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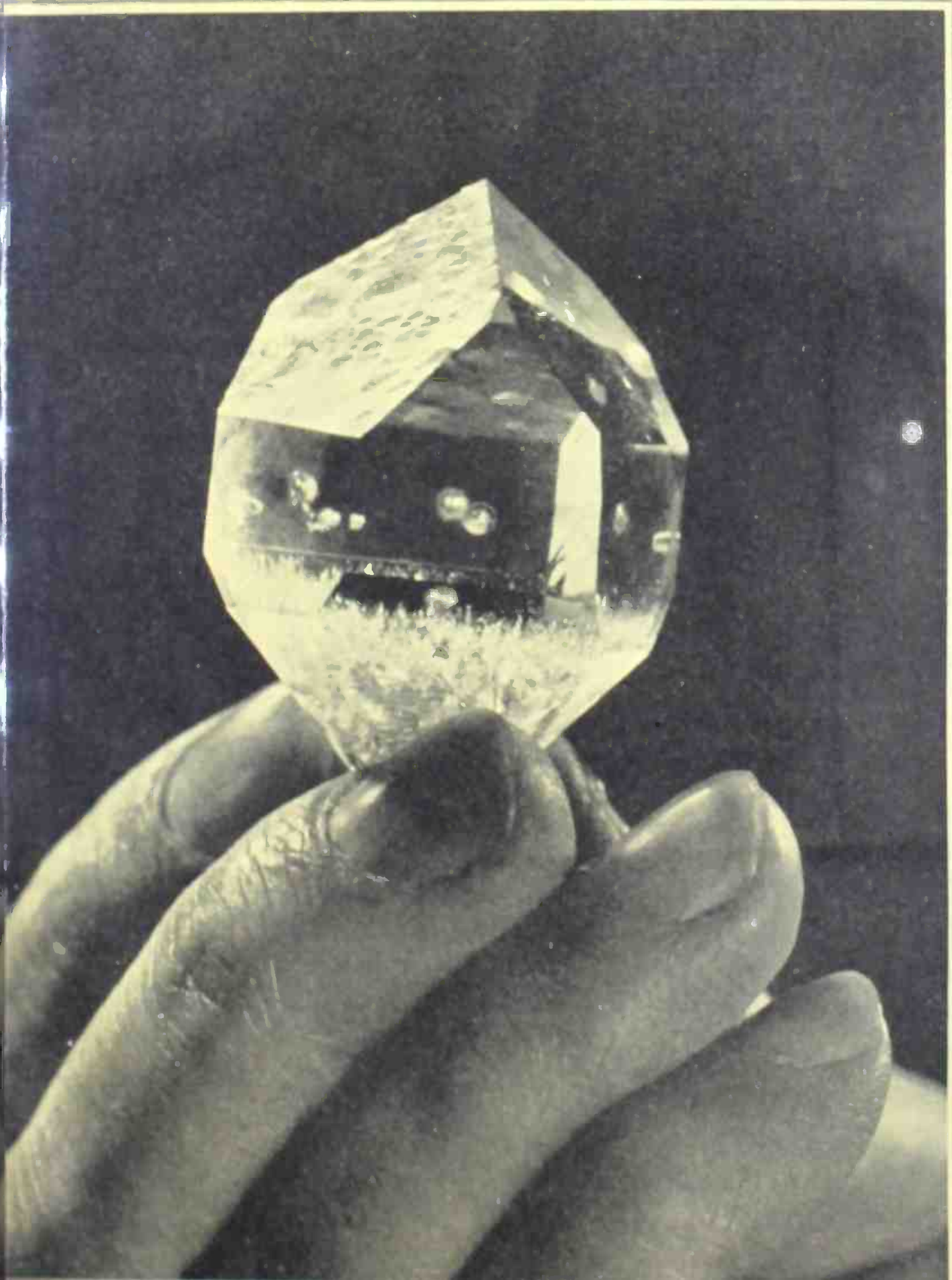

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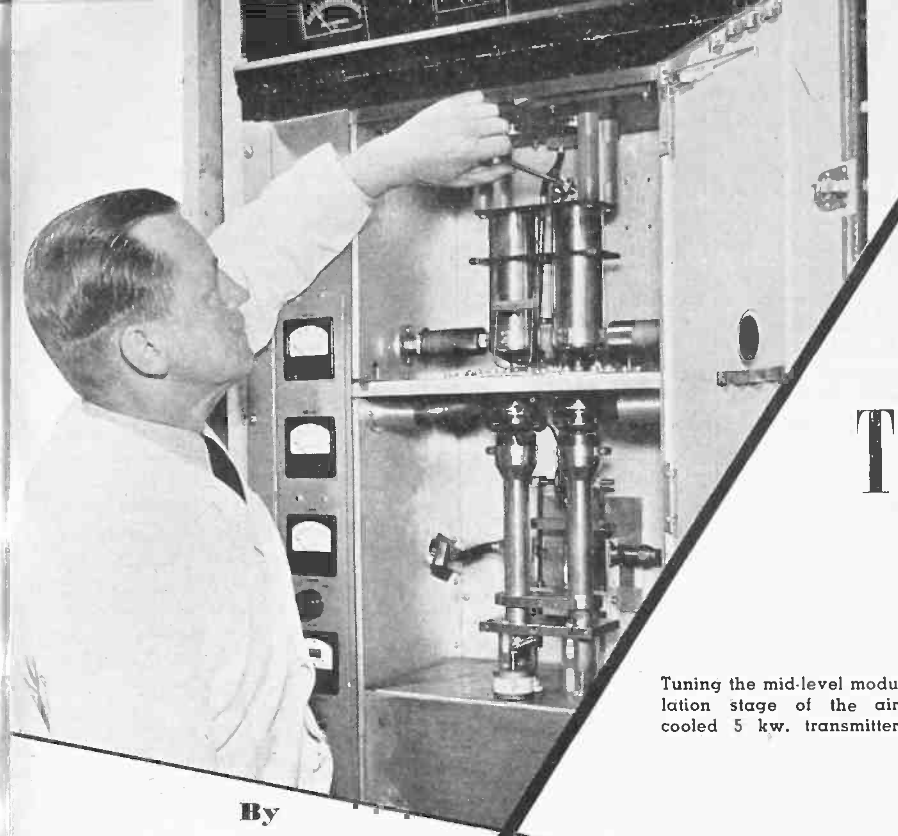
COVER PHOTO—Courtesy of Bell Telephone Laboratories

An example of a single quartz crystal in the form of a bipyramid with unusually clear side or prism faces, grown under high-pressure hydrothermal conditions in a period of 20 days. Roughness of top face, accentuated by lighting used, is superficial and similar to surface irregularities sometimes observed on such faces of natural quartz crystals.



Tuning the mid-level modulation stage of the air-cooled 5 kw. transmitter.

Air-Cooled 5 kw. TV TRANSMITTER DESIGN

By
E. BRADBURD
and J. RACKER

To be considered are RMA and FCC specifications as well as economic and convenience factors.

