The RADIO ENGINEERS' DIGEST

SEPTEMBER 1945 VOL. 2 NO. 2

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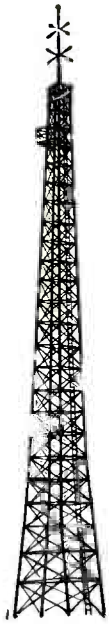
PUBLISHED BY REEVES-ELY LABORATORIES, INC.



THE RADIO ENGINEERS' DIGEST

JOHN F. C. MOORE, *Editor*

Vol. 2, No. 2 September 1945

Published monthly at New York, N. Y., by Reeves-Ely Laboratories, Inc., comprising the following operating divisions and subsidiaries:

AMERICAN TRANSFORMER COMPANY, Newark, N. J.
HUDSON AMERICAN CORPORATION, New York, N. Y.
REEVES SOUND LABORATORIES, New York, N. Y.
WARING PRODUCTS CORPORATION, New York, N. Y.
THE WINSTED HARDWARE MANUFACTURING COMPANY, Winsted, Conn.

For free distribution to our friends in the radio and electronics industries

Editorial Office, 25 West 43rd Street, New York 18, N. Y.

Printed by Criterion Products Corporation, New York, N. Y., U. S. A.

HISTORY OF THE QUARTZ OSCILLATOR-PLATE INDUSTRY, 1941-1944

Reprinted from the American Mineralogist

*By Clifford Frondel,**

Research Division, Reeves Sound Laboratories, New York, New York

IN 1881, Pierre and Jacques Curie discovered that quartz and certain other low symmetry crystals developed positive and negative electrical charges at the ends of the polar $X=a$-axes when subjected to properly directed pressure. In the following year, G. Lippmann suggested that such crystals would become mechanically deformed if subjected to an electrical field, and this converse piezoelectric effect, so-called, was experimentally verified by the Curies. The effect remained hardly more than a laboratory curiosity for many years until P. Langevin in Paris, during World War I, devised quartz plates for sending out and detecting underwater sound waves. At about the same time, A. M. Nicholson of the Bell Laboratories experimented with phonograph pickups and microphones constructed of Rochelle-salt crystals. The application of the piezoelectric effect to radio, however, did not come until 1921, when Professor W. G. Cady of Wesleyan University showed that quartz plates could be used to control vacuum tube oscillators. In this application, the alternating electrical field generated by the vacuum tube radio circuit is applied to a quartz plate, properly cut and mounted and so dimensioned that one of its natural frequencies of mechanical vibration coincides with the oscillations of the circuit, and the frequency of transmission or reception is thereby stabilized and precisely controlled. Some types of quartz oscillator-plates used by the Armed Services are shown in Fig. 1. Quartz, rather than other natural or artificial crystals, some of which give much more prononuced piezoelectric effects, is employed for the purpose primarily because of its chemical and physical stability, high elasticity and availability. An increasing demand for crystal-controlled oscillators and filter circuits developed during the 1930's and approximately 50,000 quartz oscillator-plates were manufactured in the United States during 1939.

With entrance of the United States into World War II in 1941 the Armed Services demanded almost fantastic quantities of oscillator plates — literally tens of millions. Part of the needs of our Allies also were to be supplied by Lend-Lease. Rapid and certain communication is the keystone of global war, and many thousands of aircraft, ships, tanks or other mobile or stationary ground units were to be fitted with radios, each with its complement of "crystals." The problem of supply created an industrial problem of the first magnitude. The responsibility for initiating and guiding procurement for the Army and Air Forces rested largely in the Quartz Crystal Coordination Section, General Development Division, Office of the Chief Signal Officer, War Department. This group was activated under a directive of March 5, 1942, from Major General (then Brigadier General) Roger B. Colton, Chief of the Material Branch, U.S. Army Signal Corps, which charged the General Development Division, among other duties, to "Take necessary steps to handle the problem and successfully meet it." The Quartz Crystal Coordination Section had its headquarters in Temporary Building A, later in the Pentagon Building, Washington, and comprised a

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(*The American Mineralogist, May-June* 1945)

small number of civilian and Army technicians and scientists working under the direction originally of Colonel (then Lieutenant Colonel) J. D. O'Connell. This group carried the brunt of the work during the first year or so of the crystal program. The Crystal Section was aided in its task by the Crystal Branch of the Signal Corps Laboratories at Fort Monmouth, New Jersey, and later by the Aircraft Radio Laboratory at Wright Field, Ohio. The Fort Monmouth Crystal Laboratories (later located at Camp Coles and then at Long Branch, New Jersey) was active primarily in placing educational orders enabling manufacturers to obtain necessary priorities and get set up, in awarding Development Contracts on the design and development of equipment and to investigate technical problems, and in research work. The Laboratories also operated a Pilot Plant and for a brief period gave courses of instruction to new manufacturers. The present laboratory activity includes the development of all crystals used in ground force signal equipment. The Crystal Branch of the ARL, beginning in 1943, did valuable laboratory and field work and contributed to the increase in quality of both oscillator-plates and holders.

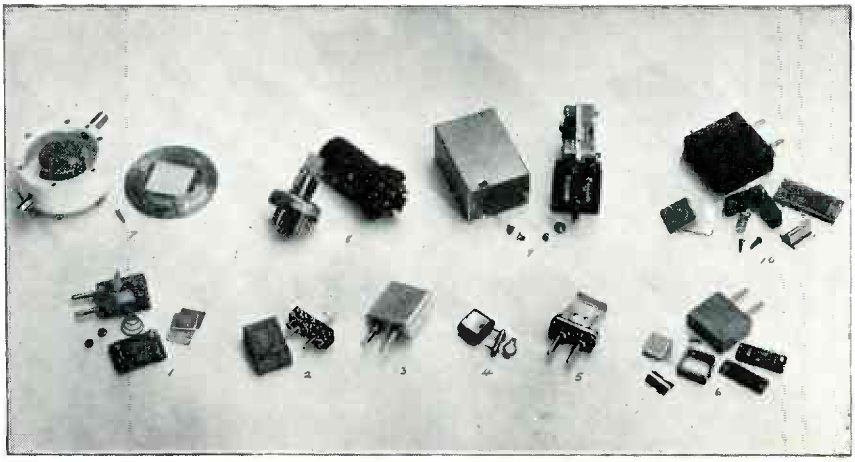

Fig. 1. Some types of mounted quartz oscillator-plates for radio use. No. 1, FT-243 type clamped crystal, showing component parts. No. 2, FT-241 wire suspension metal-plated CT-cut crystal. No. 3, hermetically sealed CR-1 crystal in solder-sealed all-metal rolder. No. 4, CR-7 type, plated wire suspension BT-cut crystal. No. 5, hermetically sealed CR-1 type crystal in solder-sealed Pyrex glass holder. No. 6, CR-1 clamped type crystal in phenolic holder. No. 7, FT-164 AT-cut crystal in variable air gap holder. No. 8, metal-plated wire suspension DT-cut crystal. No. 9, MX-12 AT-cut clamped crystals in dual mounting. No. 10, DC-11 type-clamped crystal, showing L-shaped adapter to accommodate small sized crystal within the holder.

Special acknowledgement also should be made to the Bell Telephone Laboratories and the Western Electric Company, who contributed greatly to the success of the crystal program. These companies freely supplied invaluable technical information and led in the development of several types of manufacturing equipment, notably the drill press lap, immersion conoscope, inspection tank for raw quartz and x-ray methods for controlling orientation. The fundamental theory and design of oscillator-plates is largely owing to work carried on over many years at the Bell Telephone Laboratories. They developed low temperature coefficient crystals and associated electronic equipment, studied the modes of vibration of oscillator crystals and predimensioning, and developed wire suspension metal-plated crystals.

During 1942 and the early months of 1943 about 100 new manufacturers, in addition to a dozen or so older companies, were in the production field. Several received direct government financial aid. The Signal Corps furnished instruction to all plants needing it, and also equipped many plants. This industry, driven by insistent demands of the Armed Services for immediate and large production, from 1941 to the end of 1944 delivered roughly 55,000,000 quartz oscillator-plates. The total amount of raw quartz used to manufacture these crystals amounted to thousands of tons. In addition, probably half again as much quartz was partly or completely processed but was wasted or unusable due variously to ignorance, carelessness, haste and lack of adequate technical controls. The cost of tooling up and doing the job amounted to about a third of a billion dollars. Production still is continuing on a large scale. A tabulation of the principal types of oscillator-plates put into mass production from 1942 to date is given on the next page.

Some of the difficulties that had to be overcome in establishing the crystal industry may be mentioned. Great quantities of raw quartz crystals had to be supplied. This material was obtained entirely from Brazil, where the purchasing and initial grading was carried on under the direction of governmental agencies and private importers. A considerable effort also was made to extend and mechanize the primitive quartz mining and distributing industry in Brazil. A stockpile of some millions of pounds of quartz was built up in the United States by the Metals Reserve Corporation, the material being graded by the National Bureau of Standards, and this and privately imported quartz was allocated to industry by the Miscellaneous Minerals Section of the War Production Board. During 1942 the supply situation became acute due in part to difficulties of sea transport and considerable amounts of quartz were flown by plane from Brazil to the United States and even to England. Efforts by government agencies and others to find or develop commercial supplies of raw quartz within the United States proved unsuccessful and only a few tons of domestic quartz, mostly from Arkansas, were processed. Unsuccessful attempts were made to synthesize large quartz crystals. The price of faced raw quartz crystals ranged from about \$5 to \$10 per pound for material of average quality and up to \$30 and more with increasing size and perfection. Raw quartz crystals of average size and quality are shown in Fig. 2. One pound of quartz yielded on the average little more than a dozen BT-cut oscillator-plates. Unfaced quartz was relatively abundant and cheap but efforts made to equip and teach the industry to handle such material met with reluctance.

The problem of taking a prewar laboratory-scale quartz cutting industry and equipping it almost overnight on a mass production scale with modern precision tools was very great. For many types of equipment, especially lapping machines, x-ray goniometric apparatus and frequency measuring equipment, designs had to be created. Manufacturers were found or created to make the equipment and then supplied with machine tools and other critical materials. A number of these operations were bolstered with high priorities and financed with Government funds from the Defense Supplies Corporation. The phrase "priming the pump" was popular in Washington at this time. Most of the equipment was held in Signal Corps pools and allocated to the industry. While not crystal manufacturers themselves, the Galvin Manufacturing Corporation of Chicago coordinated more than 30 subcontractors located over the entire country who made crystals in holder type FT-243 for "walkie-talkie" and other ground radio equipment of their manufacture. Galvin formed several equipment pools to supplement those formed by the Government, the most important item covered being the Atlas drill press lap, and among other services issued a series of short mimeographed bulletins (62 to date) dealing mainly with practical matters in crystal manufacturing. The North American Philips X-Ray Co., Inc., and later the General Electric X-Ray Corp. undertook the design and manufacture of x-ray equipment to control cutting angles and together have delivered about 300 units to the industry. The Naval Research Laboratory, Anacostia Station, D. C., developed the sensitive Geiger countre and electronic circuit for the Philips unit.

A number of crystal manufacturers also made important contributions to the

TABLE 1. DELIVERY OF QUARTZ OSCILLATOR-PLATES FROM THE CRYSTAL INDUSTRY TO THE ARMED SERVICES, 1941–1945[1]

Type[3]	Remarks[2]	1941	1942	1943	1944	1945
FT-171-B	AT 1.5 to 6.0 mc. Freq. tol. = ±0.02%. Temp. range −40° to +70°C. Used in armored force, field troop and artillery command sets.		132,351	846,521	521,014	
FT-241-A	DT-cut, 200 Kc. CT-cut, 300 to 1200 Kc. Tol. = ±0.02%. Range −40° to +70°C. Tank and other ground vehicle radios; field artillery.		2,836,293	3,568,651	4,488,362	
FT-243	AT and BT 2.0 to 9.0 mc. Freq. tol. = ±0.02%. Range −40° to +70°C (varies). Walkie-talkie, handie-talkie, and other portable combat sets; field artillery sets.		2,104,712	9,711,967	11,000,469	
DC-8	AT and BT 4.3 to 9.0 mc. Range −30° to +50°C. Aircraft command sets.		122,681	370,702	141,552	
DC-9	AT 1000 Kc. 15 cycles at 20° and 60 cycles over −30° to +50°C; operative −40° to +70°C. Calibrator crystal in frequency meter.		33,979	117,655	28,520	
DC-11	BT 5 to 9 mc. Freq. tol. = ±0.02%. Range −55° to +90°C. (A grade) Aircraft radios.		214,370	1,860,499	536,802	
DC-20	BT 5.6 to 5.7 mc. Freq. tol. = ±0.02%. Range −40° to +85°C. Airforce; runway localizer.		34,561	235,751	32,745	
DC-26	BT 5 to 9 mc. Predecessor to CR-1. Aircraft radio.		—	787,755	5,139	
DC-34, DC-35	AT or BT 1.6 to 4.5 mc. Freq. tol. = ±0.02%. Range −40° to +70°C. Ground forces; vehicles.		—	42,941	1,770,999	
CR-1A/AR	BT 5 to 9 mc. Freq. tol. = ±0.02%. Range −55° to +90°C (A grade) Aircraft radios.		—	1,359,957	7,274,909	
Other[4]			372,525	1,260,215	2,783,474	
	Totals	100,000 (est.)	5,851,472	20,362,614	28,583,985	30,000,000 (est.)

