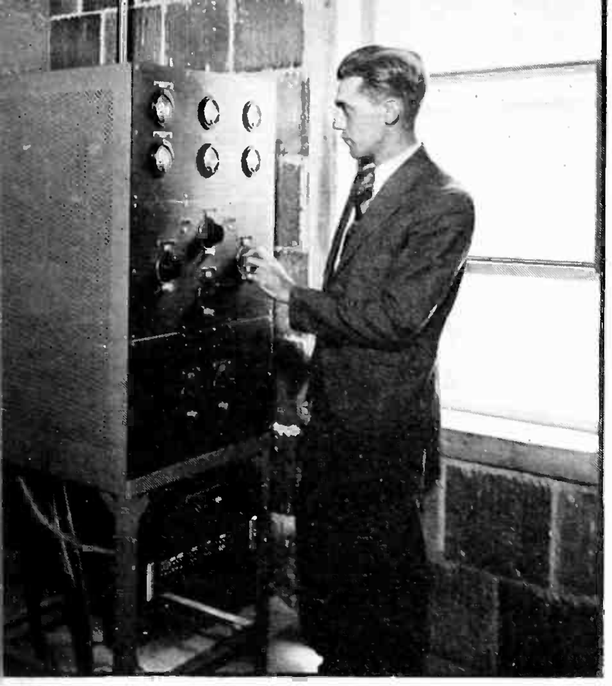
Northern Radio Co., 2208 Fourth Ave., Seattle, Wash.

Penn Electronics Co., 304 Reily St., Harrisburg, Pa.

Pierson-DeLane, Inc., 2345 W.

Three typical radio telephone units for marine coastal communications. Left: Three channel, 50 watt Hallicrafter equipment complete except for 12 volt dynamotor for transmitter. Center: Two channel, 8 watt Jefferson-Travis unit, completely self contained, and with crystal controlled receiver as well as transmitter. Right: Six frequency, 50 watt transmitter-receiver of Sound Products





This 400 watt radio transmitter which the operator is adjusting serves to link small coastal vessels cruising in the vicinity of Norfolk, Va. with local or long distance telephones. The rectifier unit is shown at the left, page 12

Washington Blvd., Los Angeles, Calif.

Radiomarine Corp. of America, 75 Varick St., New York, N. Y.

Radio Engineering Laboratories, 35-54 36th St., Long Island City, N. Y.

Radio Receptor Co., 251 W. 19th St., New York, N. Y.

Sound Products, Inc., 704 N. Curson Ave., Hollywood, Calif.

Terminal Radio Co., Wilmington, Calif.

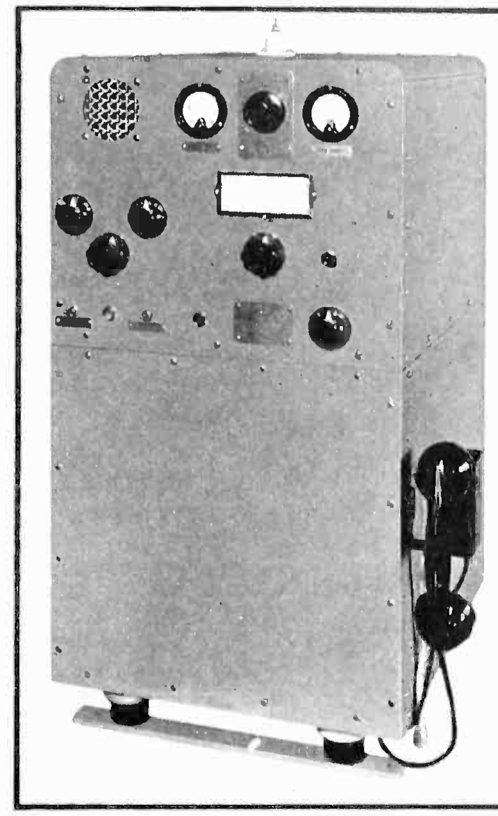
Transmitter Equipment Mfg. Co., 130 Cedar St., New York, N. Y.

Western Electric Co., 195 Broadway, New York, N. Y.

Most of the ship equipment is designed for simplicity of operation and, except for the motor generator for supplying the high voltage to the transmitting tubes, is usually contained in a single cabinet to which the handset and antenna system are connected. Since it is required that the transmitting frequency be maintained constant to within 0.04 of 1%, the transmitters are crystal controlled. Change of frequency is usually accomplished simply by changing a switch on the panel of the transmitter. In nearly all transmitters, provision has been made for three crystals, enabling communication on the intership, the Coast Guard, and ship-to-shore frequencies. In some transmitters as many as ten crystals may be used, and any one of ten transmitter frequencies may be selected at will.

The receivers are not greatly different, in their construction, from some types of broadcast receivers. In some cases a continuous range of frequencies may be covered, and several receivers have provision for reception on several frequency bands, including the broadcast band. In some receivers intended almost exclusively for ship communication, tuning is accomplished by means of a wave-change switch, and the circuits are kept tuned to the desired frequencies by means of several quartz crystals. Provision is usually made so that the operator hears his signals, at will, through a loud speaker or through the telephone handset.

The manufacturers of ship radiotelephone equipment have kept in mind the desirability of making the ship installation as simple as possible. In most cases the installation can be effected quite easily. It is merely necessary to install the radiophone unit (and motor generator, if one is used) at some convenient location having access to the ship's power supply. A single wire antenna is erected in whatever suitable space the ship affords, and the communication equipment is connected to antenna and ground. Of course attention must be given to the problem of interference if internal combustion engines are used for propulsion, but this problem is no more difficult than the similar one encountered in automobile radio installations.



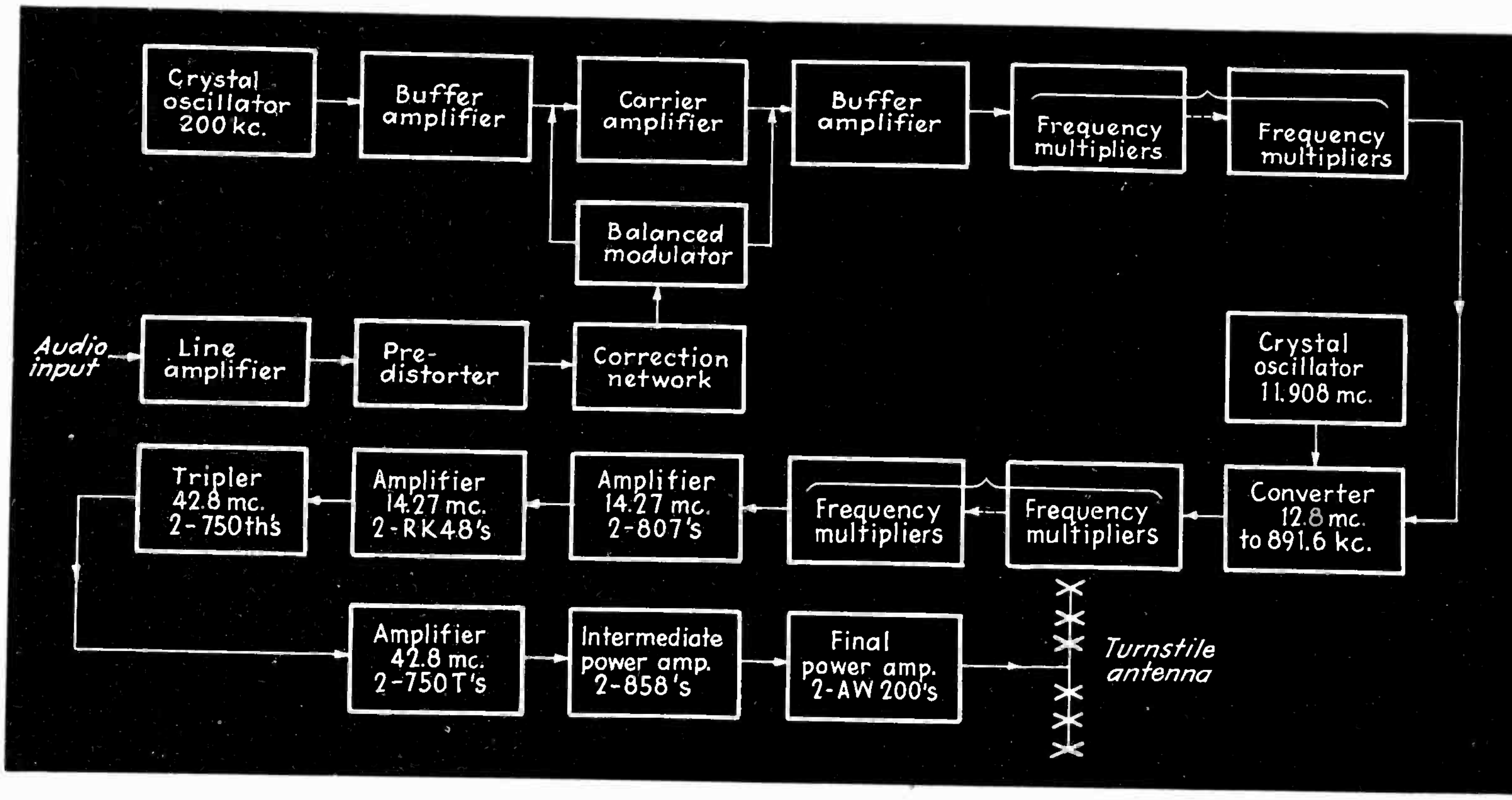
The 75 watt, 10 frequency crystal controlled operation of both transmitter and receiver of Radiomarine Corp.

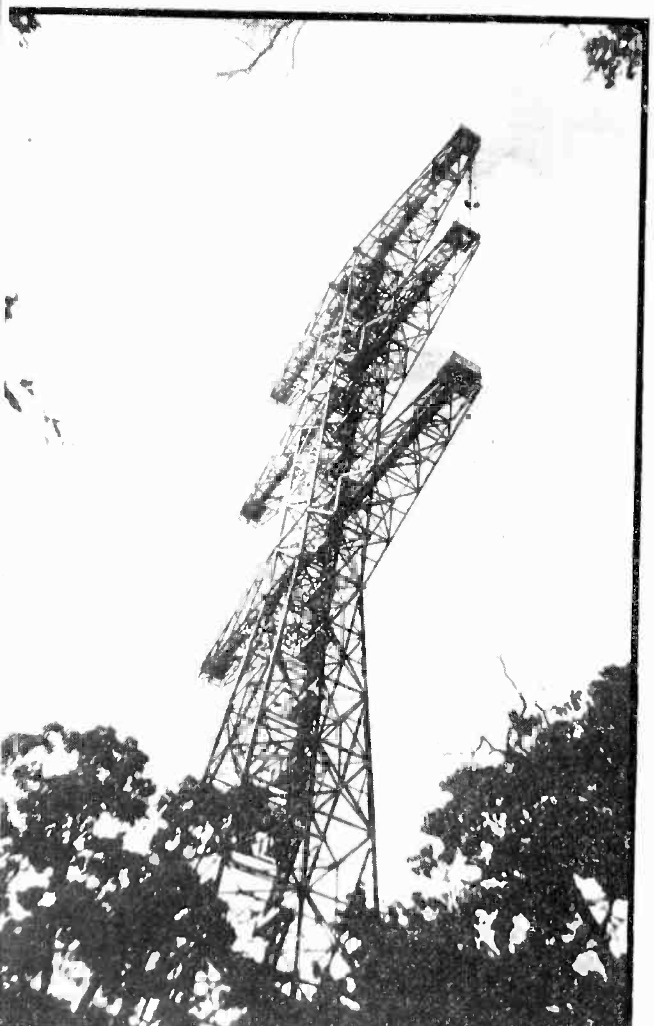
The coastal harbor radio telephone service, although still young in operation, bids well toward increasing the safety of small boats, and in increasing the effectiveness of fleets of tugs and fishing boats. For these reasons, the services which it renders may be expected to grow until it becomes a much more important factor in the communication field than at the present time.

COASTAL HARBOR TRANSMITTING AND RECEIVING STATIONS

Radio Terminal Office	Transmitter Location	Call Letters	Frequency (kilocycles)	Receiver Location	Frequency (kilocycles
Boston, Mass	Marshfield, Mass (Green Harbor)	WOU	2506	Marshfield, Mass	2110
				Newport, R. I.	
Duluth, Minn	Duluth, Minn	WAS	2550	Duluth, Minn	2158
Lake Bluff, Ill	Lake Bluff, Ill	WAY	2514	Lake Bluff, Ill	2118
Lorain, Ohio	Lorain, Ohio	WMI	2550 6470 1370	Lorain, Ohio	2158 6660 8820 3245
Memphis, Tenn	Memphis, Tenn	*WJG	2738	Memphis, Tenn	2738
Miami, Fla	Miami Beach, Fla	WOP	2514	Fishers Island, Fla	2118
		*WDR	2514	Palm Beach, Fla	2118
New Orleans, La	Port Sulphur, La	*WAK	2558	Port Sulphur, La	2166
				Willswood, La	2166
New York, N. Y	Staten Island, N. Y (St. George)	WOX	2590	Rosebank, S. I., N. Y	2198
				Tottenville, S. I., N. Y	2198
				Whitestone, L. I., N. Y	2198
				Port Jefferson, L. I., N. Y	2198
				Bav Shore, L. I., N. Y	2198
	Ocean Gate, N. J	WAQ	2522	Forked River, N. J	2126
Norfolk, Va	Virginia Beach, Va	WGB	2538	Ocean View, La	2142
				So. Virginia Beach, Va	2142
Port Washington, Wisc		*WAD	2514		2118
San Francisco, Calif	San Rafael, Calif	KLH	2506	San Rafael, Calif	2110
				Monterey, Calif	2110
San Pedro, Calif	San Pedro, Calif	KOU	2566	San Pedro, Calif	2174
Seattle, Wash	Edmonds, Wash	KOW	2522	Edmonds, Wash	2126
				Medina, Wash	2126

* Denotes construction permit only.





Four-hundred-foot steel tower atop Palisades supports turnstile antenna 900 feet above sea level. Radiating structure (see front cover) is supported between cross-arms at upper right

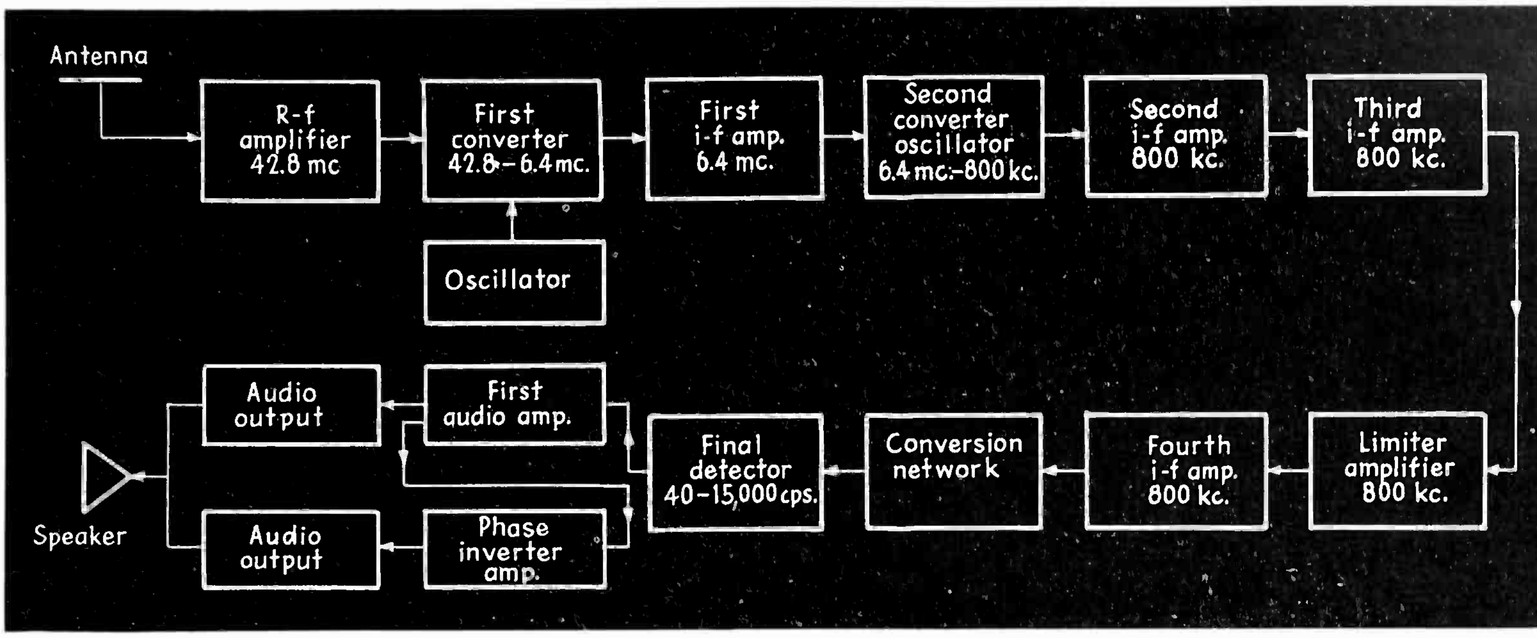
Frequency Modulation

Major Armstrong's new 40-kilowatt station at Alpine, N. J. was recently demonstrated to the editors, who report their findings herewith. Low power shown to be effective.

ON FEBRUARY 9TH, the editors of *Electronics* were given a convincing demonstration of the wide-band frequency-modulation system invented by Major E. H. Armstrong. The demonstration was made over a fifty-mile path from transmitter to receiver, on each of two frequencies, on 42.8 Mc and also on 110 Mc. The program material consisted for most part of high-fidelity vertical-cut recordings, together with a few studio presentations, involving piano music and hard-to-reproduce noise effects. The quality of the reproduction was of the highest excellence. Measurements indicate that the system is "flat" within one db from 40 to 15,000 cps, and there was nothing to gainsay the measurements so far as the ear could detect. The absence of noise in the circuit, even over the 50 mile path with the low power transmitter, was the most startling aspect of the demonstration. The background needle-hiss of the records was definitely audible, of course, but between records the circuit displayed virtually no noise at all. The effect was, in fact, as if the set had been turned off altogether. The only interfering noise was an occasional flash of ignition interference, arising from motor cars on the street directly in front of the receiver antenna. The level of this interference was low and it could not be heard except when the circuit was not modulated (in the absence of music or speech).

Behind this demonstration lies a long period of development. Previous articles in *Electronics*[1,2,3,4] have covered in detail the development of the system. Frequency modulation was considered, prior to 1935, to have little virtue and in fact was thought

[1] Frequency Modulation Advances, June 1935, page 188.
[2] Phase-frequency Modulation, November 1935, page 17.
[3] High-power Frequency Modulation, May 1936, page 25.
[4] Noise in Frequency Modulation, May 1937, page 22.
See also the brief comment in Tubes At Work, February 1939, page 36.



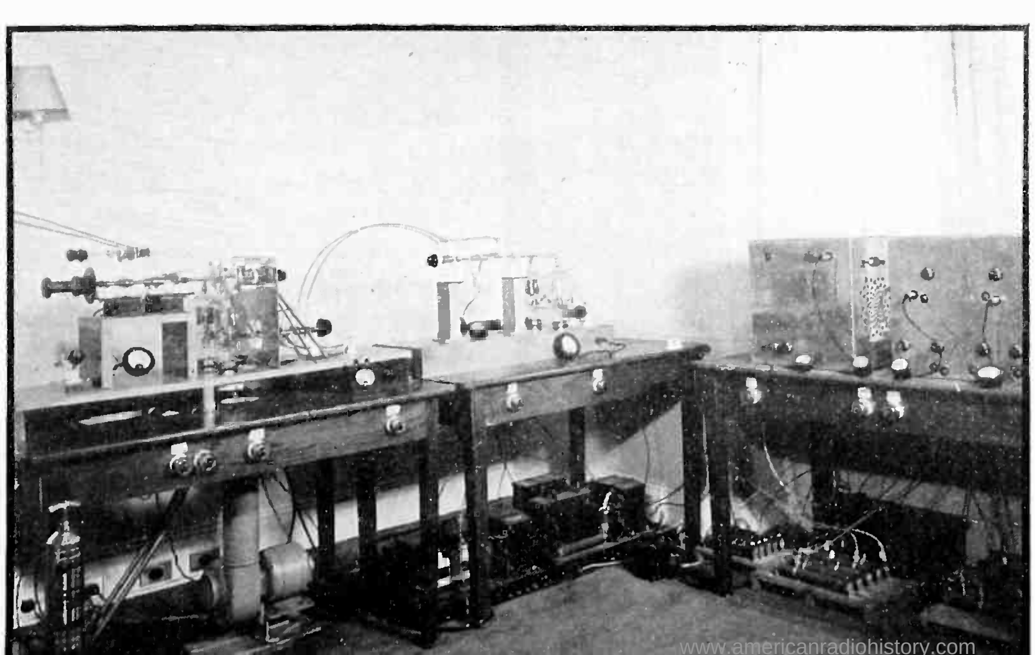
Left, block diagram of tube line-up at W2XMN transmitter, supplying 40 kw output

Above, diagram of high-sensitivity receiver used in demonstration

Demonstrated . . .

to have inherent distorting qualities. In 1935 Major Armstrong announced before the New York Section of the I.R.E. that he had developed a method of frequency modulation which was not only free from distortion but which possessed marked advantages in respect to the signal-to-noise ratio. The success of the system resides in the discovery that by introducing into the transmitted wave a swing greater than can exist in natural disturbances and by designing a receiver which is substantially not responsive to amplitude changes or small frequency changes, but only to the wide frequency changes of the signal, noise can be discriminated against. A high signal-to-noise ratio results. Furthermore, the wider the frequency swing used, the higher the signal relative to the noise, contrary to previous theory. In practice, the signal-to-noise ratio may be improved by a factor of 1000-to-1, relative to conventional amplitude-modulated transmission, when the noise is of the "fluctuation" type which arises in tubes and circuits. The available improvement is not so great when the noise is of the impulse variety associated with ignition systems, but the ratio is substantially bettered even in this case. Direct comparisons between amplitude-modulation and frequency-modulation transmissions on the same wavelength, cited in a previous article[3], show that an improve-

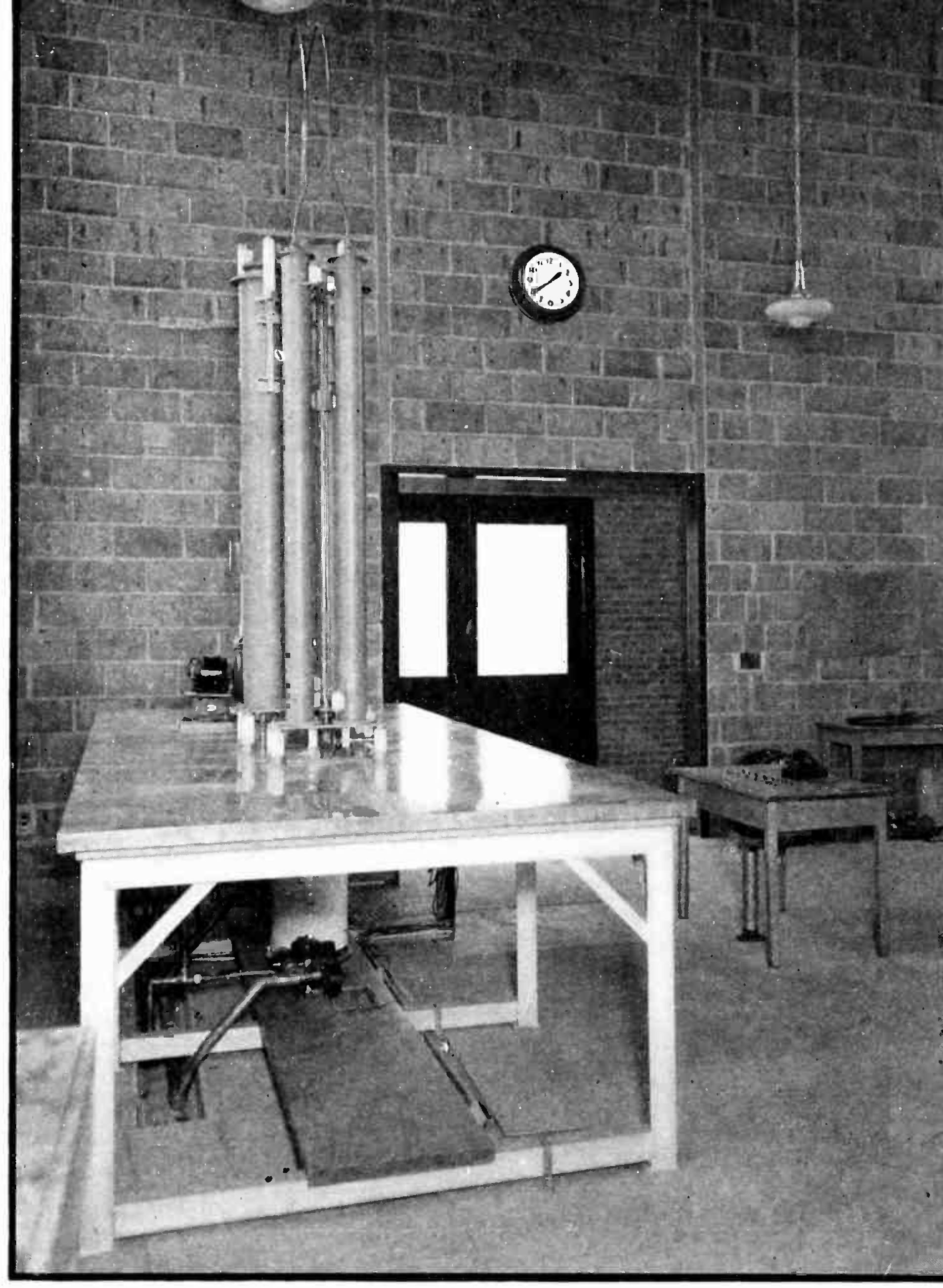
W2XCR, the 110-Mc 600-watt frequency modulation station of C. R. Runyon at Yonkers, which participated in the tests. The turnstile, above, is on a 100-foot mast



ment of 50-to-1 (35db) in the signal-to-noise voltage ratio occurs in the absence of impulse noise, and an improvement of 20-to-1 or higher in the presence of impulse noise. Comparisons with amplitude modulation on broadcast frequencies show an even greater advantage in favor of frequency modulation since the frequencies from 2000 kc to 500 kc are much more infested with atmospheric static, especially in summer.

The high-power installation in Alpine, N. J.

To show conclusively the advantage of his system over that of conventional broadcasting, Major Armstrong in 1936 began the construction of a frequency modulation station of a power commensurate with that of existing broadcasting stations. A permit was issued by the FCC to allow the construction of a transmitter of 40 kw output power, under the call letters W2XMN, at a site on the Palisades, in Alpine, N. J., about 10 miles north of the upper tip of Manhattan Island, New York. The construction was completed in all essentials in the summer of 1938, but the high power was not used until near the end of the year. Since then demonstrations have been given to various groups, notably to an I.R.E. section meeting at Bridgeport, Conn., some 40 miles distant. Tests were also conducted in the house of George Burghard at Westhampton, Long Island, about 70 miles distant, until this house was destroyed by the 1938 hurricane. Since then the receiving headquarters have been located at Sayville, Long Island, some 50 miles airline from the transmitter. The signals are heard at this point with substantially perfect performance, i.e. very low (actually inaudible) noise level and no fading. The transmitter has been heard consistently on a receiver located at the top of Mount Washington in New Hampshire, at an airline distance of 275 miles. At this distance, fading is experienced, but without distortion so that a-v-c action can be employed profitably.



Coaxial circuit (on table) for r-f power amplifiers at W2XMN shown during construction. The final stage develops 40 kw at 42.8 Mc

The transmitter is remarkable in that it produces by far the highest power ever developed for any purpose on the ultrahigh frequencies, whether for frequency-modulation or otherwise. At present the output power of the final stage is limited to 20 kilowatts, since at higher levels the grid seals of the amplifier tubes become hotter than is permissible. However, the full 40 kilowatts output (85 kilowatts input) has been developed for periods of a few minutes. At present special air blowers are being installed for cooling the grid seals, after which the full power of 40 kilowatts will be employed regularly. The effective signal level along the ground is increased by the use of a turnstile antenna system which has a power gain, in all directions, of at least two.

The transmitter building is located on cliffs which are approximately 500 feet above sea level. The antenna is supported on a massive 400-foot steel

The transmitter building at Alpine, which houses the 40-kilowatt station and experimental facilities tower. The antenna proper is mounted on a vertical mast supported at the ends of two side arms on the tower. The turnstile antenna is based on the design given by G. H. Brown[5]. Unfortunately the theoretical design does not coinside exactly with the actual design, apparently due to the effect of the metal support mast. As a result it was necessary for Major Armstrong to spend many hours daily for a period of over two months suspended on a boatswain's chair while adjusting the position of the dipoles and feeder wires. At present the turnstile consists of two sets of four horizontal dipoles each, the two groups being supported from a single mast but fed separately from each end of the mast. The power gain of this arrangement, compared to a single dipole of the same dimensions, is roughly 4 times. Further adjustments are expected to raise the ratio to 5 times. The height of the cliffs plus the tower puts the antenna about 900 feet above sea level, consequently the antenna commands within its horizon virtually the entire metropolitan area for some 35 miles in all directions. However, the limit of the station's primary service area is definitely not the horizon distance. Acceptably high fields strengths are obtained in almost any location within 100 miles of the transmitter.

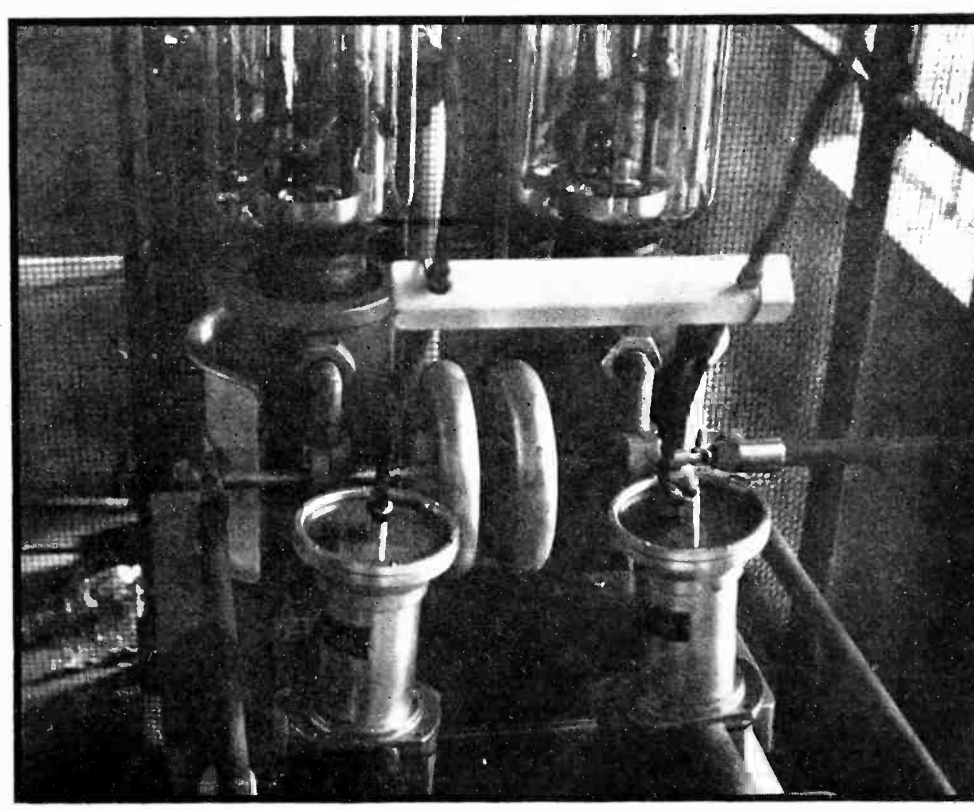
The transmitter itself is illustrated by the block diagram. The program starts in a conventional high quality telephone amplifier, and is given to a predistorter which accentuates all frequencies above 1000 cycles. The signal is then passed through a correction amplifier which introduces an amplification inversely proportional to frequency. The output of this amplifier is then used to control the phase angle of the output of a low frequency (200 kc) crystal-controlled oscillator. Subsequent frequency multiplier stages multiply the oscillator frequency, and its attendant variable phase shift, by several thousand times. The multiplied phase shift, with the amplitude inversely proportional to frequency, is equivalent to a frequency modulation, i.e. the amount of frequency deviation corresponds to the amplitude of the original program. The frequency-modulated signal is then heterodyned to a submultiple of the carrier (middle-value) frequency. Thereafter the signal is frequency-multiplied to the carrier frequency of 42.8 Mc. All this signal manipulation consumes a great number of tubes (about 50 in all) but the tubes are of small size. When the central frequency and its deviations appear at the carrier values they are at low level. Thereafter three class C amplifier stages increase the power level to the final value of 40 kw.

The input to the first of these stages uses conventional coil-and-condenser tuned circuits, but the plate circuits and all the circuits in the last two employ resonant-line circuits. The intermediate power amplifier (driver of the final stage) employs two type 858 tubes in pushpull, with four coaxial-line tuned circuits, two in the grid circuits and two in the plate circuits. The final stage employs two type AW-200 tubes, with coaxial lines in the grids and an open-wire circuit in the plates. Neutralization of the final stage is accomplished in the plate circuits. The total length of the tuned circuit in the final output is roughly 24 inches. From the output tank, an open wire balanced feeder line is used to convey the energy to the tower and thence to the two sets of dipoles in the turnstile antenna.

The efficiency of the final stage is between 45 and 50 per cent. This is remarkable performance at 42 Mc, but the explanation lies in the fact the stage acts as a class C (telegraph) amplifier. It is a characteristic of frequency modulation transmission that no variation in amplitude occurs, and consequently the class of amplifier operation is of little moment, so far as distortion is concerned. Class C is used because it is the most efficient. Furthermore the power input and output remain constant, regardless of modulation level or frequency. The result is that the carrier level of the transmitter corresponds to the peak level, rather than to one-fourth the peak level as in amplitude modulation. An antenna meter in the feeder line showed no movement whatever when the transmitter modulation was increased from zero to full level (the latter point corresponding to a frequency swing of roughly 120 kc, or 60 kc each side of the center frequency.

The three class C amplifiers are required, of course, to pass a frequency bandwidth of at least 120,000 kc (actually the sidebands extend somewhat beyond the region of frequency swing). This bandwidth constitutes a very small fraction of the carrier frequency, and for this reason no loading is required in the tuned circuits of the last three stages, since the tubes themselves introduce the

(*Continued on page* 81)



The final power stage, showing plate seals of AW-200 tubes, tank condenser and transmission line (foreground)

[5] The "Turnstile" Antenna, by G. H. Brown, *Electronics*, April 1936, page 14.