THERE are two important factors that an engineer must consider in designing a television transmitter. The first involves the specifications, (RMA and FCC), that must be met or exceeded, which immediately establishes an essentially standard performance characteristic for all transmitters. The second consists of the economic and convenience factors, i.e., initial and operating costs, simplicity of servicing and maintenance, flexibility of installation, reliability, and efficiency. In this latter category, there is room for individuality and distinction since, generally, an improvement in one feature must be balanced against a deterioration of another. For example, greater reliability must usually be attained at increased cost so that some compromise based primarily upon the designer's opinion must be made between the two.

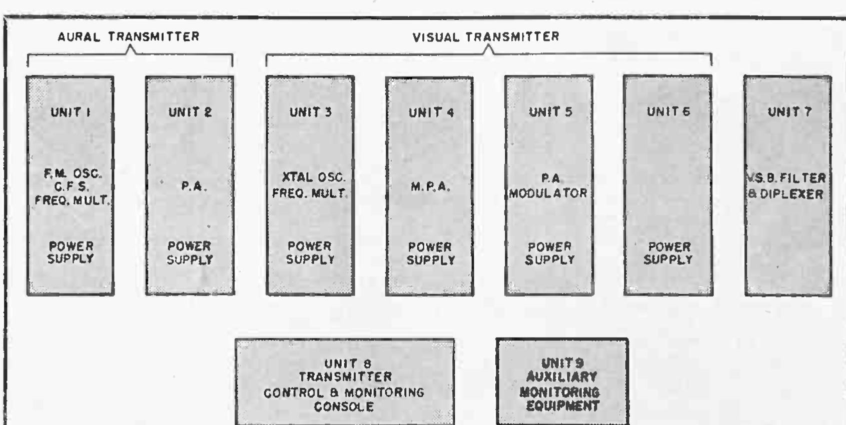
The problem is further complicated by the fact that one basic design must meet the requirements of a large number of installations since it would be impractical to custom-build each transmitter for a particular station. In this case again, individual judgment and experience must be exercised in determining what design meets the requirements of a maximum number of stations. For example, there are certain specialized installations where water cooling is more convenient, but from the experience of many broadcast station engineers, we find almost universally that air cooling is preferred. Hence, the objective of an entirely air-cooled 5 kw. transmitter, in both high and low frequency bands, is indicated by the title of this article.

Thus, all television transmitters basically provide the same performance characteristics, but differ primarily due to the fact that the engineers involved placed different stress upon the relative importance of the various economic and convenience factors. The transmitter design to be described in this article stresses air-cooling, simplicity, and economy. It will be demonstrated how specific circuits were developed to conform to this over-all objective.

The *Federal* transmitter is designed to transmit a standard 525-line black-and-white television signal with maximum fidelity permitted by the FCC. A peak visual power output of 5 kw. and an aural output of 3 kw. is obtained at any frequency in the low band (54 to 88 mc.) or high band (174 to 216 mc.). As indicated by the block diagram shown in Fig. 1, the transmitter consists of three major assemblies. They are: a) the visual transmitter, b) the aural transmitter, and c) the control and monitoring console. In this article we are primarily interested in the visual transmitter, though a brief description of the other assemblies will be given.

The visual radio-frequency carrier of all television transmitters is generated

Fig. 1. Block diagram showing principal components of 5 kw. air-cooled TV transmitter.



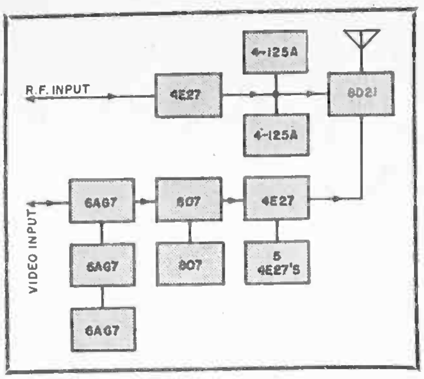


Fig. 2. Block diagram of grid-modulated tetrode TV transmitter.

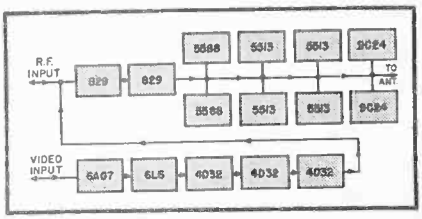


Fig. 3. Block diagram of TV transmitter employing low-level modulation.

by the same method. A crystal-controlled oscillator, operating at a subharmonic of the final carrier frequency, is frequency-multiplied and power-amplified through an appropriate number of stages until the desired carrier frequency and power output is reached.

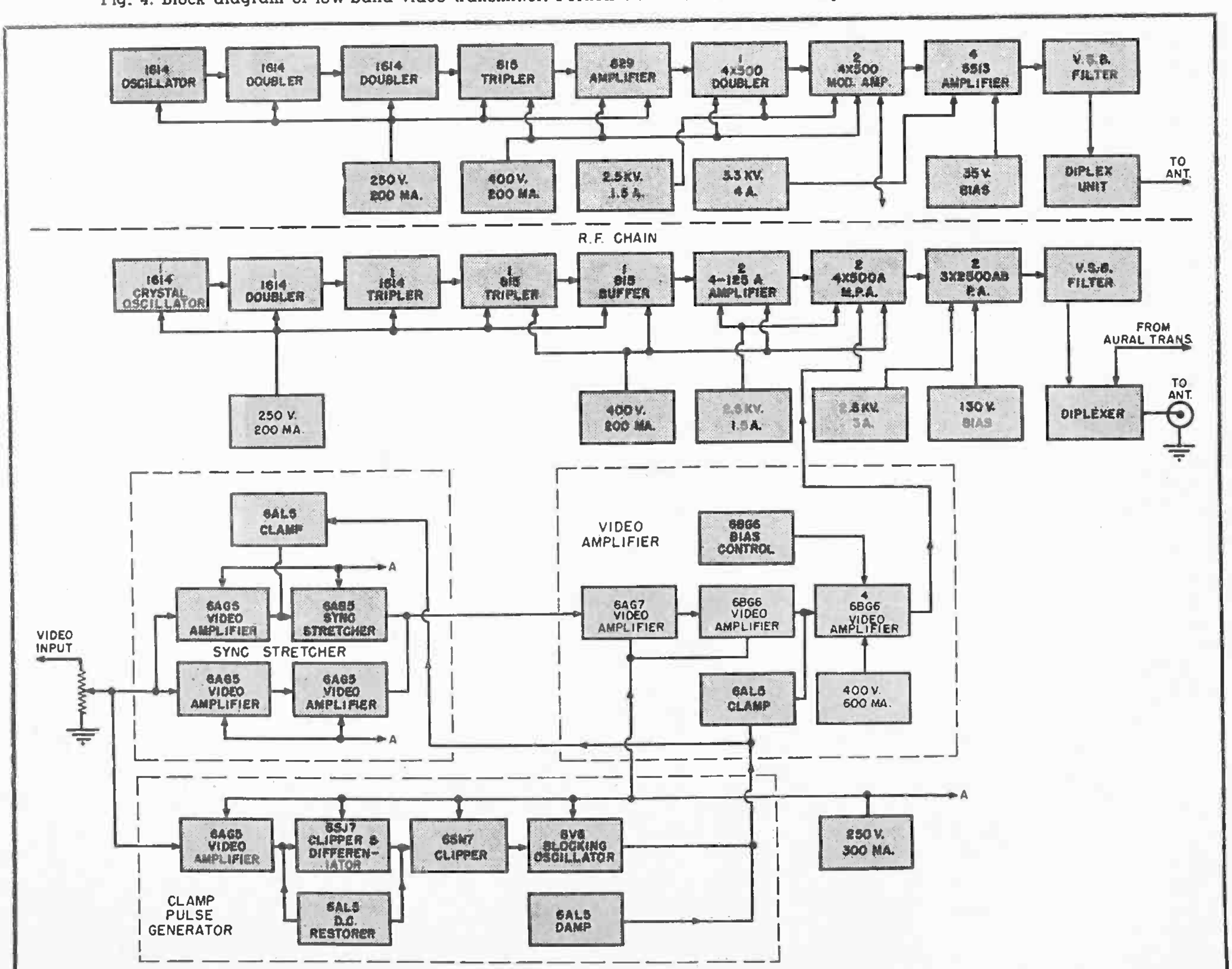
At some point between the stage at which the carrier frequency is reached and the final power amplifier, the video signal is introduced The stage at which modulation is applied is largely a function of what economic and convenience factors the engineer is trying to obtain. As is well known, introduction of the video in the final amplifier stage, as shown in Fig. 2, achieves circuit simplicity, but this advantage is offset by the requirements for a large modulator and special, water-cooled tubes. The cost of the tube complement for transmitters of this type tends to be higher than for other designs, making operating expenses somewhat higher.