[1] Figures furnished by the Signal Corps, include Lend-Lease shipments.
[2] Tolerances and temperature ranges are those currently used, and are considerably more stringent than those in effect on 1941, 1942 and most of 1943.
[3] FT numbers refer only to holders; DC and CR numbers refer to complete units.
[4] Includes Navy crystals, in part of above mentioned types.

art. The Bliley Electric Co., Bell Telephone Laboratories and Harvey-Wells Communication, Inc., pioneered the etching-to-frequency method of finishing crystals.[1] The Bendix Radio Corporation of Baltimore cooperated with Signal Corps technicians in the development of crystal cutting procedures, developed the parallelogram light-figure method of orientation, and contributed to the design of both crystal lapping and x-ray orientation, equipment. The G. C. Hunt Co. and P. R. Hoffman Co., both of Carlisle, Penna., developed the precision planetary lap. The milling method of finishing crystals was developed in the laboratory of the Galvin Manufacturing Co., Chicago. The North American Philips Co., Dobbs Ferry, N. Y., provided facilities for studying the orientation and cutting procedures described in a series of official Signal Corps publications, developed precision lapping and cutting equipment and methods of orienting quartz. The North American Philips X-Ray Co. also designed and constructed equipment for the x-ray irradiation method of adjusting crystal frequency. The Reeves Sound Laboratories, Inc., of New York City, discovered and applied the x-ray irradiation technique of adjusting crystal

Fig. 2, Faced (left) and unfaced (right) masses of quartz of average size. The sawn wafers have 0.5 x 0.6 inch blanks marked out thereon.

frequency, developed safe etching compounds for quartz, and helped investigate the cause and cure of crystal ageing.

Among the principal difficulties confronting the newly established industry were uninformed management, the scarcity of skilled personnel, and the general lack of technical information, especially that dealing with the practicalities of orienting quartz and cutting plates therefrom. The prewar experience of many of the new manufacturers was in such fields as the manufacture of lamp shades, grindstones, transformers, neon lamps, sound recording apparatus and butchers' supplies. One was an undertaker. More than one of these new companies soon were producing more crystals in a week than the whole country did in the year 1939. Electronic engineers with or without a knowledge of quartz oscillator-plates,

[1] The method of etching quartz plates to frequency with hydrofluoric acid was patented (No. 1,869,160) in May, 1928, by W. A. Marrison of the Bell Telephone Laboratories.

crystal physicists and crystallographers were hard to find and desperately sought. Many potentially useful men had already been drafted into the Armed Services. The Signal Corps did its best to help this situation by field visits of staff technicians and by publication[2] of a series of mimeographed technical handbooks and bulletins written by members of the Quartz Crystal Coordination Section, Washington, and the Signal Corps Laboratories. Steps were taken, as in other critical industries, to prevent the drafting of key men. There was also a free and ready interchange of technical advice and assistance between the various manufacturers.

Technical difficulties also beset the new industry. The so-called Beilby-layer, debated pro and con for many years, turned out to be an unfortunate reality that in 1943 nearly caused cessation of manufacture of high frequency crystals. It was found that millions of crystals held in storage in Signal Corps depots or issued to the Services had deteriorated to such extent as to make them unusable. The ageing phenonmenon commonly appeared as a spontaneous increase in frequency with an accompanying partial or complete loss of "activity." The effect was traced to changes with time in a thin skin of misaligned and possibly hydrated quartz produced by abrasive action on the plate during manufacture. Etching in a solvent to remove this layer was found to obviate the effect. It was also found that corrosion and water absorption occurred to an objectionable degree in phenolic

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[2] Publications of the Quartz Crystal Section, OCSigO, include:

Frondel, Clifford, and others, Handbook for the Manufacture of Quartz Oscillator-Plates, August 20, 1942.

The following six information bulletins were issued as supplements to the Handbook:

Waesche, Hugh H., Procedure for finishing quartz oscillators, Inf. Bull., No. 1, Sept. 25, 1942.

Waesche, Hugh H., Equipment used for quartz crystal finishing and testing, Inf. Bull., No. 2, Sept. 25, 1942.

Woods, E. K., Memorandums on ordering information, Inf.Bull., No. 3, Sept. 24, 1942.

Richmond, Wallace E., Technique of sawing quartz, Inf. Bull., No. 4, Oct. 12, 1942.

Waesche, Hugh H., and Wolfskill, John M., A method of orientation and sawing of small unfaced quartz, Inf. Bull., No. 5, March 1943.

Frondel, Clifford, Technical practices in the crystal industry of the United Kingdom, Inf. Bull., No. 5, 1943.

Parrish, William, and Gordon, Samuel G., Manual for the manufacture of quartz oscillator-blanks, February 15, 1943.

The following four papers were issued as supplements to this widely used Manual:

Parrish, William, and Gordon, Samuel G., Procedures for unfaced quartz and large quartz, Supp. No. 1, March 31, 1943.

Gordon, Samuel G., The inspection of quartz, Supp. No. 2, July 1, 1943.

Gordon, Samuel G., Salvage of quartz and reclamation of rejected crystals, Supp. No. 3, July 1, 1943.

Bottom, Virgil E., Procedures for etching crystals to frequency, Supp. No. 4, Aug. 1, 1944.

Publications of the Fort Monmouth (now Long Branch) Crystal Laboratories (Signal Corps Ground Signal Agency) comprise 21 articles to date, among which may be mentioned:

Technical News Bulletin #5, "Orientation Method for the Use of Small Unfaced Quartz," 1942.

Technical News Bulletin #7, "Limits of Usability of Raw Quartz," 1943.

Technical News Bulletin #9, "Procedure for Cleaning Crystal Blanks," September 1943.

Engineering Memo. #1, September 1943, "Recommended Procedure for Predimensioning Broad Frequency Tolerance AT and BT Oscillator-Plates."

Engineering Report #778, January 1943, "X-Ray Orientation of Small Unfaced Quartz."

Engineering Memo #4, June 1944, "Ageing of Quartz Crystal Units."

Engineering Report #12, August 1943, "Small DC-9 Crystals."

Engineering Report #7, April 1943, "The Impedance of FT-243 Crystals."

type crystal holders when used in the tropics, and this led to the use of improvised plastics relatively impervious to moisture and to the accelerated development, still under way, of hermatically sealed glass or all-metal holders. Predimensioning became the subject of much concern. Predimensioned crystals are cut to certain rigidly specified predetermined physical dimensions that ensure satisfactory performance, but most manufacturers preferred for various reasons, especially in high frequency plates, to cut to arbitrary dimensions and hand tailor each crystal individually by edge lapping to give maximum performance. The Signal Corps exerted pressure on the industry to increase the efficiency and economy of manufacture and the quality of the product. Outstanding production records in certain plants and price renegotiation also acted to stimulate the industry in these regards. During 1943 special efforts were made to conserve quartz by improving cutting methods and reducing crystal size. The use of proportion of unfaced quartz was made obligatory on most contracts. Increasing emphasis was placed on care in finishing the crystal, cleanliness and final inspection. In 1944, etching-to-frequency techniques were made mandatory, and the specifications of crystals with regard to temperature testing range and frequency and activity tolerances were further tightened. More recently, hermetically sealed holders are required for certain types of crystals in place of the older phenolic types. Price competition — largely lacking in preceding years of huge demand and small supply — is becoming marked.

No rule is so general, which admits not some exception.

ROBERT BURTON

IMPROVED VACUUM-TUBE VOLTMETERS

Reprinted from Electronics

By J. T. McCarthy

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Full advantage can be taken of the high transconductance and linear transfer characteristics of pentodes by using a cathode-coupled triode in the vacuum-tube voltmeter input. Such a combination provides an instrument having both high input impedance over a wide frequency range and high sensitivity.

MANY vacuum-tube voltmeters employ a d-c microammeter as an indicator, with 1.5-volts input giving a deflection of 100-200 microamperes. The sensitive indicating instrument is needed because, (for reasons of stability, linearity, and low grid-current) the amplifier tube is operated in a region of low transconductance, with large degenerative feedback. When the feedback is great enough, calibration can be made nearly independent of tube characteristics and changes.

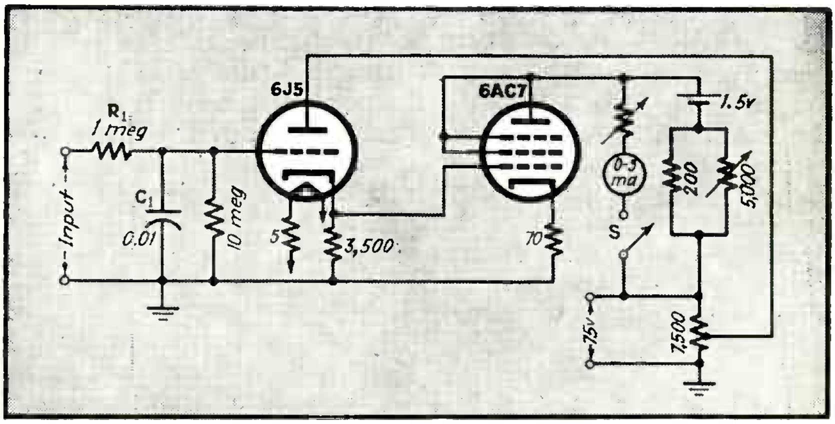

Fig. 1, Direct-current vacuum-tube voltmeter using a high-transconductance pentode isolated from the high-impedance input circuit by a triode connected as a cathode follower

Microammeters have been improved in recent years so that they are no longer regarded as expensive and fragile instruments. Many voltmeters employing them seem quite satisfactory. However. it appears that a milliammeter would still have advantages when expense, durability, and availability are important. Furthermore, a stable voltmeter built to operate with a milliammeter at 1.5 volts input could have its range extended downward by the use of a more sensitive indicator.

(Electronics, July 1945)

NEED FOR GREATER AMPLIFICATION

In order to use a less sensitive indicating instrument the vacuum tube must be operated in a region where its transconductance is high. Less degenerative feedback may be used but less is needed (for linearity at least) because the characteristic curve is more linear in this region. Although the use of television-type pentodes for voltmeters has occurred to several workers in the field, a tube of this type biased at a suitable operating point suffers from a rather large flow of grid current. This causes the input impedance to be low and produces an error in reading, the degree of error depending upon the impedance of the source.

Turner[1] has not only pointed out in detail the types of tubes with high transconductance that might be used for voltmeters but has also suggested that high effective-transconductance could be obtained by operating two or more tubes in parallel. However, parallel operation of tubes suffers from two disadvantages: first, the input capacitance and conductance are multiplied; and second, the total plate current increases greatly, so that more is demanded of the power supply.

Yard[2] has used a high-transconductance tube in a conventional circuit and obtained a deflection of 5 ma for 1.5 volts input. The deflection can be doubled by using a separate battery or cell to balance out the initial plate current. This circuit suffers from a lack of linear response, a shift of the zero-setting with line-voltage fluctuations, and a low input impedance of about 1.5 megohms. The grid resistor cannot successfully be increased very much because of the flow of grid current. These difficulties are probably inherent in any voltmeter employing a single tube of high transconductance or two or more tubes in parallel.

CATHODE COUPLING

It will be shown below that high-transconductance tubes can be used successfully in simple and inexpensive voltmeter circuits when some kind of input stage is used to provide high input resistance. High sensitivity and large output current result. The disadvantages accompanying small degenerative feedback are minimized by using balanced circuits and some means for quick calibration.

The circuit in Fig. 1 was designed to overcome, by sacrificing some simplicity, the short-comings of the single-tube voltmeter. This d-c voltmeter is essentially a two-stage amplifier with the first stage serving only to couple the source to the second tube. The first stage is a cathode-follower arrangement and is highly stable because of the large degeneration. The 6J5 is operated with low voltages on the heater and plate in order to reduce the grid current in both tubes. The high side of the input is connected through a shielded lead with a 1-megohm isolating resistor, thus providing an input resistance of 11 megohms. This resistance could be made larger.

METER CHARACTERISTICS

The bias for the 6AC7 is the algebraic sum of the voltage drops across the two cathode resistors. The initial plate current is balanced out by a No. 6 dry cell. Instead of this cell, a suitable voltage may be tapped from the bleeder resistance but this reduces somewhat the sensitivity. In order to protect the indicating instrument against excessive deflection, switch S is left open until the heater of the 6AC7 has warmed up. The sensitivity can be controlled by the rheostat in series with the milliammeter. The supply voltage is regulated by using a OA3/VR75 tube.