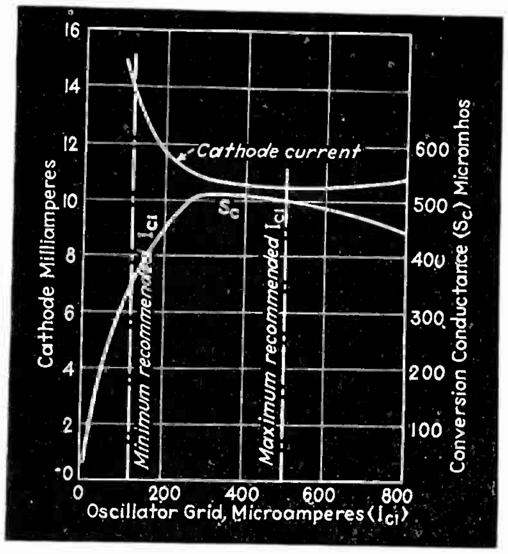


Fig. 1—Typical characteristics of cathode current and conversion transconductance plotted against oscillator grid current for small receiving tubes

Circuit Design

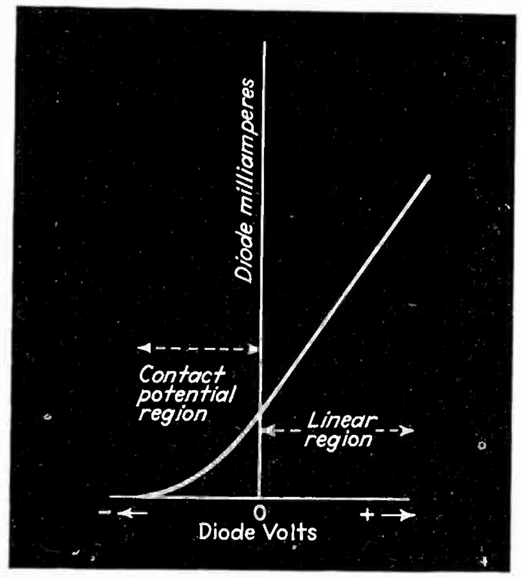


Fig. 2—With low voltages applied to the diode, linear detection is impossible because of the presence of contact potentials

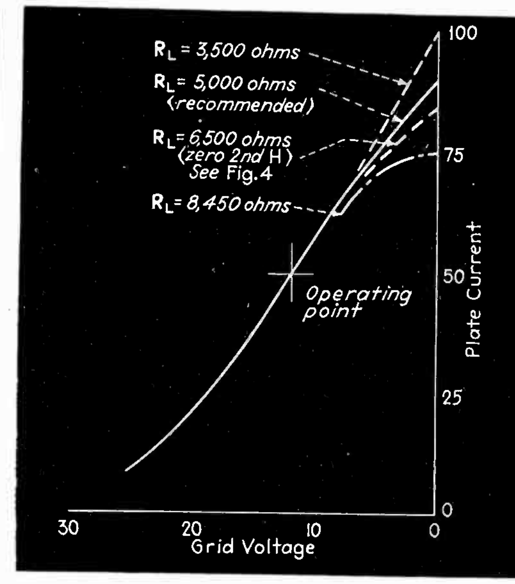


Fig. 3—Typical dynamic characteristics of a pentode or beam power tetrode for various values of external load resistance

AN important part of the work of a radio-receiver design engineer is to combine tubes and circuit elements in the proper manner to obtain a desired result. Often, in attempting to select a suitable compromise, the engineer encounters unforeseen difficulties. He may find, for example, that the output has a peculiar type of buzzing noise that cannot be traced to outside interference or that the sensitivity of a receiver changes widely as different detector tubes of the same type are used. In dealing with such problems, it becomes necessary to determine whether the tube or the circuit should be corrected.

Changes in the design of a tube type are justified when the changes are of such a nature as not to alter materially the performance of the tube in other important applications. Such changes have been made from time to time on the basis of experience with a tube type; in general, these changes improve the microphonic, hum, or noise characteristic of a tube. Many instances arise when poor receiver performance appears to be due to an undesirable characteristic of a tube, but which, after detailed consideration, has been traced to some undesirable characteristic of the circuit. This paper discusses briefly some of the difficulties that have been encountered and shows how they were corrected by a minor change in the circuit.

The substance of this paper was presented in a talk by Mr. Hollands before the Toronto Section of the Institute of Radio Engineers on May 9, 1938—Editor.

Changes in Receiver Sensitivity With Different Tubes of Same Type

Wide variations in the sensitivity of a receiver are often encountered when different tubes of the same type are inserted in a particular socket. When receiver sensitivity varies with different converter tubes of the same type, the trouble may be insufficient oscillator amplitude. When a converter tube is operated with very low oscillator amplitudes — of the order of two or three volts—the bias on the No. 1 grid is low (of the same order as the rms value of the oscillator voltage) and the so-called contact potential is an appreciable part of the total bias. Contact potential is a critical characteristic and its value varies with age and electrode voltages and is different for different tubes of the same type; therefore, its value should not be relied upon for consistent results. When contact potential is an appreciable fraction of the total bias, receiver sensitivity may be expected to vary considerably from tube to tube.

Pentagrid converters are designed for operation over a range of oscillator-grid voltages. Oscillator voltage is conveniently determined by the product of the d-c grid current, the value of grid resistor, and the rectification efficiency, which is approximately 0.8 in most cases. Because rectification efficiency is substantially independent of the magnitude of the oscillator voltage, it is convenient to express the recommended range of oscillator voltage in terms of a range of d-c current (I_g) through a grid resistor of specified value. A typical curve of conversion transconductance *vs* oscillator-grid current is shown in Fig. 1. The curve is steep at low values of I_g; when operation takes place in this region, considerable variation between tubes may be expected. Oscillator circuits should be designed to generate more than the minimum value of I_g recommended for the tube type of interest.

Under improper operating conditions, receiver sensitivity may change widely with different second-detector tubes; these are usually of the diode-triode type. In some cases, it was found that sensitivity was measured at an output of 50 milliwatts. In a receiver with high audio gain, this

Related to Tube Performance

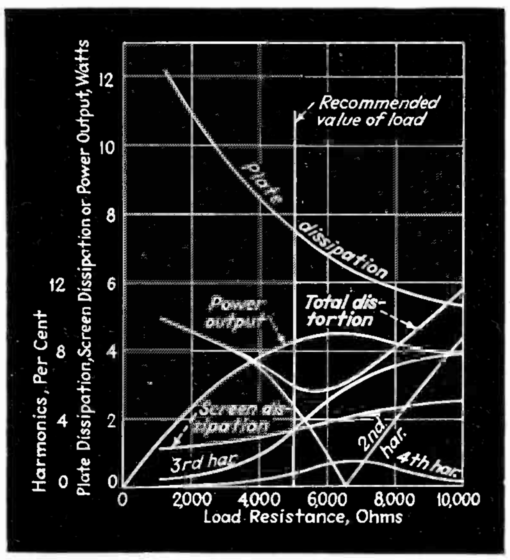


Fig. 4—Typical variations in power output, screen dissipation, and distortion for receiving tubes, with variations in load

Practical discussion of difficulties which have been encountered in receiving circuits, together with suggested changes in circuit design to give better performance characteristics from the tube and circuit

By L. C. HOLLANDS

RCA Mfg. Co.
Harrison, N. J.

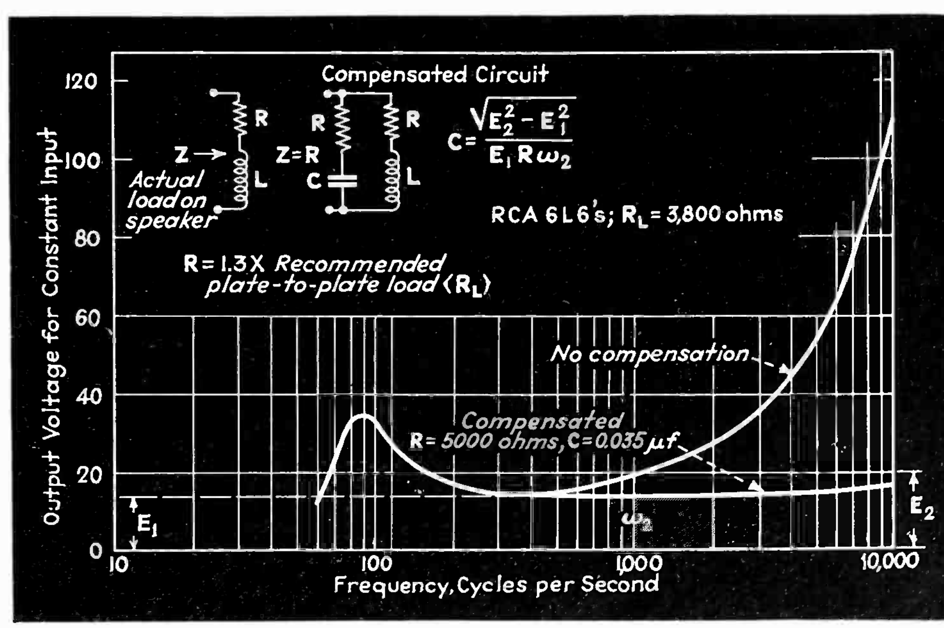


Fig. 5—Effect of compensation in the plate circuit of high impedance tubes in reducing the magnitude of transient voltages

output power is obtained with a relatively small signal on the diode—so small that no avc voltage is developed. In this case, contact potential on the diode is an appreciable part of the total voltage acting in this circuit, so that variations in sensitivity with different tubes of the same type are due to differences in contact potential. Changes in sensitivity with contact potential, in turn, are due to the action of the diode as a square-law detector at low outputs, as shown in Fig. 2. No circuit changes are advisable in this case, because it is merely necessary to measure sensitivity at 0.5 or 1 watt output where the signal voltage masks the contact potential.

Detector Troubles

In another case, a biased detector was used in a low-price t-r-f receiver in which sensitivity changed with different detector tubes. After some investigation, it was found that the detector was biased to nearly zero plate current. Because the operation of a tube at extremely low values of plate current is inherently critical, it is advisable to test some tube types at a value of plate current where good detection efficiency with good stability can be realized. In this case, the remedy was to reduce the value of cathode resistor until the plate current was 0.1 ma. It was then found that the sensitivity of the receiver at a reasonable output level was nearly the same before and after the change and that differences between tubes were small.

Power-Output Tubes

A whole series of troubles can arise in connection with the use of power-output tubes having high transconductance and high plate resistance, of which r-f oscillation, high distortion, low output are typical. The curves of Fig. 3 show typical dynamic characteristics of a pentode or beam tetrode for various values of load resistors. Figure 4 shows typical variations in power output, screen dissipation, and distortion with load. Because the screen of a tetrode or pentode is designed to dissipate a certain amount of heat, it is possible to overheat the screen when high values of load are used, as shown by the curves. Thus, attempts to secure maximum power at the expense of some distortion may result in poor tube life, because the screen dissipation may be excessive under these conditions.

High distortion is often traced to the use of an incorrect value of load or an incorrect value of bias. It is customary to adjust electrode voltages to recommended values with no signal applied and to "take what you get" at the grid-current point. This procedure may lead to high distortion and low power output. Practical power-supply units have some internal resistance, which causes a reduction in plate and screen voltages as power output increases, because of rectification in plate and screen circuits. With partial or full self-biased operation, bias increases with power output, and because plate and screen voltages decrease, the tube is overbiased at full output. High distortion is then observed. For proper operation, the ratio of screen voltage to bias at full output should equal the published ratio of screen voltage to bias. Plate voltage will be low, because the primary of the output transformer has d-c resistance, but the effect of this is small. Moreover, at full output, the load should have a value that corresponds to the screen and bias voltages existing at full output. When this procedure is followed, the design is correct for full output and you "take what you get" at low output. However, because distortion at low output is usually low, good overall performance is obtained. In any case, it is suggested that maximum voltages recommended by the manufacturer should not be exceeded at any output level.

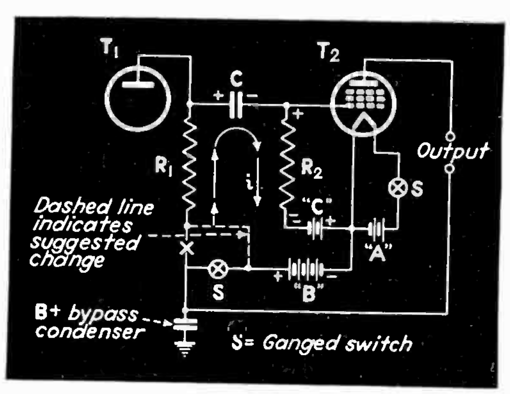


Fig. 7—Solid lines show original circuit in which blocking and high plate current resulted when switch at X was opened

Of course, when electrode voltages are reduced because of power-supply regulation, power output drops. Power output varies as the 5/2-power of the electrode voltages, so that a 20 per cent drop in electrode voltages corresponds to a 43 per cent loss in power. The efficiency of the output transformer should also be considered in power-output calculations. Measurements of the efficiency of a number of output transformers show that single-ended transformers have efficiencies ranging from 60 to 80 per cent and that push-pull transformers usually have efficiencies in excess of 70 per cent.

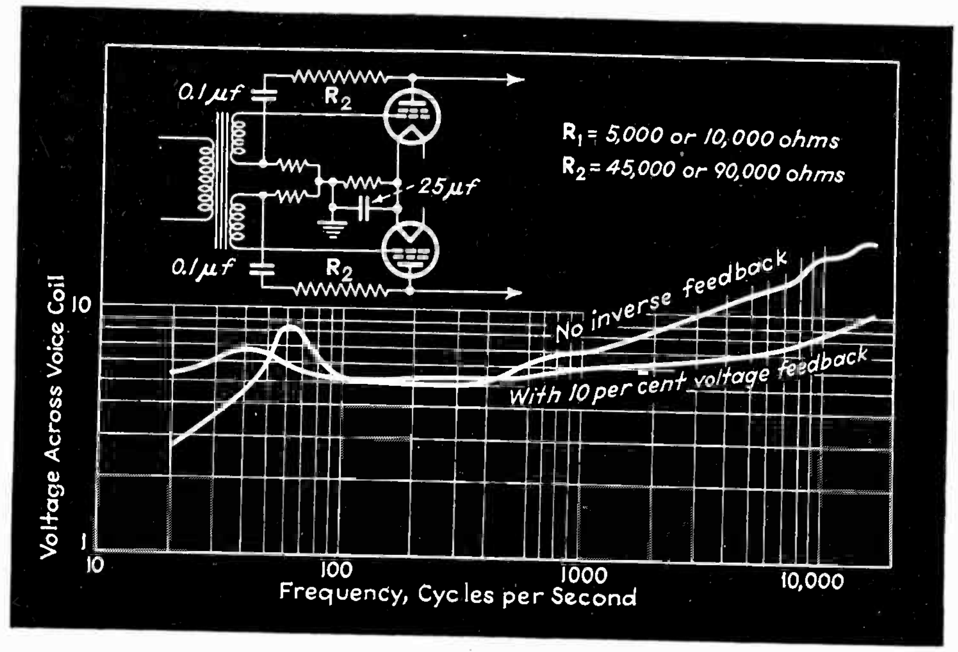


Fig. 6—The effect of a slight amount of inverse feed-back in improving the frequency response characteristics of an amplifier

Plate Compensation

The use of proper plate compensation is important from both tube and circuit standpoints. When a high-impedance pentode is used as an output tube, the voltage generated across the primary of the output transformer consists of transient and steady-state components. The transient component is generated because the speaker has inductive reactance, although shunt capacitance may contribute to the effects. It has been found that the transient voltage generated in the plate circuit may be sufficient to break down the insulation between plate and shell in the output tube. The use of proper plate compensation considerably reduces the magnitude of the transient voltage at frequencies greater than the resonant frequency of the speaker and gives a high-frequency characteristic that approximates a triode. The effect of proper plate compensation is shown by the typical curves of Fig. 5. Inverse feedback of the constant-voltage type also reduces transients, because the low plate impedance of the tube shunts the load; in addition inverse feedback reduces the peak at the resonant frequency of the speaker. The effect of inverse feedback on frequency response is shown by the curves of Fig. 6. Many problems involving poor tube life of output tubes were traced to the effects of transient voltages and were solved by using proper plate compensation or by the proper use of inverse feedback.

A case in point is the 6L6. This tube type has a comparatively high ratio of plate resistance to recommended load resistance and has a high transconductance. These characteristics, while very desirable fo optimum performance, are suitable for the generation of high transient voltages, especially under the 400-, 300-volt operating condition. Under these high-voltage conditions, therefore, proper plate compensation or inverse feedback should be used to prevent breakdown of tubes or circuit elements. It should be realized that high plate-circuit efficiency, high power sensitivity, and high power output can only be obtained with a high mutual-conductance, high plate-resistance tube and that more than average precautions should be taken in using such tubes.

Blocking in Filament Type Tubes

A peculiar case of blocking of the type 1F4 has been encountered. In this instance, the tube blocked and the plate current increased to a very high value when the ganged filament and B-supply switch was opened and closed rapidly. When the ganged switch (Fig. 7) is closed for some time, the temperature of the filament is normal and the circuit is in operating condition. When the switch is opened, the temperature of the filament decreases and condenser C discharges almost immediately. Now, when the switch is closed before the temperature of the filament reaches a very low value, the charging current from the B battery through circuit R_1, C, R_2 causes the grid of the tube to become positive by an amount equal to the voltage drop across R_2 and the temperature of the filament starts to increase. Thus, due to the heating lag of the filament, it is possible for the grid to be highly positive while the temperature of the filament is less than normal. The grid may emit secondary electrons under such conditions, because there is little space charge to limit the velocity of primary electrons. The secondary emission current flows in the same direction as the charging current (i) and the positive potential of the grid increases to a high value. The transconductance of the tube is low under these conditions.

Normal operation of the circuit can be restored by turning the receiver off long enough for the filament to cool to a low temperature and then turning it on again to restore operation.

This problem was solved by changing the circuit slightly, as shown by the dotted lines in Fig. 7. The $B+$ lead to R_1 is broken at X and R_1 is connected directly to B +. With this connection, no surge current flows when the switch is closed.

Power Sensitivity of A-F Amplifier in Radio Receivers

Experience indicates that microphonic or hum problems may become serious when the gain of the a-f section of a radio receiver is high. Measurements on a number of receivers of average design indicate that a good value of maximum a-f power sensitivity for battery receivers is 50 mhos and for a-c operated receivers, 200 mhos. Power sensitivity in mhos is defined as the ratio of the power output in watts to the square of the input signal in volts (rms). Values of power sensitivity in excess of these figures may be used when better than average precautions are taken to reduce hum and microphonics.

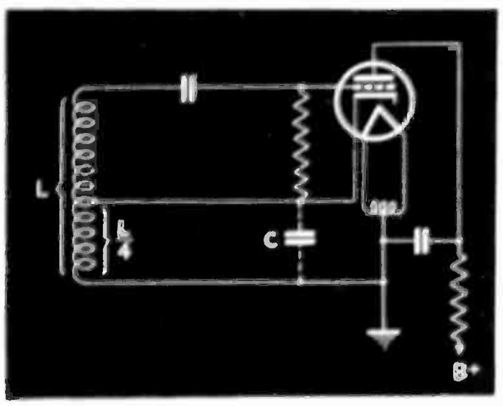


Fig. 8—Hartley circuit in which microphonics were troublesome at 18 mc.

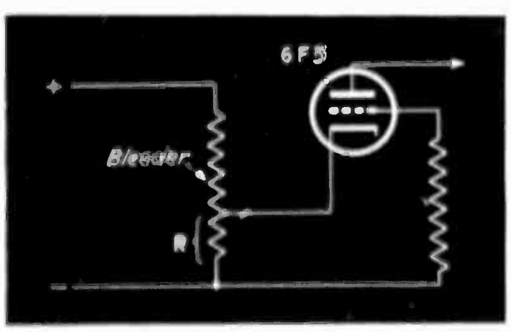


Fig. 9—Input circuit to a high gain amplifier in which excessive hum occurred

R-F Microphonics

A peculiar case of microphonics at 18 Mc has been investigated. The oscillator in this receiver was a Hartley (Fig. 8) in which the cathode was tapped part way up the coil. Because the heater was grounded, a small capacitance, representing the heater-cathode capacitance of the tube, is connected across the section $L/4$ of the total tank-circuit inductance L. Any change in the value of this capacitance changes the tuning of the oscillator and, hence, frequency-modulates the intermediate frequency. The effects of such cyclic variations in this capacitance, which are induced, for example, by the proximity of the speaker, are heard as microphonics.

A Solution to the Microphone Problem Involves Cushion Sockets

A change in capacitance ΔC across $L/4$ changes the frequency by the same amount as a change in capacitance $\Delta C' = \Delta C/4$ connected across L. Even though the change in C is small, it may not be negligible at the high-frequency end of the high-frequency band, where the total circuit capacitance is small. When this circuit is used, therefore, consideration should be given to the use of a cushion socket to minimize vibration, which is the cause of heater-cathode capacitance variation.

Hum in Fixed-Bias Amplifier

An interesting case of high hum in an audio amplifier employing a 6F5 was encountered. This is a high-gain tube and its bias was obtained from a tap on the bleeder, as shown in Fig. 9. Because the resistance R between cathode and ground was low—about 200 ohms—it was thought at first that hum voltage developed across R because of heater-cathode leakage was not sufficient to account for the observed hum output. However, the gain of the amplifier was high, and the product of the measured hum across R and the gain did account for the hum. It was necessary, therefore, to reduce R to approximately 80 ohms by increasing the bleeder current before a satisfactory hum level was obtained.

Noise Output

Several cases of crackling noise output have been noted. In each of these cases, the antenna lead or antenna coil was placed close to either the glass rectifier or glass output tube. It was found that high frequencies present in the output were coupled back to the antenna through capacity coupling between the rectifier or output tube and antenna, causing oscillation. In each case the remedy was to shield the output or rectifier tube from the antenna lead or antenna coil to reduce the capacity coupling. Of course, the use of metal tubes obviates the necessity for special shielding.

In another instance where noise output was reported, it was found that capacity coupling between antenna circuit and the lead connecting the filter condenser and rectifier tube was the cause of the noise. The remedy in this case was to move the condenser close to the rectifier tube.

The examples reported here are merely representative of the type of problem that has been attributed to an undesirable tube characteristic, but which was subsequently solved by a comparatively minor adjustment of the circuit.

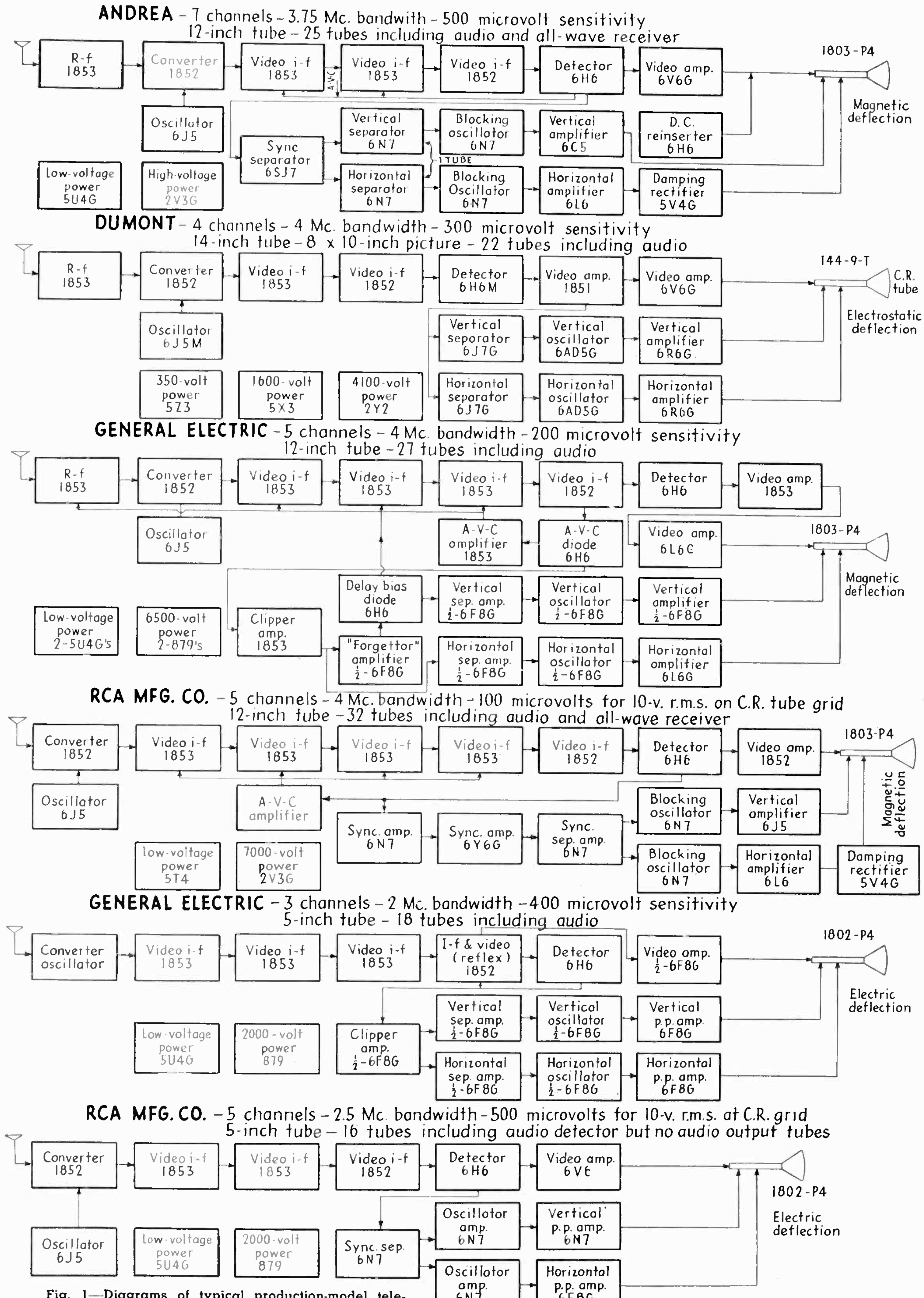


Fig. 1—Diagrams of typical production-model television receivers (video sections only)

TELEVISION RECEIVERS in PRODUCTION

On May first, television receivers will be offered for sale in New York City by six manufacturers who have announced plans to date. Herewith are the details of typical receiver designs: tube complements, components, circuits and cabinets

When it was announced, last October, that a public television service would be inaugurated in New York City coincident with the opening of the Worlds Fair on April 30th, several manufacturers immediately laid plans to satisfy the demand for television receivers which is expected to appear immediately after that date. At the time of publication, six manufacturers have definitely announced, either to the public or to their distributors, that they would manufacture television receivers for release May first. The six are: American Television Corporation, New York; Andrea Radio Corporation, New York; Allen B DuMont Laboratories, Passaic N J; General Electric Company, Bridgeport, Conn; Philco Radio and Television Corporation, Philadelphia; and the RCA Manufacturing Company, Camden. While other manufacturers are known to be definitely interested in television receiver production, no other announcements have been made to date.

During the past month the editors have made a canvass of the above manufacturers, and in all cases except one have obtained advance information on the models to be offered to the public. The following paragraphs give this information essentially as presented by each manufacturer.

DuMont Laboratories

The Allen B DuMont Laboratories of Passaic, N. J., have one chassis in development and one in actual production. The first will contain a 9-inch cathode-ray tube of the "intensifier" variety, and will be offered in a receiver to sell in the price range from $200 to $250. The production model, on which more complete details are available, is a chassis containing a 14-inch electrostatically-deflected picture tube. The same chassis will be offered in two models, a table model at $395 and a console at $445. A console model containing a separate all-wave receiver is also available.

The 14-inch tube chassis, model 180, has 22 tubes exclusive of the all-wave receiver but including audio and picture tubes. The picture is 8 by 10 inches, black and white. Six knobs are brought out to the front panel: contrast and on-off, four channel selector switch, vernier tuning, intensity, focus, and volume. The tube complement and circuit arrangment are shown in the block diagram, Fig. 1. This receiver is remarkable in that it is the only American receiver announced to date which uses electrostatic deflection with a picture tube larger than 5 inches in diameter. The sets are at present aligned according to the RMA Standards, but have been modified experimentally to receive the DuMont system of scanning-wave transmission. A typical side-by-side comparison of the two systems is shown in Fig. 2. Seven auxiliary controls are brought out at the back of the chassis, for vertical frequency, vertical gain, vertical positioning, astigmatic positioning, horizontal position, horizontal gain and horizontal frequency. The sensitivity, with a 4 Mc bandwidth, is such that the picture is fully modulated, with maximum gain, with an input signal of 300 microvolts.

Andrea Radio Corporation

The Andrea Radio Corporation has two chasses in prospect: A table model with a 5-inch electrostatically-

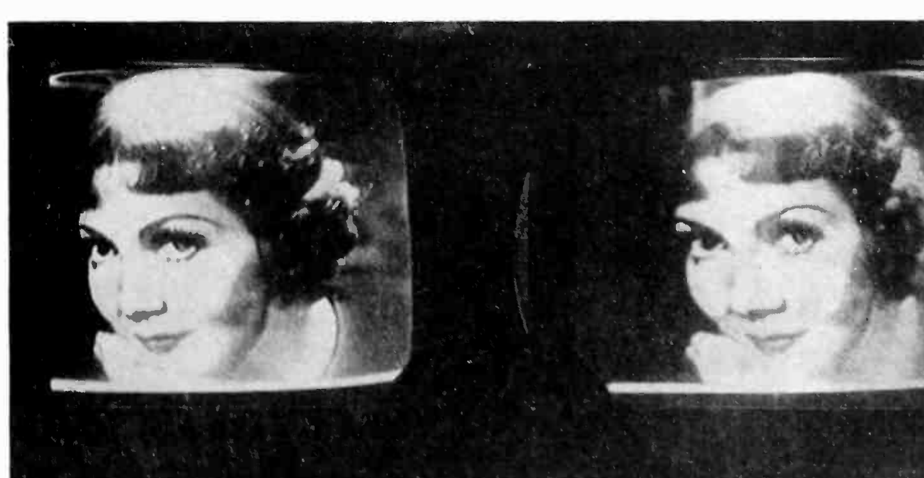


Fig. 2—Comparison of RMA (left) and DuMont television systems, Images photographed simultaneously under normal reception conditions from W2XVT transmissions

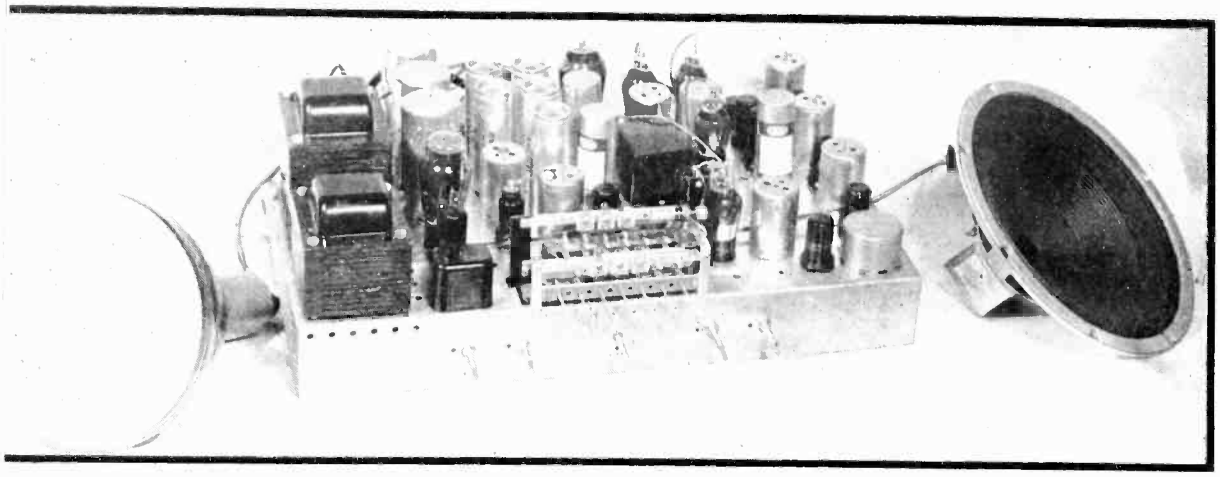


Fig. 3—Chassis of the 9-inch set manufactured by the General Electric Company, which employs a "short" tube of the magnetically-focussed variety

deflected picture tube, tuning two channels only, containing complete audio as well as video equipment, for a price of $189.50. This chassis will be sold in kit form, without tubes, for $79.95. The other chassis, intended for a console model, uses a 12-inch magnetic deflection tube, tunes seven channels (ranging from 44–50 Mc to 102–108 Mc). The image is viewed in a mirror on the lid of the console cabinet. Complete sight, sound, broadcast and all-wave facilities are provided in the set, using a total of only 25 tubes. The price is $325. A similar model in a larger cabinet and containing an automatic phonograph is to sell for $595.

The tube line-up of the 12-inch picture-tube chassis is shown at the top of Fig. 1. The arrangement is fairly typical of the designs for this size tube. An rf and three if stages are used, with but one video stage. Full peak-to-peak modulation of the cathode ray tube is obtained with a 500 microvolt signal over a 3.75 Mc bandwidth. One unusual feature is the fact that the video gain (contrast) control follows the second detector. The dc component is reinserted at the kinescope grid by a 6H6 diode as shown in Fig 1.

The cathode ray tube is an RCA Type 1803-P4 tube with a black-and-white phosphor. The second-anode voltage is 7000, provided by a tungsten filament half-wave rectifier (type 2V3G). Automatic volume control is used on the rf tube and the first two if stages. The sync separation, scanning and deflecting circuits are similar but not identical to those in the RCA deflection chassis described below.