Application of the video at a low radio-frequency power level, as indicated in Fig. 3, results in a small modulator and permits the use of standard tubes, but involves a large number of highly critical tuned circuits. In this case replacement of a tube usually requires retuning with an oscilloscope and a sweep frequency generator. In addition, the attenuation characteristics of this type of circuit must be checked frequently, an operation requiring the attention of an engineer of moderately high skill, and a factor that may result in a concealed increase in station operating costs.

By applying the modulation at a mid-level radio-frequency power stage, as shown in Fig. 6, a transmitter can be developed with a moderate-sized modulator and few non-critical tuned circuits. This design permits the use of standard types of air-cooled tubes in each stage and was, therefore, adopted for use in this unit. It is readily seen that by adopting "mid-level" modulation the major advantages of both high and low level modulation are realized.

Another problem arises in the design of the radio-frequency power amplifier stages (after modulation is applied) that involves basic differences in ap-

Fig. 4. Block diagram of low-band video transmitter. Portion above dotted line is r.f. portion of high-band transmitter.



proach. The FCC specifies that the television transmitter must conform to a specified vestigial sideband characteristic. At the present time, there are two methods for obtaining this characteristic in television applications. The radio-frequency coupling networks following the modulated r.f. stage can be designed to attenuate the undesired sideband or a filter can be placed at the output of the transmitter to achieve the desired result. In the latter case, the complexities of filter design are eliminated from all circuits containing tubes or replaceable elements. This permits readjustment of all circuits after a tube is replaced primarily on the basis of maximum power output, thereby simplifying the tuning procedure. This method was chosen for the *Federal* transmitter in adherence with the objective of simplifying the maintenance procedure.

The vestigial sideband characteristic is produced by a filter using transmission line elements. Here again, a choice of design is available between a constant resistance type of network or a conventional pure reactance type of filter. Since the constant resistance filter is inherently a more complicated structure, the purely reactive configuration was chosen. Experience indicates that a highly stable characteristic is obtained with this design and a permanent adjustment operation is all that is necessary to tune the filter. This adjustment can be made before the unit is shipped out and checked at the installation by a field engineer so that the station staff does not have to tune it at any time.

The video section of the transmitter consists of a sync stretcher, d.c. restoring and clamp circuits, and the video amplifier. The sync stretcher assures the proper ratio of sync to signal voltage at the transmitter output. Stability of black level and hum rejection are insured by use of a clamp circuit at significant points throughout the video section. The main video amplifier is designed to provide excellent high frequency response characteristics and includes a phase-correcting network to maintain an over-all linear phase response through the transmitter and vestigial sideband filter.

Transmission of the audio signal is accomplished by conventional FM broadcast techniques. In this case, the well-known FM "frequematic" modulator and center frequency stabilization system employed in *Federal* FM transmitters is used in the aural unit. The aural transmitter is similar in over-all block diagram and modulation to the *Federal* FM broadcast transmitters. It differs from this transmitter only in frequency and maximum available percentage of modulation, these latter characteristics conforming to the standards set for television operation.

A photograph of the visual and aural section of the transmitter (without vestigial sideband filter and diplexer unit) is shown in Fig. 5. As seen in this photograph, the equipment is contained in six bays, the first two (going from left to right) housing the aural section and the last four, the visual transmitter. Each of the transmitters include all necessary power supplies and may be installed, tested and operated independently if so desired. This design permits a flexibility of unit arrangements, i.e., transmitter may be installed in a straight line, "U" or "L" shape depending upon the requirements and available space in individual stations.

Each transmitter may be remotely started and stopped, and the operation of essential circuits checked by pilot lights from a panel on the transmitter control and monitoring console. This console also contains all apparatus necessary to accept visual and aural signals from the studio and feeds them to the aural and visual transmitter with proper control of levels and monitoring of input and output signals.

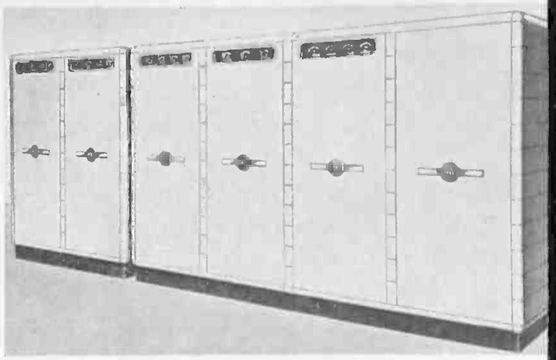


Fig. 5. Visual (last 4 bays from rt.) and aural (two bays on extreme left) portions of the TV transmitter.