This voltmeter is strictly linear; the zero point is very stable and no appreciable grid current is observable in the 6J5. An input of 1.5 volts gives a full-scale deflection on a 5 ma instrument of 1 percent accuracy. The circuit is sufficiently stable so that, by means of a more sensitive indicator, the range of the voltmeter may be extended downward by a factor of two or three at least, depending upon the voltage fluctuations in the power line. The range may be extended upward by a conventional voltage-divider across the input. Because of the filtering action of the input circuit, d-c voltages can be measured correctly even in the presence of superimposed a-c voltages.

BALANCED CIRCUIT

This type of coupling can also be applied to a balanced circuit to avoid employing a dry cell and to stabilize more easily against line-voltage fluctuations. A stabilized power supply is usually not necessary and some simplification results. This is illustrated by the circuit in Fig. 2, a stable circuit with linear response. The two 6AG7 tubes and the two sides of the 6SN7-GT should be approximately matched for optimum stability. The milliammeter is connected to the plates of the amplifier tubes in the conventional bridge circuit. A deflection of 10 ma can be obtained for an input of 2 volts but the circuit is usually operated conservatively with the constants shown so that 1.5 volts produces a reading of 5 ma. When a 1-ma meter is used, satisfactory performance is obtained with a full-scale deflection corresponding to 0.3 volt. Slight effects of the line-voltage fluctuations are observable at this sensitivity.

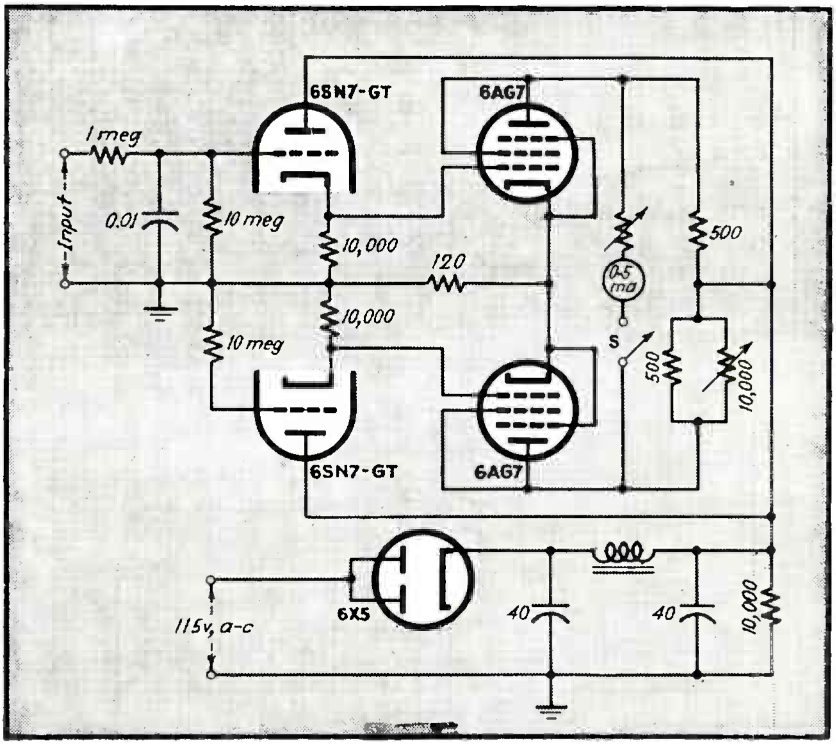

Fig. 2, Balanced voltmeter circuit uses cathode coupling and high-transconductance pentodes

Although other types of tubes were tried in this circuit, the 6AG7 gave maximum sensitivity. The response with 6AC7's is only slightly lower however, and these tubes have the advantage of lower plate current (20 ma for two 6AC7's instead of 35 ma for two 6AG7's). At high plate current 50L6-GT tubes worked fairly well. A 6F8-G, with similar characteristics, might be preferable to the 6SN7-GT because higher input resistance could be obtained to the grid coming out of the top of the tube. It is possible that selection of tubes with suitable heater ratings could be made in order to dispose of the filament transformer, to use cheaper tubes and to allow complete operation on the a-c or d-c lines.

A-C MEASUREMENT

This type of circuit can easily be adapted to the measurement of a-c voltages. If R_1 and C_1 of Fig. 1 were removed, the insertion of a diode rectifier either before or after the first stage should work well and provide a linear scale. If placed after the first stage, the high input impedance of the circuit would be retained. An even simpler arrangement would be to allow rectification to take place in the first stage. This tube would then become what Rider[3] calls a reflex rectifier, or what radio publications often call an infinite-impedance detector.

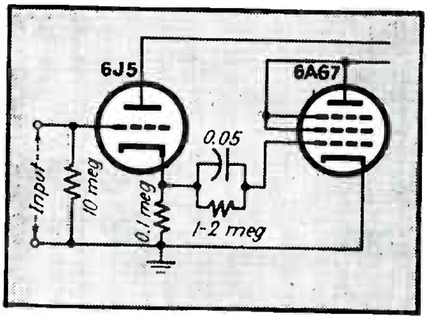

Fig. 3, Alternating-current vacuum-tube voltmeter with a cathode-coupled stage preceding the high-transconductance pentode grid-detector stage

In one adaptation to a-c that was tried, the grid circuit of the second stage was used as a rectifier, as illustrated in Fig. 3. With a 6AC7 tube, a deflection of 5 ma for 1-volt rms input is obtainable. The response is linear except over the very lowest part of the scale. Although this circuit was used only at audio frequencies, it has recently been shown by Daniels[4] that the cathode-follower circuit can be used up to several hundred kilocycles in voltmeter circuits without using an external probe.

By using ordinary triodes in all four arms of a Wheatstone-bridge circuit, Glenn[5] has constructed a voltmeter which can operate a 1-ma instrument on less than 0.5 volt input. Stability and high input resistance are claimed along with this high sensitivity. Instruments of higher range are not suitable for this circuit because all tubes must be operated at very low plate currents in order to avoid a large grid current in the input tube.

WHEATSTONE BRIDGE

The circuit shown in Fig. 4 is similar to that of Glenn, but contains the added resistors R_1 and R_2. The latter increase the power output greatly, especially when power tubes are used in the second stage. When tubes like 6V6-GT, 6L6 and 6AG7 are used at very conservative plate currents, a maximum deflection of 15 to 25 ma for 1.5 volts input is easy to obtain. Preliminary experiments have shown that the output can be made linear over the first 5 or 10 ma and that practical stability is possible. The use of separate resistors in the cathode circuits of the first stage is desirable.

LINE-VOLTAGE COMPENSATION

Although balanced circuits like those of Fig. 2 and Fig. 4 are advantageous, complete compensation for line-voltage fluctuations is not attained in them. The difficulty arises from slight differences in dynamic characteristics and in heater characteristics of similar tubes and should be more prominent in circuits like those shown above, especially when little or no degenerative feedback is used. However, it was found that power-line fluctuations in our laboratory caused a negligible error in reading when balanced circuits were used. For cases where these fluctuations are larger or where a more sensitive indicating instrument is to be used, greater stability could be obtained by using a stabilized power supply or a constant-voltage transformer.

It can be expected in the above circuits that the calibration, depending more than usual upon tube characteristics, will change slightly as the tubes age. The inclusion of a Mallory bias cell in a voltmeter allows a frequent and rapid check upon this calibration.

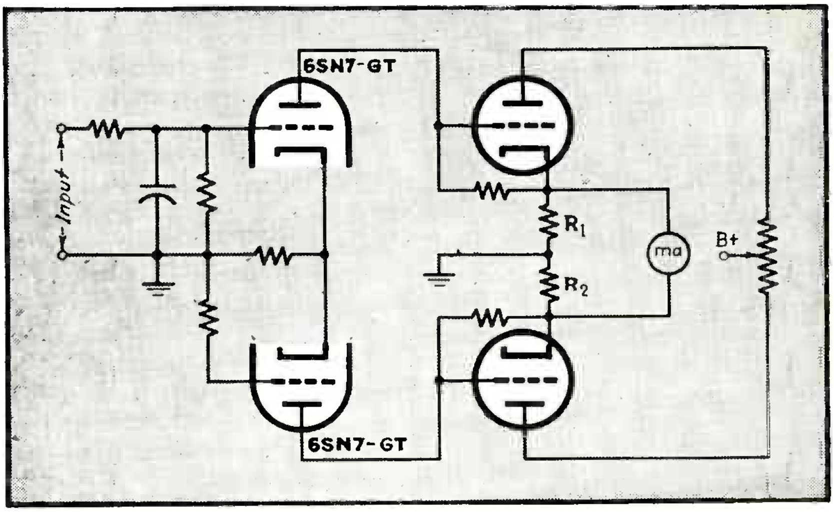

Fig. 4, Wheatstone-bridge balanced vacuum-tube voltmeter circuit combines high sensitivity and stability

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TELEVISION FOR THE AMATEUR

Reprinted from Radio News

By Oliver Read, W9ETI

Television—a new field for the postwar ham—will provide additional interest to amateur activity.

TELEVISION is not too complicated for the amateur — neither is it too expensive. The radio amateur, always inquisitive, and with a comprehensive knowledge of transmitter and receiver practical theory and operation, has only three obstacles in his path: study of high-frequency methods, study of circuits for non-sinusoidal waves, and study of the assembly of the various signal components which constitute the composite television signal. If he already has appreciable high-frequency and cathode-ray-tube experience, which I conservatively estimate 60% of the radio amateurs have obtained in their commendable war contributions, he is two giant steps closer to the television goal. A knowledge of patterns and internal electron'-tricities of the cathode-ray test oscillograph is a step in the approach. A radio amateur with high-frequency relay or link experience and with radar design, construction, or repair experience, has the acme of pre-television instruction.

To learn how the receiver functions is a major portion of the task, for understanding exactly what occurs in the receiver entails a knowledge of the composition and arrangement of the transmitted television signal. This information can be obtained by studying the present and back installments of the receiver series now appearing in RADIO NEWS.

Amateur Band Megacycles	No. of Channels	Max. Band-Width per Channel Megacycles	Television Band Megacycles
420-450	3	4	420-432
1125-1225	5	8	1125-1165
2500-2700	7	10	2500-2570
5200-5750	10	20	5200-5400
10,000-10,500	10	20	10,000-10,200
21,000-22,000	20	20	21,000-21,400

FUNCTION

What are the basic functions of the television system?

A. Transmission

1. Forms a picture signal which is a parade of electrical charges representing the light distribution on the object televised.

2. Forms a series of rectangular pulses, sync and blanking, of various amplitudes and durations, which are inserted into the picture signal at prescribed intervals, to hold the picture stationary or "in sync" on the receiver screen and to prevent picture from streaking.

3. Generation of a high-frequency carrier which is modulated by this composite television signal.

4. Generation of an associated sound carrier, which is, in commercial practice and possibly will be in amateur practice, frequency-modulated by the sound information.

B. Reception

1. The receiver in commercial practice picks up both picture and sound carriers and passes them into separate i.f. systems. The amateur can use the same method or two separate receivers, whichever is most convenient.

2. Picture signal is transferred back into light variations on the screen of the picture tube.

3. Sync pulses hold the reproduced image on the picture tube screen, prevent "tearing out" (horizontal displacement of picture elements) and "flopping over" (vertical displacement of picture elements).

Thus, the television system has two primary functions, namely: to get the light information to the picture tube, and to display it in proper sequence (synchronized) with stability.

FREQUENCY

To transmit a picture with clarity and definition, a wide-band of frequencies is necessary. Thus, if a signal is transmitted which contains two-megacycle components, a four-megacycle bandwidth is required, unless some elaborate scheme is used to partially suppress one sideband. If better definition is desired, the bandwidth must be proportionately greater.

Observation of the frequency bands allocated to the amateur shows that only the very high-frequency bands can accommodate such a wide channel. These bands are listed in the accompanying chart. One other band is five megacycles broad, 220 to 225 megacycles. This band could only accommodate one four-megacycle channel. It is not likely that television will be permitted in this band, because of interference between television stations and other types of communications on the band. It is desirable that the FCC allocate separate television sections on the high-frequency amateur bands, and specify bandwidths which become progressively wider (permitting higher definition) on the higher frequency bands. A tentative outline for such a system is shown in Table 1.

While these frequencies are considerably higher than the bands on which the amateur is accustomed to operate, many of the circuits have become more or less conventional because of the much improved efficiency of the miniature and lighthouse type tubes, and the improved quality of insulating materials. Thus, the amateur can start out using essentially conventional circuits on the lower-frequency television bands, and, as his experience increases and his knowledge improves, he can gradually convert to waveguides and resonant cavities and progress to the higher frequencies.