American Television Corporation

The American Television Corporation, New York, offers three chasses, all with small cathode-ray tubes. A console model with a five-inch tube, containing 16 tubes including the picture tube and a three-band all wave receiver, sells for $285 and $315 depending on the cabinet style. Two table models are also in prospect. One with a three-inch picture tube, including sound facilities will sell for $125, the lowest price yet announced. A similar five-inch tube chassis employing the new "short" 5 inch tube, is to sell for $150. The picture-circuit portion of the 3-inch table model employs two rf stages (type 1852), an 1852 detector, and two video stages (types 1852 and 6V6). The sync separation takes place in a 6H6 diode the output of which controls the sweep circuits. A gas-filled tube is used for the vertical (60 cps) sweep, while three tubes (885, 77, 6V6) develop the horizontal sweep (13,230 cps). Power is supplied from

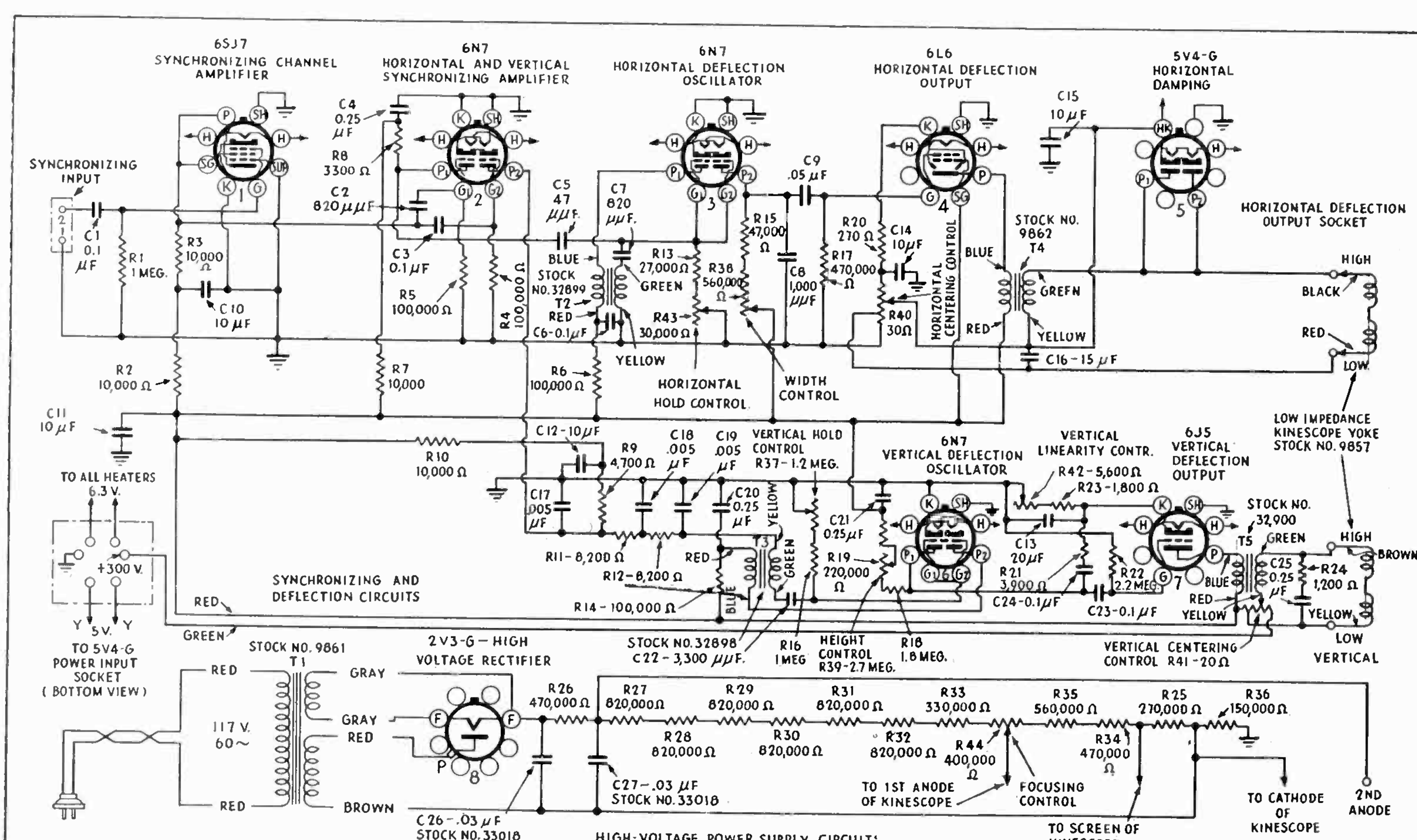


Fig. 4—Circuit diagram of RCA deflection chassis, available to licensee manufacturers

a type 80 for low voltage and a type 80 for high voltage.

A larger receiver made by American Television Corp, employing a five-inch tube, has four tuned rf stages, each 1852's, a 6F8G and a 76 for sync separation, and an 879 for high voltage power, but is otherwise similar to the smaller set. A separate viewing attachment of "Kinet" contains the cathode-ray tube, and power supply as well as the vertical scanning equipment. The horizontal scanning voltage and the video signals are fed to the Kinet by cable, from the receiver proper.

General Electric Company

Three chasses developed by the General Electric Company illustrate the tendency to design a 5-inch tube chassis to the lowest possible cost, a 9-inch chassis to a medium cost, and a 12-inch chassis to a standard of engineering considerations only. The tube complements of two of the chasses are illustrated in Fig. 1, while the third is shown photographically in Fig. 3.

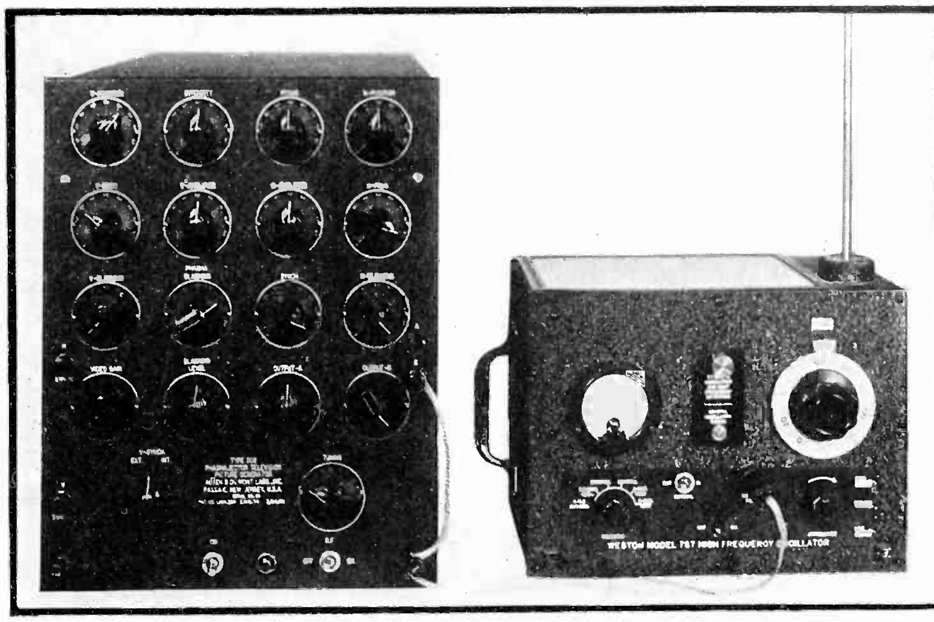
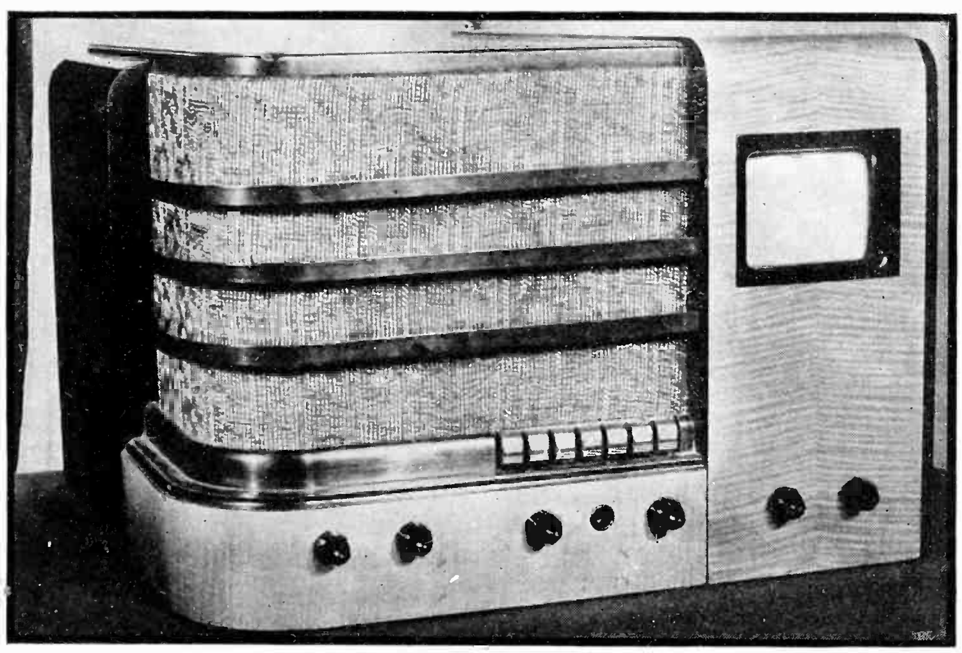


Fig. 5—Below, G. E. five-inch receiver, a table model which displays 400 microvolt sensitivity

Fig. 6—Above, DuMont signal generator and Weston u-h-f oscillator for test purposes



The five-inch chassis omits the rf stage and uses a single-tube converter. The bandwidth of the if amplifier is purposely limited to 2 Mc, which corresponds to a definition of 200 lines, the practical limit imposed by the size of the spot relative to the picture size, on a five-inch picture tube. Since the bandwidth is narrow, only four if stages are necessary to obtain sufficient gain to modulate the picture tube fully with an input signal of 400 microvolts. Two video stages are used after the detector, but one of these is reflexed through the last if tube. Manual gain control is applied to the grids of the converter and the three if stages. The entire receiver, including picture tube and all audio circuits contains only 18 tubes. The picture tube is an RCA type 1802-P4, black and white screen, electric deflection. The high voltage (second anode) is 2000 volts, the maximum rating of the picture tube. Virtually all sync separation, scanning generation and deflection functions are carried out in 6F8G tubes (double triode with a separate cathode in each section). One such section serves as the final video amplifier, another as a "clipper" (amplifier which removes the sync pulses from the detector output but does not pass the picture signals, which would otherwise interfere with the synchronization). The vertical and horizontal sync signals are separated, applied to sawtooth oscillators and thence by push-pull deflection amplifiers to the deflection plates of the picture tube. The audio system consists of two 6SK7 if amplifiers which connect to the converter output, a 6Q7G detector, avc and audio, and a 6K6 output tube. Avc is applied to the two 6SK7's.

The nine-inch G E chassis, shown in Fig. 3, has the following specifications: single-tube converter, 3–1853 video if stages (3 Mc bandwidth), one 1852 video if stage, 6H6 video detector, 1853 first video stage, 6F6

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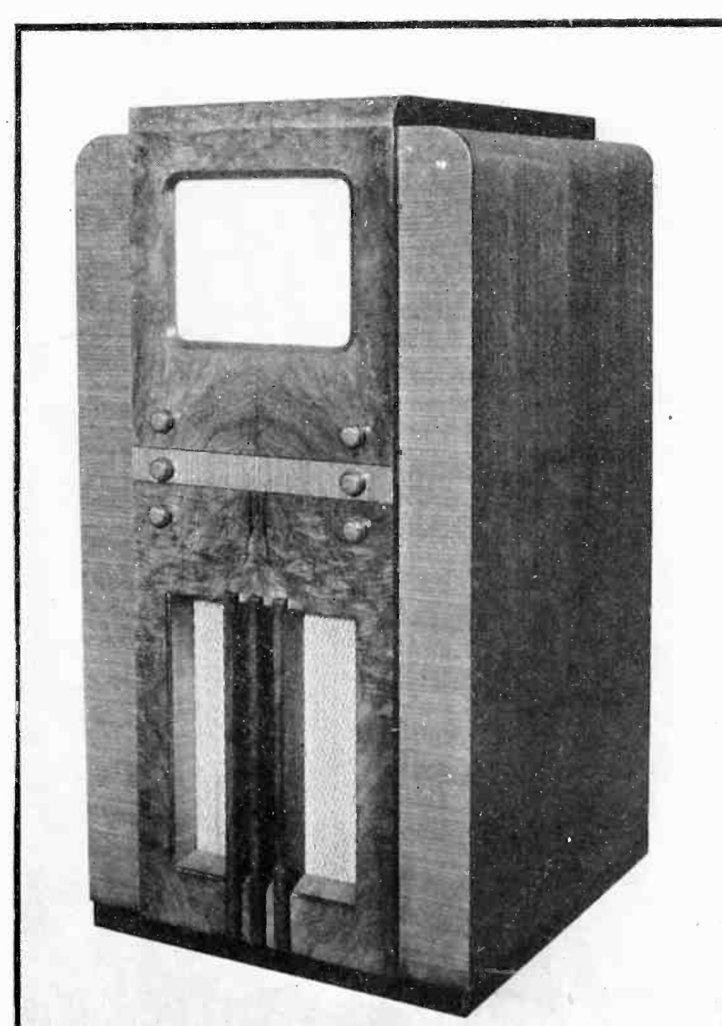


Fig. 7—Modern design in the DuMont console model, for 8x10-inch pictures

TELEVISION

Technical features of equipment being installed preparatory to the opening of public television service. Transmission standards, tube line-ups, modulation methods, antennas, coaxial filters—a host of new problems and techniques for solving them

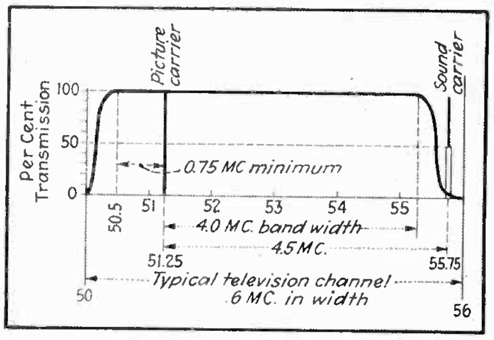


Fig. 1—Sideband arrangement according to RMA Standard T-115, which permits the use of 4-Mc modulation

THE transmitter division of video engineering occupies the attention of a small group of men, compared with those engaged in developing television receivers, but these men make up in energy what they lack in numbers. They have plenty to do, and in several important cases very little time in which to do it. The opening of public television service in New York is scheduled for April 30th and this means that a high-powered transmitter must be on the air and ready to go on regular schedule the night of April the 29th. The last transmission standard, the much-discussed RMA Standard T-115 regarding the manner of eliminating one of the sidebands, was definitely decided upon in Committee only on the 19th of January. The intervening four months have been, and continue to be, a period of hectic activity for all concerned. One engineer has compared the problem of developing a high powered (say ten kw) single-sideband transmitter at the present time to the development of a 500 kw broadcast transmitter in 1921, when broadcasting began and the word superpower had not been coined.

The background of the television transmitter picture can best be outlined in terms of the list of licensees who have transmitters installed or under construction. The list is a long one, but only a few stations have announced their intention of supplying a public service in the near future. They are the CBS and NBC transmitters in New York, the Don Lee transmitter in Los Angeles, and the General Electric installation at Albany. The plans of the others are either in the formative stage or definitely experimental in character. All of these installations intend following the RMA proposed standards of transmission, except Allen DuMont's station at Passaic, N. J., which is now actively engaged in comparing the RMA standards with the scanning-wave-transmission method (See Fig 2 page 23).

Since the RMA standards are the basis of so much work, it is worthwhile to review them and to explain the latest (single sideband) standard in detail. The standards set up a channel 6 Mc in width, which contains both audio and video carriers. These channels are situated, according to the present FCC allocation, at 44–50 Mc, 50–56 Mc, 66–72 Mc, 78–84 Mc, 84–90 Mc, 96–102 Mc, and 102–108 Mc, together with 12 other channels on higher frequencies, which are not deemed useful at present except for relaying purposes. Since transmitter efficiency and receiver gain both go down as the frequency rises, the 7 channels are listed above in order of desirability. Present plans of receiver manufacturers include only the first five channels (up to 90 Mc), and no transmitter at present (except relay and developmental installations) plans to operate on any higher frequency. The FCC licenses now issued authorize transmissions on any 6 Mc channel within the limits 42–56 Mc and 60–86 Mc, and above 110 Mc.

The locations of the audio and video channels within each channel are shown in Fig 1, which is in accordance with the RMA Standard T-115. The two carriers are separated 4.5 Mc. The high frequency video sideband is transmitted completely and the low frequency sideband is transmitted "vestigially", that is, the frequencies within 0.75 Mc of the video carrier are not attenuated. Frequencies further from the carrier are attenuated as rapidly as possible, and at the edge of the channel (1.25 Mc lower than the carrier), the side band is completely removed. Under this arrangement, the output is mod-

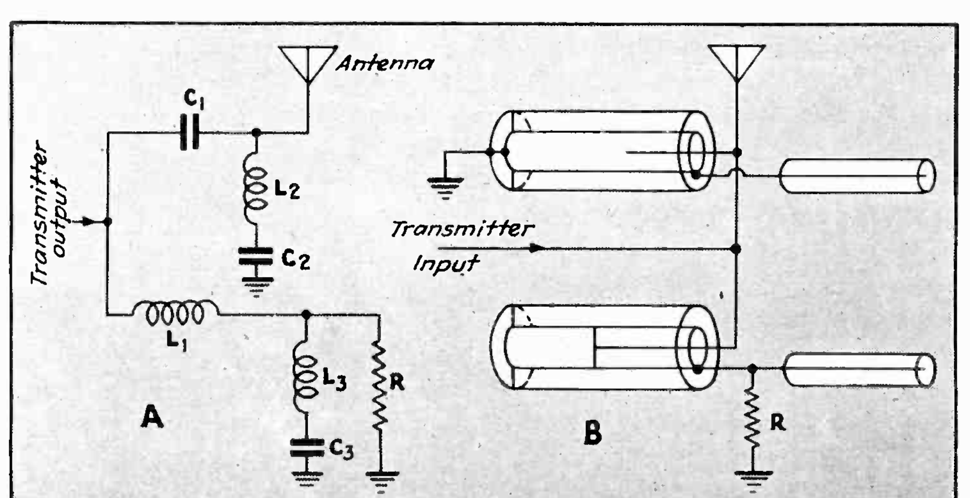


Fig. 2—Coaxial filter structure developed by RCA engineers, which absorbs portions of the undesired sideband and cuts off at the channel edges

TRANSMITTERS

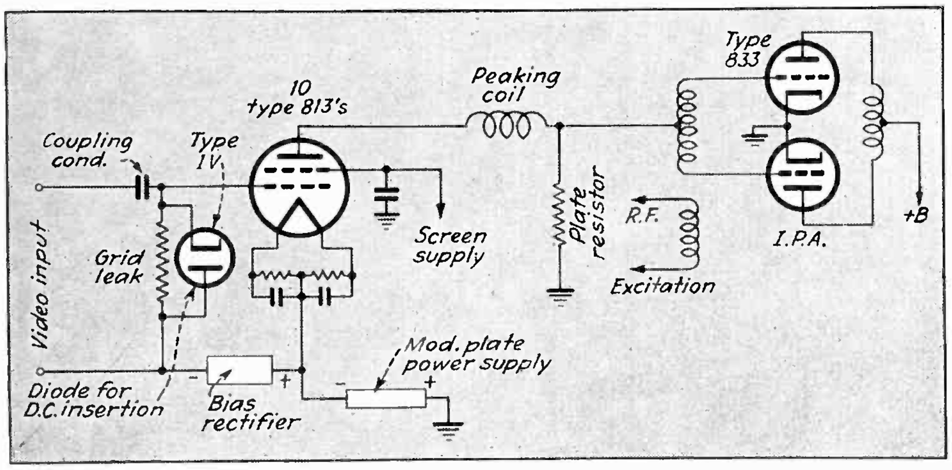


Fig. 3—Modulation stages of the RCA 1000-watt transmitter, showing d-c reinsertion system

Fig. 4—Position of signal at base of modulator characteristic

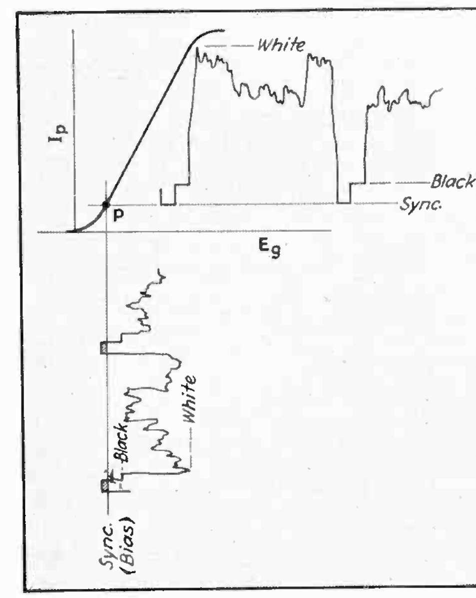
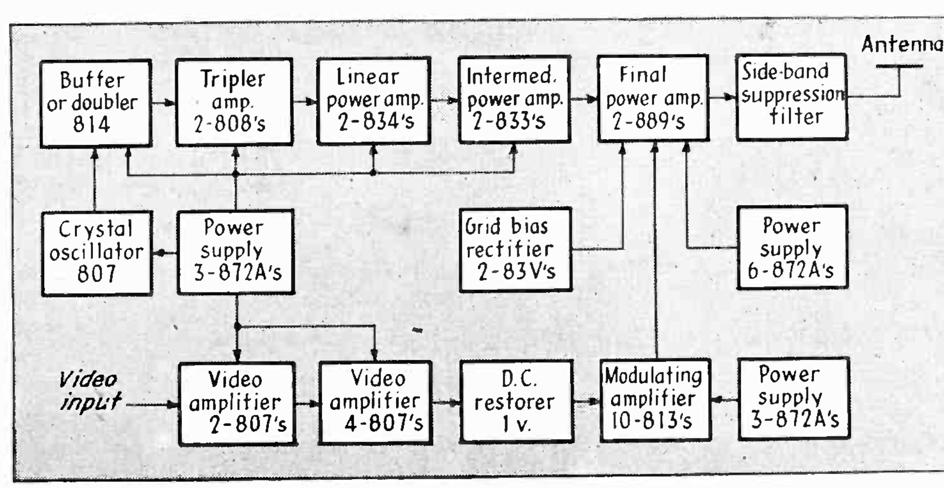


Fig. 5—Diagram of RCA transmitter for one kilowatt service, described in the text



ulated only 50 per cent (in the conventional sense) and the amplifiers which follow the sideband filter are required to pass the full bandwidth (actually about 5.5 Mc) indicated in the figure.

At the receiver, the band-pass curve of the if system is so adjusted that the video carrier falls on the upper edge of the pass region, at 50 per cent voltage response level. This restores substantially 100 per cent modulation before final detection. The band-pass of the if system need be only 4 Mc wide (as against 5.5 Mc in the transmitter) to accept fully the unattenuated sideband. It would appear therefore that the burden of design has been put on the transmitter engineers, and this seems justified from the economic point of view.

On the other hand, a lively argument existed prior to January 19th in the question of whether the transmitter carrier should be attenuated to 50 per cent, and the receiver carrier unattenuated. This would allow 100 per cent modulation at the transmitter, and would obviate the video-carrier alignment problem at the receiver, although the receiver if bandwidth would be wider in this case. The argument finally went in favor of the system first described (Fig 1), and the standard was voted. There is still an active difference of opinion on the subject. All agree that the system now standardized will work but not all agree that it is the best engineering solution.

The problem of removing the sideband, whatever system is adopted, is a major one in the transmitter design. Two approaches to the problem are available. In the first, both sidebands are generated in the final stage, and the side band removed by a filter structure in the antenna transmission line. This is the method now employed at the NBC transmitter and to be employed in the CBS transmitter, both in New York. It involves wasting power generated in the final stage at the frequencies removed by the filter, but fortunately only a small portion of the total generated power resides in this region. A typical sideband filter structure is shown in Fig 2. It consists of coaxial-line segments so arranged to produce the filter array represented by the lumped constants in Fig 2-A. The inductor L_1 tends to pass the lower frequencies (which are to be attenuated, see Fig 1) to the resistor R, while the capacitor C_1 passes the higher frequencies (present in the desired sideband) to the antenna. Before the resistor another combination L_3C_3 tends to prevent attenuation in the resistor R at frequencies which should not be attenuated. The combination L_2C_2 gives appropriate and necessary reactances at other parts of the system. An additional "notching" filter is necessary to introduce further attenuation at the low frequency edge of the channel, to avoid interference with the sound carrier of the adjacent channel.

The coaxial elements in Fig 2-B replace the lumped elements as shown. A coaxial line whose length is a multiple of a quarter wavelength and terminated in a short-circuit is an excellent "insulator" of rf energy. Hence two of these structures are em-

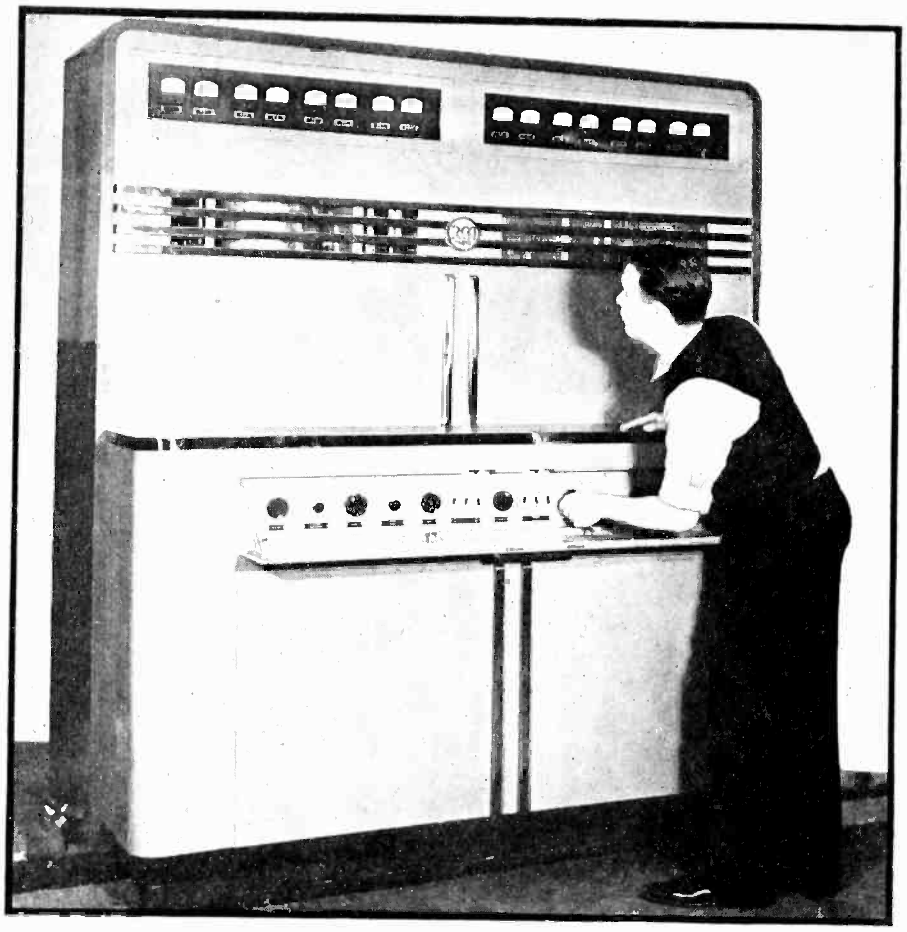
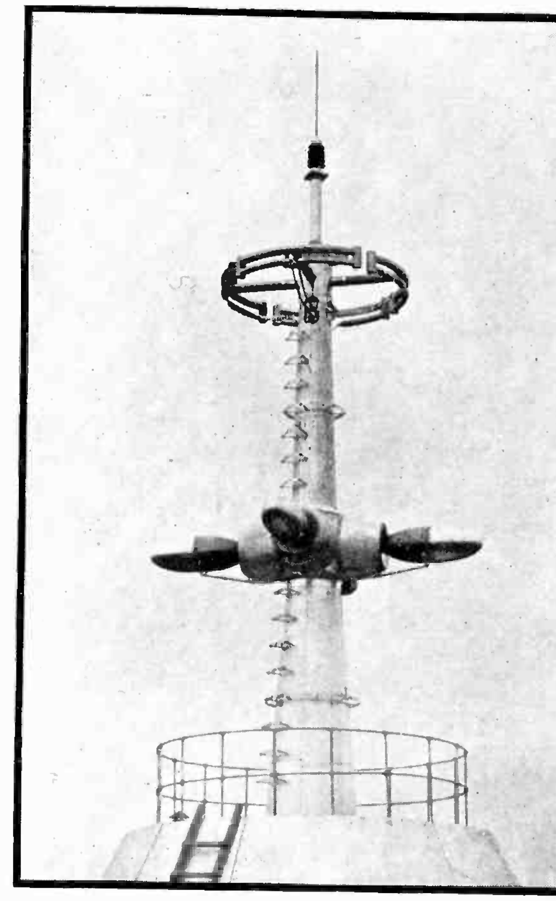


Fig. 6—The basic price of the RCA 1000-watt transmitter, above, less all accessories is $20,000

Fig. 7—Below, the wide-band television antenna on the Empire State Building



ployed as supports for other coaxial segments mounted within them. The internal segments are made less than a quarter-wave long to give a capacitive effect, longer than a quarter wave for inductive effect, and can be resonated to absorb energy, as in the case of the line terminated by the resistor R. The filter structures so constructed are cumbersome affairs at best, but they have high efficiency (except for the power consumed in the resistor) and may be designed to offer almost any desired filter characteristic.

The other, alternative, method of removing the sideband is to insert the filter structure after a low-level modulated stage (possibly using lumped constants for the purpose) and then to amplify the desired sideband and the remnant of the undesired one in a series of linear amplifiers until the desired power level is reached. This is the method to be employed in the transmitter now in construction near Albany by General Electric. It involves no waste of power from the high level stages, but it requires very perfect linearity in the stages themselves. Otherwise the removed sideband will be reinserted as a modulation product.

The Modulation Problem

It is universal practice to employ grid-circuit modulation in television transmitters, since to obtain sufficient video voltage and power for plate-circuit modulation costs much more than the improvement warrants. A fairly linear modulation curve from grid voltage to rf output can usually be obtained, but linearity is perhaps the least problem of all in modulation, since non-linearity can be corrected in the preceding video amplifier stages. The principal problem is that of obtaining high values of video voltage for modulation purposes. With existing high-power modulating amplifier tubes of the water-cooled variety, the tube capacitances are so high that flat response over a 4 Mc bandwidth can be obtained only with very low values of plate load impedance, actually below 1000 ohms in typical cases. With such low load impedance, the output voltage is necessarily low (for example, the signal may be only 1000 peak-to-peak, with 5000 volts dc applied to the plates of the tubes). With such low video output voltage, the carrier power of the modulated amplifier must be reduced until full modulation is obtained. For this reason it is extremely difficult to obtain high power in wide-band television transmitters. New tubes now in development show promise of improving the situation, however. When the modulation occurs at low level the above difficulty is not so serious since the modulating amplifier tubes then have smaller internal capacitances. In this case the rf amplifiers following the modulated stage must be extremely linear, and very little experience has yet been accumulated on this mode of operation. The highest power now contemplated is 10 kw carrier and 40 kw peak, for the low-level type of modulation. Carrier powers of 7.5 kw and less are the best obtainable with high-level modulation, at present.

One interesting aspect of modulation in television transmitters is the necessity of maintaining a "dc" reference level in the rf carrier envelope. It is convenient to visualise the operation of the transmitter as if it were a telegraph transmitter operating normally at peak power output, with maximum carrier level. The composite video signal (containing both picture and sync impulses) operates to reduce the carrier below maximum level, in effect "chopping holes" in the carrier envelope. Since negative transmission is standard in this country, the maximum (peak) carrier amplitude corresponds to the tips of the sync pulses. This level must be fixed by the bias value applied to the modulated amplifier tubes.

Another reference level which must be maintained in the modulation envelope is the "black level", which is standardized at from 75 to 80 per cent of the peak carrier level. The sync pulses are extended higher than this level, and the picture signals are below it. If the black level is fixed, the average level of the picture signal, relative to the black level, corresponds to the average brightness of the scene transmitted. Consequently to transmit average brightness it is necessary to establish the black level independent of changes in the average level of the picture signal. This function is accomplished (in an RCA transmitter, referred to below) by the method shown in Fig. 3. The video signal is fed to the modulator and to a diode rectifier and load resistor. The diode rectifies the video signal, and the average dc component of voltage across the load resistor remains constant and corresponds to the peak of the video signal. This dc voltage is a part of the bias of the modulator stage, and the polarity is such that the black level falls near the lower bend of the i_p-e_g characteristic of the tubes used in that stage. The sync signals then extend further in the negative direction, as required, while the picture signals extend into the upper portion of the operating characteristic curve. Maximum modulating current flows for correspondingly maximum points of brightness in the scanned line. This arrangement not only establishes the black level ("reinserts the dc component") but also makes the best possible use of the i_p-e_g characteristic of the modulator tube.

It will be noted that the modulator tubes are direct-coupled to the modulated rf amplifier stage. This insures that the dc levels established in the grid circuit of the modulator tubes shall produce corresponding levels in the rf carrier envelope. In the RCA transmitter arrangement shown in Fig 3, the direct coupled arrangement is obtained by operating the plates of the modulator tubes at PA bias potential, and the cathode at a high negative potential. The bias control of the modulator tube is thus directly effective in controlling the peak rf carrier level.

Tube Line-ups of Typical Transmitters

The tubes employed in transmitters are indicative of current engineering practice. A typical low-powered transmitter is the 50-watt unit manufactured by Fred M. Link, for the Allen B. DuMont Laboratories. It employs a 6L6 crystal oscillator, a 6L6 buffer stage, followed by an 807 buffer stage, a 35T intermediate power amplifier and two 100TH tubes in push-pull for the final power amplifier. The video amplifier consists of a 6L6 stage, an 807 stage, and two 100TL tubes in parallel which grid modulate the 100TH tubes. In contrast, the high power transmitter of the NBC at the Empire State Building, New York, has

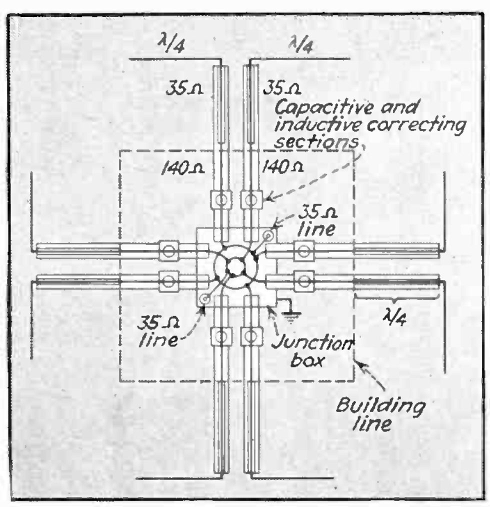
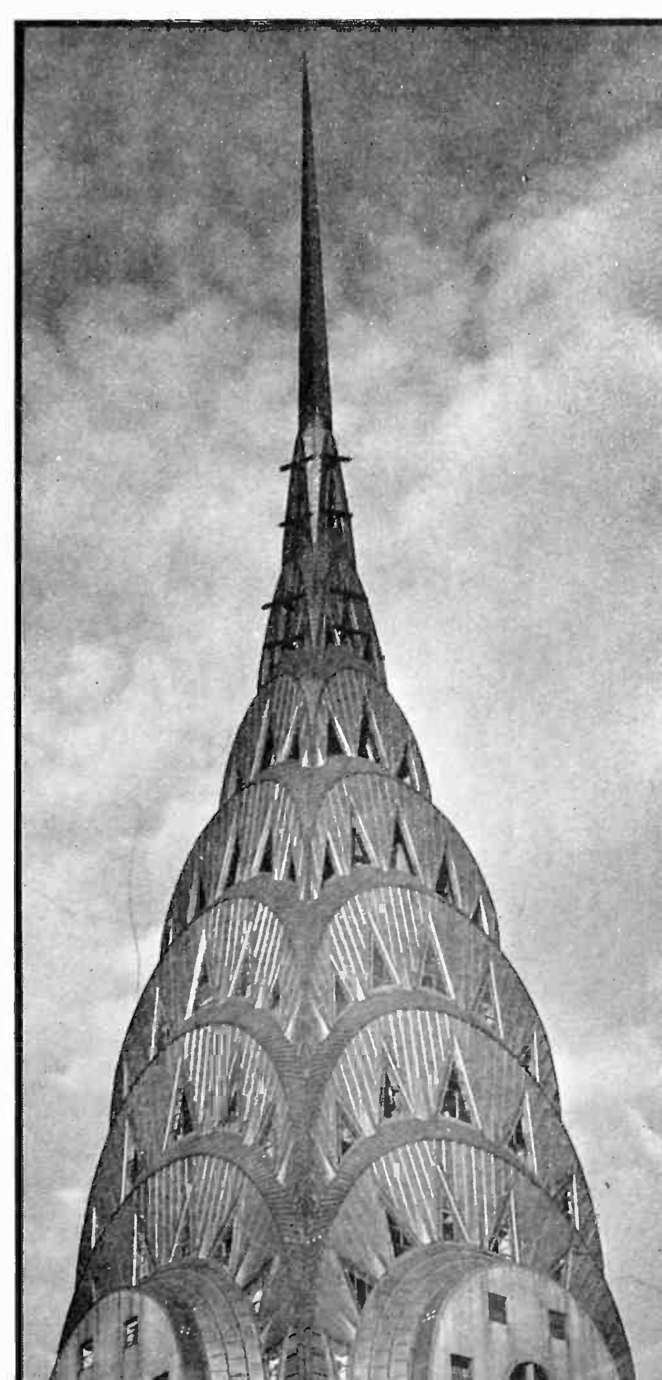


Fig. 8—Above, layout of one set of crossed dipoles in CBS antenna

Fig. 9—Below, appearance of CBS structure on Chrysler Building, as it will appear when completed



the following lineup: 6A6 oscillator-doubler (5.65625 Mc); 802 second doubler; 802 third doubler; 809 fourth doubler; 2-809's rf amplifier (45.25 Mc); 2-834's amplifier; 2-833's rf amplifier; 2-846's intermediate power amplifier; and 2-899's final power amplifier. The modulator chain is: 2-807's video amplifier; 3-807's video amplifier; 3-831's video amplifier; 848 video amplifier; 2-848's modulating video amplifier. Thirty-five rectifier tubes, large and small, are used for the various power supplies.