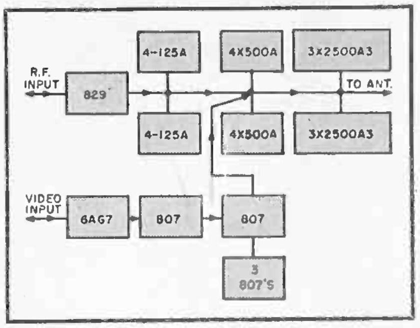


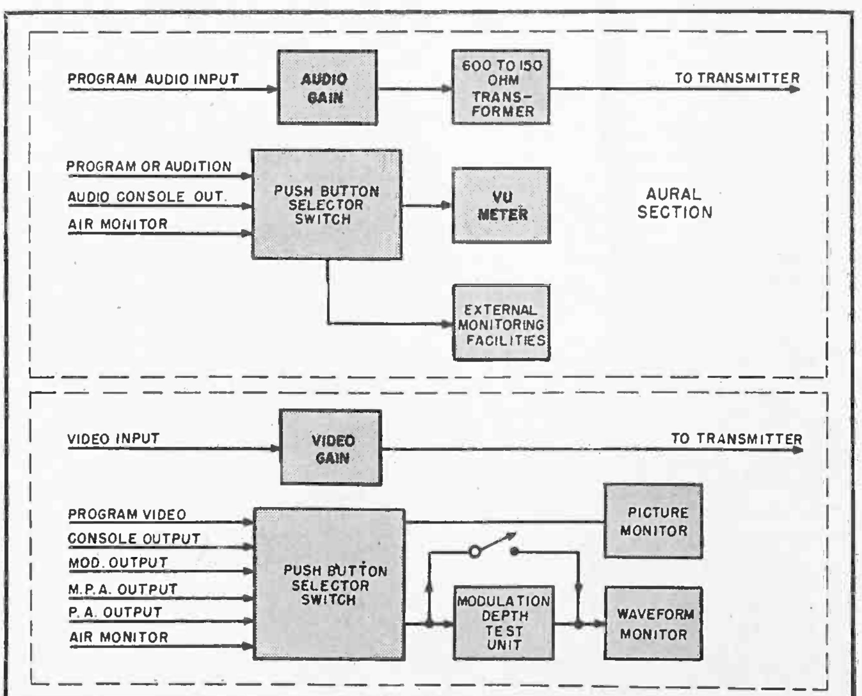
Fig. 6. Block diagram of TV transmitter employing mid-level modulation.

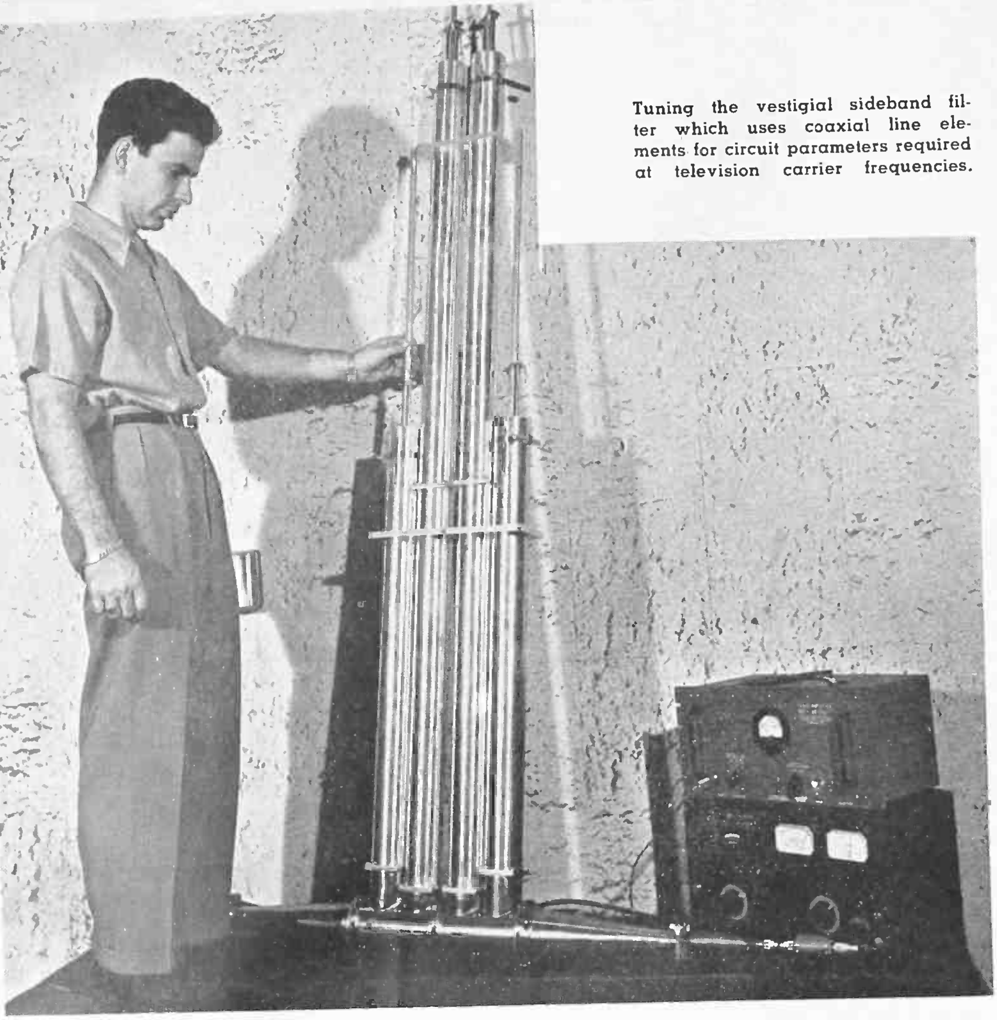
Visual Transmitter

Fig. 4 is a block diagram of the low and high band visual transmitters. It is readily seen from these figures that both transmitters use identical video sections and differ primarily in the radio frequency chain. In the low band transmitter the radio frequency signal originates in a crystal-controlled oscillator operating at one-eighteenth of the final carrier frequency. Thus, the crystals required operate at frequencies between 3.3 and 4.7 megacycles where excellent stability can be obtained with simple cir uits.

The crystal oscillator is followed by a series of frequency multiplier stages

Fig. 7. Functional block diagram of the transmitter console.





Tuning the vestigial sideband filter which uses coaxial line elements for circuit parameters required at television carrier frequencies.

consisting of one type 1614 tube operating as a frequency doubler, one type 1614 tube operating as a frequency tripler, and one type 815 tube used in a frequency-tripler circuit. This sequence of multiplication brings the output of the crystal oscillator to the final carrier frequency. For the high band transmitter, a similar crystal oscillator and frequency multiplication circuit is used, except that additional multiplication is required to reach the higher frequencies.