It would be of great benefit to the amateur and possibly to television itself, if the FCC would allocate two or three television channels for the amateur in the 200-megacycle region. Here his range would be greater and his r.f. circuits absolutely conventional, permitting him to concentrate almost entirely on the television concepts. At the start, the FCC should also permit the amateur to establish his accompanying sound on some prescribed lower frequency channel. This leniency would considerably reduce equipment costs for the amateur and would avoid the additional complexities arising from possible interaction between picture and sound transmitters. In fact, a small "peanut whistle" on 5 or 160 meters would adequately cover the same range as the television transmitter. At some later date, when cost of high-frequency equipment is less, the sound transmitter can be moved up adjacent to the picture transmitter. The above allocations and regulations would encourage amateur television experimentations, because it holds the initial cost down. Once started, the amateur is certain to contribute to the sum total, just as he has in the war, and will progress to high-definition television and, some day, color television.

THE AMATEUR STATION

The amateur station need not be expensive. A complete station can be constructed for approximately $200. if there is a standard home television receiver available. Considerable sums can be knocked off this total if the amateur has an elaborate junk box, some power supplies, and a generous supply of resistors and capacitors.

The transmitter of the television station is most likely to be some sort of stable high-frequency oscillator, frequency multiplier, and final amplifier. The oscillator will have a resonant chamber or concentric tuned circuits for stability. The final amplifier will have transmission-line sections as tuned circuits and, generally, will be grid modulated by the composite television signal. Fortunately, there is no necessity for high power at these frequencies, as long as sufficient signal is delivered to the receiver input to overcome inherent tube noises. In fact, because of line-of-sight limitations, radiation at these frequencies is primarily an obstacle course and is more dependent on antenna placement and efficiency than on radiated power. The amateur has a fertile field for antenna experiments because the physical size is small and the cost of materials low. Highly directional transmitting and receiving antennas will greatly improve signal strength, and reduce interference. Field work (glider meets, etc.) with mobile and portable equipment will arouse considerable interest.

The most costly items of the video and pulse circuits of the transmitter are the iconoscope, special transformers, and tubes. The video amplifiers and sync generator, while reasonably complex and delicate of adjustment, contain relatively inexpensive component parts. An oscilloscope is almost a must in tuning up these circuits, although a television receiver known to be in good operating condition can be used as a satisfactory test circuit.

The receiver can be a very simple and effective piece of gear if the amateur has a home television receiver. To receive the signals from a higher frequency, an additional mixer, local oscillator, and possibly an i.f. amplifier is attached ahead of the home receiver. This double-superheterodyne television system performs satisfactorily if the composite television signal is properly constructed at the transmitter. Under certain circumstances, the signal construction at the transmitter can be simplified and still a satisfactory picture received, if a few minor adjustments and changes are made on the receiver. Some sort of a switching arrangement can be used to change over between amateur and commercial reception. Consequently, if the received signal is on 430 megacycles, the local oscillator is set on 497¼ megacycles, producing a 67¼-megacycle i.f. frequency which is amplified and fed into the antenna input of the home receiver. This frequency is the picture carrier frequency when the receiver is set on commercial channel three. If the amateur has no receiver available, he can build his own and adapt it for both amateur and commercial use.

STUDY OUTLINE

What is an effective study outline for the amateur in preparation for ham television?

A. Review fundamentals. Stress the following:

1. Voltage distribution as frequency varies, for any arrangement of resistors, capacitors, and inductors, or shunt and series combinations of them. Effect of time constants on instantaneous voltages.

2. Properties of series and parallel resonant circuits.

3. Principles of vacuum-tube operation.

B. Operation of the cathode-ray oscilloscope.

1. Understand vertical and horizontal amplifiers, sweep circuits, and synchronization.

2. Oscilloscope operating circuits and power circuits.

3. Origin and information contained in various scope patterns.

4. How to use the test oscilloscope to its fullest.

C. High-frequency techniques.

1. Understand high-frequency oscillators, r.f. amplifiers, class C amplifiers, and methods of modulation.

2. Importance of correct physical layouts for high-frequency equipment. Be familiar with quarter-wave tuned lines, resonant chambers, transmission lines, and high-frequency antenna techniques.

D. Special circuits. Understand basic principles of the following:

1. video amplifier.
2. wide-band r.f. and i.f. amplifier.
3. wide-band antenna.
4. sawtooth generator.
5. pulse and sawtooth amplifiers.
6. pulse separator.
7. counter circuit.
8. multivibrator and blocking-tube oscillator.
9. d.c. restorer.
10. direct-coupled amplifier.
11. scope operating circuits.
12. clippers, limiters, and shapers.
13. keying circuits.
14. mixer and combining circuits.

E. General over-all function of the television system.

1. Trace the various signals from iconoscope to picture tube.

2. Contents and construction of the composite television signal.

F. Detailed circuit-by-circuit study.

1. Study each circuit carefully. Know how it operates and how it fits into the entirety.

2. Review and expand. Keep up with the latest developments.

TELEVISION IN SALVAGE

The jaws of salvage machines, operated at great ocean depths, are guided by television apparatus.

NOTES ON ALIGNING AND TESTING SUPERHETERODYNES

Reprinted from Radio

By W. H. Anderson

Useful short-cuts in familiar operations.

THE PRIME REQUIREMENT of any communications receiver is that it have good selectivity. The general acceptance of the superhet as against the t-r-f set, for instance, can be traced to a number of its advantages, but generally speaking, greater selectivity is its outstanding virtue. It is not unreasonable, then, to attribute this superiority to the i-f amplifier unit. Unfortunately the proper functioning of this portion of the receiver is often taken for granted and the full capabilities of the receiver are not utilized, as a result of haphazard alignment methods.

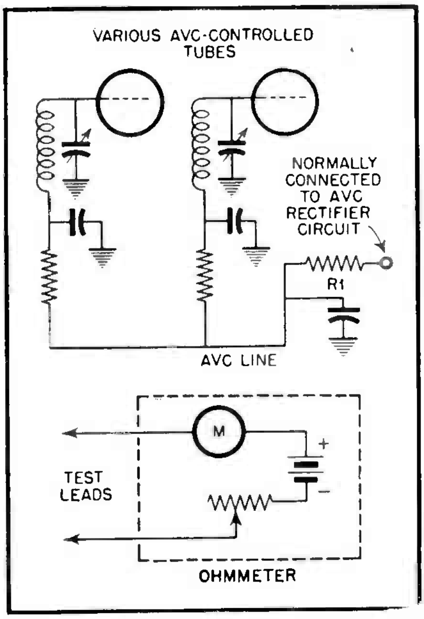


Fig. 1, Isolating and checking a-v-c line

Before actually aligning the i-f channel, a thorough check should be made of all socket voltages. In fact, the actual alignment should always be left until the last, so as not to be affected by changes in by-pass capacities, tube voltages, tube inter-electrode capacities, etc. It is surprising how a set will often work fairly well with a partially open screen grid resistor or a shorted cathode capacitor. Obviously even commercial receivers are not immune from such troubles, and should not be assumed to be normal, even though the receiver be new and of a reputable make. The various measured voltages should agree with tube handbook data, or service notes, especially in regard to bias and maximum allowable potentials. The cathode voltage in self-bias arrangements is of particular interest, not only because it represents the operating bias, but low cathode voltage means improper tube performance and consequent low amplification.

CHECKING THE A-V-C LINE

Another extremely revealing test is to isolate the a-v-c line (see Fig. 1) and measure its resistance to ground on the highest scale on your ohmmeter. This test should be conducted *with normal filament and plate voltages.* As an ohmmeter invariably employs a battery, one way of connecting the leads will place the positive battery voltage on the grid, while reversing the test leads will place a negative potential on the grid. The leakage resistance should be of the order of 30 megohms with negative grid and very close to that figure with positive grid. As most ohmmeters use a battery voltage of 3 volts or less, consequently as the cathodes generally run about 3-5 volts above ground, the grid will at all times be negative with respect to the cathode, and no grid current will flow. However any combination of ohmmeter battery and cathode voltages that will make the grid positive with respect to the cathode will result in grid current, and the ohmmeter will indicate low resistance.

Many possible sources of trouble may be detected by this test. Should any of the a-v-c line by-pass capacitors have appreciable leakage, this leakage resistance will combine with R_1 (Fig. 1) to form a voltage divider across the output of the a-v-c rectifier with only a fraction of the a-v-c voltage being applied to the various tubes and resulting danger existing of overloading on high level signals.

Recently in checking a 6L7 mixer in this manner, a considerably lower resistance with positive test lead on grid was noted. This condition disappeared

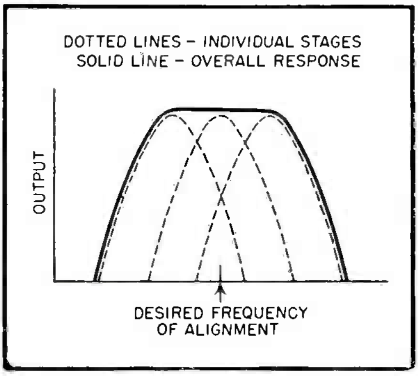


Fig. 2, Brood selectivity curve due to tuning i-f stages to different frequencies

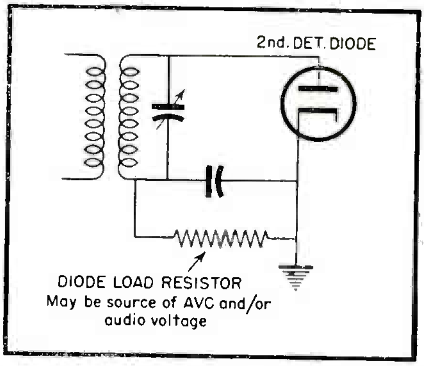


Fig. 3, Diode load resistor used for output measurements

when the h-f oscillator was disabled. All voltages were apparently normal, at least well within ratings. However, an increase of 25 volts on the 6L7 screen caused the a-v-c line resistance to be very high on both polarities of the test leads. Actually, this imperfect screen-grid action resulted from coupling existing between the control grid and the injector grid and was a potential source of oscillation and pulling between the mixer and h-f oscillator.

ALIGNMENT PROCEDURES

The customary method of alignment using an output meter across either the primary or secondary of the output transformer, or simply by loudspeaker volume, will naturally require that a modulated test signal be used. The modulation frequency used is generally 400 cycles. Therefore, considering sidebands, the signal is actually 800 cycles wide. Accordingly each i-f tuned circuit could be tuned anywhere within this 800 cycles and the output meter indication would be unaffected, regardless also of whether all are tuned to the *same* frequency or not. For instance, one may be tuned to the desired frequency plus 400 cycles, another to desired frequency minus 400 cycles or any other intermediate values. Even in reception of phone signals, an i-f bandwidth of 800 cycles plus the unavoidable slope of the response on both sides, gives an overall response that has much too broad a "nose." (See Fig. 2). Similarly aligning by ear on atmospheric noise or with a magic eye or a vacuum-tube voltmeter on the a-v-c line is very misleading, as the breadth of the signal contributes to the indication. In the alignment procedure outlined below it will sometimes be noted that the meter will drop down, but the audio output will actually increase as an i-f trimmer is tuned, definitely indicating that the i-f stage has an increasing output by virtue of passing a broader band. It is evident, then, that the methods mentioned above cannot be relied upon to indicate when the i-f channel is in its most selective condition.

UNMODULATED SIGNAL NECESSARY

An unmodulated signal with its theoretically zero bandwidth must therefore be employed. The only place that a measurement may conveniently be made of such a signal is in the 2nd detector circuit. (See Fig. 3.) Output measurement may be

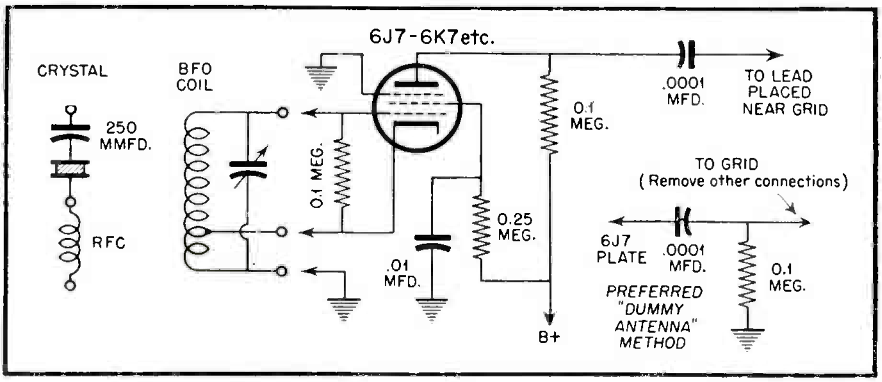


Fig. 4, Simple signal generator for i-f alignment

made with a voltmeter across the diode load (preferably a vacuum-tube voltmeter to avoid altering the normal load on the diode due to the shunting effect of the meter) or a milliameter may be used in series with the load resistor.

When the plate load of a tube changes, its grid input characteristics change (this is known as "Miller effect"), it will be seen to be necessary to align from the 2nd detector "back" to the 1st detector. In order to get the most pronounced "swing" on the meter and a more definite and sharper peak reading, indicating proper adjustment of the trimmer, it is generally best to align with a.v.c. off. This assures that the set will be aligned in its most sensitive condition — i.e., when receiving cw signals, or phone signals too weak to actuate the a.v.c. The further precaution should be taken of cutting down the output of the signal generation occasionally to make sure this causes the meter to drop sharply, otherwise the stage or stages are being overloaded. In short, the signal generator output should be kept as low as possible and still provide a reading of suitable "swing" as the i-f trimmer is tuned through resonance.