More detailed specifications are shown in Fig 5 of a transmitter offered for sale by RCA and of which the modulator has already been described. The tube line-up shown is self-explanatory. An interesting feature is the use of *ten* type 813 tubes in parallel (somewhat reminiscent of the early days in Arlington) for the video output amplifier which modulates the final stage. This transmitter has a nominal peak power output of 4 kw, or one kw carrier. Its physical appearance is shown in Fig. 6. The power rating applies to any video carrier frequency lower than 90 Mc, but the transmitter can be adjusted to higher frequencies. A video voltage of 2 volts peak-to-peak across a 72 ohm impedance is required at the input to the first video amplifier stage (2-807's) in the modulating chain. The figure-of-merit (equal to the sum of the products of vertical and horizontal resolutions in each of twelve test squares) shall be at least 555,000, and in practice is considerably superior to this.

Antennas: High, Wide and Handsome

The transmitting antenna of a television station may very easily be

(*Continued on page 47*)

New Coaxial Transmission Line

BY WILLIAM S DUTTERA
Radio Facilities Section
National Broadcasting Co. Inc.

IN December, 1938, a coaxial transmission line having many new features was installed at WTAM in Cleveland, Ohio. This transmission line carries the licensed carrier power of 50,000 watts from the transmitter to the antenna. Those features of the line which are new will be described in this article.

Much has been written on the subject of coaxial transmission lines from both an electrical and mechanical standpoint. Coaxial lines have been used quite frequently in the past by UBC and many others. Almost all engineers have felt that certain mechanical and electrical improvements were sorely needed. It was generally felt that the ideal transmission line should approximately meet the following specifications:

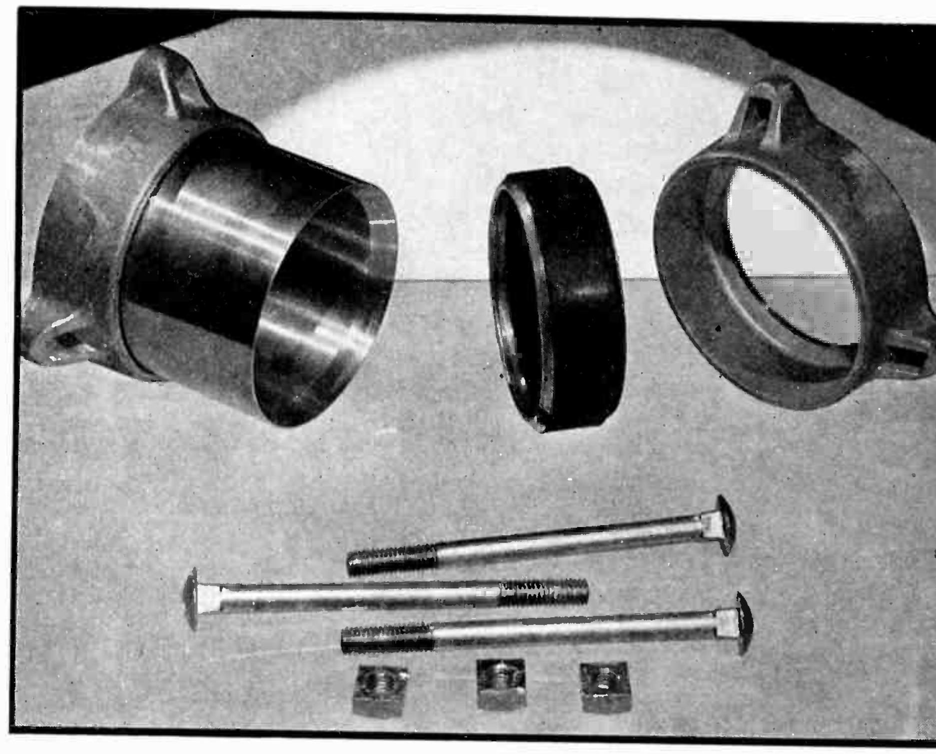


Fig. 1—Compression rings, sleeve, bolts—essential elements of the new aluminum co-axial transmission line at WTAM

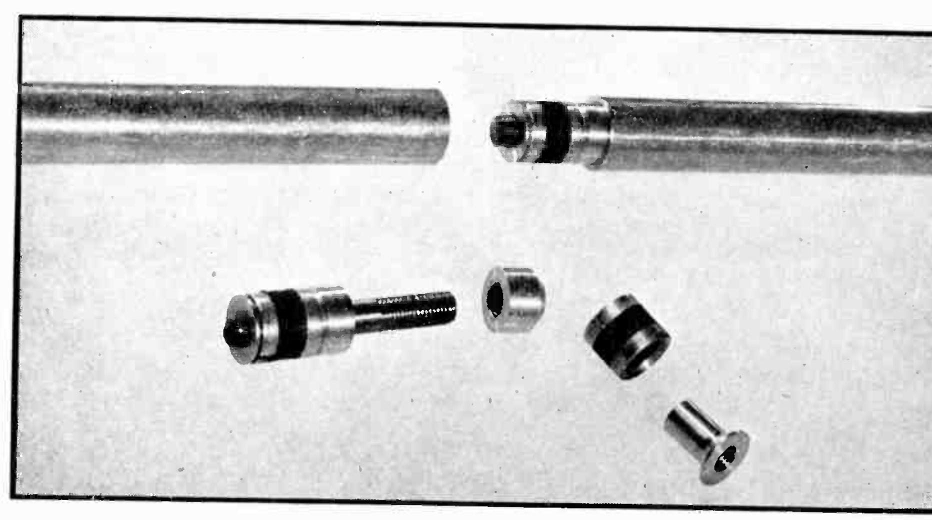


Fig. 2—Inner couplings used to connect individual lengths of the inner conductor into one continuous path for rf current

(1) Improved Dependability

The line should be so constructed as to be reasonably dependable under all conditions and if failure should occur the component parts should be readily accessible for repair or replacement.

(2) Low Loss

The power loss attributable to either the conductors or the insulators should be a small percentage of the transmitted power.

(3) High Flashover Voltage

The flashover voltage should be as high as possible and should approach the flashover value of the conductors alone. In other words, the flashover voltage should not be unduly limited by the insulators or atmospheric conditions and the flashover voltage should not decrease with recurring flashovers.

(4) Lower Cost

Of course, the cost must bear a reasonable relationship to the improvement and should preferably do better than that or perhaps even show a lower cost than past designs.

The transmission line to be described very nearly meets those specifications as will be apparent from the following description:

Outer Conductor and Couplings

The outer conductor is aluminum tubing having an inner diameter of three inches and a wall thickness of 0.120 inches. This tubing is in lengths of 20 feet. The ends butt on each other within the couplings and thus there are no irregularities on the inner surface to produce premature voltage breakdowns. The construction of the coupling may be seen in Fig. 1. (This coupling was manufactured by the Raybould Coupling Company). The coupling is composed of (a) two compression rings, (b) a sleeve, (c) two ends and (d) the tightening bolts. As can be seen from this figure the compression ring has tapered metallic ends. The central portion of the ring is hard rubber. The two ends of the coupling have sloping inner surfaces which face one side of the compression ring while the sleeve has sloping ends

at WTAM

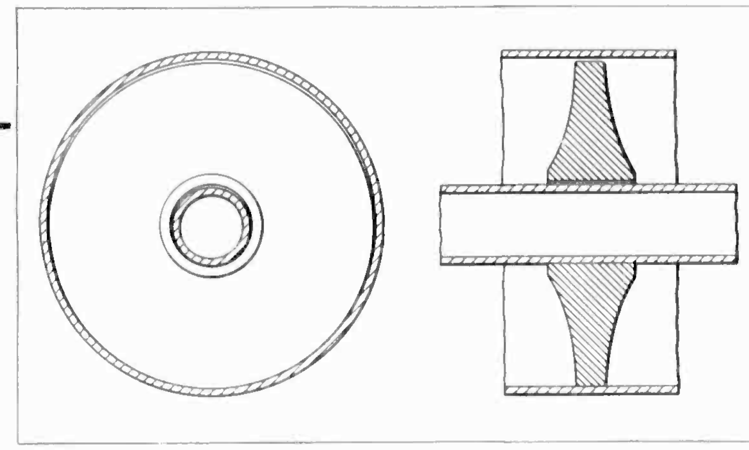


Fig. 4 — Insulator used on WTAM line

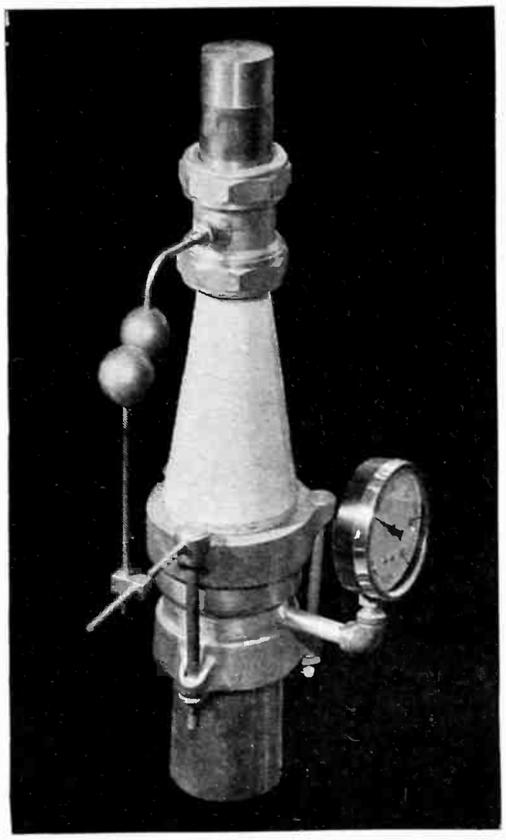


Fig. 5—End seal of aluminum coaxial line

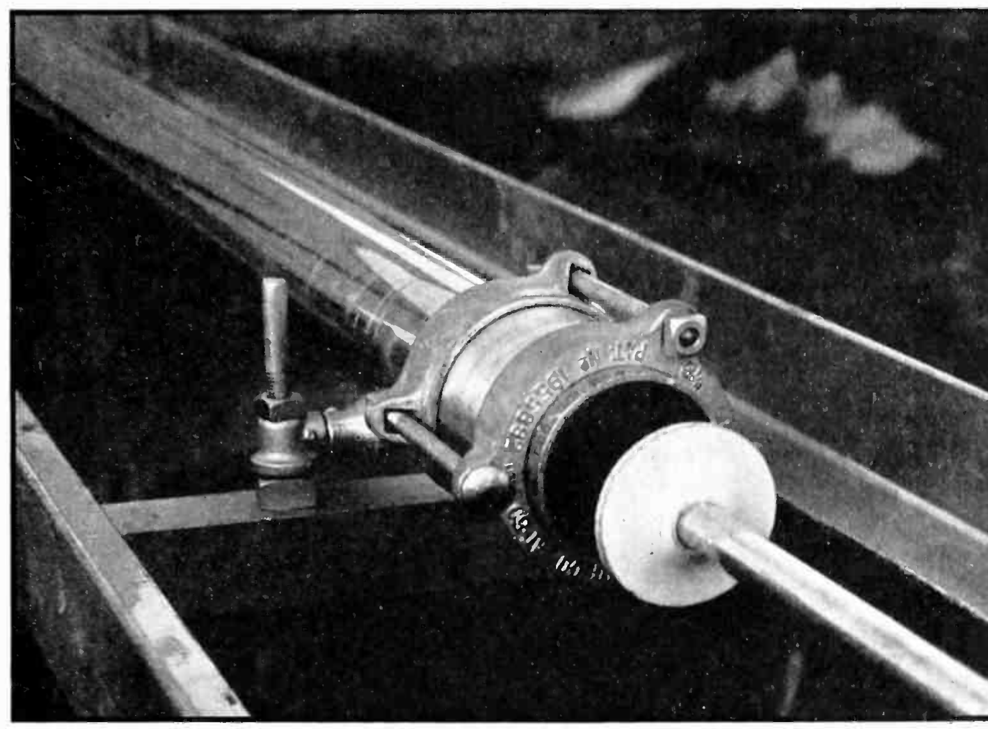


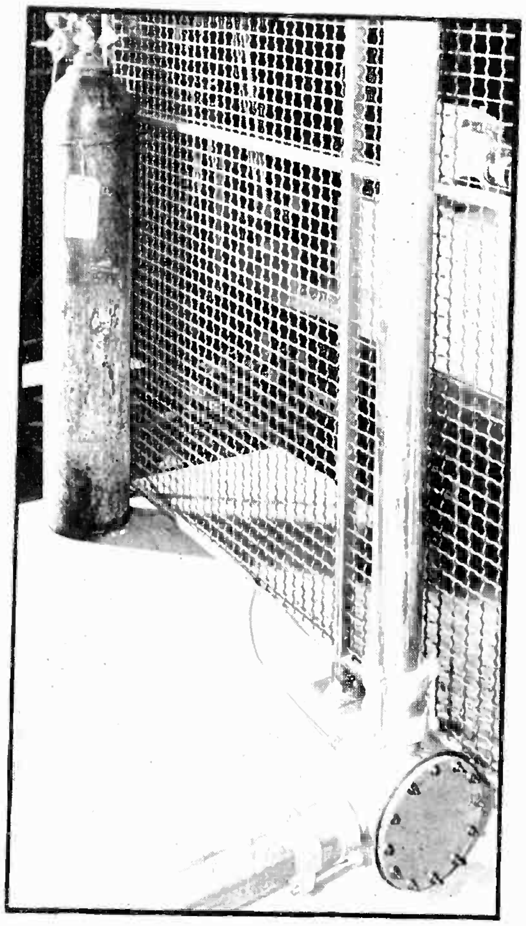
Fig. 3—Method of supporting transmission line which is 480 feet long overall, of which 15 feet are vertical

which face upon the other end of the ring. When the bolts are drawn up the compression ring is forced to expand and results in a gas-tight connection. A very low resistance electrical connection is obtained at the same time through the metallic ends of the ring. Due to the fact that the rubber is not exposed to the elements and is not subject to any appreciable stress reversals, it has a long life. A similar type of coupling has been used on pipe lines and even high pressure steam lines for years with success. Due to the nature of the coupling a moderate amount of out-of-roundness of the tubing or a rough surface on the tubing is of no consequence.

Inner Conductor and Couplings

The inner conductor is also aluminum tubing. It has an outer diameter of ¾ inch with a wall thickness of 0.065 inches. The tubing is in lengths of 20 feet. The couplings fit within the tubing and permit the ends to butt. Thus on the inner conductor also there are no surface irregularities to cause premature voltage breakdown. The inner couplings are shown in Fig. 2. They work in exactly the same manner as the outer couplings, that is, by the compression of two compression rings. The only differences are that these rings tighten upon the inside of the tubing and that the compressive force is supplied by the central threaded rod which is threaded into the ends of the coupling. After inserting the coupling between the ends of two pieces of tubing, the tubing is turned. The friction between the rubber ring and the tubing is sufficient to cause the coupling ends to screw together and expand the ring. Woven strap wrenches were used for this operation and the couplings pulled the ends of the tubing together so tightly that the tubing metal was forced out at the point of contact. This obtrusion indicated very good electrical contact. The surface was then smoothed off by light filing and sanding.

The insulators are shown in Figs. 3 and 4. The surfaces of this insulator adjacent to the inner and outer conductor are silvered. This insulator design was evolved by the National Broadcasting Co. after a series of tests upon various types. This insulator will take practically the full voltage that the cylinders alone will withstand. This means a voltage increase of more than 300 percent over most types previously available. The insulators are glazed and are of the low loss material having a power factor in the order of .07 at 1000 kc. (This is on the basis of information supplied by the manufacturer, The Isolantite Co.) The insulators are secured to the inner cylinder by slightly swelling the inner cylinder, and they are placed on four foot centers. They are free to move in the outer cylinder. All tests on these insulators indicate that while an arc may instantaneously form across an insulator, the arc quickly moves away from the insulator and if sustained does not endanger the insulator. It



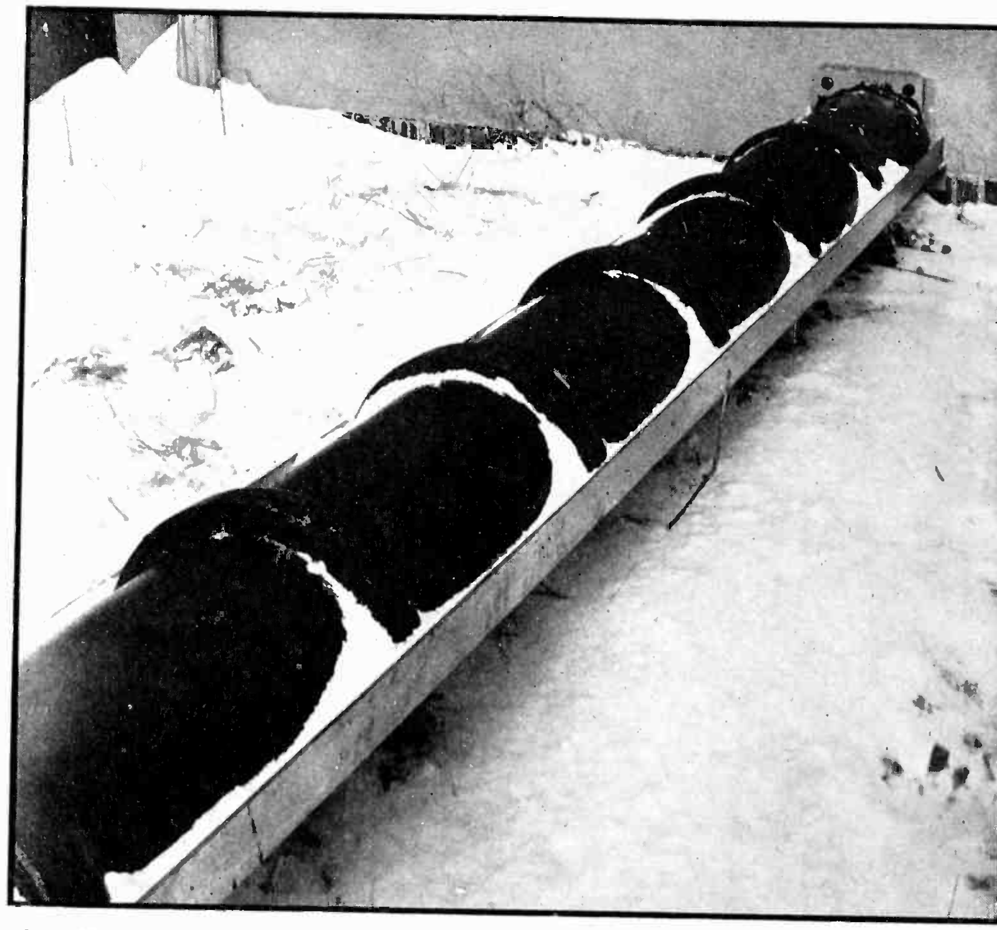


Fig. 6 (left)—Junction box coupling a vertical run to a horizontal run. Note gas connection to tube
Fig. 7 (right)—Cable enters the tuning house where the outer conductor is bolted to a plate which is bolted to the house

has also been found by test that repeated arcovers do not seem to reduce the voltage at which subsequent breakdowns occur. The silver coating on the inside and outside surface prevents high air gap stresses which prematurely lower the arcover voltage. All insulators were individually proof tested to 85 percent of maximum voltage that the cylinders alone would withstand. This was considered necessary in order that one or two insulators, out of some 115 insulators, would not appreciably reduce the investment in safety factor.

End Seals and Junction Box

The end seal is shown in Fig. 5. To eliminate abrupt changes of inner surface continuity, the inside diameter of the insulator is the same as the inside diameter of the tubing. This, of course, requires a reduction coupling similar to the straight type previously described. The small end of the end seal insulator has a two inch coupling to seal it into a 2 inch tube having a closed end. A flexible connection from the inner conductor to the closed 2 inch tube permits any differential expansion to be adequately provided for. Ball gaps are provided on both ends of the line and are installed on the end seals. The tuning house end has a gas connection for a valve and the transmitter end has a gage attached.

The junction box permits the coupling of a vertical run to the horizontal run. This is shown in Fig. 6. The gas connection to the box can be seen in this figure.

Line Supports and Protection

The method of line support may be seen in Fig. 4. The line rests upon pipe rollers placed on 10 foot centers. The piers are placed on 20 foot centers. The angle sections support 12 inch split channel pipe as shown in Fig. 7. This figure also shows the entrance into the transmitter building. A plastic, non hardening, asphalt cement is used to seal the joints in the channel pipe.

The line is 480 feet long. Of this length, fifteen feet are vertical, in order to couple to the power amplifier which is on the second floor.

The inner conductor is rigidly tied to the outer conductor at the middle of the horizontal run. The outer conductor is rigidly secured at the transmitter end and any expansion or contraction is accommodated by flexible connections at the tuning house. The outer conductor is held by a coupling bolted to the plate, seen in Fig. 7. This plate in turn is bolted to the building. Any great differential expansion between the inner and outer conductors is eliminated by the watertight channel pipe over the line. The channel pipe also protects the line from stray gunshot, horses, mules, jackasses, etc. In other words it provides a necessary mechanical protection as well as preventing undesirable temperature differences between the inner and outer cylinders.

The line showed negligible loss of gas when a pressure of 40 pounds per square inch was maintained. At the operating pressure of 15 pounds it is indicated that a negligible amount of nitrogen will be consumed.

The surge impedance of this line was measured to be 82.7 ohms. The reasons for desiring such a surge impedance are three, (1) To obtain less costly terminating equipment in comparison with that required for a lower surge impedance line and (2) To obtain nearly optimum performance from the insulators and (3) To keep line losses near the minimum.

All of the requirements previously mentioned in the ideal specifications seem to have been obtained to a very substantial degree.

A Television Formulary

Definitions, equations, and design formulas abstracted from the manuscript of a book on television engineering, now in preparation and to be published by the McGraw-Hill Book Co.

By DONALD G. FINK
Managing Editor, Electronics

I. Image Analysis

Symbols:

d_c—critical viewing distance, beyond which structure of picture is not evident.

f—frame repetition rate, number of complete pictures per second.

f'—field repetition rate, number of interlaced fields per second.

h—height (inches) of the reproduced picture.

k—utilization ratio, relating vertical definition to number of scanning lines (values range from 0.75 to 1.0).

k_h—ratio of horizontal retrace scanning velocity to horizontal active scanning velocity.

k_v—ratio of vertical retrace scanning velocity to vertical active scanning velocity.

N—total number of picture elements in picture (contained in all active scanning lines).

n—total number of lines in the scanning pattern, from beginning of one frame to beginning of the next frame.

n_a—number of lines actively employed in reproducing the image, equal to n less the number of lines produced during vertical retrace scanning motion.

R—rate (per second) of scanning of picture elements.

w—width of reproduced picture in same units as h.

R.M.A. Proposed Standards:

Aspect ratio $= w/h = 4/3$.

Frame rate $= f = 30$ per second.

Field rate $= f' = 60$ per second.

Total lines $= n = 441$.

Horizontal scanning ratio, k_h, between the limits 7 and 10.

Vertical scanning ratio, k_v, between the limits 10 and 15.

Equations:

Critical viewing distance:

$$d_c = 3450\, h/(kn_a) \text{ inches} \qquad (1)$$

Note: Equation based on visual acuity of one minute of arc.

Number of picture elements per picture:

$$N = (w/h)\, k^2\, n_a^2 \qquad (2)$$

Number of active scanning lines per frame:

$$n_a = n \frac{1}{1+1/k_v} \qquad (3)$$

Rate of scanning picture elements:

$$R = (w/h)\, k\, f\, n^2 \left[\frac{1+1/k_h}{1+1/k_v}\right] \text{ elements per second} \qquad (4)$$

II. Television Camera Action

Symbols:

A_p—area (sq ft) occupied by a particular picture element on photosensitive camera surface, equal to picture area divided by N (Eq (2)).

E_p—illumination (footcandles) falling on that particular picture element.

Δf—total range of frequency (cps) occupied by television signal (see Eq 14).

R—resistance (ohms) across which output signal voltage is developed.

R_n—signal-to-noise ratio (noise in r-m-s volts) across resistance R.

S—sensitivity (μa per lumen) of photosensitive surface, corresponding to color of light on picture element considered.

V_s—output signal voltage, storage type camera (Iconoscope).

V_i—output signal voltage, non-storage type (Image-dissector).

Equations:

Storage camera output:

$V_s = S\,N\,E_p\,A_p\,R$ microvolts, for particular picture element considered (5)

Note: Assumes storage for one frame only, at 100 per cent efficiency.

Non-storage camera output:

$V_i = S\,E_p\,A_p\,R$ microvolts for particular element considered (6)

Signal-to-noise ratio:

$$R_n = V/\left(\sqrt{1.6 \times 10^{-20} R \Delta f}\right) \qquad (7)$$

Note: V may be V_s or V_i depending on type of camera considered. Temperature of resistor R is taken at 20° C.

III. Electron Beams

Symbols:

c—speed of light, 3.0×10^{10} cms/second.

D—distance (cm) from screen-end of deflecting field to fluorescent screen.

d_e—distance (cm) of deflection, measured on screen from axis of electron gun, for electric deflection.

d_m—distance (cm) of deflection, measured on screen from axis of electron gun, for magnetic deflection.

e/m—charge-to-mass ratio of electron, 5.3×10^{17} e s u/gram (electric units) or 1.7×10^{7} e m u/gram (magnetic units).

H_d—strength of magnetic deflecting field, e m u.

l—length (cm) of deflecting field measured along axis of electron gun.

s—separation (cm) between deflecting plates.

v—velocity of electrons in electron beam, component along axis of gun.

V_d—deflection voltage, volts.

V_a—Accelerating (second anode) voltage, volts.

Equations:

Electron velocity:

$$v = c\sqrt{1-\frac{1}{(V_a e/(300mc^2)+1)^2}} \text{ cms/sec} \quad (8)$$

Note: This equation takes into account the increase in electron mass with velocity, which cannot be neglected for V_a above 2000 volts. e/m in electric units.

Electric deflection:

$$d_e = \frac{V_d\, l\, e}{300\, sv^2 m}(D + \tfrac{1}{2}l) \text{ cms} \quad (9)$$

Note: Ratio e/m in electric units.

Magnetic deflection:

$$d_m = \frac{H D l e}{m v} \text{ cms} \quad (10)$$

Note: Approximate equation, true when l is small compared to radius of deflection path within field. Ratio e/m in magnetic units.

IV. Fourier Series of Waveforms

Symbols:

f—fundamental frequency of the wave in cps ($1/f$ equals duration of one cycle).

n—order of the final harmonic in the series.

t—time, secs.

$V(t)$—the wave function; overall peak-to-peak amplitude is unity.

Equations:

Square wave:

$$V(t) = \frac{2}{\pi}\left[\frac{\sin 2\pi ft}{1} + \frac{\sin 2\pi 3ft}{3} + \frac{\sin 2\pi 5ft}{5} \ldots + \frac{\sin 2\pi nft}{n}\right] \quad (11)$$

Note: n odd only; origin at center of wave.

Ideal sawtooth wave (zero retrace time):

$$V(t) = \frac{1}{\pi}\left[\frac{\sin 2\pi ft}{1} - \frac{\sin 2\pi 2ft}{2} + \frac{\sin 2\pi 3ft}{3} - \frac{\sin 2\pi 4ft}{4} + \ldots \pm \frac{\sin 2\pi nft}{n}\right] \quad (12)$$

Note: Even order harmonics plus, odd order minus. Origin at center.

Non-ideal sawtooth wave (finite retrace time):

$$V(t) = \frac{1}{\pi^2(p-p^2)}\left(\frac{\sin \pi p}{1}\sin 2\pi ft + \frac{\sin 2\pi p}{4}\sin 2\pi 2ft + \frac{\sin 3\pi p}{9}\sin 2\pi 3ft + \frac{\sin n\pi p}{n^2}\sin 2\pi nft\right) \quad (13)$$

Note: p is the ratio of the duration of the forward trace to the duration of the complete cycle. Origin at center.

V. Video Amplification

Symbols: (See also symbols in Section I)

C—(see figures for capacitance values).

C_{gk}—grid-cathode capacitance ($\mu\mu$f) of tube.

C_{pk}—plate-cathode capacitance ($\mu\mu$f) of tube.

C_{gp}—grid-plate capacitance ($\mu\mu$f) of tube.

f—any frequency (cps) within the video range.

f_m—highest frequency in the video range (constant gain and time delay required up to this frequency).

G—voltage gain of amplifier (output volts/input volts).

g_m—grid-plate transconductance (amperes per volt) of tube.

L—(see figure for inductance symbols).

μ—amplification factor of tube.

ϕ_a—phase shift (degrees) in addition to 180° shift introduced by amplifier tube.

R—(see figure for resistance symbols).

r_p—dynamic plate resistance (ohms) of tube.

ω—$2\pi f$, angular frequency.

Equations:

Highest frequency to be amplified in video range:

$$f_m = \frac{(w/h)\, k\, f\, n^2}{2}\left[\frac{(1+1/k_h)}{(1+1/k_v)}\right] \text{ cps} \quad (14)$$

Note: f in this equation is the frame repetition rate. See Section I.

Figure-of-merit for amplifier tubes:

$$\text{Figure-of-merit} = g_m/(C_{gk} + C_{pk} + C_{gp}(1+G)) \quad (15)$$

Note: G, the gain per stage, may be taken as 15 for pentodes, 3 for triodes.

Total shunt capacitance per stage:

$$C_t = C_s + C_{gk} + C_{pk} + C_{gp}(1+G) \ \mu\mu\text{f} \quad (16)$$

Note: C_s is stray and wiring capacitance, in $\mu\mu$f.

Design formula for output load resistor, R_o (see Fig. 1):

$$R_o = \frac{1}{2\pi f_m C_t} \text{ ohms} \quad (17)$$

Note: C_t in farads, f_m in cps.

Design formula for shunt compensating (peaking) inductance L_o (see Fig. 1):

$$L_o = 0.5\, C_t R_o^2 \text{ henries} \quad (18)$$

Note: C_t in farads, R_o in ohms.

High frequency gain of shunt compensated stage (Figure 1):

$$G = \frac{g_m R_o \sqrt{1 + (\frac{1}{4}f^3/f_m^3 + \frac{1}{2}f/f_m)^2}}{(f/f_m)^2 + (f^2/(2f_m^2) - 1)^2} \quad (19)^1$$

Added phase shift of shunt-compensated stage:

$$\phi_a = +\tan^{-1}\tfrac{1}{4}(f^3/f_m^3 + 2f/f_m) \text{ degrees} \quad (20)^1$$

Design formula for series compensating (peaking) coil (Figure 2):

$$L_c = \frac{1}{8\pi^2 f_m^2 C_o} \text{ henries} \quad (21)^2$$

Note: f_m in cps, C_o in farads.

High frequency gain of series-compensated stage:

$$G = 1.50\, G_o \quad (22)^2$$

Note: G_o is gain of shunt-compensated stage (See Eq. 19) having same value of C_t and f_m.

Low frequency gain (as a complex quantity) of RC compensated stage (Figure 3):

$$G = \frac{g_m R_o \omega(\omega - j/(C_F R_p))}{(\omega - j/(R_F C_F))(\omega - j/(R_g C_c))} \quad (23)^3$$

Gain of cathode-coupled stage (Figure 4):

$$G = \frac{\mu R_k}{r_p + R_k(\mu+1)} \quad (24)^3$$

[1] Analysis and Design of Video Amplifiers, S. W. Seeley and C. N. Kimball, *RCA Review*, 2, 2, 171 (October 1937).

[2] Analysis and Design of Video Amplifiers. Seeley and Kimball, *RCA Review* 3, 3, 290 (January 1939).

[3] Some Notes of Video Amplifier Design, A. Preisman, *RCA Review* 2, 4, 421 (April 1938).

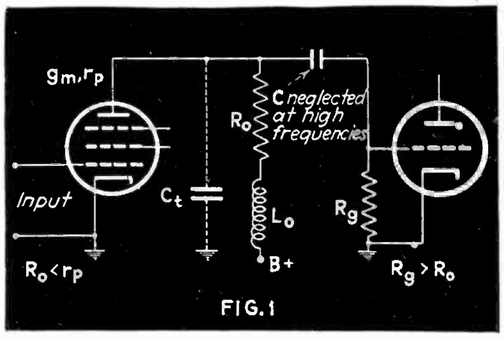


Fig. 1—Diagram of shunt-compensated video amplifier applicable to Eqs. (17), (18), (19), and (20)

Output impedance of cathode-coupled stage (Figure 4):

$$R'_o = \frac{R_k r_p/(\mu+1)}{R_k + r_p/(\mu+1)} \text{ ohms} \qquad (25)[3]$$

VI. Coaxial Circuit Parameters

Symbols:

A —attenuation introduced by cable.