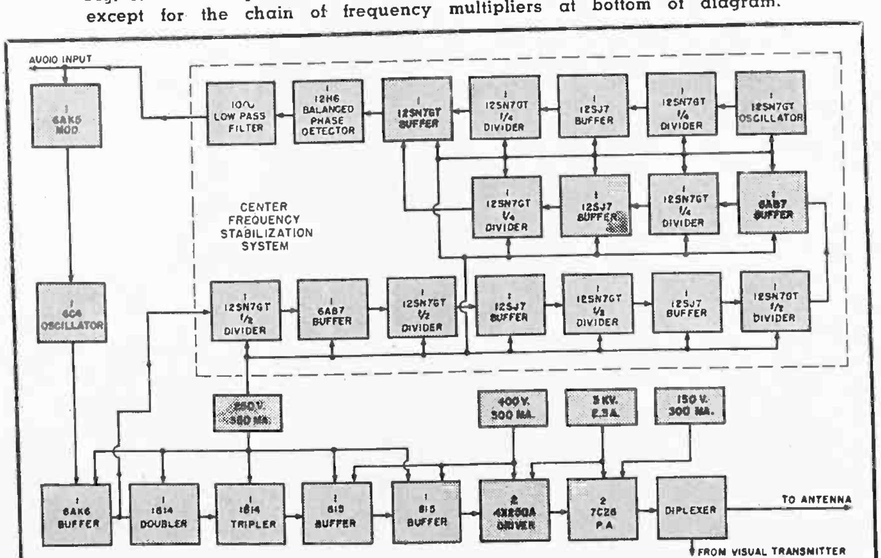
A buffer stage (with a type 815 tube) is then used to drive two type 4-125A tubes connected as a push-pull amplifier. The power output of the two 4-125A tubes is approximately 150 watts. Grid-bias modulation is introduced in the next stage which consists of a push-pull amplifier using two type 4X500-A tetrodes. A power output of one kilowatt at the peak of the synchronizing pulse is achieved. The tuned circuits coupling this stage to the following output amplifier are designed with sufficient bandwidth so that they have negligible effect on the vestigial sideband characteristic. This results in simplified tuning procedures and prevents detrimental effects on picture quality when changing tubes.

The modulated stage is followed by a power amplifier consisting of two type 3X2500A3 tubes in a balanced push-pull, grounded-grid amplifier circuit. The power output of this stage is in excess of 5 kilowatts at the synchronizing peak. Broad band coupling is also used at the output of this stage to simplify adjustment. This power is delivered into an RMA standard 1⅝" coaxial line of 51.5 ohm characteristic impedance, through a shielded tuned loop which enables a balanced amplifier to couple into an unbalanced load.

In the high-band transmitter, a higher initial frequency is used, 7.2 to 9 megacycles, which is frequency-multiplied by 24 times to reach the final carrier band of 174 to 216 megacycles. The modulated stage is essentially the same as the low-band unit except that in this case transmission line elements, rather than coils and condensers, are used for the tuned circuits of the interstage coupling network. In order to generate a 5 kw. peak signal at the high band frequencies with air-cooled tubes, four type 5513 tubes are used in a paired push-pull grounded-grid amplifier circuit.

The required vestigial sideband characteristic is produced by a filter following conventional design principles. This filter, based on an *m*-derived configuration, uses sections of coaxial line as circuit elements. Great care has been taken to obtain a phase characteristic as good as possible, consistent with specified requirements for sharpness of cut-off. In addition, the video amplifier section of the transmitter includes a phase-correcting network which introduces a compensating effect to correct the residual phase shift, so that the over-all phase response through transmitter and sideband filter is essentially linear.

Fig. 8. Block diagram of low-band aural transmitter. High-band is similar except for the chain of frequency multipliers at bottom of diagram.



Video Section

The video amplifier and modulator is a relatively small part of the transmitter because of the "mid-level" modulation design. This section consists of a sync stretcher, a clamp pulse generator, and the main video amplifier. The main video amplifier consists of three stages using tetrodes, and has excellent phase response and gradual attenuation of the high frequency spectrum. This factor helps eliminate any transient peaks that

(*Continued on page* 28)

By SAMUEL A. PROCTER
Consulting Engineer, Chicago, Ill.

AUTOMATIC CONTRAST CONTROL for TV Receivers

White level and contrast are held constant when modulation and signal strength vary.

THIS article describes a recently developed method of automatic contrast control for any type of television receiver, wherein a contrast control voltage is obtained from the picture signal and applied in such a manner that it not only acts to compensate for all variables that affect the video signal level but functions as a white level control.

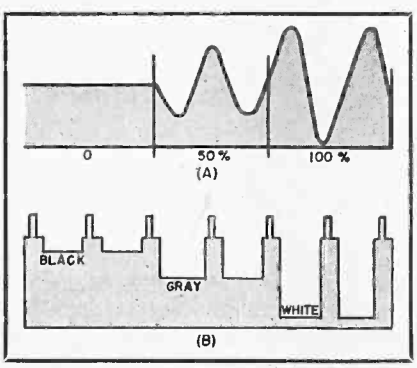
"Men will welcome anything new so long as it is exactly like the old," is an old saw that might be applied to the contrast control systems heretofore employed in most TV receivers, particularly in the early products of the industry.

The majority of TV contrast control systems (circuits) are either direct copies or first cousins of volume control circuits used in radio receivers. But since the sound modulation of a radio frequency carrier and the video modulation of a carrier are considerably different, the nature of the modulation components are by no means similar and the reproduction of this modulation is as different as sight is from sound. It seems not unreasonable that there must be some difference in the requirements of the control systems for the reception of amplitude modulated carrier for sound and amplitude modulation of a carrier with a video signal.

Since present day contrast control systems are based on or are copies of radio's automatic volume control systems, it might be well to consider what occurs in each instance to better understand the requirements of contrast control in TV receivers. An amplitude modulated radio frequency carrier is represented graphically in Fig. 1A. The first part of the figure shows the level of the carrier when no modulation is applied, the second part when modulated 50%, and the final part when modulated 100%. Examination of this representation indicates that the maximum energy of carrier signal is present when modulation is 100% and minimum when there is no modulation. A video modulated carrier is represented in Fig. 1B with the first part having no modulation and corresponding to a dark or blacked-out screen. The second part shows 50% modulation, representing a medium gray screen, while the final part shows 100% modulation which represents a white screen. It is evident from the examination of this graphical representation that maximum carrier energy is transmitted when the screen is dark and the minimum when the screen is white. With sound modulation of the carrier the energy increases in direct proportion with the percentage of modulation. With the video signal the situation is just the opposite, with the minimum signal energy occurring when the carrier is modulated 100%.

In the conventional radio 'Automatic volume control' is not what the name implies. This circuit controls the *gain* of the receiver in accordance with the modulation peaks of the radio frequency carrier. The radio receiver automatic volume control circuit develops a bias voltage which increases with an increase in modulation, which in turn decreases the gain of the receiver.

Fig. 1. (A) Amplitude-modulated r.f. carrier. (B) Video-modulated r.f. carrier.



Thus an increase in modulation produces a compression effect which is very slight. This is as it should be for a large degree of compression in sound reproduction destroys realism.