In order to prevent interaction between stages, it is advisable to couple the generator to the grid of the last i-f tube and then align the 2nd detector grid and last i-f plate, then move to the grid of the next to last i-f tube and tune the last i-f grid and next-to-last i-f plate, and so forth to the 1st detector grid. Once a stage has been aligned, do not go over the following stages in an endeavor to "trim" them up. Incidentally, the signal generator should always be well grounded to the set chassis.

SIMPLE SIGNAL GENERATORS

The signal generator itself may be readily improvised, if necessary, from a b-f-o coil of proper frequency and a small oscillator tube such as 6J7. (See Fig. 4). Calibration may then be effected by beating a harmonic of such an oscillator against stations in the broadcast band — e.g., the second harmonic of 465 kc is 930 kc, a readily identified broadcast frequency. As has been emphasized before, it is not so important that all stages be aligned to a certain specified frequency, as it is that they be aligned to the *same* frequency.

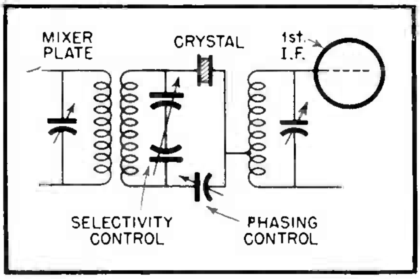


Fig. 5, Conventional crystal filter circuit

SINGLE SIGNAL RECEIVERS

If the set has a crystal filter, the crystal may be hooked into the oscillator (See Fig. 4) and alignment to the exact frequency effected. In such sets, when the alignment process has reached the point where the oscillator is coupled to the mixer grid, the vacant crystal socket in the receiver should be bridged out with a large capacitor (.1 μf or so) and the phasing and selectivity controls set at approximately the most used positions. Alignment of the i-f grid and mixer plate circuit may then be done. A slight compromise is involved in this case as the variation of the selectivity control (See Fig. 5) will couple a varying load to the mixer plate circuit which will in turn reflect (Miller effect) a varying impedance into the mixer grid circuit. This slight loss in selectivity is of course more than made up by the use of the crystal in the filter.

FRONT-END ALIGNMENT

Adjustment of the front end of a superhet for tracking, etc. varies widely between sets, and individual instructions are generally issued. While the adjustment of the grid circuit of the first tube in any set is very important as it determines largely the overall signal to noise ratio, it cannot be overstressed that proper and careful i-f alignment is absolutely necessary for good selectivity.

GIANT AT THE DAM

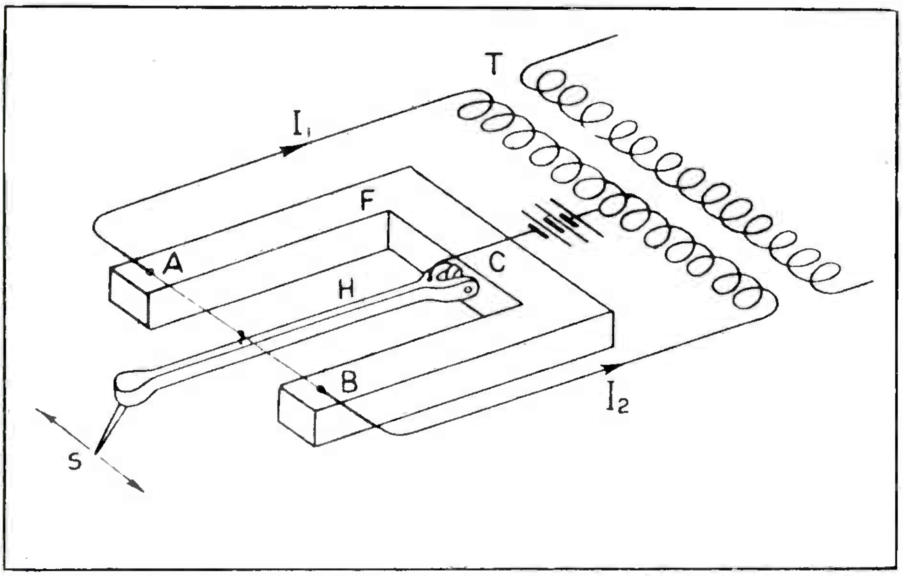
Seven turbines at Boulder Dam convert water into 800,000 *horsepower of electrical energy to serve all types of industries.*

STRAIN-GAGE PHONO PICKUP

Reprinted from Electronic Industries

THE PRINCIPLE of the strain gage, now being applied in a wide variety of ways in industry, has been put to a new purpose by the General Electric Co., Schenectady, which has developed an entirely new type of phonograph record pickup that has certain unusual features. General Electric engineers have long investigated problems having to do with record reproduction* and this latest development represents the culmination of much intensive work along these lines.

The strain gage, as most everyone knows, depends for operation upon the changing resistance of a fine wire as it is minutely elongated under stretch or strain. Such gages are currently being used in measuring strain in mechanical members such as bridge girders, aircraft parts, engine connecting rods and a host of other applications. It is the principle of such gages that has been put to work in the new phonograph pickup.



Diagramatic sketch of the principle on which the new General Electric strain-gage pickup operates to cause current variations only through lateral movement

The accompanying sketch, which is purely diagrammatic in form and does not closely resemble the actual construction of the pickup, illustrates the manner in which the device operates. A yoke or frame F supports the strain element, which is a short length of fine resistance wire AB fastened at each end and under slight tension. A small cantilever beam H, carrying the stylus S is pivoted to the yoke at C and attached to the resistance element at its midpoint.

In operation, lateral movement of the cantilever, as the stylus follows the record groove, alternately stretches and relaxes each half of the resistance element, thereby slightly altering its resistance. The change in resistance is directly proportional to the movement of the stylus. The electrical circuits include a transformer, since the strain gage element is a low impedance device, and a source of direct current.

It may be seen from the diagram that when the stylus is at rest and the cantilever in a central position, both sides of the resistance element are under the same tension and the currents I_1 and I_2 will be equal. As the resistance of sections A and B is changed as they are stretched or relaxed under movement of the cantilever, the currents become unbalanced and the net magnetizing force in the transformer produces an alternating current which is directly proportional to the movement of the stylus. The frequency response is said to be better than can be obtained by other means.

A principle advantage of the new pickup is that because of its small mass, the stylus can be made to follow the record grooves accurately with pressures in the order of 10 to 15 grams, thus materially reducing record wear. Like other pickups, this new recorder effectively discriminates between horizontal and vertical movement of the the stylus. In lateral type recordings, only lateral movement of the stylus is desired. Vertical movement of the usual stylus is due to pinch effect and to roughness of the record groove, dirt scratches, and produces undesired record noise.

In the strain gage pickup as made for lateral recordings, vertical movement of the stylus does not cause any movement of the cantilever and thus does not cause any unbalance in the circuits and hence no output.

ROBOT ADDS YEARS TO LIFE OF HIGH SPEED MACHINES

A balancing machine which checks vibration in motors, generators and other high speed electrical devices is adding years to the life of the equipment. The machine is so sensitive that it can detect a cause of unbalance as minute as a drop of water, or vibrations as slight as 100,000th of an inch. A robot "brain" then calculates where the equipment is unbalanced and the amount of weight required to restore balance.

CYLINDERS FOR BETTER SOUND

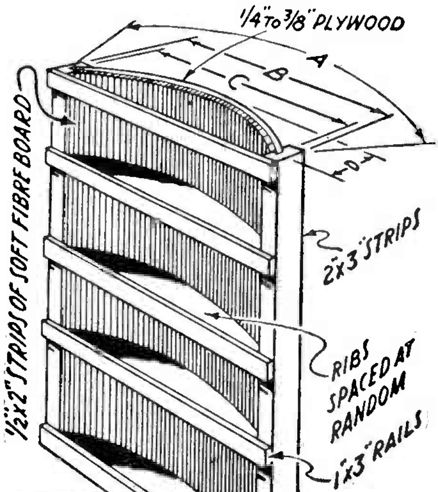
Reprinted from Radio-Craft

By Nathaniel Rhita

ACOUSTIC design is concerned with the problem of maintaining clear and natural music and speech in auditoriums and studios. Investigations are carried on not only from the physical point of view but also from the subjective. The final opinion as to acoustic excellence comes from the audience. Acoustic measurements of the room will, of course, indicate general conditions existing and possible improvements to be made.

A listener sometimes has opinions which are the result of his special experience. One who is accustomed to music played in deadened rooms may not care for lively rooms at first. A flat frequency response might seem "unnatural" to one who has always listened to limited fidelity reproduction.

Less reverberation in any given room may be tolerated for speech, since the words must be free of interference from succeeding sounds. However, some reverberation must be present. Music, on the other hand, requires more reverberation, the resulting superposition of notes adding to harmony and making the music more pleasing.



A	B	C	D
36	37½	34½	4½
42	42½	39¼	6
48	47½	44½	7¾

Fig. 1, Construction of a diffusing panel

Optimum reverberation time is therefore a major factor in acoustic design. Listening tests show that a different optimum exists for each size and type of room. It should be kept in mind that compromises may be necessary, however, since different types of music and instruments may require slightly different reverberation periods. For example, brass requires a different period than does string music. Also reproduced sounds require a shorter reverberation time than original sounds.

The well-known Sabine formula was formerly the basis of all acoustic design calculation. This formula takes into account the sound absorption due to each surface in the room. By using surfaces made of material with a high absorption constant, the reverberation period could be decreased. The formula generally applies to rooms with flat surfaces.

Since absorption material usually introduces frequency discrimination, it is often found that the low frequencies are only slightly attenuated, while the highs almost disappear. The former could be brought down in most cases only by eliminating the latter entirely.

POLYCYLINDRICAL SURFACES

A new approach to the problem has recently been disclosed.* In use for several years, unusual results have been obtained by recording studios and broadcasting stations as well as auditoriums. Polcylindrical plywood panels are used as walls and ceiling to diffuse the sound waves and reflect them irregularly. Typical measurements and construction of such a panel are shown in Fig. 1. Segment braces are spaced at random with insulating material between them and the panelling to prevent rattles.

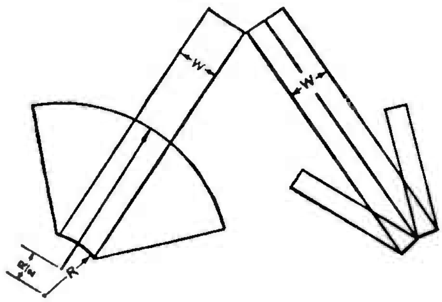


Fig. 2, Reflection from flat and curved surfaces.

The theory (as well as the results) show that a number of improvements can be expected from these curved reflecting surfaces, although the plywood does not possess a high absorption constant. More uniform sound pressure distribution, better diffusion, greater absorption of low than high frequencies, less interference between direct and reflected sound and minimization of echoes are obtained with convex reflecting surfaces. Fig. 2 shows the comparison of interference characteristics of flat as against curved panels. The reflections do not periodically add and subtract from the incident waves when the latter are used, to as great a degree.

The wave front is effectively diffused as is shown in Fig. 3 because the curved panels send the energy over a wide area. Flat panels reflect the sounds to a limited area, and some areas receive no energy.

Because of the haphazard reflections, the average room energy decays uniformly rather than in steps such as is assumed in the Sabine formula. This means, of course, more reflections per unit of time. Greater reverberation can be tolerated since successive sounds are not heard as being distinct but rather continuous until their final decay.

Another important factor is the sounding-board effect. Each panel vibrates at a number of frequencies not harmonically related, especially at low frequencies. Since absorption usually takes place at the high frequencies, these two effects form an excellent balance to provide a flat frequency curve. Auditoriums using these new surfaces have been constructed with an essentially flat reverberation period from 40 to 17,000 cycles.

* BROADCAST NEWS, published by the Radio Corporation of America

It is also common to make use of the advantages of optimum room dimensions. Fig. 4 shows the chart made use of by acoustic designers, to eliminate the piling up of room resonances. Optimum measurements are shown for four different types of rooms of given volume

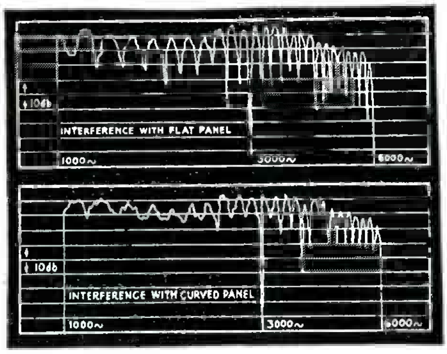


Fig. 3, Diffusion of wave-front fram flat and curved panels.