C —capacitance per unit length of cable, farads.

d_i—diameter of inner conductor.

d_o—diameter of outer conductor, same units as d_i.

G —conductance per unit length of cable, mhos.

L —inductance per unit length of cable, henries.

ϕ —phase shift introduced by cable, degrees.

R —resistance per unit length of cable, ohms.

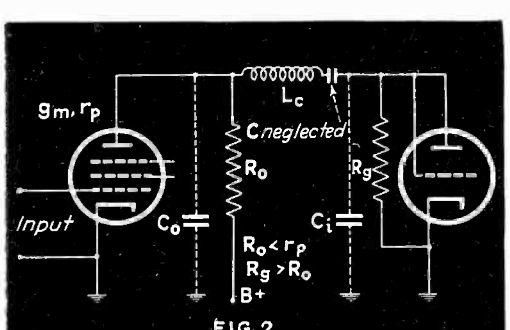


Fig. 2—Diagram of series-compensated video amplifier. Ro is determined by Eq. (17)

t —time delay introduced by cable, seconds.

Z_o—surge impedance of cable, ohms.

[4] Some Notes on Ultrahigh Frequency Propagation, H. H. Beverage, *RCA Review*, 1, 3, 76 (January 1937).

Equations:

Surge impedance:

$$Z_o = \sqrt{\frac{R+j\omega L}{G+j\omega C}} = \sqrt{L/C} \text{ ohms} \qquad (26)$$

Note: Second form applies only when R and G are small.

Design formula for surge impedance:

$$Z_o = 138.5 \log_{10} d_o/d_i \text{ ohms} \qquad (27)$$

Attenuation:

$$A = 0.031\ R/(\log_{10} d_o/d_i) \text{ db per unit length} \qquad (28)$$

Time delay:

$$t = \sqrt{LC} \text{ seconds per unit length} \qquad (29)$$

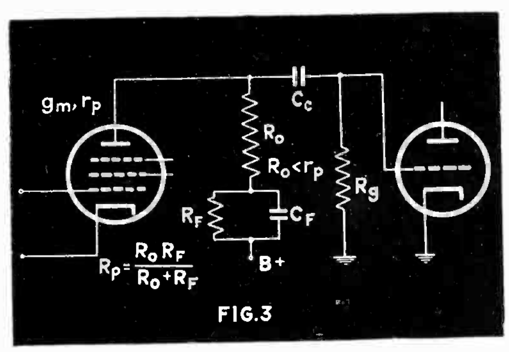


Fig. 3—Diagram showing low-frequency compensation circuit for which gain may be calculated by Eq. (23)

Phase delay:

$$\phi = 2\pi f \sqrt{LC} \text{ radians per unit length} \qquad (30)$$

VII. R-f Propagation and Amplification

Symbols:

a —height (meters) of receiving antenna.

Δf—total width of communication channel (cps).

E —field strength at distance r (volts/meter).

f_r —resonant frequency of tuned circuit (cps).

h —height (meters) of transmitting antenna.

λ —operating wave length (meters).

L —inductance of tuned circuit (henries).

R —resistance shunted across tuned circuit (ohms).

r —distance from transmitting antenna (meters).

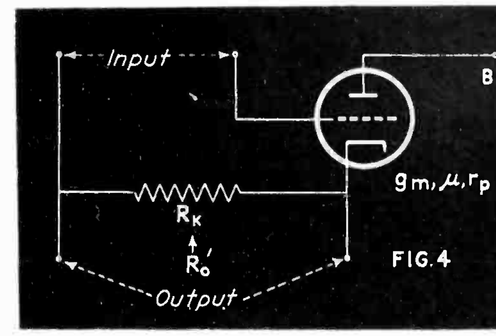


Fig. 4—Connections of the cathode-coupled ("cathode-follower") stage, used for low-impedance output applications

r_h—distance to horizon, viewed from top of antenna (meters).

W—transmitter power (watts).

Equations:

Horizon distance:

$$r_h = 1.23 \sqrt{h} \text{ miles} \qquad (31)$$

Note: h is in feet in this equation.

Field strength (within horizon distance):

$$E = \frac{88\sqrt{W}\ a\ h}{\lambda\ r^2} \text{ volts per meter,} \qquad (32)[4]$$

Field strength (beyond horizon at 40-60 Mc):

$$S = E_h\ (r_h/r)^{3.0} \text{ volts per meter.} \qquad (33)[4]$$

Note: E_h is the field strength at the horizon.

Gain of r-f stage contained single loaded tuned circuit (Figure 5):

$$G = g_m R \qquad (34)$$

Note: This is the gain at the resonant frequency (middle of the communication channel). At the edges of the communication channel, the gain is 70 per cent of the above value, when the condition of Eq. (35) is fulfilled.

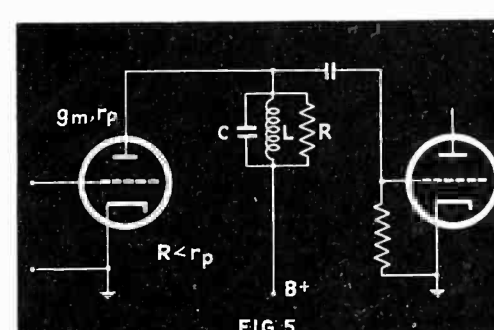


Fig. 5—Diagram of wide-band r-f amplifier employing single, loaded, tuned circuit between stages, for Eqs. (34) and (35)

Design formula for shunt loading resistance R:

$$R = (2\pi f_r L)\ (f_r/\Delta f) \qquad (35)$$

Note: A single tuned circuit cannot offer uniform gain over the width of the communication channel. Circuits coupled either capacitively or inductively must be used to obtain "flat-top" response.

SECOND ANNUAL BROADCAST

Engineering Conference

COLUMBUS . . . February 6-17

Dr. W. L. Everitt, Ohio State University, Director of the Conference

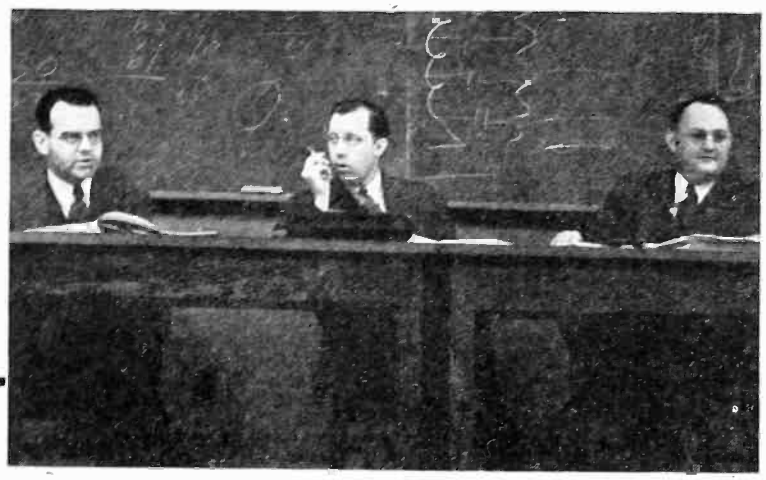
L. F. Jones, chief contact engineer on television, RCA Manufacturing Co.

John F. Morrison, Bell Telephone Laboratories, lecturing on antennas

E. E. Spitzer, Radiotron, RCA. Leader of round table talk on power tubes

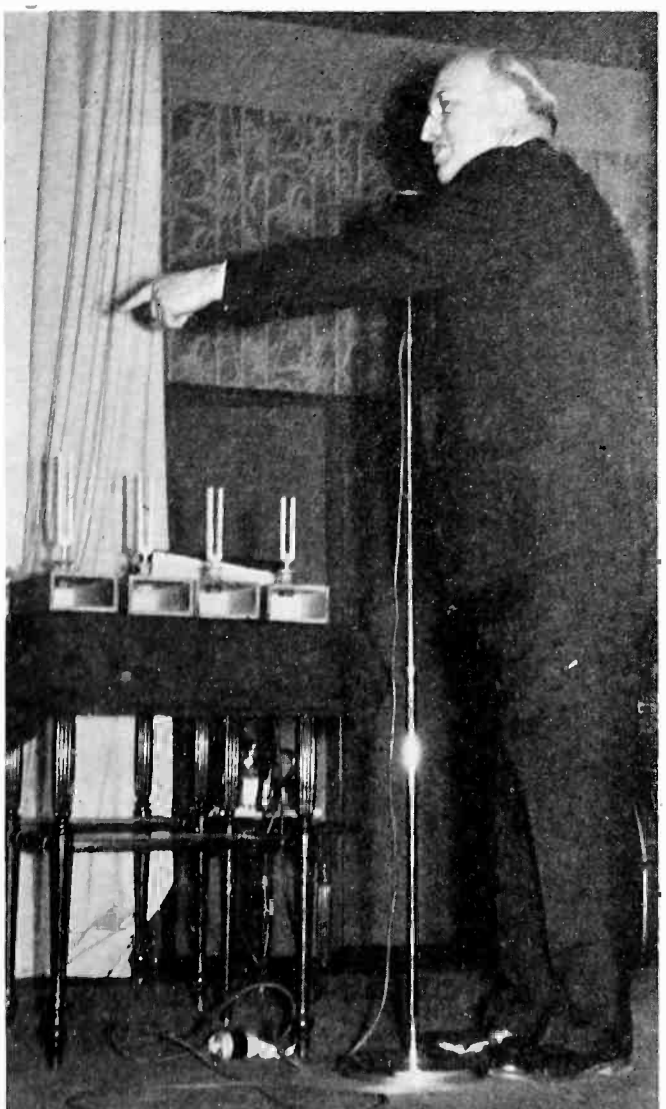
C. J. Young RCA, delivering a highlight of the meeting—facsimile

R. M. Morris, NBC; "Development of proposed standard volume indicator"



Stuart L. Bailey, consultant; John H. DeWitt, WSM; and Andrew D. Ring, FCC, "Standards of Good Engineering Practice"

C. J. Young, RCA; C. F. Quentin, WMT; and Professor R. S. Glasgow, Washington University discussing facsimile, with samples



Dr. J. O. Perrine, BSTJ, "Waves, Words, and Wires"

Dr. V. K. Zworykin, RCA, lecturing on some aspect of electron optics

Howard A. Chinn, engineer in charge, audio engineering, CBS, New York

Informal discussion on facsimile. C. F. Quentin, WMT; R. J. Rockwell, WLW; Paul Loyet, WHO; and D. W. Gellerup of station WTMJ

Dr. Donald B. Sinclair, General Radio Company; F. W. Cunningham, Bell Laboratories; L. W. Stinson, KVOO.—All photographs by Wilbur H. Vance, Jr.

TUBES AT WORK

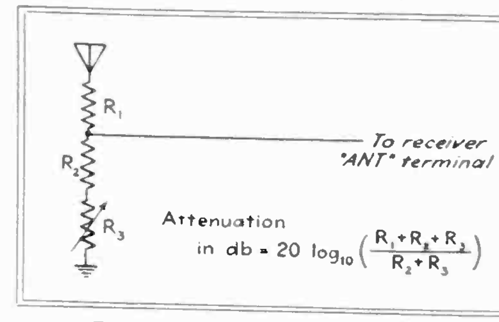


Fig. 1—Basic antenna control circuit

TWO "how-to-do-it" descriptions of tube applications: for limiting the antenna voltage of a receiver, and for regulating power supply

Input Control Circuit

BY W. W. WALTZ

SOME TIME AGO an English contemporary, *The Wireless World,* described a circuit used in some European receivers to limit the signal voltage on the grid of the first tube. In effect, the circuit is analogous to the one-time common practice of locating the volume control in the antenna circuit. However, the European idea involved automatic control depending upon the signal voltage; in a sense it was an a-v-c system functioning to limit the signal on the first grid rather than, as conventionally, to control the receiver gain.

The idea seemed particularly appropriate for inclusion in a receiver—a somewhat modified version of the high-fidelity t-r-f tuner described by W. N. Weeden in *Electronics,* February 1937, page 19—which was to be used in close proximity to two fifty-kilowatt transmitters, WOR and WJZ. Experience with several radio sets had demonstrated that the signals from these transmitters were more than sufficient, under any and all conditions, to seriously overload the first tube.

It is a well-known fact that serious distortion can and does originate from overloading the grid of the first tube of a receiver. Despite the fact that the grid may, under the influence of the a-v-c system, be operating at minus twenty or more volts, this affects only the gain of the tube and has nothing whatever to do with the ability of the tube to handle a signal—in other words, the bias voltage is not necessarily a measure of the signal-handling capacity of the tube.

In the absence of field-strength measuring equipment, a tuned circuit in shunt with a v-t voltmeter was connected between an antenna—the same, it should be noted, as intended for use with the completed receiver — and ground. On tuning the circuit to various frequencies, a series of comparative readings was obtained; these are given in the accompanying table.

It will be seen that the ratio between the strongest and weakest signals, which might be received by the set, is of the order of 5000 to 1—a difference in level of 74 db.

The sensitivity of the receiver was such that the lower-level signals could be received satisfactorily—that is, those stations on 570, 810, and 1550 kc were sufficiently above the noise level to insure good reception under most conditions. The real need was to reduce the level of those transmitters that were inducing four and five volts in the receiving antenna.

Frequency, kc	*Voltmeter reading*
570	0.001 (estimated)
660	0.22
710	4.8
760	4.1
810	0.001 (estimated)
860	2.00
1010	0.9
1250	3.59
1550	0.001 (estimated)

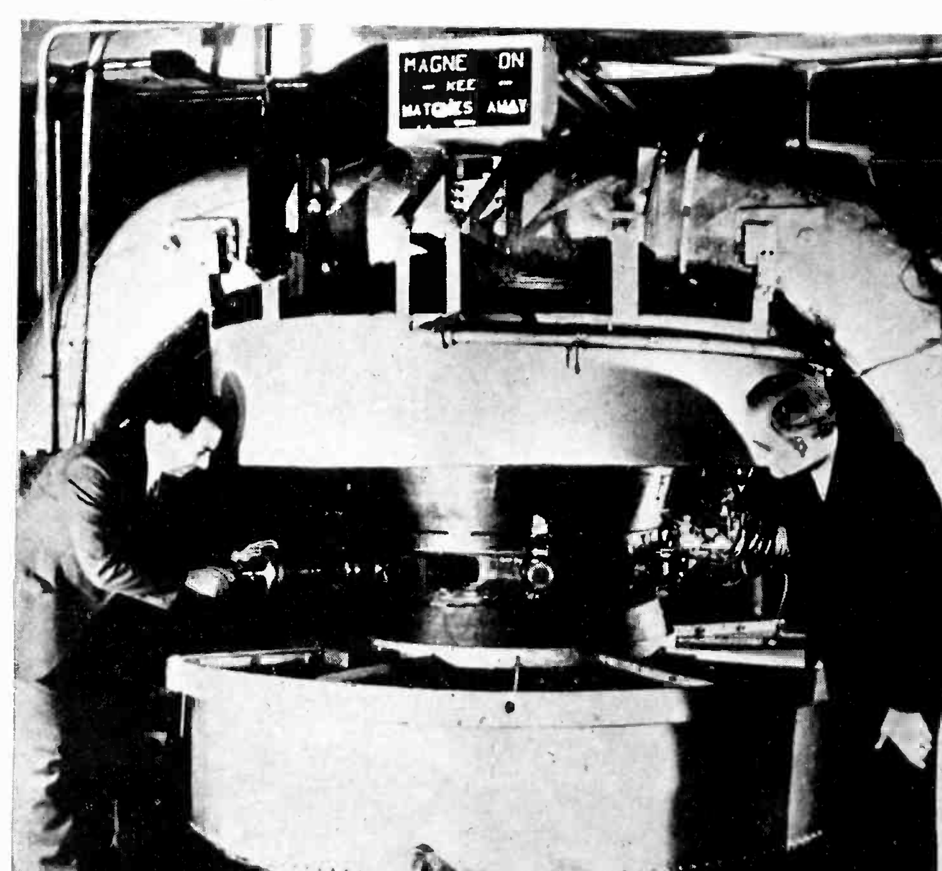
The general idea of the circuit adopted to accomplish this reduction is shown in Fig. 1. In this, a simple potentiometer, the variable resistance, R_3, is actually the internal plate resistance of a vacuum tube. The mathematical expression shown in the figure gives the measure of attenuation afforded by such a potentiometer or voltage divider.

Variation of the plate resistance of a tube is a function of, among other things, the control-grid voltage, and the suppressor-grid voltage. Examination of a group of characteristic curves for various types of tubes indicated that the so-called sharp-cutoff r-f amplifier (as the 6C6, 6J7) would be preferable due to the rather wide range of plate resistance, especially when under the control of the suppressor-grid voltage. Curves showing this are given in Fig. 2, where the variation in plate resistance of a 6J7 is plotted as a function of suppressor potential; curves are given for two values of control-grid bias, —3 and —5 volts.

It is apparent that over the range of voltage which might be expected from

(*Continued on page* 40)

ATOM SMASHER AT COLUMBIA



Prof. John R. Dunning, left, making adjustments on the 150,000 pound cyclotron, while Dean George B. Pegram, of the graduate faculties at Columbia University looks on.

The D-shaped core provides the magnetic circuit through which atomic "bullets" are fired at 25,000 miles per second to transmute chemical elements.

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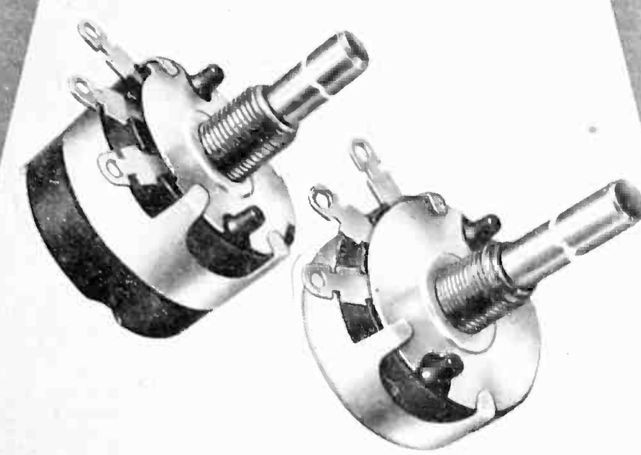

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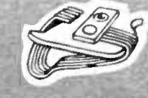

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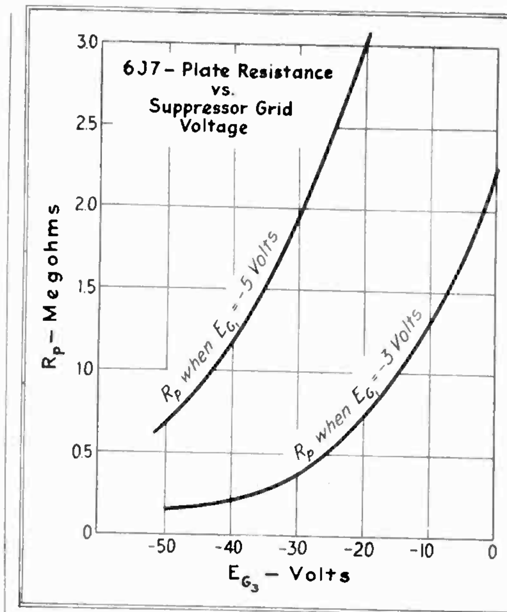


Fig. 2 — Relationship between resistance and control voltage

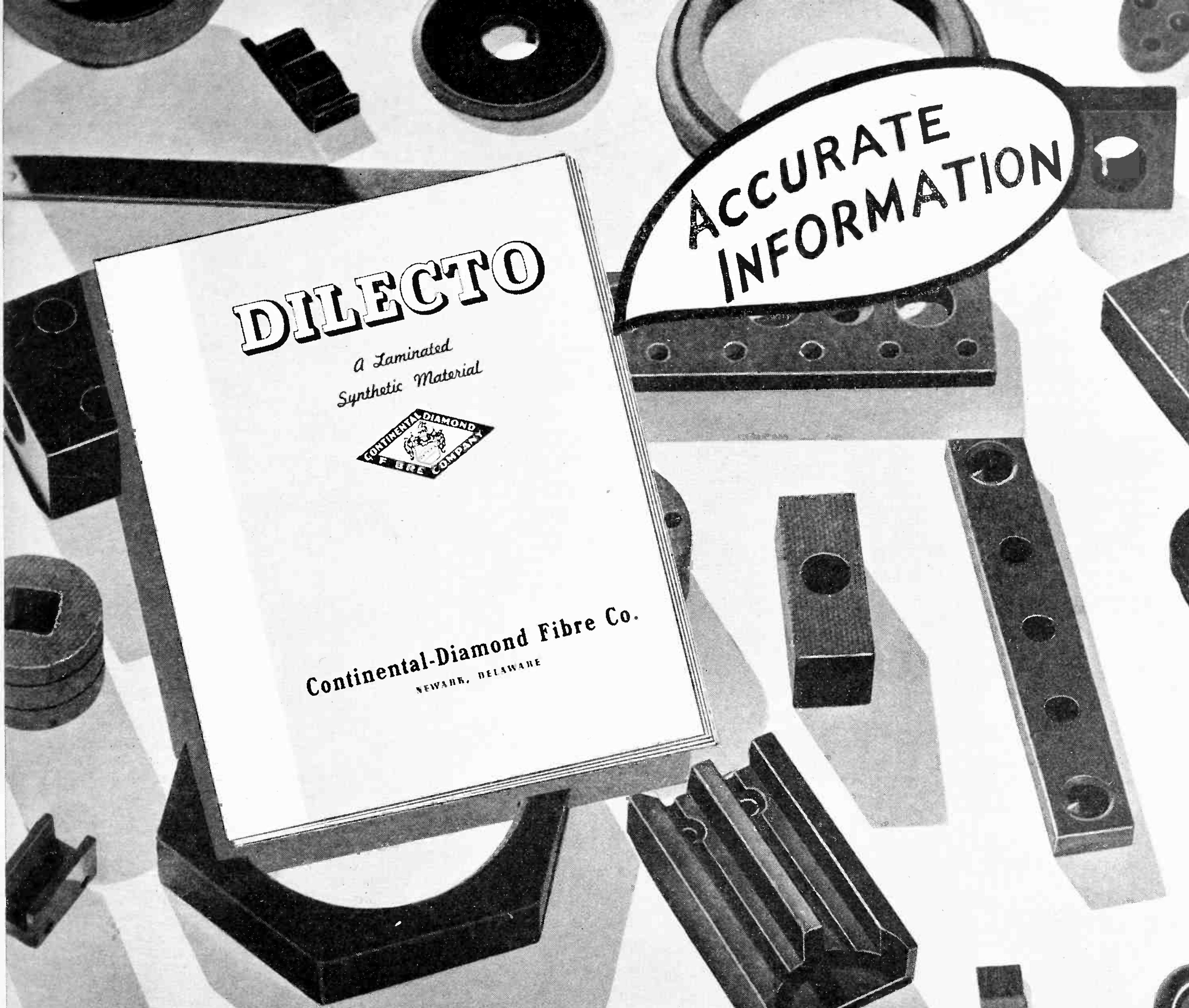
an a-v-c system (say, to —40 volts) there is a wide swing in plate resistance, especially at control-grid bias of —3 volts.

The original version of this circuit, described in the publication mentioned above, employed a separately-connected diode to furnish a positive voltage for the control grid of the input-control tube. It is felt that considerable simpli-

• • •

U-H-F WAVES DIRECTED BY HORNS

How horns are useful in directing very high frequency radio waves was recently demonstrated before the New York meeting of the Institute of Radio Engineers by Dr. George C. Southworth. The degree of directivity obtainable depends upon the shape of the horn, but the effect may be the same as an increase in power in the desired direction, of 500 times.



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fication has been achieved by making use of the regular negative a-v-c voltage and applying it to the suppressor to effect the desired change in plate resistance.

The circuit as actually applied to the high-fidelity t-r-f receiver is shown in Fig. 3. Condensers C_1 and C_2, in series with the internal plate resistance of the 6J7 form the potentiometer or voltage divider illustrated schematically in

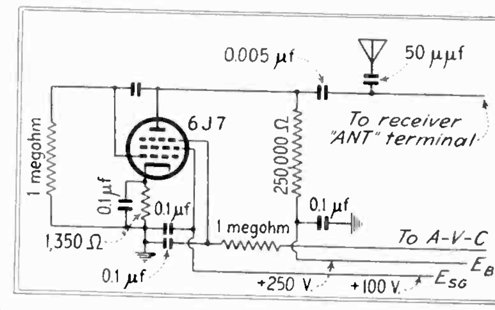


Fig. 3—Actual circuit employed for control

Fig. 1. These condensers were given such values that, for variation in a-v-c voltage from zero to —50, a total attenuation of approximately 20 db is obtained. Since 20 db represents a reduction by a factor of 0.1, the decrease in the highest signal voltage (4.8 volts for 710 kc station) brings it well within the limit which the tube can handle.

Tests on the receiver in actual service indicate that the system is doing all expected of it. Because of the fact that the same conditions could not be simulated, it was deemed unwise to attempt to make a series of voltage readings across the receiver input for comparison with the earlier readings (see above). However, the operation of the receiver is singularly free of troubles arising from distortion in the input circuits, and the entirely automatic control does away once and for all with sensitivity controls, etc.

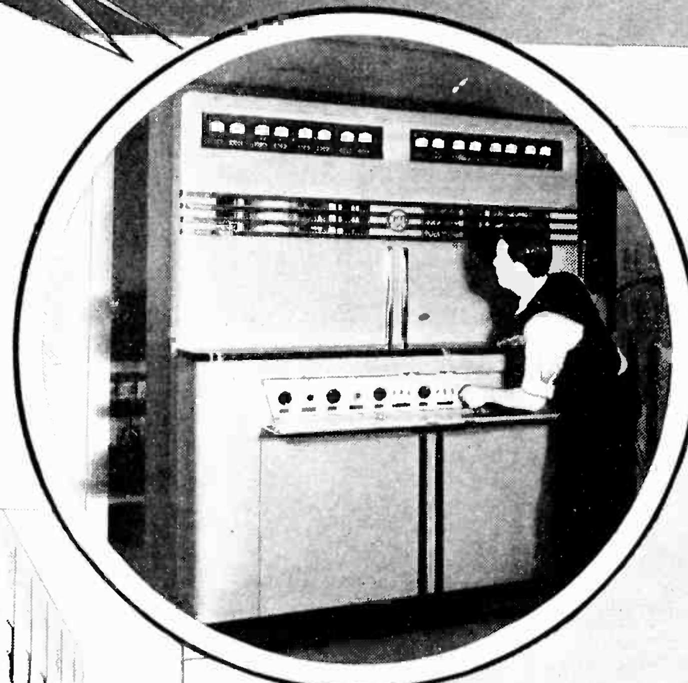
(*Continued on page* 48)

• • •

RADIO EQUIPPED FIRE BOATS

Two way communication between ship and shore to New York's fire boats is being demonstrated by Lt. John H. Reagan, aboard the "Firefighter". The ship is equipped with a 50 watt transmitter. The receiver is fixed-tuned to pick up messages from the Fire Department's 500 watt transmitter on shore.

From the darkness of un

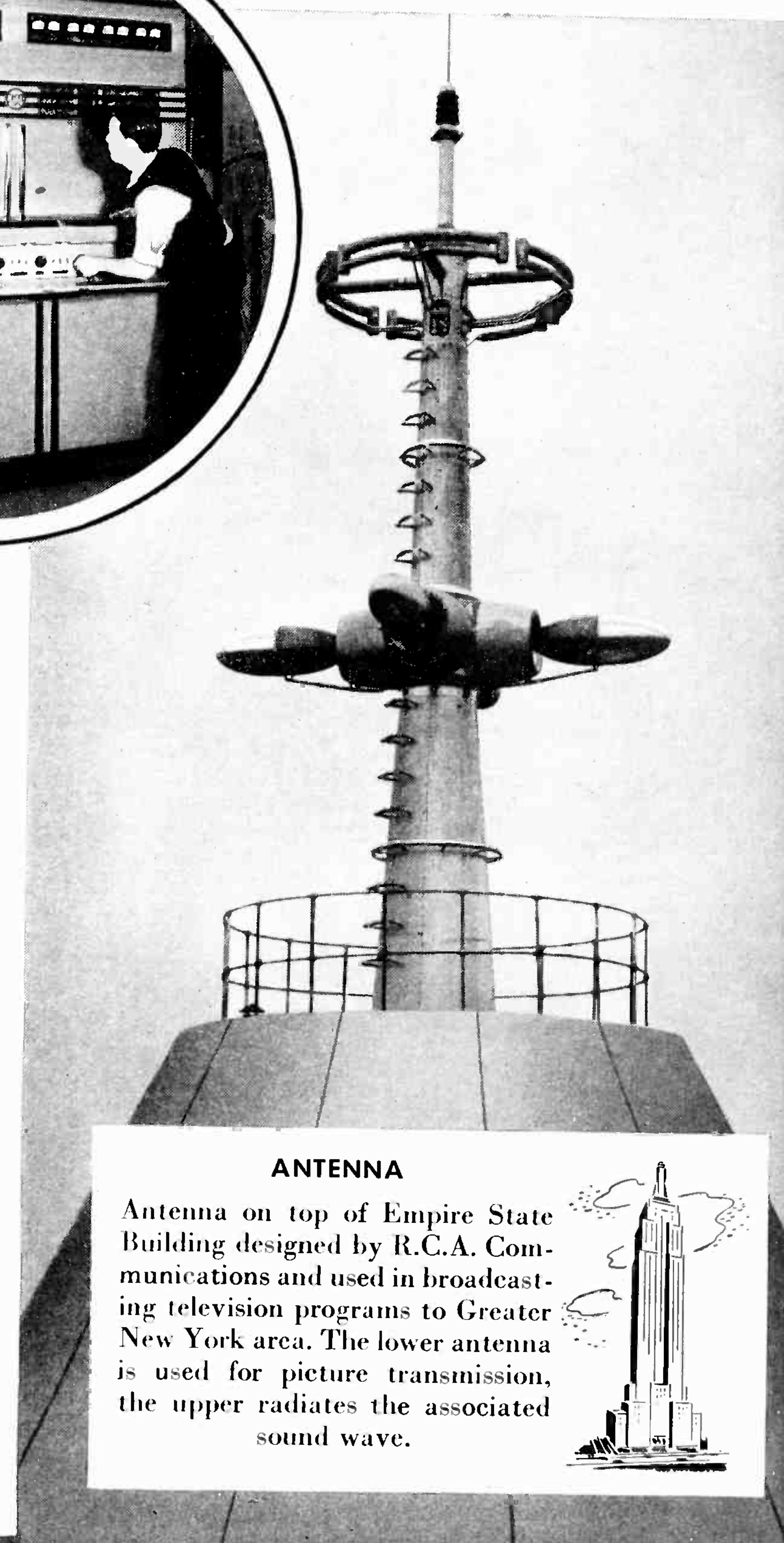


TELEVISION TRANSMITTER

First RCA 1 KW Television Transmitter developed as a compact unit for experimental use and announced for general sale to broadcast stations.

MOBILE TELEVISION TRANSMITTER

Mobile Television Transmitter Unit designed for picking up "on the spot" television broadcasts. Used in RCA-NBC field tests.



ANTENNA

Antenna on top of Empire State Building designed by R.C.A. Communications and used in broadcasting television programs to Greater New York area. The lower antenna is used for picture transmission, the upper radiates the associated sound wave.

RCA TELEVISION EQ

RCA MANUFACTURING CO., INC., CAMDEN, N. J.

ertainty RCA has Produced Light!

TELEVISION *is here!*

Yes — and RCA now offers broadcasters a variety of equipment for telecasting . . . equipment that you can depend upon to perform with accuracy and efficiency . . . equipment resulting from endless years of research in the RCA Laboratories.

TELEVISION CAMERA

One of the television cameras developed by RCA. This camera utilizes the RCA Iconoscope.

TELEVISION! Few advances in civilization have been so widely discussed, so mystifying, so difficult to perfect. For years television has been regarded as a certainty . . . but the question of *when* has been unanswered—until now!

Television is here! Gone is the uncertainty. No longer is it strictly a laboratory problem. Years of research by engineers in the RCA Laboratories have produced it in a practical state. And now, although many problems are yet to be solved before television can approach the status of perfection that radio knows today—it has reached a point where forward-looking broadcasters can use it for the transmission of programs.

On these pages are illustrated three RCA television products designed for broadcasters (or telecasters). They employ the same fine workmanship —result from the same painstaking research— which have combined to produce the outstanding RCA broadcast equipment that is used by so many radio stations today. We shall be happy to discuss them with you in detail.

TELEVISION PROJECTOR

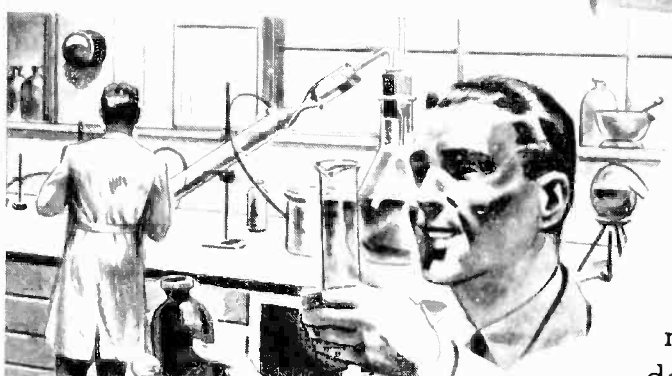
Television Projector for showing image produced by optical enlargement or projection from a small brilliant image on the kinescope.