The requirements of contrast control in a television receiver will now be considered. The obvious and prime objective of an automatic contrast control is to maintain contrast variations within a desirable range. To do this the control circuit must develop a control voltage that will counter the effects of varying signal level, fluctuating line voltage and changes in picture composition and background lighting. In addition, this control voltage must be a function of the video signal applied to the picture tube, rather than the i.f. carrier. *In this control circuit automatic contrast control is effected by fixing the white level of the video signal.*

The basic a.v.c. or a.g.c. circuit is shown in Fig. 2. When a sound modulated signal, represented in Fig. 1A, is fed into this circuit the d.c. output will be proportional to the lowest level of the carrier plus a little more than half the carrier amplitude effected by modulation, depending upon the time constant of the filter circuit and the frequency of the modulation component. When an adaptation of this circuit shown in Fig. 4 is employed, with or without amplification in TV receivers, due to the nature of the video carrier modulation and the time constant of the filter circuit, it can be seen that the d.c. output is affected by the percentage of modulation, although not as much as in the previous circuit of Fig. 2.

With a circuit of this type in a TV receiver, compensation for variations in signal strength and to some extent, for line voltage variations are obtained, but there also is a variation in the d.c. output with the percentage of modulation, making the gain maximum when the modulation is maximum, and minimum when the modulation is minimum. This introduces an expansion action which, in the case of the picture tube, is not desirable.

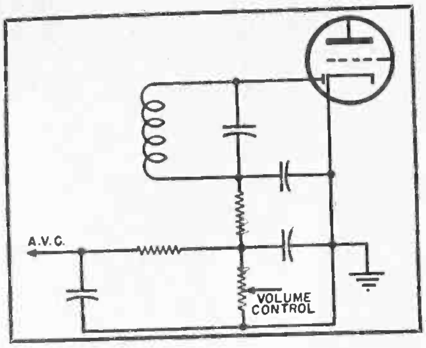


Fig. 2. Basic a.v.c. or a.g.c. circuit.

The average TV receiver when used with a filter or magnifier is usually operated at, or near, maximum contrast which means that if the modulation voltage is not closely controlled it will drive the picture tube off the straight portion of its curve with a resultant loss of focus and detail in the highlights. In circuit arrangements where the final output tube is working at its maximum level, over-modulation results in loss of gradation in the light or nearly white portions of the picture. To avoid the loss of highlight gradation and focus it is necessary that the control voltage reduce the gain of the receiver when modulation is maximum and increase it when modulation is minimum to sustain shadow detail. In the a.g.c. circuits, with or without amplification, if the time constants permit a change in the control voltage with changes in modulation, or white level, these changes will effect an expansion action, increasing the gain when modulation is maximum and decreasing gain when modulation is minimum.

The circuits offered here fulfill all the above outlined requirements for automatic contrast control, are quite simple to construct, and parts values are not critical.

This control system consists of two rectifiers and their associated filter networks. One rectifies the i.f. carrier, at second detector level, to provide an a.g.c. voltage. The second rectifies the video voltage at picture tube level to provide an a.c.c. voltage. Since this voltage is considerably higher than the required bias voltage, it is returned to ground through a controllable bucking voltage (contrast control), and the difference voltage is applied to the grids of the tubes to be controlled by this circuit.

In receivers where the second detector output is negative going, that is, the voltage developed across the load resistor is negative with respect to ground, this voltage can be used as the a.g.c. component of the system.

Three a.c.c. rectifier circuits are shown in Figs. 5, 6 and 7. The half-wave plate excited circuit of Fig. 5 is for use where the video signal is applied to the picture tube grid. A half-wave cathode excited rectifier circuit of Fig. 6 is for use where the signal is applied to the cathode of the picture tube. The peak to peak rectifier circuit of Fig. 7 may be used in either instance or where very sensitive control is desired such as a projection tube working at its maximum output. In receivers where the video stages are non-linear or the final stage is signal biased, the peak to peak rectifier, shown in Fig. 7, may be necessary.

Fig. 3 shows the complete circuit and how the a.g.c. and a.c.c. are combined and fed to the stages to be controlled. This circuit permits the a.c.c. voltage to control the stages to which it is connected so long as the a.c.c. voltage is greater than the a.g.c. voltage. Under conditions that cause the a.c.c. to become less than the a.g.c., the a.g.c. then controls the entire system.

The reactions of the system to the variables encountered in video reception now may be considered. This reaction can be made clear by observing the behavior of the a.g.c. and a.c.c. rectifiers separately, and then how their combined action effects automatic contrast and white level control.

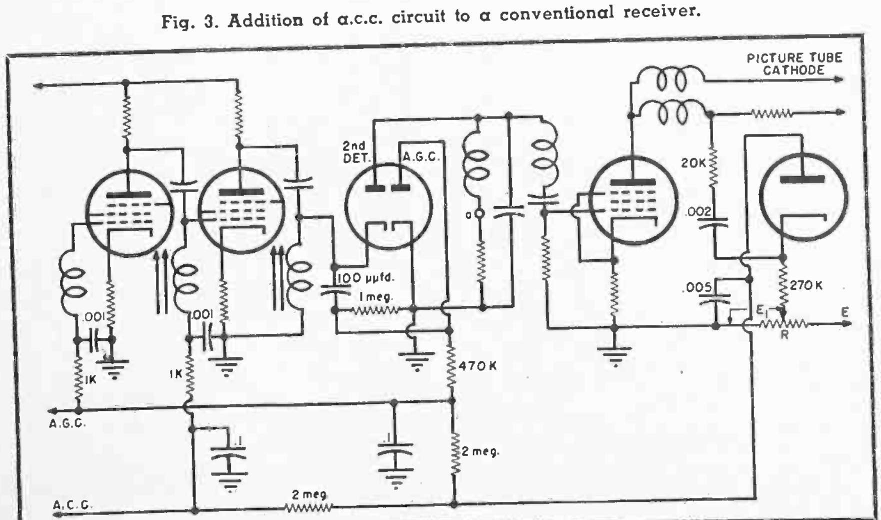
There are two variables affecting picture contrast. One is varying signal strength, brought about by fading, reflection, and voltage variations within the receiver. The other is modulation percentage resulting from contrast variations in the picture, and the maximum white level affected either by modulation or the background lighting of a given scene.

In the case of the a.g.c. rectifier output, let it be assumed that there is no change in percentage of modulation or background lighting but that the signal level increases. With a circuit of this type the only result can be an increase in the output of the a.g.c. circuit effecting a reduction in the gain of the stages it controls and tending to hold the video output at a constant level. Considering this same circuit with the signal level held constant and the modulation increased, a drop in the output of the a.g.c. results. The amount of drop depends upon the time constant of the circuit *RC*, Fig. 4. This action would result in increased gain of the controlled stages and a greater percentage of increase in video output than was intended.

Before considering the effect of the signal variables on the a.c.c. circuit, an analysis of the circuit and its action may be of some help in understanding its action. For this purpose refer to Fig. 5. To facilitate explanation a set of average figures will be used. Let there be assumed a peak to peak video voltage of 30 volts, an a.g.c. voltage of -3 volts and an a.c.c. voltage of -5 volts. Under these conditions the contrast control voltage E_1 will be about 10 volts. The series impedance, to the video signal, of R_3 and C is quite low compared to the parallel impedance of R_1 and R_2, therefore the video signal appearing on the plate of the diode is approximately 30 volts peak to peak. This voltage is negative going during the blanking and sync intervals, and positive going during the scanning interval. The whiter the picture the more positive this voltage will go. When the positive going value of the video voltage becomes equal to the sum of E_1 and the a.g.c. voltage, the diode begins to conduct and condenser C takes on a charge equal to the difference between the peak positive value of the video and the sum of E_1 plus the a.g.c. In the aforementioned set of typical values this difference amounts to 5 volts.