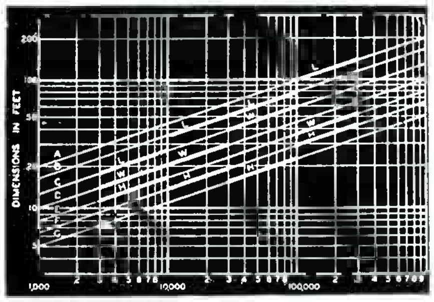


Fig. 4, Preferred dimension ratios: Average rooms — H:W:L=1:1.6:2.5=F.D.B; long rooms — H:W:L=1:1.25:3.2=F:E:A; low-ceilinged rooms — H:W:L=1:2.5:3.2=G:C:B; small rooms H:W:L 1:1.25:1.6 E:D.C. (Letters A-G refer to curves above.)

Polycylindrical plywood panels were first used by RCA in connection with motion picture recording. The practice proved so successful that it was followed by various radio station studios throughout the country. Among notable installations are those of the Philadelphia Academy of Music; Walt Disney recording studios; Stations WFAA-KGKO, Dallas; Naval Air Station, Anacostia.

NEW HEALTH GUARD FOR WORKERS

A newly devised mercury-vapor detector, an electronic instrument, can measure mercury vapor concentrations of one part in 3,000,000 parts of air. It is used to guard the health of employees in glass, chemical, smelting and electrical manufacturing plants.

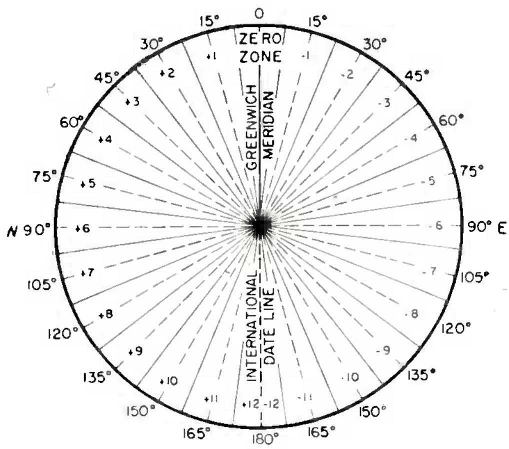
A MATTER OF TIME

Reprinted from CQ

By Lawrence LeKashman, W2IOP

Translating Local, Zone, Standard, Daylight and War Times into GMT for Ham Working and Logging.

JUST AS the average amateur in the United States must confine his operating to available hours of leisure, the DX stations cannot be expected to be transmitting at any and all hours of the day. Thus it follows that the best hours to work any particular foreign country are those which coincide with the leisure hours at the DX station. For example, when it is 10:00 P.M. Eastern War Time, it is 4:00 A.M. British War Time — a mighty poor hour to expect many of the English stations to be operating. Normally there is 5 hours difference in time between the east coast and the United Kingdom. Today, however, the east coast is on war time(plus 1 hour) and the United Kingdom is on double war time (plus 2 hours) making a difference of 6 hours. On the other hand, if the English hams are looking for United States west coast contacts, the hour of 4:00 A.M. in Britain, corresponding to 7:00 P.M. Pacific War Time, would be ideal. (We refer to War Time as a matter of expediency. It demonstrates the idea. Naturally, there are no QSOs during "War Time.")

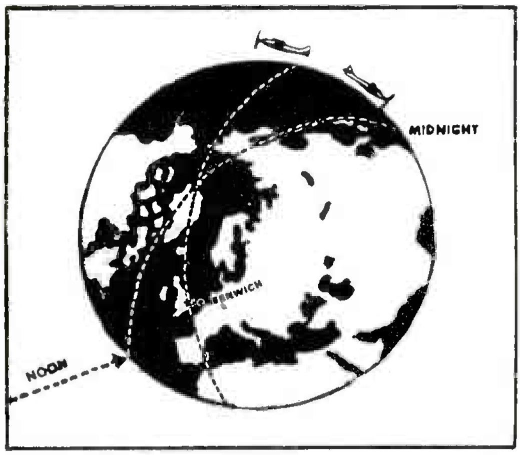


Time zones described in a polar diagram. Eastern Standard Time is 75 degrees and five hours west of Greenwich

One of the confusing things in DX work is the difference in time — especially when expressed in terms of local hour only. The adoption of the Greenwich Civil Time (GCT) system would simplify the problem to a great degree. The radio amateur is primarily concerned with four kinds of time — Greenwich Civil Time, standard time, zone time, and daylight and war saving time, the latter two being considered together.

Greenwich Civil Time or Greenwich Mean Time (GMT) as it is sometimes called. is used almost exclusively for navigation tables, for checking time on aircraft or shipboard, and anywhere else where a standard is required. On a plane flying three hundred miles-per-hour from New York to London, it would be virtually impossible to keep an intelligible set of records in zone time, since it would be constantly changing. Starting out on GCT, there is always an immediate point of reference.

Navigation tables and charts are tabulated in such a way that information may be found for any instant of Greenwich Civil Time. Obviously, it would be impractical to tabulate all these data for each meridian of the world, and so the zero degree meridian of Greenwich, England, is chosen as standard. Since Greenwich is on the 0 degree meridian, its local civil time, standard time, and zone time are all identical. GCT is often referred to as "universal time" because time in most parts of the world is derived from GCT, which thus serves as a standard for the times of different places.



Crossing the International Date Line. Traveling east, subtract one day. Going west, add a day—
Courtesy AAF

TWENTY-FOUR-HOUR TIME

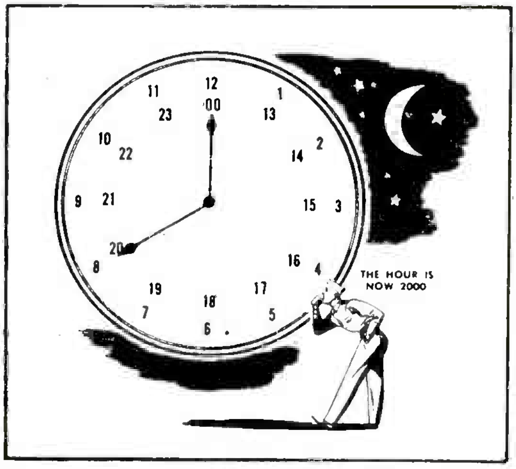
GCT is expressed from 0 hour to 24 hour. Since the everyday clocks and watches in this country are marked only up to 12 hours, a Greenwich Civil Time of more than 12 hours, for example 18 hours, cannot be indicated directly except on special time pieces. In the instance of 18 hours, the face of the regular clock would read 6 hours. In addition, the clock does not give the Greenwich date, which may be the same as the local date, or the day before or after. There need be no trouble or ambiguity if the rules of time are carefully applied, bearing in mind that continuous practice and daily use is the only way to become familiar with GCT.

Zone time is derived directly from GCT. If you start at a given place, and travel around the world eastward, setting your watch one hour ahead for every 15-degree (24 hours for 360 degrees) change in longitude as you should do, when you get back at your starting point, you will find that you are one day ahead of the day there. If you travel westward, instead of eastward, then you will be one day behind the date when you return to your starting point. In going around the world, the date must be changed enroute on crossing the 180th meridian, by subtracting one day from the date when sailing eastward, or adding one day when sailing westward. The instant of GCT noon is the only time during a day that the same date prevails throughout the world.

ZONE TIME

Each of the time zones is 15 degrees wide, making the total of 24 zones. The first two zones of 15 degrees has the 0 degree meridian, Greenwich, as a bisecting line. Traveling east, the zones are plus. Traveling west, the zones are minus. It is important to remember the GCT hour is the same all over the world. But the zone or "standard" time is local.

In the United States local civil time prevails in belts or zones extending as nearly as practicable, 7.5 degrees on either side of a "standard" meridian, making each zone 15 degrees wide. Such time is designated "standard time." With the meridian of Greenwich taken as the initial starting point, others are assigned at every 15 degrees of longitude. Thus in the United States the standard meridians are the 75th, 90th, 105th, and 120th west, and in Alaska the 135th, 150th and 165th west. All the people of the same meridian, regardless of the latitude, have the same time.



Twenty-four-hour time is standard in parts of Europe. Above is a conventional twelve-hour dial with an inner circle adding up to twenty-four-hour time. —Courtesy AAF

The local civil time of the 75th meridian is called Eastern Standard Time. Similarly, that of the 105th meridian is Central Standard Time, etc. Eastern Standard Time (75th meridian time) differs from Pacific Standard Time (120th meridian) by 3 hours because the two standard meridians differ by 45 degrees of longitude. PST is 3 hours behind EST because the sun, our timekeeper, rises in the east and thus becomes visible in New York 3 hours before it rises in San Francisco, which is west of New York. For the same reason, the sun crosses New York's meridian about 3 hours before crossing San Francisco's. In other words, when it is noon in New York it is 9:00 A.M. in San Francisco.

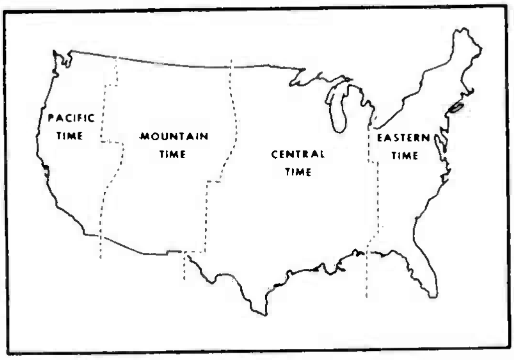
CIVIL TIME

The local civil times of two places differ as their exact longitudes. Their standard time varies as the longitudes of their standard meridians. This simply means that standard time invariably differs by one or more whole hours, since the standard meridians are always one hour apart in longitude. For example, local civil time, between New York and San Francisco, which are 48 degrees 30 minutes apart in longitude, would differ by 3 hours and 14 minutes.

Many irregularities have crept in, as communities decided to keep the standard time of some large city nearby. Daylight and War Saving time have introduced further complications. During the spring and summer months, when there are more hours of daylight than of darkness, many localities adjust their standard time so as to "save" or utilize daylight to the greatest extent, by advancing clocks and watches at a specified time, so that they keep the time of the next standard meridian eastward. During the daylight-saving period, New York City which usually keeps Eastern Standard (75th meridian) time, keeps 60th meridian standard time instead.

War Time in the United States has added an hour to the standard time of each zone — so what was formerly 9:00 P.M. Eastern Standard Time becomes 10:00 P.M. Eastern War Time. England has double war time, or two hours "off" their standard time. Thus 0800 GCT is 8:00 A.M. throughout the British Isles. However, double war time makes 0800 GCT actually equal to 10:00 A.M. during the present emergency.

A very few communities prefer to be precise, and differ from GCT by the exact latitude and longitude. An example of this would be the city of Stephenville in Newfoundland, which is minus 2½ hours from GCT on their local time. Thus when it is 1900 GCT it is 1630 hours, or 4:30 P.M. Stephenville War Time. Stephenville is located in approximately the center of the fourth time zone west of the Greenwich meridian, giving them a precise time zone of minus 3½, but they have added an hour to their standard time to gain additional daylight.



Time zones in the U. S. A. Local time may differ from the four standard times — Courtesy AAF

Knowing the longitude of a place, the time at another place of known longitude may be found as follows: To the time of the first place apply the longitude difference, expressed in time units (15 degrees equals 1 hour). Add if the first place is westward, subtract it if eastward. The result will be the local time at the second place. Remember that the time at the eastern place will be later than at the western place.

TIME AND LONGITUDE

As a further illustration, assume station A is at longitude 72°-00′ W; station B at 46°-00′ W. The difference in longitude is 26°-0′ degrees, which, expressed as time units, is one and eleven fifteenths, or, since the zone system avoids fractions, except in special cases, two hours. If the local time at A is 9:30 P.M., local time at B, which is west of A, is 9:30 - 2=7:30 P.M.