UIPMENT

A Service of the Radio Corporation of America

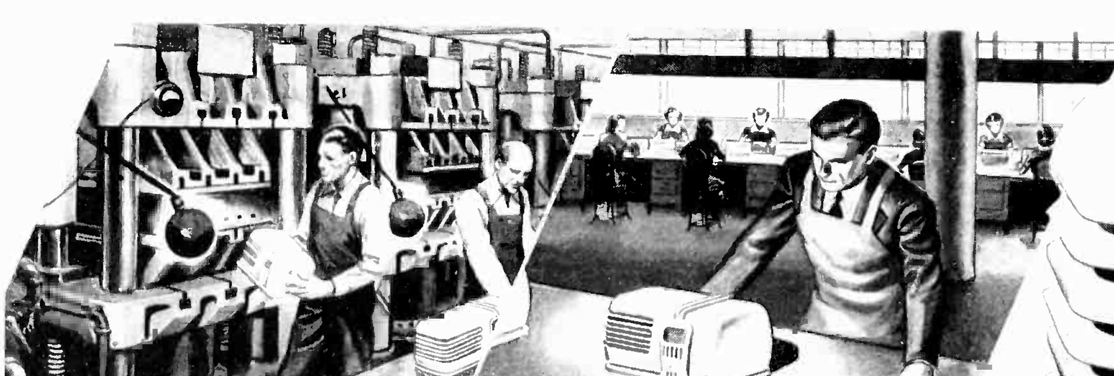
RICHARDSON COMPLETE PLASTICS SERVICE

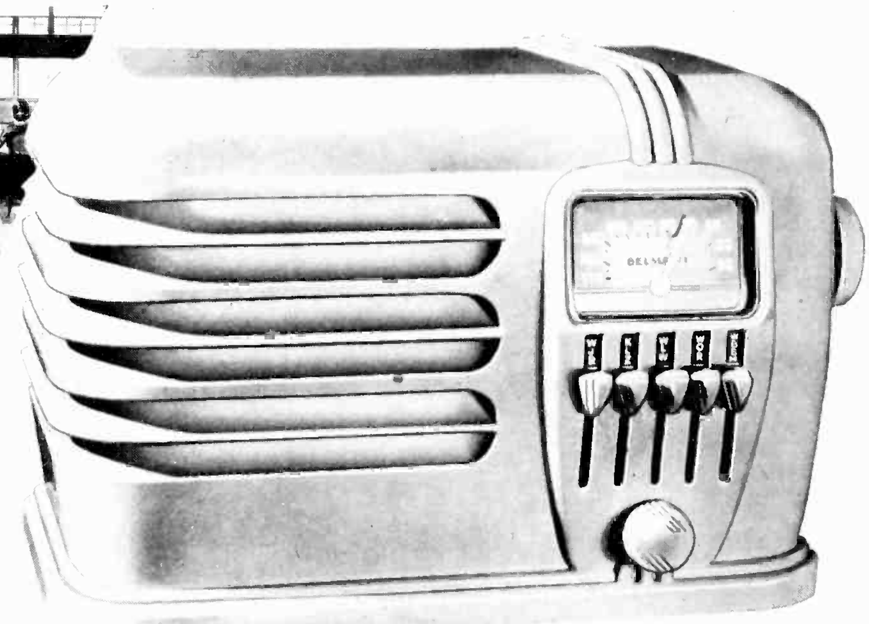
From sketch to finished product!



Devoted exclusively to the plastics arts, Richardson offers complete, comprehensive, exceptional service to users of plastics in radio, television, communications and allied electrical industries. Design, Research and Engineering departments cooperate in solving problems covering the application of plastics to products or production processes. Upon chemists and plastics technicians rests the responsibility of determining the plastic for the specific requirement. Mechanical engineers design the intricate models; skilled tool and die makers in Richardson shops create the molds and dies. Able craftsmen, with years of experience in precision molding and fabrication, at hundreds of modern machines, produce the plastic parts and products. Culminating the continuous searching scrutiny exercised over every step of production is the approval of final inspection. ● Whatever your plastics interest . . . a simple molded or laminated part, an involved, intricate precision molding, a laminated gear or completely finished product . . . it will be to your profitable advantage to entrust your requirements to Richardson.

INSUROK





INSUROK, the precision plastic by Richardson, is available in sheets, rods, tubes, punchings and other forms, both molded and laminated, for fabrication in your plant, or in completely finished parts ready for assembly. Richardson facilities encompass the use of Bakelite, Beetle, Durez, Plaskon, Resinox, Tenite and other forms of synthetic resin plastics. Literature and INSUROK catalogues on request

Radio by Belmont Radio Corp., Chicago, Ill.

The RICHARDSON COMPANY

Melrose Park, (Chicago) Ill. *Founded 1858* Lockland, (Cincinnati) Ohio
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Television Transmitters

(*Continued from page 29*)

the bottle-neck of the whole system. It must be mounted high in the air, to command a wide horizon; it must present a substantially constant impedance over the width of the transmitted band (5 Mc at least); and preferably it should not be an eyesore since it is usually mounted on a skyscraper whose architecture must be taken into account.

Two outstanding solutions to this tripartite problem are the antennas for the NBC and the CBS transmitters in New York. The first, illustrated in Fig 7, was designed by N. E. Lindenblad of RCA Communications for the NBC installation in the Empire State Building. The upper structure is made up of four dipoles which radiate the audio. The lower structure, appearing much like four footballs, consists of two horizontal dipoles of unusual shape, for the video carrier. The particular outline of the dipole elements was chosen in accordance with theoretical calculations which indicate a constant load impedance (within a few per-cent) over a band of some 30 or 40 Mc. Measurements have shown that the performance is in substantial agreement with the theory. Since the band to be accommodated by the vision carrier is only 5.5 Mc, it is expected that nearly perfect performance can be achieved with the new antenna. There is no mutual impedance between the audio and video radiating systems.

The CBS installation makes use of the metal surface of the spire atop the Chrysler Building as part of the radiator. The audio radiator will consist of two dipoles on each of the four sides of the spire, at the top, and spaced one-quarter wavelength from the surface of the tower. The video radiator consists similarly of two sets of crossed half-wave dipoles on each face of the building. One such set is shown in Fig 8. Each leg of each dipole is connected through a 35-ohm ohm line to a 140-ohm matching section, and thence to correcting filter sections (coaxial in shape and containing inductive as well as capacitive elements) which flatten the impedance in the range from 50 to 55 Mc. The side-band elimination filter is located on the 75th floor, and from this filter a 70-ohm line leads to the correcting sections. The use of two sets of crossed dipoles is expected to give a power increase of roughly 4-to-1 over that of one set. Initially, only one set of dipoles (one for audio and one for video) will be installed on each face of the building, to speed up installation and to obtain experience before proceeding with the double array. The design is the result of collaboration between Peter C. Goldmark, Chief Television Engineer of CBS, and RCA engineers who made the transmitter. Figure 9 shows the antenna as it will appear when completely installed.—D.G.F.

High-Definition Television Stations in the United States

Experimental Licenses

New York City—W2XAX	Columbia Broadcasting System	7,500 watts
New York City—W2XBS	National Broadcasting Company	12,000 watts
New York City—W2XBT	National Broadcasting Co (portable)	400 watts
New York City—W2XDR	Radio Pictures, Inc	1,000 watts
Passaic, NJ—W2XVT	Allen B DuMont Laboratories	50 watts
Boston, Mass—W1XG	General Television Corp	500 watts
Philadelphia—W3XE	Philco Radio & Television Corp	10,000 watts
Philadelphia—W3XP	Philco Radio & Television Corp	15 watts
Philadelphia—W3XPF	Farnsworth Television Corp., Inc of Pa	250 watts
Camden, NJ—W3XEP	RCA Manufacturing Company	30,000 watts
Camden, NJ—W3XAD	RCA Mfg Co (portable)	500 watts
Kansas City, Mo—W9XAL	First National Television, Inc	300 watts
Iowa City, Iowa—W9XUI	University of Iowa	100 watts
Los Angeles—W6XAO	Don Lee Broadcasting System	1,000 watts
Portable-Mobile—W1OXX	RCA Manufacturing Co.	50 watts

Construction Permits

Albany, NY—W2XB	General Electric Co	3,000 watts
Bridgeport, Conn—W1XA	General Electric Co	3,000 watts
Schenectady, NY—W2XD	General Electric Co	40 watts
Schenectady, NY—W2XH	General Electric Co (relay)	40 watts
Chicago, Ill—W9XZV	Zenith Radio Corp	1,000 watts

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Screens for Television Tubes, I. G. Maloff and D. W. Epstein, November 1937, p 31–34, 85–86

20-100 Mc. Signal Generator, C. J. Franks, August, 1936, p 16–18

Scophony Television, March 1936, p 30–33

A New Television Film Projector, Harry S. Bamford, July 1938, p 25

Characteristics of Prosphors for Cathode Ray Tubes, December 1938, p 31

Design and Performance of a Voltage Regulator

THE INFORMATION BELOW has been obtained from the Application Note No. 96 issued by the RCA Radiotron Division of Harrison, N. J., concerning the design and use of voltage regulators for use with electron tubes. The diagram shown in Fig. 1 shows the series regulator tube (type 2A3 or 45) whose grid is regulated by the type 6J7 control tube. A 2-watt neon lamp is used to provide cathode bias in this latter

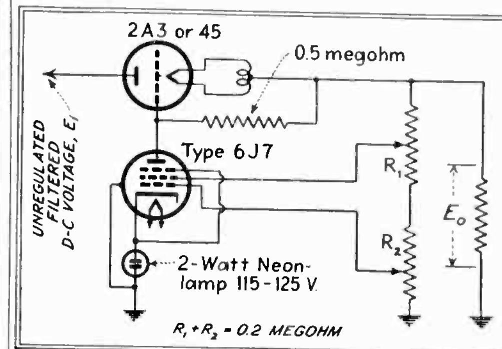


Fig. 1—Wiring diagram of voltage regulator

tube, and the voltage across the neon tube is substantially independent of current.

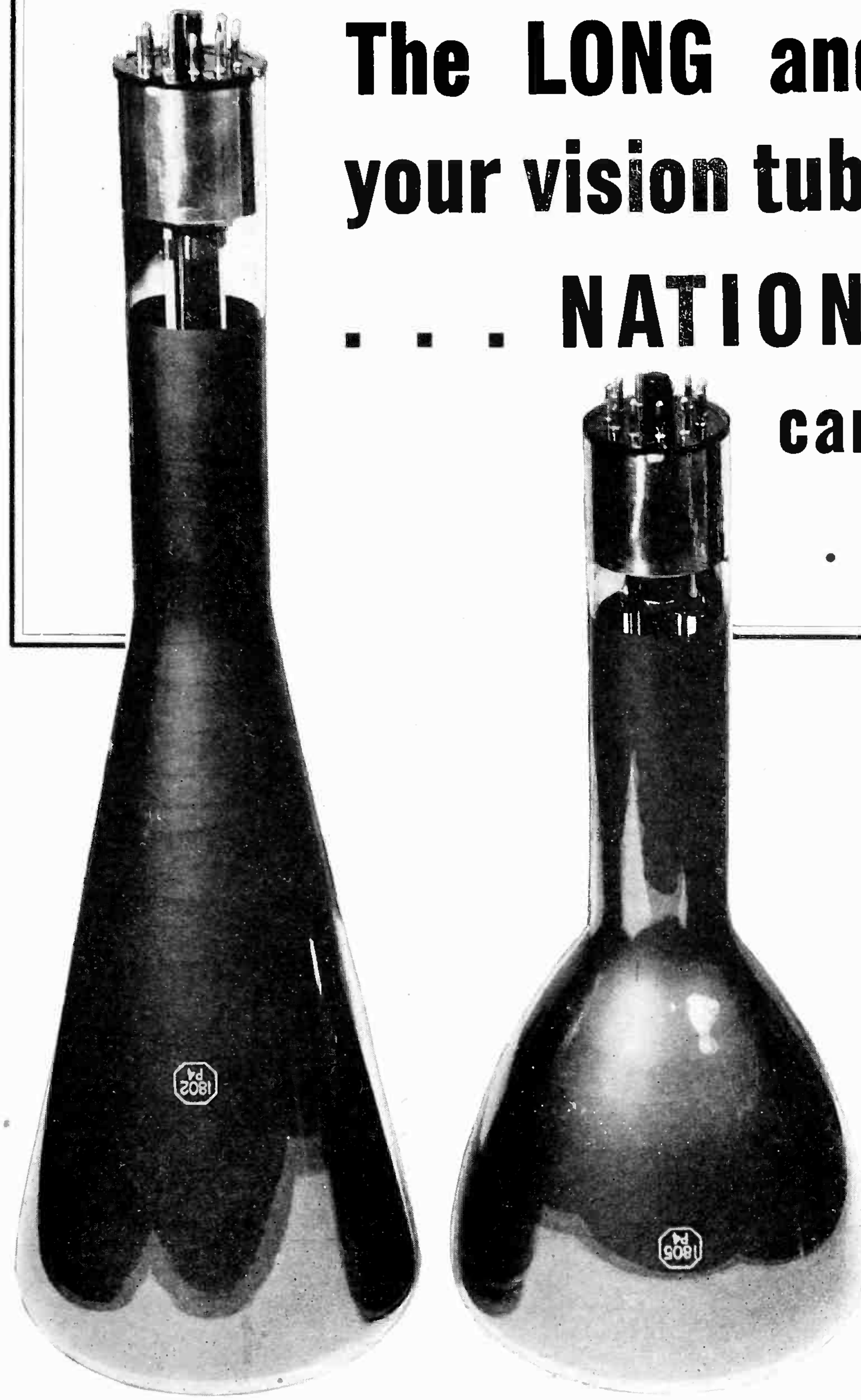
If the load current tends to increase for any reason, the output voltage tends to go down and the voltage across the grid of the 6J7 and ground is reduced in proportion. The voltage across the neon tube, which is in series with the cathode and grid of the 6J7 remains constant. The net result is an increase in the negative bias of the 6J7 tube. The plate current of this tube therefore falls and the bias value across the 500,000-ohm grid resistor decreases. The regulator tube therefore decreases in re-

• • •

MAGNETICALLY OPERATED TUBE

Shown undergoing tests is the "permatron"—a magnetically controlled electron tube invented by P. L. Spencer and intended primarily for industrial use.

The LONG and SHORT of your vision tube problem is . . . NATIONAL UNION can supply them . . . NOW!



TYPE 1802, Long 5"

NEW TYPE 1805, Short 5"

Look at the new SHORT 5" tube shown here with longer mate . . . this is National Union's latest contribution to the art of making vision tubes . . . National Union can supply either style and the characteristics are similar. Write for prices and data.

Read These Features of N. U. Videotrons*

1. Designed for television reception.
2. High brilliance.
3. Non-magnetic deflection plates.
4. Ceramic mounted gun.
5. No defocus along trace.
6. Good modulation characteristics.
7. Constant sensitivity.
8. Perfect trapizium correction.
9. Clean sharp focus.
10. 441 line definition.
11. No defocusing at extremes of sweep.

* Trade Mark

OTHER NATIONAL UNION VIDEOTRONS INCLUDE:

Type	Nominal Diam.	Max. Overall Length	Screen Color	Deflection
2002	2"	$7\frac{7}{16}$"	Green	Electrostatic
906-P1	3"	$11\frac{7}{8}$"	"	"
906-P4	3"	$11\frac{7}{8}$"	White	"
1803-P4	12"	$25\frac{3}{8}$"	"	Electromagnetic
1804-P4	9"	$21\frac{3}{8}$"	"	"

Monotron Picture Signal Generator Tube

Type	Nominal Diam.
2030	3"

For Prices and Data Write: NATIONAL UNION RADIO CORP., Newark, N. J.

CABLE ADDRESS: TUBES NEWARK

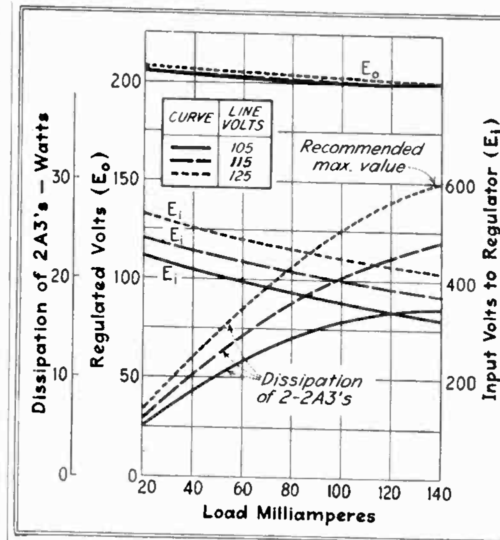


Fig. 2—Performance characteristics of regulator using two type 2A3 tubes

sistance, thus increasing the load voltage, and the desired regulation action is obtained. The performance of the circuit using two type 2A3 tubes is shown in Fig. 2. The maximum load current in this case is 140 milliamperes and the regulated voltage is in the vicinity of 200 volts. It will be noticed that throughout the range from 20 to 140 milliamperes the change in voltage remains within plus or minus 2 volts, and is practically independent of the line voltage applied to the rectifier. It is recommended that an aging period of approximately 30 hours be allowed to bring the neon tube to stable operation.

In connection with the use of neon lamps as bias devices, the editors have received word from Mr. H. M. Ferry of the Commercial Engineering Department of the G. E. Vapor Lamp Company to the effect that neon glow lamps without resistance in the base are available throughout the range from ¼ watt to 3 watts. A bayonet-type socket of good construction is available from the G-M Laboratories, Chicago, Ill., for use with these lamps.

• • •

ELECTRONIC PIANO

Details of the "Novachord," which resembles the piano but which can be played to simulate the tones of many other instruments are shown to the conductor Arthur Bodansky, by Frank Day.

Step-Up the Performance
of High-Frequency Parts
with low-loss Bakelite Plastics

Tube sockets, condenser brackets, antenna terminal strips, and cases, forms and bases for coils in the new "110" National Co. Receivers are made from Bakelite Polystyrene. Molded by Thomas Mason, Inc.

NEW OPPORTUNITIES for improvements in the design of electronic equipment are now open to you through use of Bakelite Low-Loss materials. Even for *ultra*-high-frequency devices, you can obtain special Bakelite insulating materials that furnish a unique combination of electrical and mechanical advantages.

For example, consider the new "110" experimental receiver pictured. Six vital parts made from Bakelite Polystyrene molding material contribute much to its fine performance at wave-lengths as low as one meter. The material, itself, possesses a power factor of less than .0002 at 1,000,000 cycles! Its mechanical strength, toughness and adaptability to accurate forming aid compact, durable design.

Other Bakelite plastics include special phenolic low-loss plastics and many other dielectric and decorative materials. They present unlimited possibilities for betterment of your products.

Step-up the electrical performance of your products...improve their appearance to win added sales...by applying Bakelite plastics throughout your design. Write for Portfolio 13 of detailed booklets describing these materials.

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At this single central source, more than 2,000 plastic materials are available, including molding materials, laminated stock and insulating varnishes of unusual value to radio designers. They offer wide selection of color, transparent or opaque effects, toughness, power factor and other characteristics.

Fill your needs more accurately with Bakelite POLYSTYRENES, UREAS, CELLULOSE-ACETATES, PHENOLICS.

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PLASTICS HEADQUARTERS

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THE ELECTRON ART

Characteristics of luminescent materials, electronic voltage stabilizers, determination of e/m, and the characteristics of magnetron oscillators included in this month's technical news

Characteristics of Phosphors

THE JANUARY ISSUE of the *Journal of Applied Physics* contains an article entitled "Electrical and Luminescent Properties of Phosphors Under the Electron Bombardment", by W. B. Nottingham, containing results of investigations made on zinc-orthosilicate, calcium-tungstate, zinc-sulfide: and cadmium-sulfide plus zinc sulfide. These materials are those most commonly found in cathode ray tubes for oscillographic or television work.

The results of this summary indicate that:

1. For low current densities, light output per unit area is accurately proportional to the current densities. This is the equivalent when using low current densities of saying that light per unit of current is constant.

2. With increased current density the light per unit current at constant voltage falls by an amount which depends primarily on the current density.

3. Except for the zinc-sulfide; cadmium phosphor, the light per unit at low densities as a function of the electron energy, V, is proportional to some power of the voltage, V, the exponent being approximately 2 in most cases.

4. Secondary emission properties of insulated phosphors operating in high vacuum determine the maximum useful operating voltage.

Luminescent Material

THE FUNDAMENTAL PROCESSES governing both the excitation and emission of radiation in luminescent material are studied in an article entitled, "Light Output and Secondary Emission Characteristics of Luminescent Material" by S. P. Martin and L. B. Headrick, which appears in the February issue of the *Journal of Applied Physics*.

The authors' summary is as follows:

Light output and screen potential data are given for zinc sulphide, calcium tungstate, willemite and several orthosilicate phosphors sprayed (from suspension) on Nonex glass and bombarded by electrons. The bombarding voltage range of from 0.5 to 10 kilovolt tubes is covered. The limiting potential of willemite and other zinc silicate screens fall in the range of 6 to more than 10 kilovolts, depending on the condition of exhaust and preparation. The limiting potential of two zinc sulphides fall in the range from 6 to 9 kilovolts, while calcium tungstate has a limiting potential usually less than 5 kilovolts. Light output as a function of screen voltage over the range from 0.5 to 10 kilovolts is shown to follow a law of the form:

$$L = Af(i)\,V^n$$

where L is the intensity of light, i is the current density, V is the electron energy at the screen in kilovolts, and A is a constant. The data show that $n<2$ for willemite or other zinc silicates, $n = 2$ for sulphide, and $n>2$ for calcium tungstate and a fused layer of willemite. Analysis and comparison of the light output current density characteristics of the persistence characteristic shows that a definite relation exists between them in the case of silicate phosphors. The function of current amplitude may be represented by,

$$f(i) = Ai\left\{\left[1 - \left(\frac{a}{a+b}\right)\right]e^{-\alpha/\beta i} - \left[b/(a+b)\right]e^{-\gamma/\beta i}\right\}$$

The constant α and γ are those appearing in the persistence characteristics of the material as:

$$L = [a/(a+b)]\,e^{-\alpha t} + [b/(a+b)]e^{-\gamma t}$$

a formula which expresses well the persistence of silicate screen.

STANFORD RHUMBATRON

Generating equipment capable of producing substantial power at 10 cm. has been developed at Stanford University. Inspecting the equipment are, in clockwise order, Russell H. Varian, kneeling, Sigurd Varian, David L. Webster, William H. Hansen, and John R. Woodyard.

London Exhibit of Scientific Apparatus

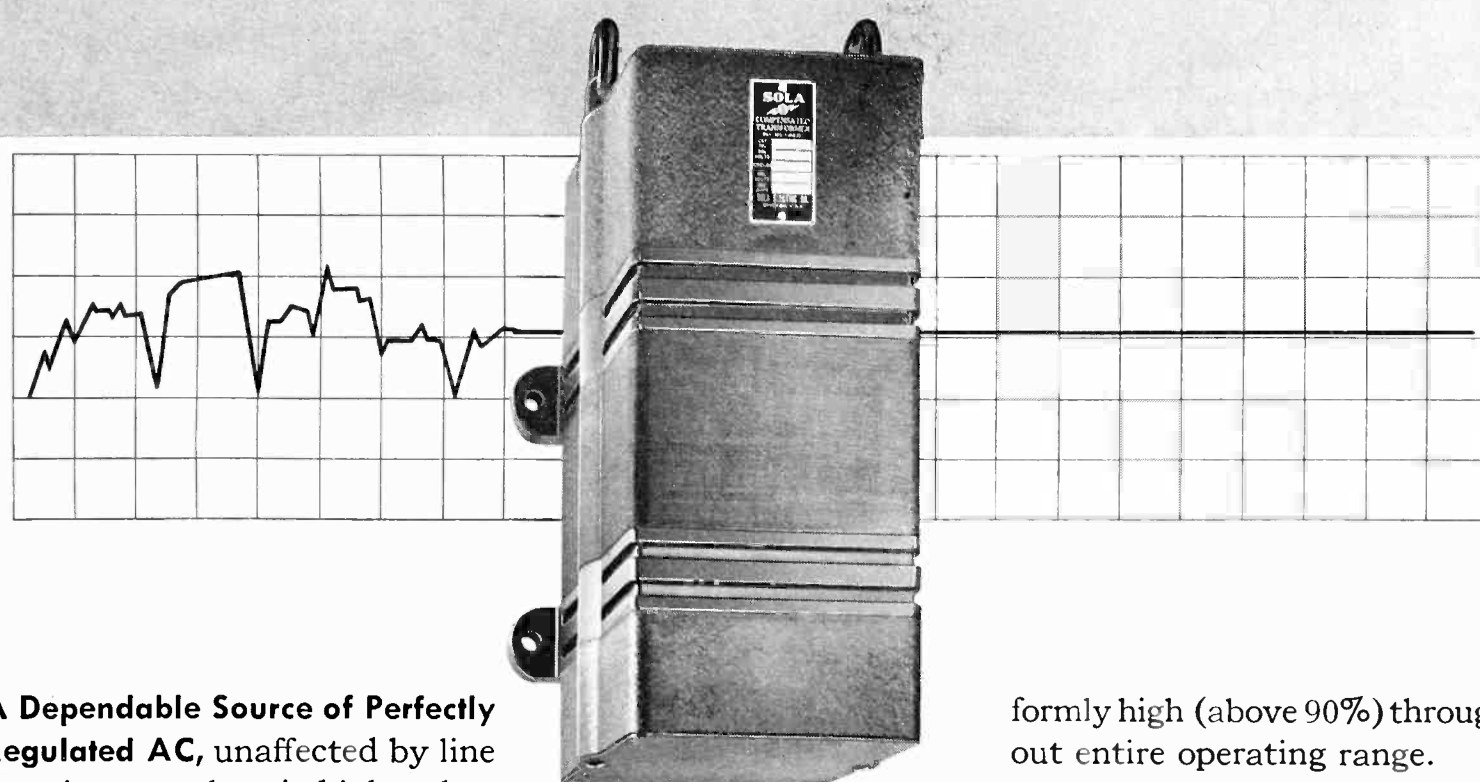
BY JOHN H. JUPE
London, Eng.

The annual exhibition of the Physical Society, held in London recently, introduced many new and interesting instrument features.

Electron tubes were prominent and the double beam oscilloscope, shown for the first time last year, was offered in a low priced, revised form as a mains operated unit, capable of showing practically any two cathode ray tube phenomena simultaneously. Another exhibit showed a standard oscilloscope arranged to show four separate traces at once. This was accomplished by switching each of four circuits on to the cathode ray tube in turn and fast enough to allow the persistence of vision to cause the illusion of simultaneous presentation.

Few new photocell uses were exhibited but an ingenious set-up for

Announcing . . . a new
CONSTANT VOLTAGE TRANSFORMER



A Dependable Source of Perfectly Regulated AC, unaffected by line transients or chronic high or low voltage levels. A highly perfected, commercially practical unit. Smaller . . . more compact . . . low enough in price to be within the range of production equipment applications. Consider carefully then a few of the many outstanding advantages of this new SOLA Constant Voltage Transformer:

Constant Output Voltage Maintained to within ±1%, from any input within the specified limits.

Low Harmonic Content. Practically no distortion of output wave form over entire operating range.

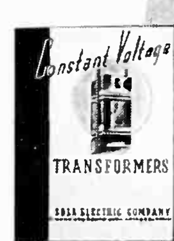
High Efficiency. The general over-all efficiency closely approaches that of a well designed double-wound transformer.

High Power Factor. Input power factor is uniformly high (above 90%) throughout entire operating range.

Automatic Regulation and Trouble-Free Operation. No moving parts. Nothing to adjust or lubricate. Regulation is instantaneous, continuous and absolutely dependable. No maintenance or replacements necessary.

Self-Protecting. Both transformer and associated circuits protected against damage by accidental short circuits.

Unlimited Flexibility of design and capacities to meet practically any requirement.



BULLETIN SM-22

A bulletin giving complete engineering data available on request. Write for it on your letterhead.

SOLA ELECTRIC COMPANY

2525 CLYBOURN AVE., CHICAGO, ILLINOIS

SOLA CONSTANT VOLTAGE TRANSFORMER

rectifier type cells was shown. The object was to use these cells in conjunction with robust relays but without the necessity of tube amplification. A saturable reactor has two windings on its core and one is connected in series with supply mains and a heavy current contactor. The other is connected to the cell. When the cell is illuminated the resultant current flowing in the winding is sufficient to change the core flux, alter the impedance of the contactor winding and so allow it to operate. Control of a 15 amp. 240 volt, non-inductive load is possible.

Almost limitless scope in industrial electronics has been opened in another direction by the introduction of commercial apparatus for determining various chemical and physical changes in terms of electrical capacitance.

The principle of operation depends on the hetrodyning of a quartz crystal stabilised circuit with a test circuit, in which are two variable condensers in parallel with a measuring cell. Adjustment or calibration is carried out by means of standard condensers of known capacitance or with chemicals that have definite dielectric constants. If absolute measurements are not required, the instrument can be calibrated in other qualities such as moisture content, polymerization stages, etc.

A new thermo-couple instrument was shown, in which ranges are changed by plugging in different couples, exactly as radio tubes are plugged into sockets.

Every year new radio- and audio-frequency instruments are being produced and this exhibition introduced some

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SCIENCE IN BRITISH ARMY

A Vickers anti-aircraft "predictor" shown above is operated by a crew of six men, and gives bearing, elevation and fuse settings. The instrument corrects for wind, variations in barometric pressure and path of the trajectory. The instrument was exhibited recently at the Science Museum, South Kensington, London, by the British Army

good ones. One of these is a commercial model of a noise meter calibrated in phons. Particular care has been taken that intermittent and impulsive sounds are assessed correctly, as these form a large percentage of the man-made noises. A piezo-electric, non-directional microphone is used.

Wave analysis has been made easier by the introduction of a portable instrument capable of dealing with either complex audio frequency waves or the modulation components of radio frequency ones. This instrument can also be used as a direct reading voltmeter, responding to only a narrow band of frequencies. Range: 100 μv to 300 v. Input impedance at audio frequencies, 1 megohm.

Although not electrical, a typewriter was on show, that has been specially made in Germany for scientific work and is the only one of its kind in England. It has 135 characters but only the normal number (45) of keys. This is done by using two shifts and the particular machine is fitted with an assortment of Greek letters and mathematical symbols.

Numerous bridges and test sets were shown for the first time and the following is a typical example.

A precision universal inductance bridge has a range of 1 μh to 100 h and is accurate to $\pm$ 0.1%, and 10 $\mu\mu$f to 1 μf, with accuracy of $\pm$ 0.2%.

Electronic Voltage Stabilizers

ACCORDING TO an article by F. B. Hunt and R. W. Hickman, "On Electronic Voltage Stabilizers" in the January issue of the *Review of Scientific Instruments*, voltage stabilizing circuits employing thermionic tubes can be classified according to tube operation.

All of the stabilizing circuits can be divided into the following classes: (1) Circuit derived from the bridge circuit for measuring the variational transconductance of triode. (2) Circuit derived from the bridge circuit for measuring the variational amplification factor of triode. (3) Circuit derived from the single stage degenerative direct amplifier. (4) Combination circuit built up from the foregoing classes or circuits formed by adding one or more stages of amplification to one of the foregoing classes.

The author describes each type of stabilizer, and derives the essential

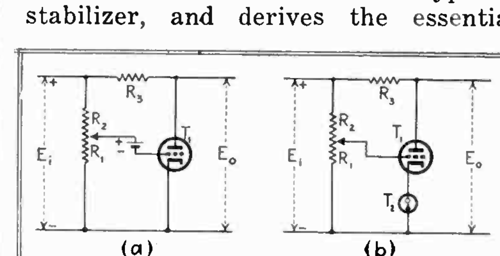
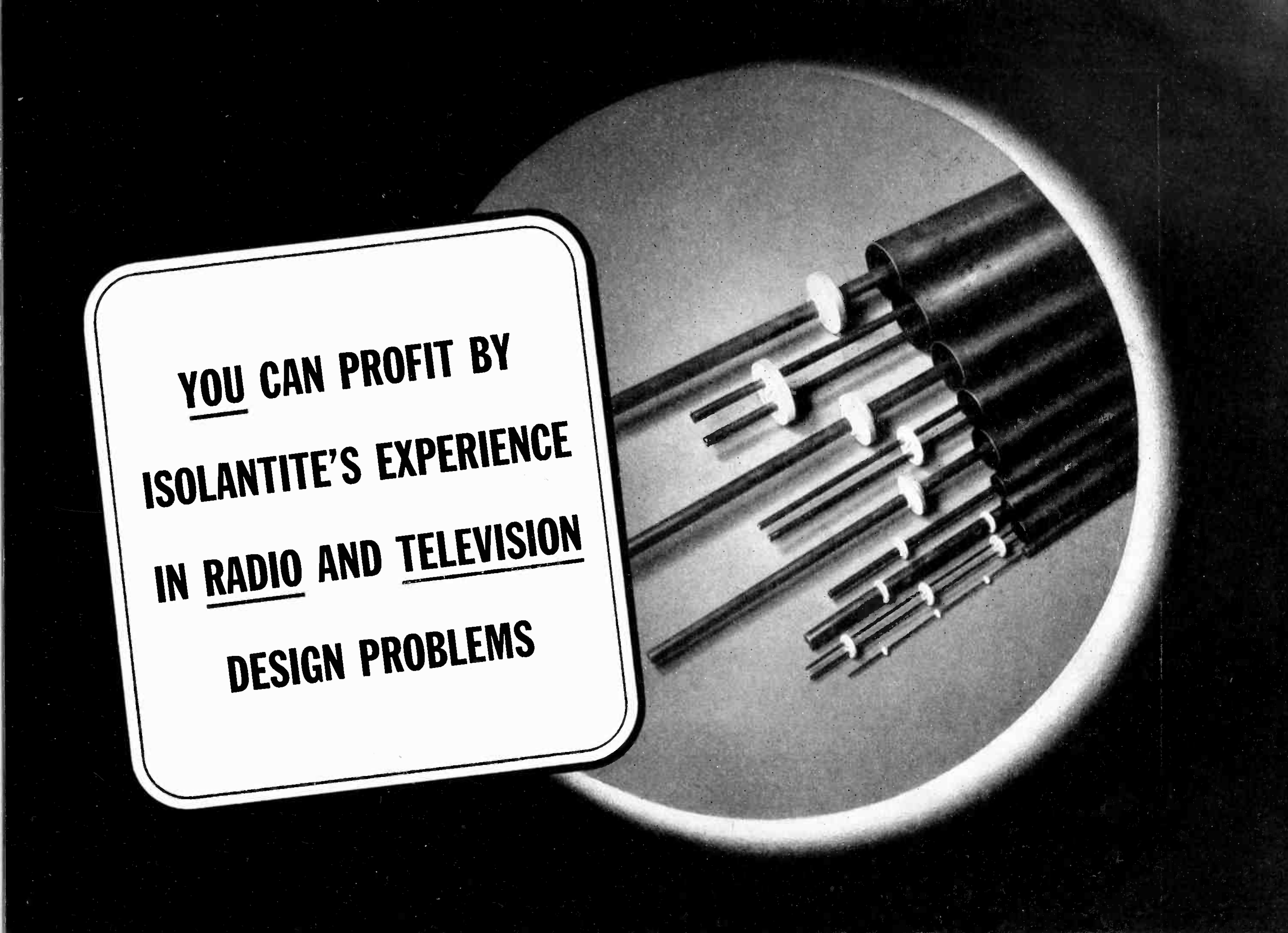


Fig. 1—Schematic diagram of two modifications of the transconductance type of voltage stabilizer

equation of operation for each type. The vacuum tube bridge circuit such as that suitable for the determination of transconductance or amplification



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factor may be used as voltage stabilizers under the proper conditions. Fig. 1 shows two modifications of the trans-

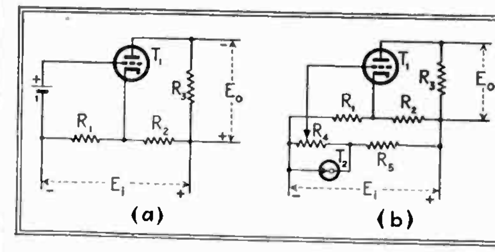


Fig. 2—Two types of voltage stabilization based upon amplifier type of stabilizer

conductance type of stabilizer, Fig. 2 shows two possibilities of the amplification type of stabilizer, while Fig. 3 gives two examples of a stabilizer em-

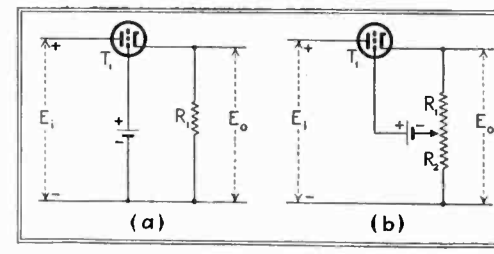


Fig. 3—Elementary diagrams of two types of voltage stabilizers making use of degeneration

ploying degeneration. Through the use of various combinations of the fundamental forms, combination circuits may be derived which have certain advantages over the elementary circuit.