In this circuit when the carrier increases, with the modulation remaining constant, there is produced an increase

Fig. 3. Addition of a.c.c. circuit to a conventional receiver.

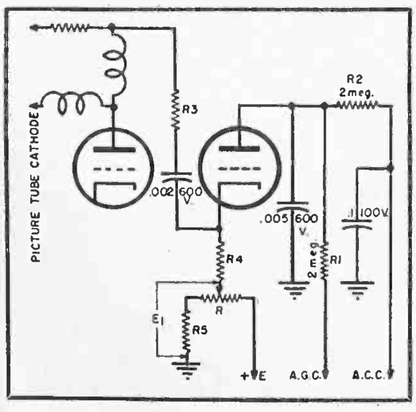


in video voltage. Since no change takes place in the value of E_1 and the increase in the a.g.c. is negligible, practically all of the increase in the video acts to increase the charge developed in condenser C thereby increasing the a.c.c. bias by the same amount. If, for instance, the increase in carrier strength caused the video to increase to 40 volts peak to peak, one half of this would add to the charge in C and the a.c.c. would increase by 5 volts. This much increase would probably be enough to cut off an i.f. amplifier under control of the a.c.c., so instead of a change of 5 volts in the a.c.c. there would actually be only a change of about ½ volts with a resulting increase in peak to peak value of 1 volt. In so far as direction of change is concerned the a.c.c. circuit reacts to an increase in carrier level exactly the same as the a.g.c. but with greater sensitivity.

Now for the second variable and its effect upon the a.c.c. Assume the carrier remains constant and the modulation increases, an increase in the peak to peak voltage results and the same action outlined for the reaction of the a.c.c. in the preceding paragraph takes place and the gain is reduced to maintain the video voltage constant. The reaction of the a.c.c. to an increase in modulation is just the opposite to that of the a.g.c.

The opposed actions of the a.g.c. and a.c.c. to modulation variations have two notable results. First the a.c.c., by increasing with an increase in modulation, counters the expansion effect of the a.g.c. which decreases with an increase in modulation, and secondly this opposed action prevents excessive compression which would result if the a.c.c. were in complete control of the gain. Such a condition would permit the gain to reach a very high value when the screen goes dark. Should the screen go completely dark, no modulation, the a.c.c. would drop to a value lower than the a.g.c. and at this point the a.g.c. takes over complete control of the receiver.

Fig. 6. Half-wave cathode-excited a.c.c. for use when video signal is applied to the cathode of the picture tube.



The system has unusual sensitivity and freedom from noise. This can best be illustrated by again using our typical figures. Let it be assumed that reception is from a station whose signal level develops an a.g.c. of -3 volts and the signal is modulated so that the a.c.c. is -5 volts. Then the receiver is tuned to another station whose signal level is considerably lower. First the a.g.c. would drop to perhaps -1.5 volts, increasing the gain of the stages under its control until the video voltage exceeds the contrast control voltage to develop an a.c.c. voltage to control those stages connected to the a.c.c. circuit. The a.c.c. developed would be just enough to maintain an average peak to peak video signal of 30 volts. Should the signal level drop still lower so that the peak to peak value became less than 30 volts the a.c.c. output would be zero and the tubes controlled by the a.c.c. would now have the same control voltage as those controlled by the a.g.c., and hence, the receiver would be working at maximum sensitivity. Increasing the contrast control would have no effect.

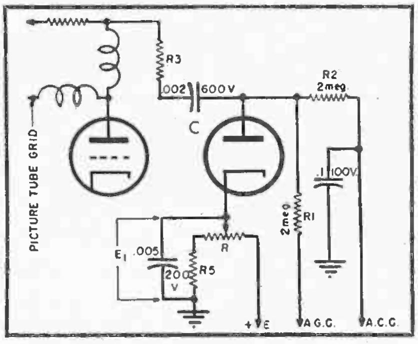


Fig. 5. Half-wave plate-excited a.c.c. for use when video signal is applied to the grid of the picture tube.

Since the a.c.c. rectifier works on the white level of the signal and the white level results from minimum carrier level the a.c.c. voltage is not affected by noise, for noise corresponds to an effective increase in carrier level and produces a negative going voltage at the a.c.c. rectifier circuit. The a.c.c. does not reduce contrast to zero, which obviously would be of no value.

The peak to peak rectifier, Fig. 7, by utilizing both the negative and positive going peaks of the video signal, functions as a voltage doubling rectifier and has twice the output of the half-wave rectifier shown in Figs. 5 and 6. Use of this a.c.c. rectifier arrangement doubles the sensitivity of the control action and since the circuit utilizes both peaks of the video signal, it may be used equally well with either cathode or grid excited picture tubes. Another advantage of the peak to peak a.c.c. rectifier is that it will work with video amplifiers that are driven off the straight portion of their operating curves. Non-linear operation of these circuits will not affect proper response to white level variations where the half-wave rectifiers are used.

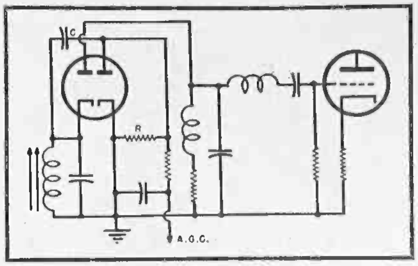


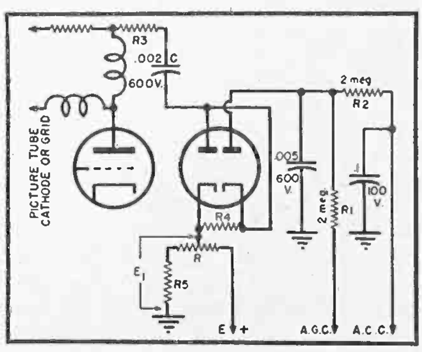
Fig. 4. Intermediate step in the design of an a.c.c. system.

The choice of which stages will be controlled by a.g.c. and which will be controlled by a.c.c. depends largely upon the receiver in question. Generally the front end should be controlled by the a.c.c. In the i.f. amplifier alternate control may be employed or the first stages may be controlled by a.g.c. and the latter stages by a.c.c., as this control voltage is higher. If the sound circuit is of the intercarrier type, it may require some experimenting with control selection to eliminate sync buzz. This problem should not be too troublesome because the output of the a.g.c. rectifier during the sync interval increases and that of the a.c.c. decreases. This will cause the stages controlled by the a.g.c. to lose gain and those controlled by the a.c.c. to increase gain, the over-all effect on gain being negligible.