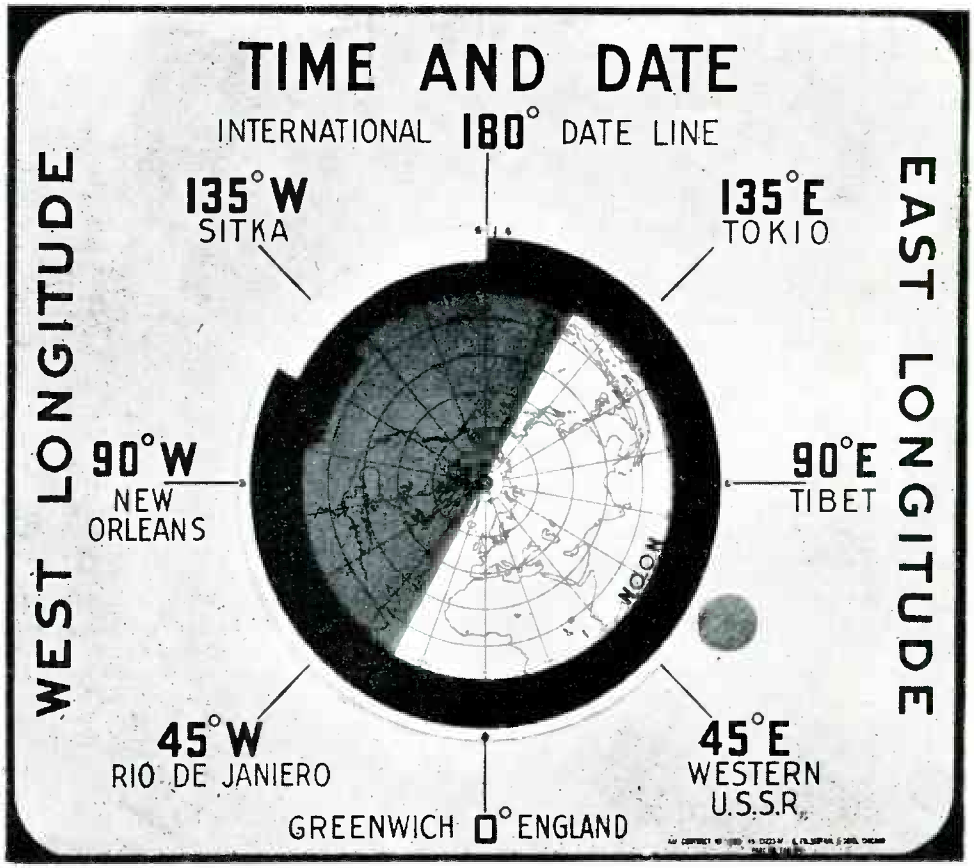
Another case: station C is at 12°-35′ E. Station D is 71°-46′ W, at which place it is 11:30 P.M. By adding values, we get the difference in longitude. We must travel to 0° and back to 12°-35′ E. If the sun should exceed 180 degrees it is necessary to subtract 180 degrees. In this instance it is 84°-21′, and in time units 6 hours. The time 11:30 P.M. plus 6 hours, (since we are going from west to east) means the local hour at station C is 5:30 A.M. There is also a change in day, the easterly station being the later date. It is important to avoid confusing the changes in date as a result of a change in standard time as compared with GCT.

WATCH YOUR DATE

At midnight local time in NYC, which is also midnight for the entire zone, the calendar date changes. However, since NYC is located in zone 5, five hours behind GCT, if we are working on a GCT system, the calendar date changes at 7:00 P.M. Eastern Standard Time. This actually presents no problem if the records are kept constantly on the 24 hour GCT basis. When you advise a station of a schedule at 2230 GCT May 11th, there is less chance of confusion than to say 5:30 P.M. EST May 11th, since it may be a different date at the other station on the zone system.

To summarize and attempt to eliminate any confusion, remember these salient facts. The *Greenwich Civil Time* hour is the same all over the world at any instant of time. *Standard Time* and *Zone Time* are almost invariably the same. Each time zone is 15 degrees in width, extending 7½ degrees on either side of the standard meridian. The plus zones run west of the Greenwich meridian, the minus zones run east of the Greenwich meridian. GCT is converted into standard time by adding or subtracting the zone time difference from the zero Greenwich meridian. *Daylight* and *War Saving* time means the addition of one or more hours to standard time.

To avoid any possibility of error in computing differences of time, a simple diagram should be used. Reference to a map will serve as well. For local station use, there should be no more difficulty than following the present system. Operating pleasure will be materially increased when you can tell a fellow "QRX until 1545" without another thought of dates, A.M. or P.M.



"Time and Date" panel illustrates the function of the International Date Line. This device demonstrates that crossing the International Date Line does not change watch time—only calendar date. — Courtesy AAF, Technical Aids Division

MOBILE RADIO TELEPHONY "PAYS OUT"

Reprinted from Electrical World

Communication for directing operations of line crews from central points proves reliable and speedy in both normal and emergency periods—Interchanges between office and field help public relations.

SEVERE TEST of the efficacy of mobile radio as an aid in operating and service restoration was given by the hurricane of September 14-15, 1944, on the Atlantic seaboard. From the experiences of three utilities in this region it appears that in general, money invested in this type of equipment greatly reduced the duration of service interruptions, contributed to good public relations, and minimized many hazards to employees and the public. In the following article are presented some of the salient points of these experiences without identification of companies, based on a private presentation for the benefit of utility executives and distribution engineers.

Company A has operated two-way radio telephone equipment since the fall of 1940. The division reviewed covers about 140 sq. mi., with the farthest point 12 mi. in air line distance from the service headquarters. The radio telephone equipment consists of a 25-watt fixed transmitter at headquarters, a superintendent's car and three line trucks, each having a 15-watt transmitter, besides three supervisors' cars having receivers only. All the equipment is AM (amplitude modulation). The transmitter power and antenna height are adequate and understandable conversation is had between the service building and a mobile unit anywhere in the division. There are 190 street mi. of underground and 350 mi. of overhead construction serving 51,000 domestic customers, 8,400 having electric ranges and there are 8,000 power and commercial customers. Under favorable conditions the equipment has a range in excess of the divisional needs, and in an ice storm two years ago, when the superintendent was directing work 28 mi. away in another division without telephone facilities, material was obtained via radio through headquarters and another operating center with a saving of 24 hours over the time required to drive to a point where telephones were in order.

In this company the original investment in mobile radio telephony was justified by the elimination of a standby trouble crew during working hours. At the time of purchase another field crew was indicated as necessary and the choice was between buying and equipping a truck or installing the mobile radio and using the standby trouble crew. While no dollar value was placed on the improved emergency coverage, it was estimated that the savings would cover first cost in less than five years.

In the hurricane the number of emergency two-way conversations in 24 hours increased from an average of 1.5 to 80, and included direction of crews to clear up hazards, reporting sectionalizing completed, and calls for material. Long branch lines have been patrolled by the superintendent's car. In one war plant making plastics, and where all three feeders were out, utility headquarters contacted a line crew by radio and found 10 wires down in six places. The material was sent out from the service building and a supervisor who had picked up the call on the receiver in his car went to the job bringing two linemen from another crew.

(Electrical World, July 21, 1945)

SATISFIED WITH FM

Effect on the public has been notably good. The men are proud of the radio equipment and take every opportunity to tell people that they were contacted by this method. Company A feels that it would now be lost without mobile radio telephone facilities as an aid in accelerating service restoration and as a necessary tool for economical operation.

Company B installed FM (frequency modulation) radio telephone equipment on five distribution trouble cars in 1942. The main unit is installed at an important substation, rated at 250 watts, 31,460 kc., with an auxiliary station connected by the ground cable to distribution headquarters 2 mi. away. A steel mast without guys, 141 ft. high outside the substation is used for an antenna. An emergency battery power supply is provided for the main unit. The mobile units are of 25-watt capacity each.

A monthly inspection of all equipment is made by a second-class licensed operator, and about 40 other men hold a fourth-class restricted radio telephone license to allow them to talk over this system. The limit of good two-way operation on this system is about 20 mi., with a few dead spots in one area. These dead spots can be overcome by asking the mobile unit to move to a new location, not over ¼ mi., to get clear. In two years of service with this outfit, the company finds that it works very satisfactorily under all conditions of weather, with a minimum of trouble.

Company C made trial demonstration of radio communication in 1936, using amateur equipment, which definitely indicated the possibility of radio and led to a formal request in 1937 for a trial installation. Pending the installation of the company's own equipment, there were several urgent cases in which trouble men were contacted by police radio. The company's first equipment went into service in 1941 with a 25-watt transmitter at a central point and one 15-watt mobile unit in a trouble car operating in an outlying district. Good coverage was obtained within a 3-mi. radius and spotty coverage up to 6 mi., except during thunderstorms. About 18 troubles per month were handled with this first car, the results being good enough to convince the company of the desirability of completing system coverage, with a conversion to FM to minimize interference difficulties. In the Fall of 1942, 21 cars were equipped for complete system coverage.

TWO FIXED PICKUP RECEIVERS

Each car unit is designed for two-way service, using 35-watt transmitters. To obviate some difficulty due to distant mobile units (in ranges of 15 to 20 mi. from the center of the system and in certain localities) being unable to transmit to the main station, the company installed two fixed pickup receivers on carrying poles at about 300-ft. elevation at two different points on the system. From the pickup stations, voice is brought in via leased telephone lines and matched with the radio output at the loudspeaker. An automatic throwover switch is provided at the main station in case the normal supply is interrupted. If both services fail, power may be obtained from a motor-generator set energized from a local storage battery.

There are two dispatching positions normally covered. Each uses a conventional telephone handset in connection with a cord and plug type telephone turret. Calls are answered or made by plugging the cord into a jack. By means of a two-position key on the turret, the same handset may be connected into the radio circuit and transmission may be made after depressing the "push to talk" button built into the handset. A loudspeaker is located centrally between the despatchers with a volume control switch to permit cutting the speaker out, thus using the handset entirely if so desired.

Equipment is also provided to impress a 1,000-cycle "tone" in certain instances when it is known that troublemen may be a short distance from their cars and might not hear voice transmission.

All employees using radio have Restricted Radio Telephone Operator permits. Testing is permitted not to exceed two minutes in each hour and all mobile units are tested once every 24 hours. Communications are kept brief and are confined to necessary information for operating work. Detailed reports on trouble are handled by telephone after emergencies are cleared up. Coding of messages is not done up to the present time.

ASSIGNMENT TIME CUT 64.5 PERCENT

During the 22-month period since full system coverage was completed, approximately 1,800 emergency jobs have been handled by radio. This is about 20 percent of the total troubles handled by the despatchers. The monthly average was 81 jobs varying between a minimum of 53 (April, 1944) and a maximum of 147 (July 1943). Each trouble handled required an average of 2.5 transactions per trouble (exclusive of one case). The average time to assign these 1,800 jobs by radio was 5.1 min. compared with 14.3 min. average to assign approximately 1,400 emergency jobs by telephone during 4 months in 1934.

During the recent hurricane for the 28-hour period beginning at 8 p.m., September 14 and terminating at midnight the following day approximately 550 transactions were handled by radio, an average of 20 per hour. Several peaks of 30 transactions per hour occurred during this period which is very close to the limit of a single channel.

In various cases troublemen finding a hazardous condition in the field can order circuits made dead without leaving the scene of trouble. As a result of the hurricane experience the company has requested the installation of a recorder which will eliminate the necessity of keeping a log record during extreme emergencies.

Emergency Transactions Handled by Mobile Radio in 28-Hours

Transactions	Approx. % of total	Type of Work Handled
233	42	Operating work on primary distribution circuits, such as: switching to restore essential services to hospitals, telephone exchanges, railroad signal services, water departments, etc. There were also several cases in which field men ordered circuits out of service due to emergencies.
116	21	Reports of wires down including primaries, series street lighting and secondaries.
60	11	Mobile units used to contact line trucks not equipped with radio for urgent assignments.
42	7.5	Reports of wires burning, not down.
38	7	Operating work on series street lighting circuits, mainly ordering circuits out of service due to hazardous conditions.
24	4.5	Electrical equipment flooded in buildings.
23	4.5	Group reports of service outages indicating possibility of wires down.
14	2.5	Reports of poles down or in dangerous condition.
550		

ELECTRIC MUSIC BUILDS JOBS

The electrical recording of music, shown in tests to increase factory production, is expected to create jobs for 26,000 broadcast directors.