Fig. 4 shows one type of transconductance type stabilizer circuit with an amplification factor circuit arranged to provide a stabilized bias voltage.

An amplification type stabilizer circuit arranged so that amplification of control grid voltage allows a favorable selection of the resistor is shown in Fig. 5.

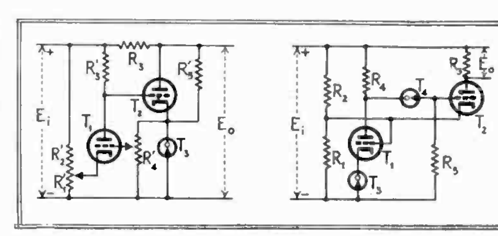


Fig. 4—Left. Circuit of transconductance type of stabilizer with stabilized bias voltage. Fig. 5—Right. Circuit for amplifier type of stabilizer

It is pointed out by the author that in general the circuit of the bridge type, such as is shown in Figs. 1 and 2, will be most suitable when the stabilizer is intended for operation at no load or some constant load. A circuit of the transconductance or amplification factor variety, such as that of Fig. 4 or Fig. 5, will be chosen according to whether the output is to have the negative or the positive side grounded. When the stabilizer is to provide a variable load current or one having alternating components, or when the output voltage is to be continuously adjustable, a unit having a low internal resistance is desirable.

Characteristics of Magnetron Oscillators

One of the design considerations in the split-anode magnetron is the slot angle, i.e., the angle subtended by the slot at the anode axis. The results of an experimental determination of the effects of the slot angle on the power output and efficiency of a negative resistance magnetron oscillator operating with constant anode current are given by Leo Rosen in the November, 1938 issue of the *Review of Scientific Instruments*, in an article entitled "Characteristics of a Split-Anode Magnetron Oscillator As a Function of Slot Angle."

A number of split anode magnetrons were constructed, all of which were essentially similar except for the variations of slot angle. The maximum power output and the efficiency of each of these tubes were then measured for a given field strength, anode current, and wave length. The tubes were compared at equal field strength and plate current, according to the following procedure:

1. The field current was set to the desired value.
2. The maximum filament current was adjusted to the proper value.
3. The emission current was set to the desired value.
4. The plate voltage, load position on the Lecher wire system, and the angle, θ, which the axis of the tube makes with the magnetic field, were adjusted successively until maximum output was obtained, as measured by means of a load consisting of an incandescent lamp.
5. The magnetrons all operated at a wave length of 1.7 meters and a record was made of the field current, the plate current, the angle between the magnetic field and the anode axis, the plate voltage, and the load position on the Lecher wire system.

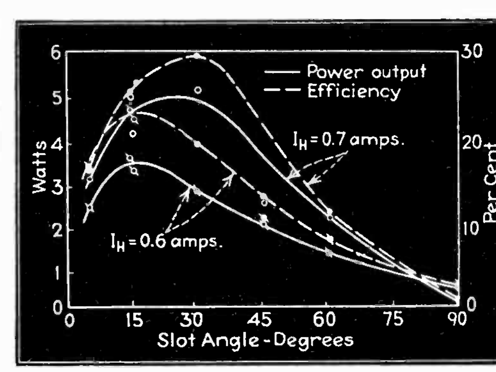


Fig. 1—Curves showing the efficiency and output of magnetron oscillator as a function of slot angle

The diagram shows the power output and efficiency plotted against the slot angle. From this experimental study, it is evident that maximum power output, at a given frequency, field strength, and plate current, is obtained if the anode slot angle lies between approximately 15 and 30 deg., when the magnetron is operating as a negative resistance oscillator. The exact slot angle is not critical, as the curves show a broad maximum between 15 and 30 deg.

Precision Determination of e/m

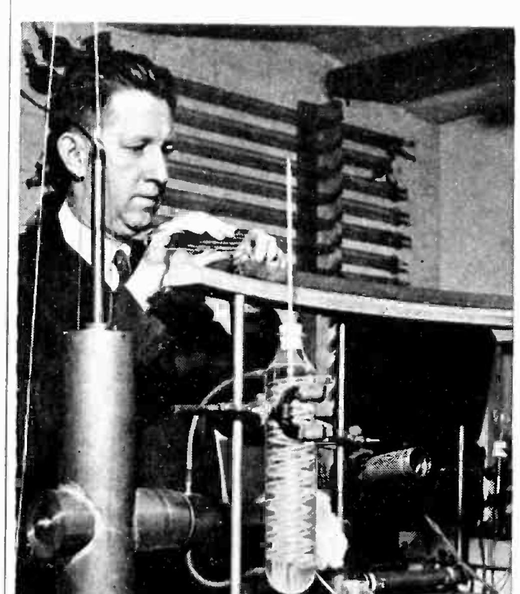
In its "Resumés of Recent Research" a new precision method for the determination of the charge-to-mass ratio for electrons is summarized in the December issue of the *Journal of Applied Physics*. The new method of determining this important ratio has been developed by Dr. A. E. Shaw, of the University of Chicago, and is recorded in a recent issue of *Physical Review*. The method does not require a knowledge of the velocity at which the electron travels, which is necessary in practically every method thus far developed for determination of the charge-to-mass ratio. In the method developed by Dr. Shaw, the electrons are focussed under the simultaneous action of the electric and magnetic fields so that the electron travels in a circular path. Electrons are emitted by an incandescent filament and pass through a narrow slit in a cylindrical condenser, where they are collected by means of an anode or collector electrode. For this method, the ratio of the charge-to-mass is

$$\frac{e}{m} = \frac{4E}{H^2\rho}$$

where E is the electric field intensity, H is the magnetic field intensity and ρ is

• • •

MEASURING CHLOROPHYLL CONCENTRATION



Dr. Earl S. Johnston, of the Division of Radiation and Organisms, Smithsonian Institution, is shown here with a device he has perfected for measuring the concentration of chlorophyll—the green coloring matter of grass and leaves. Solution is placed in the beam of light which falls on the thermocouple. The greater the amount of chlorophyll, the greater the absorption of light, and consequently, the smaller thermocouple reading

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Photograph of three simultaneous electrical phenomena on a 330C screen.

Photograph of a high-speed transient taken with 326C tube. Fundamental frequency of oscillation is 1 megacycle, with 3 megacycle component showing. Vertical line (right) represents a spot speed of 63 Km/sec. on screen of tube.

Left to right: The 325 type, 326 type and 330 type Cathode Ray Tubes.

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GENERAL CHARACTERISTICS

	325 TYPE	326 TYPE	330 TYPE
Max. Length (in.)	16½	22	23-1/16
Max. Screen Diam. (in.)	4⅝	7⅛	7⅛
Heater Voltage	5.0 Volts	5.0 Volts	5.0 Volts
Heater Current	0.55 Amps.	0.55 Amps.	1.65 Amps.
Accelerating Voltage	1000-5000 Volts	1000-5000 Volts	1000-5000 Volts
Deflection Sensitivity with 2000 volts Accelerating Potential	130 Volts/inch	80 Volts/inch	80 Volts/inch

SCREEN CHARACTERISTICS

325A, 326A, 330A	325B, 326B, 330B	325C, 326C, 330C
Green. Medium persistence, for visual observation and photography with green-sensitive film.	Blue-green. Long persistence, for observation and photography of non-recurrent and low frequency phenomena.	Blue. Highly actinic, for photography with blue-sensitive film.

the radius of curvature of the circular orbit.

The value of e/m obtained with this apparatus is $(1.7571 \pm 0.0013) \times 10^7$ electromagnetic units. With the present equipment, no attempt is made to obtain the maximum possible precision, but it is hoped to make additional measurements with a probable error of one part in 3000, or less.

Matching R-F Lines

A SIMPLIFIED TREATMENT of the matching lines problem is to be found in the "Review of Simple Transmission Theory Relating to the Matching of Radio Feeder Lines", in the October 1938 issue of *The Post Office Electrical Engineer's Journal*.

This article treats of the problem of inserting a matching line of impedance Z_m between a load of impedance Z_r and feeders of impedance Z_o (or Z_k), so that the impedance at the end of the matching line remote from the load, to which point the feeders are to be connected, is Z_o. The presentation is in simple form so as to fulfill the author's aim to clarify these equations, especially to those who lack technical class facilities or text-books on the subject.

The author indicates clearly his derivation of the matching formulae for aerial loads and shows its extension to problems requiring more than one matching line. A two-matching line system is shown in Fig. 1. This proves

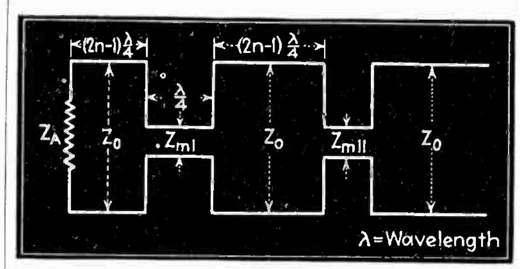


Fig. 1—A two wire matching line system

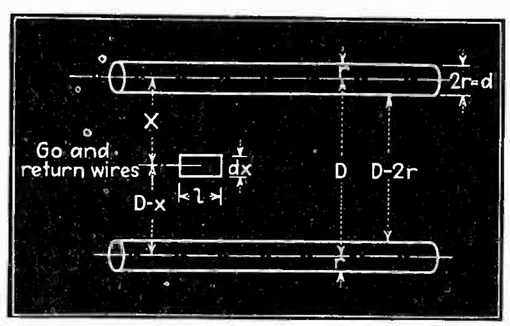
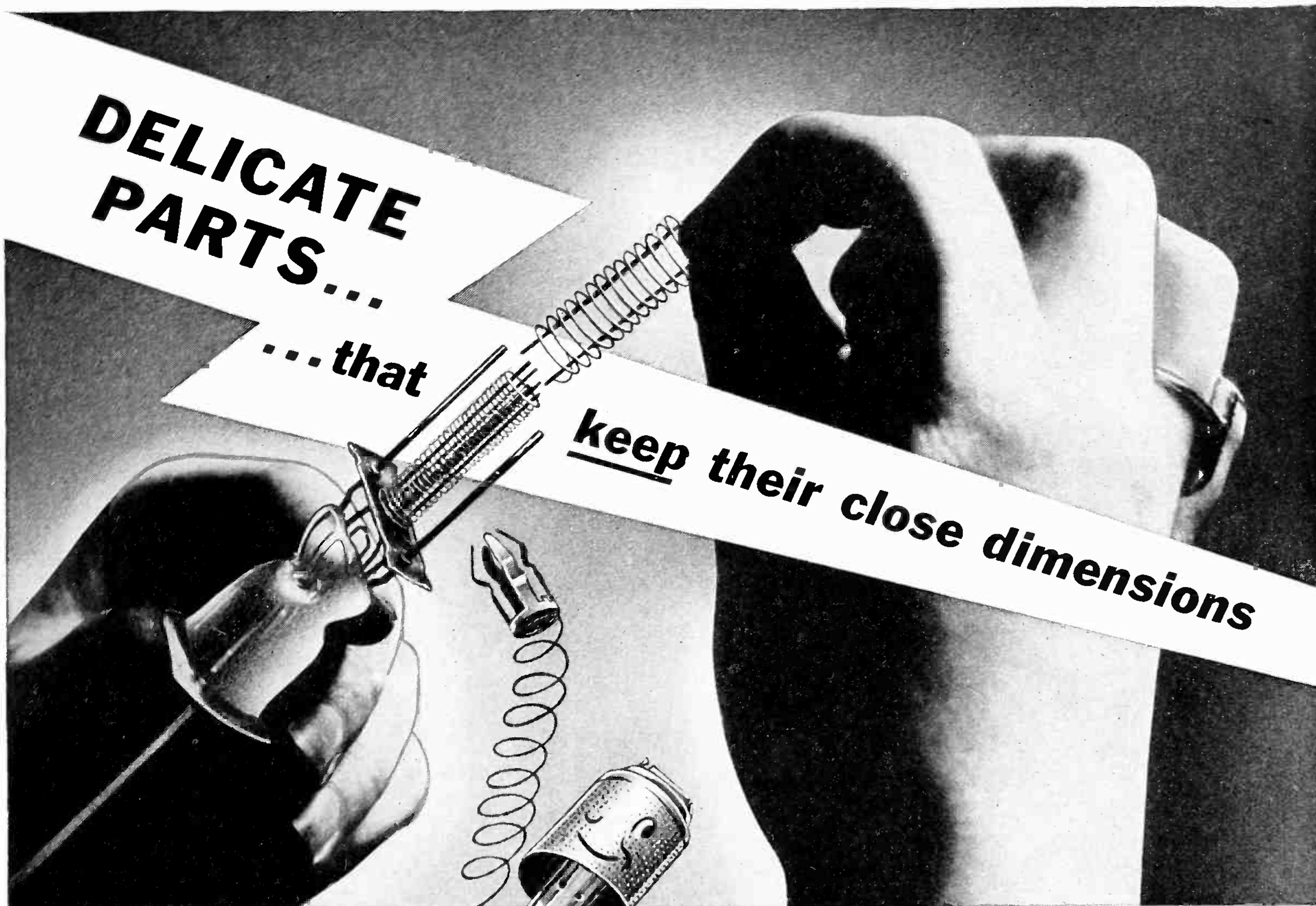
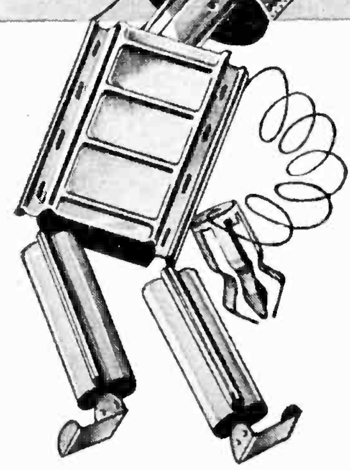


Fig. 2—Transmission line upon which the theoretical analysis is based

useful in situations where Z_{m_I} has been found to be insufficient. In this case $Z_{m_{II}}$ is inserted, usually λ/4 behind Z_{m_I} and away from the load.

Using the well-known fact that at high frequencies the surge impedance of a line is essentially $Z_o = (L/C)^{\frac{1}{2}}$ ohms, he proceeds to find L and C from a diagram such as Fig. 2 and shows by elementary calculus the derivation which leads to the final value of $(L/C)^{\frac{1}{2}}$. This result he gives as 120 $\log_e D/r$ or 276 $\log_{10} D/r$ ohms.





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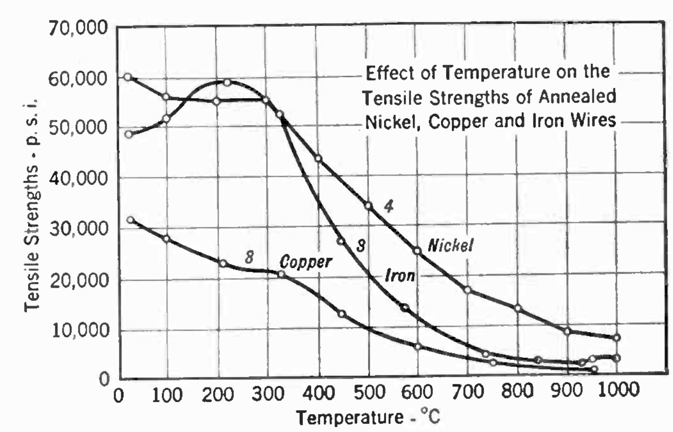

Precision-made tube parts turned out by the million—what holds them to close dimensions? What metal, in such intricate forms, can withstand handling and mounting, and also bombardment at temperatures up to 1875° F.?

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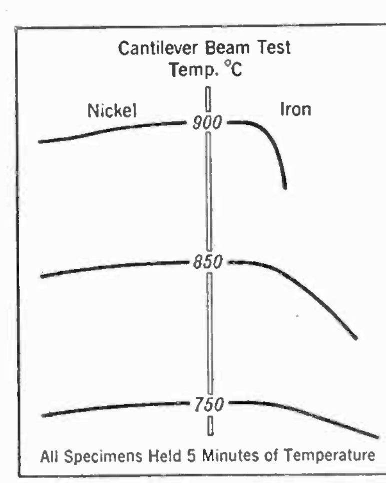

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THE INDUSTRY IN REVIEW

Dual Diversity Reception Simplified

By McMURDO SILVER

E. I. Guthman & Co., Inc.

RECENT articles dealing with dual diversity reception methods appear to have aroused much interest in amateur and communication circles. A new and greatly simplified method of dual diversity reception has recently been disclosed by the writer. It retains the advantages of the multiple receiver diversity method, but eliminates the increased cost, noise and bulk necessary to this type of receiver. This new method may be reduced to a small accessory unit which will function in conjunction with any superheterodyne receiver having an if of between 450 and 480 kc either with or without avc and almost regardless of age.

Proceeding from the premise that a fading signal does not fade simultaneously on two different antennas and that generally the signal can be found on one of two antennas in the same plane if they are a wave length apart, or on one of two antennas when one is in a vertical plane and one in a horizontal plane, a method was developed of automatically switching from one to the other, this switching action following the signal phase shift or fading.

In the first experimental models a SPDT switch actuated by the fading signal did not prove entirely satisfactory because the signal phase shift was not invariably exactly 180 deg, but often was but a fraction of 180 deg, although the phase shift usually did complete a 360 deg cycle. The switch was also discarded because of the click unavoidably associated with its make and break contacts, not to mention the upset in the receiver avc system during the brief interval of time during which it had no antenna connected. Despite these disadvantages, this direct antenna switching system worked and proved the soundness of the basic concept.

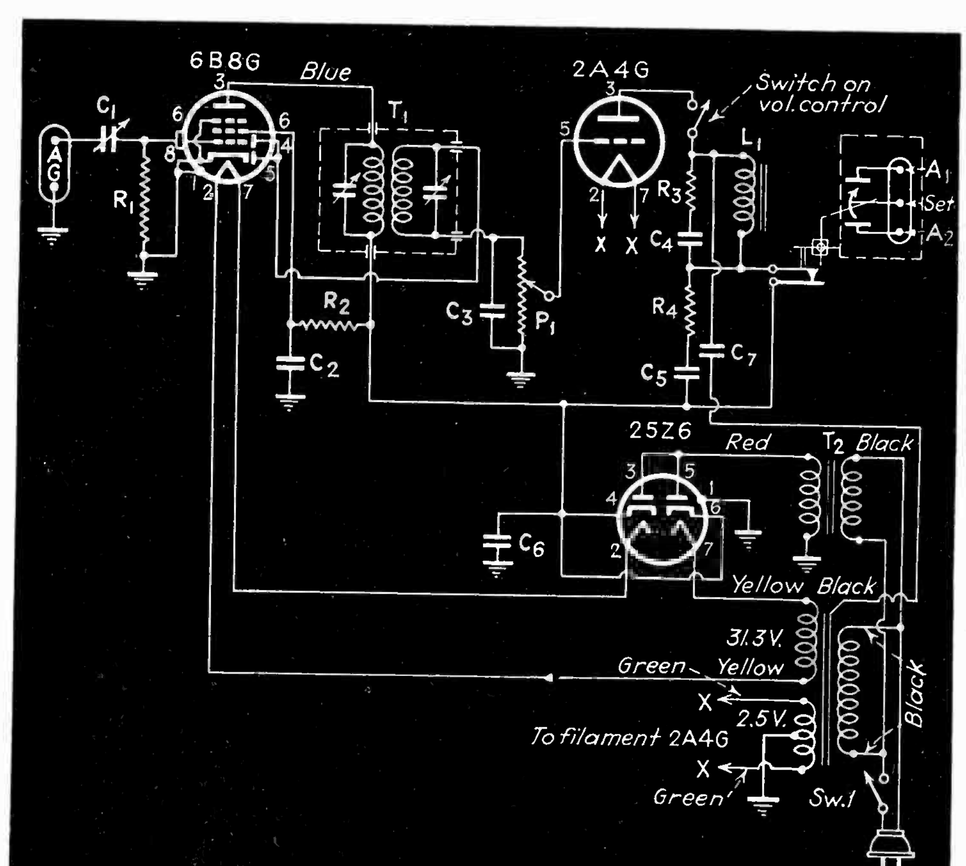
Some means of automatic antenna selection was needed which was not abrupt and so would not introduce noise due to its own operation. An ideal antenna selecting method would have to be able to combine in varying degree the signal voltage from the two antennas, as well as to simply select between them. The solution of this problem lay in the use of a balanced, or differential, variable condenser having two stator sections with a common rotor. Its rotor was connected to the receiver antenna terminal, a horizontal antenna was connected to one stator and a vertical antenna to the other stator. Rotation of this balanced condenser provides the conditions of one or the other antenna with a series condenser, or portions of both antennas, connected to the receiver through the common rotor of this differential condenser.

Analysis confirmed by experiment indicated that the same relay in conjunction with a 2A4G tube used in the experimental direct antenna switching system, when augmented by a suitable amplifier and rectifier, was an ideal means of operating the differential antenna selecting condenser. This relay was equipped with a rotating shaft, which was connected by means of Bakelite gears to the condenser shaft, the relay action being communicated to the two shafts by means of a ratchet. This proved to be the simplest method of effecting the desired antenna selecting action.

Simulation of the condition of five distinct antenna angles was affected by a ratchet having eight teeth, the eight-tooth ratchet giving 45 deg of rotation for each relay impulse. Experimentally a sixteen-tooth ratchet was tried, which gave nine antenna conditions. While this showed some slight improvement over the eight-toothed ratchet on slowly fading signals, the eight-toothed ratchet proved to be more satisfactory, for rapid movement sometimes becomes imperative upon rapidly fading signals. The sixteen-toothed ratchet necessarily requiring twice as many ratchet impulses to complete a cycle, the change from one antenna to the other required twice as long, and under some reception this movement was found not to be rapid enough to follow a rapid phase shift.

Where one antenna may have a better signal-noise ratio than the other, the coupler will locate on the antenna having the best signal-noise ratio. This is because the noise impulses, being of short duration, do not develop sufficient voltage at the grid of the coupler amplifier tube to control the 2A4G. The antenna selecting condenser will then continue to rotate until sufficient control voltage is developed at the grid of the 2A4G control tube from one antenna or the other to temporarily "lock" it.

Rotation of the antenna selecting condenser being dependent upon the ratchet for positioning, it can be understood that, as the signal fades, the relay being actuated by the 2A4G which is in turn controlled by its amplifier and signal voltage from the receiver, the



Circuit diagram of diversity reception set-up

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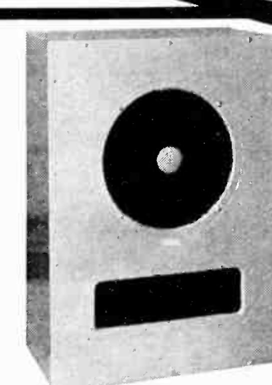

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antenna selecting condenser will continue to rotate until it finds a signal of sufficient strength to prevent the 2A4G from ionizing and actuating the relay.

Because many receivers still in use do not have amplified avc and in some cases do not have adequate filtering networks to permit taking off a portion of the receiver-developed signal voltage for operation of the diversity coupler, a signal amplifier and rectifier is incorporated in the diversity coupler which facilitates its use as a control medium and enables the coupler to operate with receivers having no avc systems. This amplifier and rectifier provides adequate voltage for proper operation of the 2A4G relay control tube.

From the receiver if amplifier at the plate of the last if tube, a small amount of the if signal voltage is taken through a variable coupling condenser mounted in the diversity coupler, and applied to the grid of a 6B8 pentode-duo-diode tube. An if transformer of conventional design couples the plate of this tube to its diodes. The amplified voltage developed across the diode load resistor is then used to control the 2A4G grid. This built-in amplifier having a voltage gain of 100 and the minimum voltage required to prevent the 2A4G from ionizing being nine volts, the grid of the 6B8 tube need only be supplied with less than one tenth volt for complete control. When the voltage at the grid of the 2A4G tube falls below nine volts the tube ionizes, suddenly increasing its plate current sufficiently to actuate the relay.

To obtain smooth control of this grid voltage a ½ meg potentiometer having a reverse "audio volume control" taper is used as the diode load resistor. This permits a very critical set-up adjustment so that extremely small decreases in signal level to below any level established by the setting of this potentiometer cause the diversity coupler to operate.

It must be realized that the possibilities of this and other methods of dual diversity reception, as they affect the overall signal level to the receiver, are entirely dependent on the presence of a signal on one or both of the antennas in use. In case fade-out becomes complete on both antennas no form of dual diversity reception can be of any help. This simple new coupling system allows almost any operator to enjoy its antifading advantages with existing single receivers, and at very small cost.

"Spatial Expander"

THE following notes describe a system of audio frequency sound projection which has been on demonstration for some time in the office of Maximilian Weil of the Audak Company, and which is released for the first time now. It is a system which, according to its inventor Mr. Weil, overcomes the directional effect at the higher frequencies of the ordinary loud speaker, and

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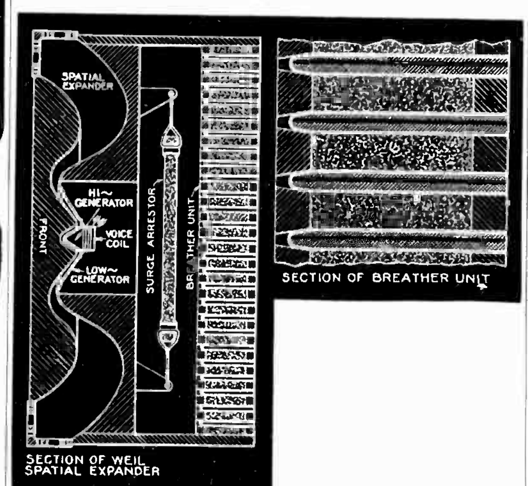
which, at the same time, has other advantages.

It is well known, although not often appreciated, that sound reaching the ear in an auditorium is a composite mixture of directly-transmitted and reflected sound. As much as 85 per cent of the sound reaching the ear may be by reflection. The slight difference in time of arrival of the direct radiation and the reflected sounds produces a "spatial" effect which is not evidenced when the sound originates and is heard in the open air.

A person listening to a program from a radio receiver, however, gets the full power of the machine directed at him; or he sits off the beam of high frequency energy and misses much of the beauty of the program. He does not get the spatial effect. What is desired is some means of dispersing the sounds from the



Details of "Spatial Expansion"

loud speaker so that the listener is really immersed in a sea of sound.

Attempts have been made to break up a beam of high frequency energy. Suppose, however, that sound originating in a radio, or phonograph, were released as a wall of sound extending from wall to wall and from floor to ceiling.

In Mr. Weil's spatial expander system the sound generator is so designed as to make possible a compression chamber wherein the propagation of sound waves takes place in a nearly ideal manner. The sound waves propagate from a point in zero area in the center of the diaphragm to the periphery of the compression chamber over its full circumference.

The part labeled as "front" in the illustration is the forward wall of an exponentially shaped chamber. It is rigidly mounted and located so that its inner area, immediately opposite the diaphragm, is spaced at a carefully predetermined distance from the diaphragms. By this construction sound is discharged into the room from the complete periphery of the expander. This produces the wall of sound desired, instead of a concentrated cone.

One other problem remains, according to Mr. Weil. This is to eliminate the back pressure of sound originating from the back surface of the diaphragm. By "breather cells" this back pressure is dissipated. Two walls spaced about 4 in. apart have the space filled with

sound absorbing material, light and fluffy in nature, and highly effective in their absorbent action. The walls themselves are punched with 2000 holes ⅜ in. in diam. so located that when the walls are properly placed, the holes are concentric. Into each of these holes is forced a tube made of fine mesh metal screen, tapered on one end to assist in easy insertion into and through the material between the walls.

Listening tests indicate a considerable liveness and lack of resonance or beam effects which characterize present-day radio receivers. The construction of the essential elements of the system is shown in the drawings. An installation made for Benny Goodman brought forth the statement "Swing is to freedom of music what this system is to freedom of sound. It is the first time I heard the reproduction of music that really gives the effect of the real orchestra."

Tungsten Treater

EISLER ENGINEERING CO. has brought out a standard type of tungsten rod treating equipment which can be used for treating slugs and rods from 6 inch to 30 ins. long, round or square. The specifications are approximately as follows:

After the tungsten powder is compressed and cindered it must be heat treated. The heat treating is accomplished under a high electric current in the following manner:

The tungsten rod, wire or slug *A* to be treated is placed in a floating spring jaw clip contact *C* on the lower end. The top end of the clamping jaw is held in the stationary jaw *B* and the lower jaw *C* floats in a mercury cup *D* that is cooled by water which circulates through the system. The purpose of the jaw *C* is to compensate the shrinkage which usually occurs during the treating under high current and which sometimes runs from approximately 8 to 15%.

The upper part of the tungsten to be treated is held in a jaw *B*, opened and closed with a handle *H*. After the clamping of the tungsten rod is accomplished the handle *H* is then removed to give the bottle a chance to pass by. Bottle *E* is then lowered into position as shown by the dotted lines. The lower portion of the bottle is also sealed with mercury to prevent any gases from escaping.

After the bottle is lowered into the proper position, hydrogen gas is permitted to flow into the system. The current is then gradually turned on to the required degree of heat. While the operation is being completed, the tungsten slug is continuously under an atmosphere of hydrogen gas. The bottle is made in a double wall arrangement to permit water to flow freely through the entire equipment, not only through the bottle, but also through the rod which supports the upper jaw and the

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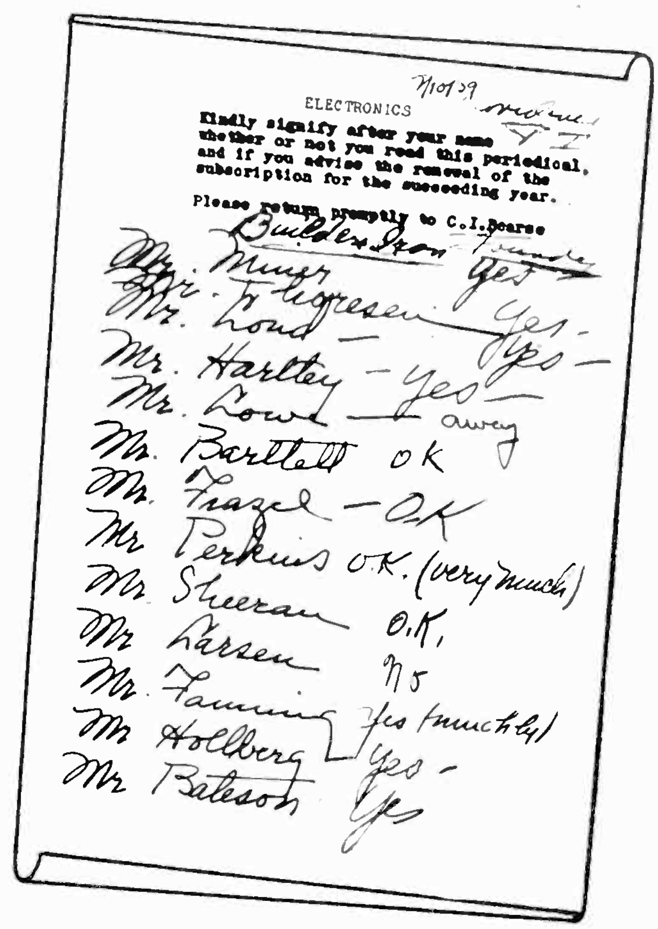
Without words from us, an advertiser can see on this slip the dramatic story of the demand for ELECTRONICS among the engineering and design and production men in a progressive company.


ELECTRONICS

Kindly signify after your name whether or not you read this periodical, and if you advise the renewal of the subscription for the succeeding year.

Please return promptly to C.I.Bearse

Builders Iron Foundry

Mr. Hartley - yes

Mr. Bartlett OK

Mr. Perkins O.K. (very much)

Mr. Sheeran O.K.

Mr. Larsen

Mr. Hollberg

Mr. Bateson

Why This Demand for Electronics?

We wrote to Mr. C. I. Bearse, Purchasing Agent for Builders Iron Foundry, asking him why he found such a demand for ELECTRONICS among members of his Engineering and Sales Staff. Here, in part is his letter to us:

"As you noted from the questionnaire, the response was practically unanimous in favor of renewal of the subscription . . .

"We have checked with our various engineers and they feel that you are doing a mighty good job now in the articles and information which you publish and have no definite suggestions for its improvement.

"Wishing you continued success, we are

Yours very truly,

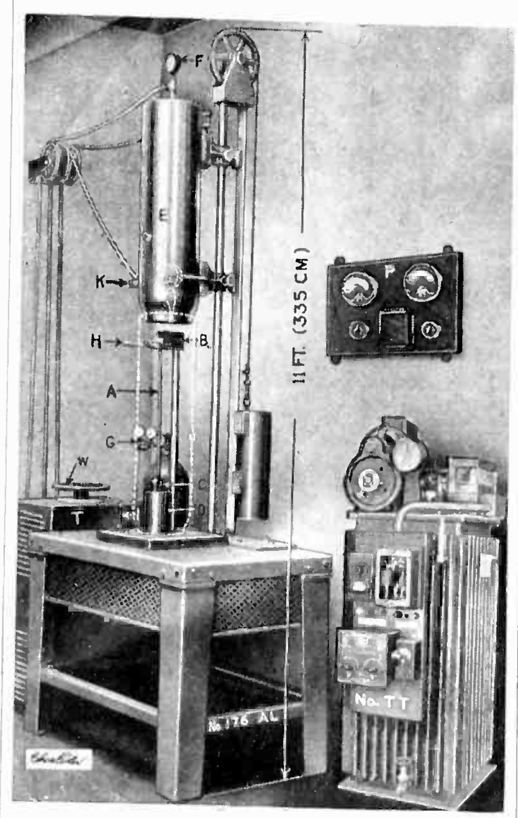
BUILDERS IRON FOUNDRY
By C. I. Bearse (Signed)
Purchasing Agent.

Of course, all companies do not have the size staff of this equipment manufacturer, but a conservative estimate of pass-on circulation for ELECTRONICS is 3.8 per copy. ELECTRONICS reaches every Company — every man — of importance in the electronic and allied fields — subscribers who pay $5.00 a year and more than three times that number who are drawn to ELECTRONICS each month because of its editorial authority and because its advertising pages are a catalogue of materials they need.

PUT YOUR SALES MESSAGE IN ELECTRONICS

jaw *B* itself.

Transformer *A* is used for gradually regulating the current to produce the required degree of heat which is gradually increased in accordance with the proper requirements. This equipment is also supplied with a current controlling and heat regulating device *TT* which automatically increases the current gradually to the required degree of heat until the slug is completely treated.



Eisler tungsten rod treating apparatus

The bottle is provided with a peep hole *P* so that the operator may observe the degree of heat by means of instruments in addition to checking with electrical measuring meters. Gauge *F* is used as an indicator to show the hydrogen gas pressure in the bottle during the course of operation. To check the gas in the bottle, a petcock *I* is provided which can be ignited to make sure that the slug is continuously under an atmospheric pressure of hydrogen.

The flexible rubber tubing shown on the side of the equipment nearest to the gauge *F* is used to permit the hydrogen gas to flow into the bottle under pressure and the two other rubber hoses are used to admit the water into the equipment and to return, so that a continuous flow is kept in the water-cooled bottle. Suitable counter-balance is provided so that when the bottle is in an operating position it will remain there,. The approximate degree of heat for treating slugs is 3300 deg C.

Current is maintained through the upper jaw *B* on the rod for a period of 15 to 20 min at different degrees of heat within 80 to 90% of the melting point of the tungsten bar. The current passes with approximately 2140 amps and at approximately 8 to 18 volts. The melting point of tungsten is 3385 deg C.

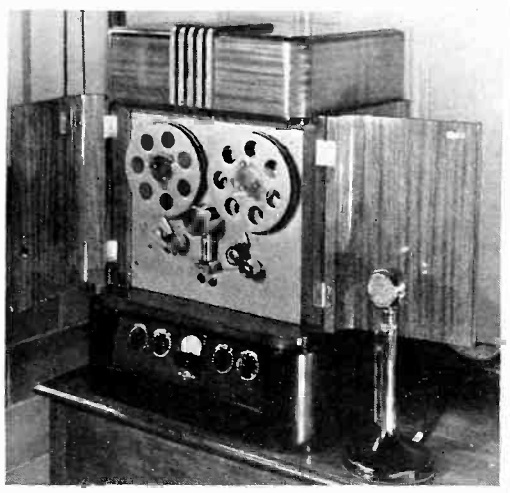
Dry hydrogen is permitted to flow through the system at approximately

350 liters per hour at a very low pressure. The hydrogen enters through the top at *F*. The same equipment is also used in treating molybdenum.

Tape Recorder

SEVERAL recording devices of varying nature have been demonstrated to *Electronics*' editors recently. One machine, developed in the Middle West utilizes either paper or cellophane tape and gives permanent filable sound records at a cost of about $1 per hour.

This machine, developed by Merle Dustin of Audio Tape Recorder Corp., Detroit, moves the tape past a stylus which produces an electro-chemical action. Present speed of about 50 ft per min covers the voice frequency range of 200 to 3000 cycles effectively. The same amplifier is used for recording and play back. It uses 6 tubes and an audio avc is employed for telephone pickup and conference work where the several speakers may be at different distances from the mike. Stop, start, and rewind can be controlled from a distance.



Merle Dustin's Tape Recorder

Changeover Unit

THIS is a hot cathode full wave mercury vapour rectifier of extremely high efficiency. It was designed especially for motor changeover work or for any place where 12 amps full wave pulsating dc at about 110 volts rms is satisfactory.

A small transformer is used for heating the cathodes and it supplies 104 watts for this purpose regardless of load. The voltage drop in the arc of each tube is only 5 to 8 volts, so that the efficiency of the unit supplying 110 volts dc is about 80% and when used to supply 220 volts dc, it is about 90%.

The efficiency of this unit is very apt to be underrated practically, if the usual voltmeters and ammeters are used to make measurements because almost all ac voltmeters measure effective (rms) values while almost all dc voltmeters measure average values, so that if the rectifier were 100% efficient the voltmeters would still indicate only 90% efficiency.

$$\frac{E_{av}}{E_{ef}} = \frac{.636F_m}{.707F_m} = .90$$

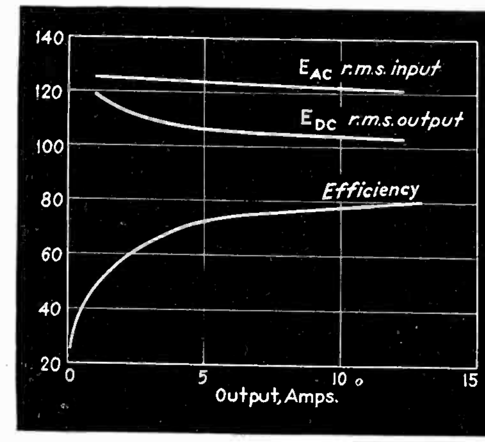


Fig. 1—Performance characteristics

Therefore instruments which have the same type of movements should be used to measure the input and the output. A wattmeter would of course measure the effective value on either ac or dc.

Fig 1 is a curve showing the actual results with this rectifier on 125 volts alternating current.

The entire unit weighs but 29 pounds.

This device was invented, developed and designed by Harold J. McCreary, who is also the sole distributor. The unit is manufactured by Thomas B. Gibbs Co. of Chicago and a number of installations have been in operation since last fall in Chicago giving perfect performance.

News

✦ A television testing laboratory has been launched by National Union Radio Corp., Newark, N. J., to assist radio makers in design and manufacture of their sight receivers. . . . William Abbett Lewis, Jr., engineer with the Westinghouse Elec. & Mfg. Co., has been appointed director of the School of Electrical Engineering, Cornell University. . . . Arthur J. Williamson is now Metallurgical Engineer in charge of research and development at Summerill Tubing Co., Bridgeport, Pa. . . . Electrical Testing Laboratories are now located in their new building at East End Ave., at 79th St., New York City. . . . R. F. Bergmunn, Chief Engineer of Rayon Machinery Corp., Cleveland, O., in describing the new, continuous process for the spinning of viscose rayon yarn developed by the above mentioned company, pays tribute to modern synthetic plastics and their increasing use in commerce, science, the arts and industry.

Literature

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Dial-Indicating Thermometer. Catalog No. 1170. C. J. Tagliabue Mfg. Co., Park and Nostrand Aves., Brooklyn, N. Y.

Chime Equipment. Catalog List Price contains suggested installations. Rangertone, Inc., Newark, N. J.

Engineering Properties of Nickel. Technical information on monel, nickel and nickel alloys. International Nickel Co., Inc., 67 Wall St., New York City.

Application Note. On input loading of receiving tubes at radio frequencies. No. 101. RCA Mfg. Co., Inc., Harrison, N. J.

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General Information. On National Electrical Manufacturers Association standards and definitions. Bulletin 610. The Louis Allis Co., Milwaukee, Wis.

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Loudspeakers. Selection and placement and other subjects discussed in "Oxford Techni-Talks," Vol. 1, No. 1. Oxford-Tartak Radio Corp., 915 W. Van Buren St., Chicago, Ill.

Call Phone. Inter-communication equipment described in Catalog No. 108. Literature also available on beat frequency standard signal generator Type CR-6, cathode-ray oscillograph Type CR-3, Model B, and beat frequency audio oscillator Type CR-4. United Sound Engineering Co., 2233 University Ave., St. Paul, Minn.

Ground Rods. Complete information contained in "Solid Copper Star Ground Rod" bulletin. Anaconda Wire & Cable Co., 25 Broadway, New York City.

Engineering Data Book. 1939 edition. Products manufactured by Spaulding Fibre Co., Inc., Tonawanda, N. Y.

Molded Color. Illustrates and summarizes the history of progress of plastics. Plaskon Co., Inc., Toledo, Ohio.

Television Receivers

(*Continued from page 25*)

output video stage. The 9-inch picture tube is magnetically focussed and magnetically deflected, and is of the "short" variety. The second anode voltage is 4000 volts (2V3G rectifier). Sync separation, etc., is carried out mainly in 6F8G tubes, except the horizontal scanning current output tube, which is a separate beam power tube. The two chassis (power and receiver) contain 21 tubes including audio tubes and are mounted in a console type cabinet of the "direct-viewing" (no mirror) type. The audio system is a 6SK7 if, a 6B8 if and detector, 6SC7 audio and two 6F6 output tubes. Push button tuning for five television channels is provided, and the sensitivity is 300 microvolts for full modulation of the picture tube, with full gain.

G. E. 12-inch tube chassis has 100 microvolt sensitivity

The large 12-inch chassis of the GE company is illustrated in Fig. 1. So far as the video section of the receiver is concerned it represents one of the most elaborate designs thus far announced. An rf stage, a separate avc amplifier and avc detector, a delay bias diode and forgettor (rapid integrator) amplifier provide the specialized functions not found in the cheaper models. The sensitivity is very great indeed, 100 microvolts for full modulation of the picture tube. The audio system contains two 6SK7 if stages, a 6Q7 detector and af, and a 6L6G output. A high fidelity broadcast and shortwave three-band receiver which switches into the af output circuits can also be included in the design. The high voltage (6500 volts) is provided by a voltage doubler circuit employing two 879 tubes. The bandwidth corresponds to the maximum limit of the transmitted sideband, 4 Mc.

RCA Manufacturing Company

The 5- and 12-inch chasses of RCA are shown in Fig. 1. The 12-inch chassis will also be used, without major changes, to operate a 9-inch tube in a direct-viewing console. The five-inch tube will be used in a table model and in a console, both direct viewing. The five-inch table model will have no audio amplifier tubes, but will contain all sound if tubes including the second detector. A plug will be provided for plugging in to the "phonograph" terminals of any broadcast receiver (that is, connecting to the af amplifier tubes and loudspeaker of the receiver).

The five-inch receiver employs three picture if stages with a nominal bandwidth of 2.5 Mc, which is sufficient to provide horizontal detail approximately as fine as the luminous spot of the kinescope. The sensitivity, based on the input signal required to give 10 rms volts at the picture tube grid, is 500 microvolts. Only one video stage is used, and the kinescope is the usual 1802-P4, black-and-white electrically deflected tube. Type 6N7 tubes are used for sync signal separation, and sawtooth generation. Push-pull deflection is accomplished by a 6N7 in the vertical and a 6F8G in the horizontal direction. The audio chain is an 1853 if tube, a 6B8 if and detector, and the af tubes associated with the all wave receiver, which is built into all models except the 5-inch table model. The receiver is tuned, by switching, to any of 5 channels from 44–50 to 84–90 Mc.

The 12-inch chassis (video section shown in Fig. 1) contains a total of no fewer than 32 tubes, including high fidelity all-wave receiver, audio tubes and kinescope. Five stages of picture if are used, having an overall bandwidth of four megacycles. Only one video amplifier stage is employed. An avc amplifier controls the first four video if stages. The audio circuit consists of an 1853 if, 6SK7 if, 6H6 detector, a 6SF5 first audio, and push-pull 6F6G audio output. The latter three audio tubes being a part of the all wave receiver included in the set. The all-wave receiver contains a 6SK7 rf, a 6SA7 detector-oscillator, a 6SK7 if, 6SQ7 detector and avc, a 6U5 tuning indicator, a 5U4G rectifier and the audio tubes mentioned above. The low voltage rectifier for the television chassis is a 5T4. The high voltage rectifier is a 2V3G operated at 7000 volts total rectified. The dc re-insertion is accomplished at the kinescope grid by a 6H6.

The synchronizing and deflection circuits are more or less conventional except for the 6Y6G clipper tube which operates with minus 3 volts on the control grid, plus 6 volts on the screen, and plus 9 volts on the plate. When so operated the tube displays a limiting-type of i_p-e_g characteristic which greatly aids in obtaining sharp square-topped pulses before separation of vertical pulses from horizontal.

Scanning Chassis

The RCA scanning and deflecting circuits can best be described in terms of the so-called "power and deflection chassis" now being manufactured by RCA and offered for sale to licensee manufacturers. The purpose of this chassis is to provide all the specialized equipment required for high voltage, for scanning and for sync separation in a television receiver of the magnetically deflected type, but to omit any features which could be provided equally well by the licensee manufacturer. The full circuit diagram of this unit is shown in Fig. 4. The unit consists of a 6SJ7 synchronizing channel amplifier, a 6N7 separator amplifier. 6N7 vertical blocking oscillator and discharge tube, 6J5 vertical output amplifier, 6N7 horizontal blocking oscillator and discharge tube, 6L6 horizontal output tube and 5V4G damping tube. Also are included a 2V3G high voltage rectifier, transformer and filter capable of supplying 7000 volts, and all the necessary component parts of the sync separation and scanning circuits, mounted on a single chassis. Power supply from 105 to 125 volts ac is required; also 300 volts, 100 ma, and heater currents of 6 volts 4 amp, 5 volts 2 amp are required from external supplies. The unit is supplied complete with low-impedance scanning yoke (low impedance windings in both vertical and horizontal windings).

An input signal at least of 0.1 volt, consisting of the sync pulse only (the picture signals removed) is required. By careful elimination of cross-talk between the vertical and horizontal deflecting circuits, substantially perfect interlace is obtained and maintained regardless of power supply changes, etc, and regardless of changes in signal strength down to the point where the picture itself is not visible on the kinescope screen. Six controls are provided at the one side of the chassis, all of which require no adjustment after installation of the receiver.

Testing Equipment

With the development of television receivers comes the necessity of providing organizations equipped to handle service problems in the field. Several manufacturers have already undertaken to establish a corps of trained men in the New York area specifically for this purpose. It seems likely that the radio serviceman may require many months of training and experience, after sets are first released, before he can tackle the problems of wide band alignment and scanning circuit adjustment, etc. It is clear also that highly specialized testing equipment will be necessary. Several items of this nature are already making their appearance. In Fig. 6 is shown a DuMont phasmajector tube mounted in a chassis designed to produce all necessary scanning, blanking, and sync signals. The output in this unit feeds a Weston ultrahigh frequency signal generator which delivers a standardized rf signal, modulated with the video signal, to the antenna terminals of the television receiver under test. Two other pieces of test equipment are the Square-wave Generator type 305-A and the video sweep oscillator, type 351-A which have recently been made available by RCA.

New Tubes

Many of the tubes shown in Fig. 1 may be new to the readers of *Electronics* who have not followed television closely during recent months, hence a brief review of their functions and characteristics is in order. The principal pentodes are the 1852 and the 1853, both of which are single-ended 6.3-volt high transconductance tubes of 10 ma rated plate current. The 1852 has a rated transconductance of 9000 micromhos, the 1853 of 5000 micromhos. The 1853 has remote cut-off construction, intended for use as an rf and if amplifier with grid-bias gain control. The 1852 is very commonly used as a video amplifier, and as a video if amplifier preceding the second detector. The 6J5, a unanimous choice as the oscillator in uhf converter circuits, is a high-transconductance triode, which has found wide use in other applications. Another high transconductance pentode is the 1231 manufactured by Hygrade Sylvania. The 2Y2 is a high voltage half-wave rectifier with coated cathode. The 2V3G is a half-wave high voltage rectifier (peak inverse voltage, 16,500 volts maximum) with a pure tungsten (2.5 volt, 5 amp) filament, suitable for any high voltage work up to 10,000 volts. The 879 is a high voltage half-wave rectifier with coated filament, suitable for levels up to 2500 or 3000 volts (7500 peak inverse voltage). In the Arcturus line, type 5X3 is a high voltage rectifier used for electric deflection power supply, and types 6AD5G and 6R6G are a hi-mu triode and remote cut-off pentode amplifier, respectively, intended for electric deflection amplification.

Cathode ray tubes for television purposes have been announced by four companies: DuMont Laboratories, Hygrade Sylvania, National Union and RCA. The DuMont tubes are all of the electric deflection type: Type 54–11–T, 5-inch, white screen, intensifier; Type 94–11–T, 9-inch white screen, intensifier; type 144–11–T, 14-inch white screen, no intensifier. The RCA tubes include 906-P4, 3-inch white screen, electric deflection; 1802-P4, 5-inch white screen, electric deflection; 1804-P4, 9-inch white screen, magnetic deflection; and 1803-P4, 12-inch white screen, magnetic deflection. The suffix P4 refers to phosphor number 4, a white non-sulphide material. The 1805 is a "short" five-inch tube with white screen offered by National Union. Nine-inch tubes are also manufactured by this company. Hygrade Sylvania has thus far offered cathode-ray tubes only in the smaller diameters.—D.G.F.

Frequency Modulation

(*Continued from page* 17)

necessary damping.

The station itself is arranged with the low level modulating stages inclosed in a doubly shielded room, containing a high quality phonograph turntable for both vertically- and laterally-cut recordings. The last two or three frequency-multiplying stages are outside this room, and feed the first class C amplifier. The last two amplifiers, which employ the resonant lines, are mounted on a table and completely surrounded with a wire shield. The high voltage power supply is located across the room from the final amplifier. The station, despite the large number of small tubes used, is extremely stable and simple to operate. "Cranking up" the transmitter consists simply in lighting the filaments, starting the air blowers, and bringing up the high voltage power to the desired level. Virtually no supervision is required after the station is on the air, since there are no peaks of power. As a result rectifier arc backs are extremely rare, and the station has thus far never been forced off the air for any reason other than a momentary loss of power from the incoming 60-cycle lines. The operators do not "ride gain" in any sense, since overmodulation cannot occur, in the usual meaning, and since the peak frequency swing (corresponding to maximum audio level) can be readily adjusted to the limits allowed by the channel.

The 110-Mc Transmitter at Yonkers, N. Y.

The other transmitter used in the tests was W2XCR, at the home of C. R. Runyon of Yonkers, N. Y., who has been associated with Major Armstrong throughout the development of the system. The modulating equipment is essentially the same as that used at Alpine, but the carrier frequency is 110 Mc, and the output of the final linear amplifier is only 600 watts. This station was originally an amateur station (call W2AG) operating above 110 Mc. However, in order to transmit music after the December 1st amateur regulations went into effect, an experimental license was obtained. The antenna is a 7-element turnstile array supported on the top of a 100-foot steel tower. This tower is 700 or 800 feet below the line of sight to the receiving location at Sayville, but this circumstance appears to have little effect on the strength and quality of the reception. The antenna power gain (non-directional) is five, making an effective power of three kw.

The receivers employed (except the 110-Mc receiver) were constructed by the General Electric Company to specifications laid down by Major Armstrong. The block diagram shows the line-up. These receivers contain 15 tubes (1 rectifier, 4 audio, 10 rf), and will deliver a recognizable program with but 1 microvolt input. However, proper limiter action is obtained only with a signal of perhaps 2 to 5 microvolts, which can be obtained well beyond the horizon distance, up to 100 miles if the effective transmitter power is of the order of three kilowatts or greater, at reasonable antenna heights.

Details of the test demonstration

The following brief resume of the impressions gained during the demonstration indicate the quality of the system as a whole. The first demonstration was at the apartment of Major Armstrong, on the east side of Manhattan Island, roughly 14 miles air line from the transmitter. The receiver was mounted in a conventional but massive console located in a room on the south side of the building and had but three controls, tuning, volume and tone. When the Alpine station came on the air, exact tuning was accomplished by listening to the noise level, since no tuning meter was provided on the set. Tuning was not at all critical, and required no readjustment, once set. The quality of the system, as previously stated, leaves nothing whatever to be desired. The background noise was, so far as the ear could detect even within a foot of the speaker, completely inaudible. The antenna used was a 6-foot length of twisted lamp cord, with the outer ends unraveled for a few feet to produce a dipole. Moving the antenna about in the room had no noticeable effect. One noticeable fact was the high audio level at which the receiver could be operated without any apparent distress to the ear. The lack of distortion and of background noise probably account for this.

One interesting comparison was made at the Alpine station, to which the editors traveled before going to Sayville. At the station, a loudspeaker was so connected that it could be switched rapidly from the ingoing audio line (from the turntable pickup amplifier) to the output of a monitor receiver which picked up the frequency-modulated signals from the output of the station. Thus a direct side-by-side comparison of the distortion and noise introduced by the frequency-modulation system could be made, relative to the original audio-frequency signal. It was literally impossible to tell the difference between the two switch positions. In response to a request for a demonstration of "over-modulation", Major Armstrong increased the audio level gradually to 15 db above normal, thus increasing the frequency swing greatly beyond its normal limits. No distortion could be noticed in the monitor receiver until roughly 10 db above normal range was reached.

At Sayville, the results were substantially the same as in New York City, although the receiver was approximately 40 miles farther from the transmitting station. As previously mentioned, the only sources of noise were needle-hiss on the records, and very occasional ignition interference, the latter being of such low level that it could not be heard when music was being received. After several recordings were received from the Alpine station a relay was arranged whereby the 110 Mc station at Yonkers was picked up at Alpine (about one mile from Yonkers) and rebroadcast on 42.8 Mc to Sayville. As was to be expected, the results in this case were the same as when recordings originated at Alpine. However, Mr. Runyon's home at Yonkers provided a studio (actually a living room) for some piano music, and for several sound effects. The piano music was extremely good, since there was no background noise whatever. The sound effects consisted of tearing a piece of paper, lighting a match and a cigarette, pouring water from a bottle into a glass, and similar noises in which high frequencies predominate. This was the most perfect example of sound reproduction the writer has ever witnessed, no doubt due to the fact that 15,000 cps was actually reproduced. But if the slightest background noise had existed the crispness of the reproduction would have suffered. The absence of distortion was shown by the ringing of a bell and of a set of chimes. The disonant upper partials in the bell tone were correctly reproduced without "overhang" or blurring. This was a most effective demonstration of what truly high fidelity, coupled with low background noise, can mean to a sound reproduction system. The antenna used was a 6-foot partially unraveled lamp cord, tied to the curtain rods near the set.

As a final test, a 110 Mc receiver was used to receive the signals from the Yonkers location directly over the 50 mile path. A dipole and single reflector were mounted on the roof as a semi-directional receiving antenna. Despite the fact that the effective power of the 110 Mc station was 3000 watts, or roughly 1/30th of the Alpine transmitter, and that the frequency was 2½ times as high, the

110 Mc reception was virtually the equal of the 42.8 Mc case. The only difference was that a slight background hiss could be heard, but only if the audio output level of the receiver was raised to its highest point. A switch was arranged for transferring from 42.8 to 110 Mc reception, on the same program, and no difference whatever could be detected, except the almost imperceptible increase in background noise in the 110 Mc case. The test showed that a frequency modulated transmitter of moderate power (600 watts output at the final amplifier) and a simple antenna can cover a radius of 45 or 50 miles with a completely satisfactory signal. Other tests not witnessed by the editors indicate that the useful range of the low power transmitter is nearer 100 miles.

Plans are now underway to provide demonstrations of the system to interested persons, such as owners and operators of conventional broadcasting stations, during the coming summer. Studio as well as recorded programs will be made available from station WQXR, local high fidelity station in New York, as soon as telephone repeaters having a low enough noise level are installed in the line from the WQXR studio.—D.G.F.

• • •

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1,449,252, J. E. Stout, Automatic phonograph; 1,800,803, 1,875,641, W. R. Moore, Jr., Automatic talking machine; 1,837,608, Bodwell & Bellows, Combined talking machine and advertising device; 2,125,706, Wupper & Davis, Phonograph; Re. 20,818, P. H. Smyth, Jr., Selective phonographic playing machine, filed Dec. 14, 1938, D. C., W. D. Pa., Doc. 136, *Rock-Ola Mfg. Corp.* v. *M. A. Ginsburg et al.* (*Atlas Novelty Co.*). Same, filed Dec. 15, 1938, D. C., N. D. Tex. (Dallas), Doc. 34, *Rock-Ola Mfg. Corp.* v. *Electro Ball Co. et al.*

CONTACTS

FOR THE FIELD OF ELECTRONICS

SEARCHLIGHT SECTION

EMPLOYMENT : BUSINESS : OPPORTUNITIES : EQUIPMENT—USED or RESALE

UNDISPLAYED RATE:

10 cents a word, minimum charge $2.00.

Position Wanted. (full or part-time salaried employment only). ½ the above rates, payable in advance.

Proposals, 40 cents a line an insertion.

INFORMATION:

Box Numbers in care of our New York, Chicago, or San Francisco offices count 10 words additional in undisplayed ads. Replies forwarded without extra charge.

Discount of 10% if full payment is made in advance for four consecutive insertions of undisplayed ads (not including proposals).

DISPLAYED—RATE PER INCH:

The advertising rate is $6.00 per inch for all advertising appearing on other than a contract basis. Contract rates quoted on request.

An advertising inch is measured ⅞" vertically on one column, 3 columns—30 inches—to a page.

(New advertisements must be received by March 29th for the April issue)

TELEVISION Headquarters

Always a leader in Radio, Sun Radio Company sets the pace for Television engineers with a complete stock of components, kits, tubes *and* information. Make Sun your Headquarters for Television just as you have for Radio.

IN STOCK

RCA TELEVISION Parts including Deflecting Yokes, Power Transformers, Vertical Output Reactors, Vertical Oscillating Transformers, Power Supplies, Kinescopes, etc. We also carry Meissner Television Kits. Kinescope Circuit Diagrams available. Write for them.

SUN RADIO CO.
212 Fulton Street, New York, N. Y.
Cable Address: SUNRADIO NEW YORK

Who —beside yourself— Reads this paper ?

Radio Sets, Tubes, Parts
Engineers, executives and other personnel engaged in the design, manufacture, sales or maintenance and service of home radio receivers, home facsimile or television equipment, radio-phonograph combinations or home phonographs; and components entering these or other home entertainment devices.

Communications
Management, engineering, operation and other personnel of broadcast, police, aircraft, ship, amateur, government, state, municipal, point-to-point, ship-to-shore, radio stations or systems; telephone and telegraph systems, wire, radio, carrier or space communications; and manufacturers of equipment and components entering into such wire and radio station equipment.

Sound Pictures and Public Address
Personnel in sound pictures and electrical transcription recording studios; in studios recording sound for home, public address or theatre entertainment; manufacturers and users of public address equipment; and manufacturers of components entering into this type of equipment.

Industrial Electron-Tube Equipment
Personnel in the plants of manufacturers and users of electron tubes and associated apparatus for industrial purposes such as control, power conversion and transmission, packaging, sorting, counting, traffic control, etc., medical equipment and components entering into such equipment.

Miscellaneous
Patent Attorneys, Consulting Engineers, Government, Public Libraries, Universities, Teachers and Students, etc., etc., etc.

Have you a business message for any of these men? Employment, Equipment or Business needs or "opportunities" to bring to their attention? You can do so quickly, effectively and at small cost through advertising **right here**—in

The SEARCHLIGHT SECTION of ELECTRONICS

POSITIONS WANTED

(See also "Selling Opportunities Wanted")

SOUTH AMERICAN technical position desired by radio engineer. Present position as plant supervisor radio engineer. Present position as plant supervisor of NBC eastern station nine years. Thirteen years experience construction, installation and operation of radio plants. Age 32. PW-189, Electronics, 330 W. 42nd St., New York, N. Y.

RADIO MAINTENANCE ENGINEER: Eleven years experience. Desire contact with responsible company requiring services of field engineer or representative. Thoroughly familiar with installation, inspection and maintenance of radio communication and general electronic equipment. Have also done transmitter design, and radio communication network organization. PW-194 Electronics, 330 W. 42nd St., New York, N. Y.

E.E. LABORATORY ASSISTANT, age 35, diversified experience communication, power. Versatile resourceful adept. PW-195 Electronics, 330 W. 42nd St., New York, N. Y.

E.E. POST GRADUATE work in high frequency and television. 8 years industrial and patent experience. Foreign languages. Executive ability. Excellent references. PW-198, Electronics, 330 W. 42nd St., New York, N. Y.

JUNIOR ELECTRICAL ENGINEER, communication, electronics, B.S., Maine University. Desires interview for employment on trial anywhere. Research, design, production, service. PW-196 Electronics, 330 W. 42nd St., New York, N. Y.

POSITION WANTED—Four years laboratory and ten years field experience with large eastern manufacturer of radio receiving equipment. Desire position in field engineering and maintenance on commercial radio equipment. Age 35. Willing to travel. Best of references. PW-197 Electronics, 330 W. 42nd St., New York, N. Y.

SELLING OPPORTUNITIES OFFERED—WANTED
Selling Agencies—Sales Executives
Salesmen—Additional Lines

OPPORTUNITY WANTED

SALES ENGINEER AVAILABLE. Graduate E.E. 15 years sales and laboratory experience radio receiving and transmitting, electronic equipment with largest companies in field, would like to hear from aggressive, growing concern requiring sales development of technical equipment, and open to ideas on allied devices for new fields. SA-186, Electronics, 330 W. 42d St., New York, N. Y.

HIGH GRADE USED ELECTRON TUBE MACHINERY
Huge Stock of Every Type and Variety
KAHLE ENGINEERING CORPORATION
Specialists in Equipment for the Manufacture of Neon Tubes, Radio Tubes, Incandescent Lamps, Photo Cells, X-ray Tubes, etc.
900 DeMott St., North Bergen, N. J.

E. H. RIETZKE PRES. OF CREI

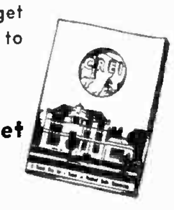
Our own "coast to coast network" of CREI men in more than

275 Radio Stations

—is proof that CREI training pays!

Chief engineers want men who possess modern technical training. The fact that more than 275 broadcasting stations employ one or more CREI students or graduates is evidence of the opportunities that await the trained man. Just ask "any engineer" what he thinks of CREI Practical Radio Engineering courses—and you'll be convinced that we have the very thing you need to get ahead in radio. We'd like to send you details.

Write for FREE New illustrated booklet
"A Tested Plan for A Future in Radio"



CAPITOL RADIO ENGINEERING INSTITUTE
DEPT. E-3, 3224-16TH ST. N.W., WASH., D. C.

DEPENDABLE Used ELECTRONIC TUBE EQUIPMENT
A complete line of used equipment for the manufacture of Radio Tubes, Neon Tubes, Incandescent Lamps, etc.
Write for Bulletin showing savings from 25 to 75%
EISLER ELECTRIC CORP.
534 39th Street, Union City, N. J.

If its radio, we have it!

AUTHORIZED DISTRIBUTORS

2 completely stocked Terminal radio supply houses now serve broadcast stations, engineers and laboratories. We carry all the popular records. Both stores open evenings till 8:00 P.M.

Phone: VAnderbilt 6-5050
Cable: TERMRADIO

TERMINAL Radio Corp.
2 STORES IN NEW YORK CITY
80 CORTLANDT ST. • 68 WEST 45th ST.

INDEX TO ADVERTISERS

NOW.. ULTRA HIGH FREQUENCY SIGNALS WHERE YOU WANT THEM

22 TO 150 MEGACYCLES

24 hours a day!

WITH THE NEW

WESTON Television ULTRA HIGH FREQUENCY OSCILLATOR

- Frequency—continuous range 22 to 150 megacycles—no band switching.
- All frequencies fundamental.
- High order of stability and resetability over entire range.
- Equipped for television modulation.
- Employs continuously variable inductive tuning.*
- Equipped for use with crystals.
- Battery operated (self contained).
- Equipped with 400 cycle modulator.
- Used with portable antenna (included) or with standard output leads.
- Jack provided for external power to increase radiation.
- Over 5700 degrees of continuous dial rotation.
- Meter equipped, for six control measurements.
- Small size, light weight, extreme portability.

* Patents Pending

Essential for all branches of television, for police radio, aircraft, maintenance trucks, etc.

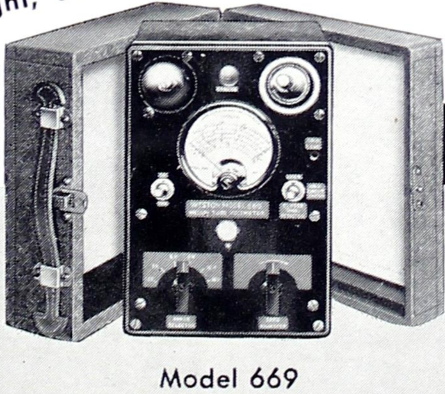
Model 772

5000 VOLT

TE[illegible]ON AND RADIO ANALYZER

Se[illegible], 20,000 ohms-per-volt.
Input impedance 100 megohms on top range.
Specially designed low-leakage jacks.
Breakdown voltage in accordance with AIEE safety standards . . . 11,000 volts.
Current readings down to ½ microampere.

NOTE—present owners of 20,000 ohms-per-volt analyzers can bring them up-to-date with the compact WESTON 5,000 volt Televerter . . . an inexpensive multiplying unit which fits the carrying case.



Model 669

VACUUM TUBE VOLTMETER—measures gain in video and sound amplifying channels—peak voltages in thyraton (saw-tooth) generators in oscillator circuits—grid potentials on cathode ray tubes—as well as other essential measurements in all sound receivers.

SEND COUPON FOR COMPLETE INFORMATION

Weston Electrical Instrument Corporation
618 Frelinghuysen Ave., Newark, N. J.
Send bulletin describing the Model 787 Ultra High Frequency Oscillator and other WESTON Instruments.

Name______________________
Address______________________
City______________ State______________

RCA offers a Complete Line of TELEVISION TUBES

READY FOR DELIVERY!

RCA KINESCOPES WITH WHITE SCREEN

The RCA-906-P4 is a 3" Television Kinescope
available at unusually low cost. Provides low cir-
cuit cost because of its low voltage operation. Has
conductive coating which minimizes deflecting-
plate loading and prevents drifting of the pattern
with changes in bias $15

The RCA-1802-P4 is a 5" Television Kinescope
having electrostatic deflection. Provides excellent
quality television pictures. The deflection sensi-
tivity is such that the beam may be deflected across
the entire screen with no more voltage than is
required for full deflection on 3" tube. Separate
terminals are provided in new Magnal 11-pin base
for each deflecting plate. $27.50

The RCA-1804-P4 is a 9" Television Kinescope employing electro-magnetic deflection of the electron beam. Can be operated with an anode No. 2 voltage up to 7,000 volts and provides a brilliant picture with excellent definition. $60.00

The RCA-1803-P4 is a 12" Television Kinescope employing electro-magnetic deflection of the electron beam. Like the 1804-P4, this tube can be operated with an anode No. 2 voltage up to 7,000 volts—but its large size lends greater brilliance and detail to pictures, making it especially suitable for use with large groups of people. $75.00

Over 325 million RCA radio tubes have been purchased by radio users . . . in tubes, as in radio sets, it pays to go RCA All the Way.

RCA presents the Magic Key every Sunday, 2 to 3 P. M., E. S. T., on the NBC Blue Network.

RCA RECTIFIERS

The RCA-2V3-G is a tungsten - filament type of high-vacuum, half-wave rectifier for use in suitable rectifying devices to supply the high d-c voltages required by kinescope and cathode-ray tubes. $3.00

The RCA-879 is
high-vacuum, ha
wave rectifier of fil
ment type for use i
suitable rectifying de
vices to supply the
d-c voltage require-
ments of cathode-ray
tubes. . . . $3.00

RCA R-F AMPLIFIERS

The RCA-1852 and 1853 are r-f amplifiers offering high mutual conductance, resulting in surprisingly high gain and superb signal-to-noise ratio. Both of these tubes have the grid connection at the base, thus eliminating grid cap and decreasing feed-back at high frequencies. This feature also greatly improves circuit stability. These two tubes are particularly well suited for television amplifier applications. The 1853 has remote cut-off characteristics which permit the handling of a larger range of signals.

$1.85 apiece

RCA Radio Tubes

RCA MANUFACTURING CO., INC., CAMDEN, N. J. • A Service of the Radio Corporation of America