WHAT'S BEING READ THIS MONTH

As a regular feature of our magazine, we take pleasure in presenting each month a complete list of the articles which have appeared in the current issues of the leading trade and professional magazines. The list for this month is as follows:

COMMUNICATIONS (August 1945)

SOUND ENGINEERING
Resonant loudspeaker enclosure design........*Sgt. Frederick W. Smith, Jr.*

TUBE PRODUCTION TESTS
Calibrating instruments for use in vacuum-tube manufacture........*Eugene Goodess*

TELEVISION ENGINEERING
An electronic counting circuit........*Max Weber*

AERONAUTICAL COMMUNICATIONS
Maintenance of the AACS wartime radio circuits........*Cpl. Mark Weaver*

V-H-F OSCILLATORS
Crystal oscillators in F-M and television (Part 1 of a series)........*Sidney X. Shore*

MATERIAL ANALYSIS
Skin effects in round conductors........*W. B. Shepperd*

RADAR
Radar in U.S. and Great Britain

RESISTIVE NETWORKS
Resistive attenuators, pads and networks (Part VII — Application in Mixer and Fader Systems)........*Paul B. Wright*

CQ (September 1945)

EXCITER AND R-F AMPLIFIER FOR THE 144-148 mc BAND
A crystal-controlled job you can go on the air with now...*L. W. May, Jr.*, W6AJG

DON'T LET IT PHASE YOU
Clarifying the matter of phase relationships with examples from familiar radio circuits........*W. H. Anderson*, VE3AAZ

PANORAMIC RECEPTION
This new receiving system has wide applications in ham radio. You can tell at a glance just how active a band is and locate stations quicker........*Harvey Pollack*, W2HDL

TELEVISION SCANNING AND SYNCHRONIZATION
A simple explanation of a complex subject. Hams can do lots to help television — and it's fun........*B. W. Southwell*, W6OJW

RADIO AMATEUR'S WORKSHEET, No. 4 — RECEIVER ANTI-NOISE CIRCUITS

ELECTRONICS (September 1945)

POSTWAR ELECTRON TUBE BUSINESS
Potential demand for receiving, transmitting and industrial types is estimated........*W. C. White*

WIRE SPLICE DETECTOR
Magnetic poles created at steel-wire discontinuities trigger an electronic circuit........*F. S. Hird*

THE SCR-268 RADAR
Detailed technical description of a unit designed to direct anti-aircraft searchlights and guns

TRANSIENT PEAK VOLTMETER
Discussion of an instrument with which the amplitude of a single short pulse is readily determined........*C. Ryerson and M. Aronson*

CANADA'S INTERNATIONAL SHORT-WAVE PLANT
Description of new facilities at Sackville, New Brunswick, employing high-gain curtain arrays........*H. M. Smith*

TIME-BASE CALIBRATION
Circuit provides triggering and calibrating signals for sweep-linearity measurements........*Walter W. Ludman*

ELECTRONICS AIDS IN WATERWAY DEVELOPMENT
Marine experiments performed with models utilize tubes to measure wave heights and water pressure........*Eugene H. Woodman*

INTERFERENCE IN F-M RECEIVERS
Review of pertinent interference-suppression equations, and procedure for experimental verification........*Robert N. Johnson*

RESTORER-CIRCUIT OPERATION
Explanation of how constant brightness is maintained in television receivers........*Emanuel Last*

VIBRATION CONTROL FOR ELECTRONIC PRODUCTS
Specialized components for protection against shock and vibration

STABILIZED NEGATIVE IMPEDANCES, PART III
Applications of negative impedances used to improve circuit characteristics conclude this three-part paper........*E. L. Ginzton*

DETERMINING Q OF CAPACITORS
Chart minimizes calculations needed in converting Q meter readings into Q factor values of capacitors........*L. E. Pepperberg*

ELECTRONICS INDUSTRIES (September 1945)

POSTWAR ENGINEERING
How technological advances born of war efforts are likely to affect communications and industrial electronic design

NAVY'S FLOATING ELECTRONIC LABORATORY

ATOMIC FISSION WILL HAVE PROFOUND EFFECT
Transmutation of elements and cheap power generation may revolutionize electronic world — Ionization effect......*Dr. Harlan T. Stetson*

ELECTRONICS INDUSTRIES (September 1945) *Continued*

SYNCHRO CONTROLS FOR METERS AND SERVOS
Angular rotation and the sum and difference of two or more angles can be used to control distant operations........................*Raymond Goertz*

FM POWER CONVERTER
Armstrong's design for a transmitter converter unit to permit simultaneous FM broadcasting on two frequencies......*Frank A. Gunther*

CRASH FAILS TO STOP NBC TELE STATION
WNBT, unharmed, transmits pictures of bomber crash at Empire State building immediately after disaster

TELEVISION vs. FOLIAGE
Cases where set-owners in wooded areas have had video reception impaired April to October. Conditions beyond line-of-sight

NOMOGRAPH FOR Q METER

GLOSSARY OF COMMON RADAR EXPRESSIONS
A dictionary of technical and military terms used to identify various kinds of radar equipment, their parts and uses

AMERICANIZED-BRITISH RADAR TUBE

FM-TELE STANDARDS
FCC engineering proposals, largely approved by industry, provide for 4 classes of tele stations — See FM soon displacing AM

WESTINGHOUSE PROPOSES FLYING TELE-FM STATIONS

RADIO DOOR ACTUATOR
Simple modification of standard automobile broadcast set permits remote control through an induction relay circuit..........*R. G. Rowe*

PHASE SHIFT EFFECT IN AMPLIFIERS
Formulae and curves are presented for evaluation of phase shift as function of frequency in tuned amplifiers......*Goswin Schaffstein*

THRU THE LABORATORY KEYHOLE
Current research that forcasts future electronic developments

PHONO HEAD BALANCE
Dynamic adjustment of cutters and reproducers reduces the amount of distortion introduced in the system..................*Norman L. Chalfin*

GAGING BY THE BLIND
Upper and lower limit switches introduce capacitors in audio oscillator circuit changing loud speaker tone

$1000 *EDITORIAL AWARD*
Three awards to be made by Electronic Industries for engineering articles of outstanding value in advancing electronic principles

TUBES ON THE JOB

PROJECTION C-R-O TUBE
High speed photographic recording and projection oscillography facilitated with the new DuMont design..................................*Rudolf Feldt*

RADAR DEVELOPED ELECTRONIC NAVIGATOR

FM AND TELEVISION (August 1945)

WHAT'S BEHIND THE AM vs. FM BATTLE............*Milton B. Sleeper*

VIBRATING-REED FREQUENCY METERS............*Donald E. Andersen*

A NEW FACSIMILE DISPATCH AND REPORT SYSTEM............*Milton Alden*

FM RELAY EXPERIENCE IN NORTH AFRICA............*Russell A. Berg*

FM HANDBOOK, CHAPTER 7............*René T. Hemmes*

FM POWER FREQUENCY CONVERTER............*Frank A. Gunther*

PROCEEDINGS OF THE I.R.E. (September 1945)

THE ROLE OF THE SECTIONS IN THE I. R. E. PROGRAM............*William A. Dickinson*

GEORGE W. BAILEY, EXECUTIVE SECRETARY

THE ORGANIZATION OF RESEARCH IN THE RADIO INDUSTRY AFTER THE WAR............*W. Rupert Maclaurin*

TONAL-RANGE AND SOUND-INTENSITY PREFERENCES OF BROADCAST LISTENERS............*Howard A. Chinn and Philip Eisenberg*

EXALTED-CARRIER AMPLITUDE — AND PHASE — MODULATION RECEPTION............*Murray G. Crosby*

ELECTRON REPULSION EFFECTS IN A KLYSTRON............*L. A. Ware*

EXTENDING THE FREQUENCY RANGE OF THE PHASE-SHIFT OSCILLATOR............*Rodney W. Johnson*

CONVERSION LOSS OF DIODE MIXERS HAVING IMAGE-FREQUENCY IMPEDANCE............*E. W. Herold, R. R. Bush and W. R. Ferris*

ELECTRICAL TESTING OF COAXIAL RADIO-FREQUENCY CABLE CONNECTORS............*Chandler Stewart, Jr.*

Q S T (September 1945)

SIGNAL CORPS RADIO RELAY IN NORTH AFRICA
The first application of a v.h.f. radio relay system to military operation............*Capt. O. D. Perkins*, SC, ex-W7MH, *and A. David Middelton*, W2OEN

CHOOSING U.H.F. SITES
Using contour strips to predict circuit performance......*Philip S. Rand*, W1DBM

MATCHING THE ANTENNA FOR TWO-BAND OPERATION
Flat lines with fundamental and second harmonic......*John G. Marshall*, W9ARL

HOW MICROPHONES WORK
A discussion of various types of voice pick-ups............*Albert Kahn*, W9KYM

THOSE SINGING MASTS
The story of a sea-going radio broadcasting station............*Lt. Anthony W. Borgia*, W6EOU

"TOM THUMB"
A combination single-tube transmitter-receiver complete with power supply............*Paul J. Palmer*, W8UGR

RADIO (August 1945)

RADIO INSULATING MATERIALS, PART 2
In this article the author discusses newer plastics, such as melamine and aniline formaldehyde, combination laminates, and their radio applications .... *Albert H. Postle*

RAILROAD RADIO COMMUNICATION ON THE V.H.F.'s
Describing the system used by the Chicago, Burlington and Quincy Railroad, problems involved and how they were overcome .... *T. W. Wigton*

MODERN QUARTZ CRYSTAL PRODUCTION, PART I
A detailed discussion of the new manufacturing methods which have made possible quantity production of high precision quartz oscillator plates .... *Richard E. Nebel*

NOTES ON AUDIO AND SUPERSONIC FREQUENCY MEASUREMENTS
Practical data on the technique of measuring frequencies in this range .... *A. K. McLaren*

RECTIFYING CRYSTALS
An analysis of modern crystal detectors, as employed in microwave receivers .... *Arthur C. Gardner*

RADIO DESIGN WORKSHEET: No. 39 — DETECTORS

CHART — SECTOR TO BE REMOVED FROM FLAT CIRCULAR SHEET TO FORM CONE vs. APEX ANGLE OF CONE

RADIO BIBLIOGRAPHY, No. 19 — FREQUENCY STANDARDS — U.S. DEPARTMENT OF COMMERCE NATIONAL BUREAU OF STANDARDS

RADIO-CRAFT (September 1945)

BEWARE! THE SERVICEMAN! .... *E. A. Witten*
DYNAMIC PHONO PICKUP .... *J. M. Lee*
A DECIBEL NOMOGRAPH .... *Nathaniel Rhita*
RADIO ROBOT FLAME TANKS .... *Hugo Gernsback*
MAKING WARTIME ENGINEERS .... *Dr. K. R. Sturley*
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RADIOS SERVICED BY OBSERVATION .... *Lyle Treakle*
TUBE REPLACEMENTS, PART III .... *I. Queen*
SUBSTITUTE FOR 35Z5's .... *Gerry L. Gaydo*
"LOUD" CRYSTAL RADIO .... *Joseph Dante Amorose*
A STARTLING SUPERHET .... *W. T. Connatser*
SUPERHET COIL DESIGN .... *Sgt. Lionel R. Blattner*
INTERCOMMUNICATOR .... *E. J. Thompson*
CHASSIS CRADLE FROM PIPE FITTINGS .... *William Lyon*
ADAPTER FOR THE V.T.V.M .... *Alfred Shortcut*
SIMPLE MULTITESTER FOR VOLTS AND OHMS .... *Homer L. Davidson*
TRACER WITH TRIODE PROBE .... *D. T. Moore*
TRANSCONDUCTANCE TESTER .... *Hyman Herman*

RADIO NEWS (September 1945)

AUDIO OSCILLATORS AND THEIR APPLICATIONS......J. C. Hoadley
"JUNK BOX" SHORT WAVE RECEIVER......Harry D. Hooten, W8KPX
0-300 VOLT REGULATED POWER SUPPLY......Gerald W. Davis
QUARTZ CRYSTALS — TODAY AND TOMORROW......F. Earle Clark
AMPLIFIER-TYPE VIBRATING-REED FREQ. METER......Rufus P. Turner
Q T C......Carl Coleman
GENERATING R.F. AT 600 Mc......William Maron
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– LET'S FINISH OURS !

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IDEAL AS COMPONENTS OR INDEPENDENT UNITS
RUGGED — WITHSTAND CONTINUOUS OPERATION
PROVIDE CONTINUOUSLY ADJUSTABLE VOLTAGE
MAINTAIN POWER FACTOR—WAVE FORM UNDISTORTED

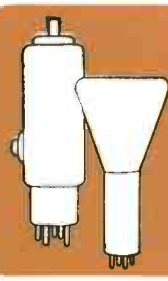
TH TRANSTAT FOR .3 TO 20 KVA

For 115, 230, 460 v. single and polyphase circuits. Maintain voltages within a narrow range in changing from no load to full load. Varnish impregnated for high turn, layer and sectional insulation. Long brush with low current density for cooler operation. Maintain brush setting when mounted in any position. Ask for Bulletin 51-2

NEW TH 2½A TRANSTAT

One piece brush arm has large heat dissipating surface; operating shaft quickly changed for table, panel or gang mounting. Varnish impregnated core and coil. Plastic base has terminal barriers, provides base to base mounting individual units. Single units 300 VA, dual 520. Wgt. 5½ to 13½ lbs. Ask for Bulletin 171-01.

AMERICAN TRANSFORMER COMPANY, 178 Emmet St., Newark 5, N. J.



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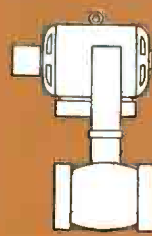
Smooth voltage control in production testing of electronic tubes can be provided with Transtat voltage regulators. Easy to operate—long, trouble-free life.



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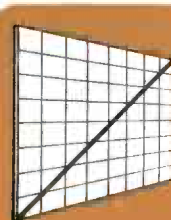
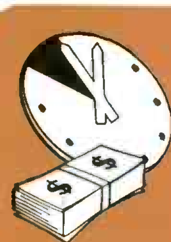
Electric furnaces, soldering apparatus or other electric heat-treating devices may be controlled smoothly and quickly by Transtat regulators. Voltage sensitive AC motors can be regulated to selected RPM—efficiently and economically with a Transtat.



SMOOTH COMMUTATION

The wide brush tract of evenly spaced segments separated by solid insulation provides an ideal commutating surface



HIGH EFFICIENCY

Transtats transformer efficiency costs less in the long run than resistive control. High dimensional uniformity, flexible mounting speed assembly

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