In spite of the long time constant of the filter circuit (R_2 and C_2) the reaction of the a.c.c. is rapid enough to almost completely cancel the effects of airplane reflections, yet is not affected by the most extreme variations in picture composition or noise. Fig. 3 illus-

(*Continued on page* 25)

Fig. 7. Peak to peak circuit gives greater sensitivity and may be used when video signal is applied to either the grid or cathode of the picture tube.



A plastic tube guides the light from the pilot lamp load to a calibrated photocell.

Photo of the probe type construction, showing two extra probe tips.

Self-Contained U.H.F. WATTMETER

By NORMAN B. RITCHEY

Advanced Development Labs., Sylvania Elec. Prod. Inc.

SEVERAL methods of power measurement will be described for use in determining the output of low power u.h.f. oscillators. The particular frequency range of interest is 400 to 1000 megacycles. Some advantages and disadvantages of each method will be pointed out.

A novel probe type wattmeter is described having accuracy comparable with other systems. The simplicity and self-contained features of this unit have much to recommend it for a convenient laboratory tool. The probe uses a barrier type photocell to measure the brilliancy of a lamp load. The arrangement is unique in the use of a highly polished plastic rod as a light guide which provides a path of fixed separation and density between the light source and the detecting photocell, and by total internal reflection in the rod avoids the square law reduction in illumination which is otherwise involved in physical separation between the light source and the detector.

Basically, the considerations of a.c. power measurement differ from d.c. measurement only in the addition of phase angles. In resonant load circuits the power factor is essentially unity and the basic voltammeter can be used to determine power. In theory, at least, such a method of power measurement is independent of frequency. The difficulties arise in the design of voltmeters and ammeters for use at the higher frequencies. Peak reading voltmeter probes can be designed to work into the u.h.f. region, but require corrections for resonant rise and premature cut-off effects if any accuracy is to be expected. The calibration of voltmeters becomes a major problem in itself. Ammeters for r.f. work must be of the hot wire or thermocouple type to avoid placing high impedances in the circuit. Instruments of this nature consume appreciable power when used in circuits of low power levels. Thermocouple instruments are particularly sensitive to r.f. burn-out by pickup in the secondary circuit if adequate shielding precautions are not taken. In addition, the difficulty encountered in trying to measure both voltage and current at the same reference point along a resonant line makes the direct voltammeter method of power measurement very cumbersome and unwieldy at high frequencies.

A far more convenient method depends upon the expression $P = E^2/R$ for resonant loads of unity power factor. This requires only one measuring device in the u.h.f. region inasmuch as R may be made constant over very wide frequency ranges with little difficulty. The instrument required is an u.h.f. voltmeter which is easier to construct and calibrate than an u.h.f. ammeter.

A basic requirement for a method of this nature is that the voltmeter probe be placed across the load resistance with zero separation and zero lead length if the meter is to be made insensitive to variations in standing wave ratio.

An instrument using this principle is commercially available. It uses a coaxial-type, 50 ohm resistance associated with a crystal-type voltmeter probe. However, there is some physical separation between the load and the voltmeter probe. The result is a voltmeter reading which can vary with standing wave ratio and which is not necessarily indicative of power at standing wave ratios of greater than unity. The unit in question is a completely satisfactory termination to a 52 ohm line at frequencies up to 500 megacycles, but at higher frequencies the standing wave ratios exceed 1.1 and this together with resonances in the voltmeter probes can give false indications if frequencies in excess of 500 megacycles reach the instrument. Power discrepancies of major proportions are observed if lower frequency signals contain appreciable harmonics. Thus it becomes necessary to use low pass filters ahead of this type meter to avoid spurious responses to harmonics. The low pass filter must furnish a satisfactory impedance match and must be calibrated as to insertion loss. It is the usual case that if equipment is available to measure the filter insertion loss further measuring systems of lesser accuracy are superfluous.

A measuring device more suited to rapid measurements and limited budgets is the bolometer bridge using ordinary radio pilot lamps as the sensitive element. This instrument is a Wheatstone Bridge in which the unknown branch is a pilot lamp whose resistance varies as a function of the temperature of the filament. Pilot lamps are available in a range of power capabilities giving sensitive bridge conditions over the range 0.005 to 5.0 watts with four different lamps. This is a very sensitive instrument for detecting small variations of r.f. power, but the sensing element (the pilot lamp) must be connected both as a load on the oscillator and as an element of the Wheatstone Bridge. Isolating chokes are necessary to keep r.f. out of the bridge, and more important to keep the bridge from loading down the oscillator and taking power away from the load.

The efficiency of the isolating chokes is always questionable and may be tested by connecting and disconnecting the bridge from the load lamp and watching for perceptible dimming of the lamp load. A rough estimate of the power lost may be made by coupling the load lamp to the oscillator with the bridge chokes disconnected, matching a similar lamp bulb excited by d.c. to the same brilliance as the load, connecting the chokes and rematching the d.c. bulb to the new brilliance of the load. The change in power necessary to rematch the load brilliance is the loss produced by the chokes. Considerable experimentation with isolating chokes leads to the conclusion that some loss must be expected when connecting the bridge to the load. Thus, although the bridge method is sensitive, it cannot measure the full output of an oscillator because losses, which cannot be accurately evaluated, are introduced by the chokes. In some cases at higher power levels the choke losses may be neglected and the bolometer method becomes quite useful.

The ideal method of u.h.f. power measurement seems to be one in which the load can be located right at the oscillator with no attenuation in any intervening cables, and in which no external circuit need be connected to the load with power absorbing chokes.

This requires the detection of power in the load with no electrical connection to it. The manifestations of power in a lamp load are heat and light. Heat is a direct function of power input and light is a fourth power function of temperature. The measurement of load power might thus be based on either of these manifestations.

Heat may be measured on a comparative basis by the use of a radiation thermocouple or on an absolute quantitative basis by a calorimeter. Calorimetry usually requires a mass of water, insulating jackets, etc, surrounding the load. In a u.h.f. oscillator this would necessarily require a separation between load and oscillator and introduce cable and matching losses.

The radiation thermocouple can be used to compare the heat given off by a load lamp to that given off by the same lamp on direct current. When the power input to the d.c. bulb is adjusted for the same indication of radiated heat as when the lamp was lighted by r.f., it should be safe to assume that the d.c. power is equal to the r.f. power. The disadvantage of the thermocouple method lies in the thermal inertia of matter and the subsequent long-time delay needed for the themocouple indication to stabilize at a useful reading. Sometimes as long as fifteen minutes are required for the bulb temperature to assume an equilibrium value. Heat radiation from surrounding objects and cooling of the bulb due to drafts are both possible sources of large error if great precautions are not taken. The thermal method does not offer the possibility of observing immediately the effects of various changes in the circuit of the oscillator and thus is useful only as a final measurement of power and not as a tool to aid in oscillator tuning and adjustment.

This leaves only the light output of a load lamp as a means of comparison which is rapid, yet requires no physical connection to the load. Light output can be compared visually by matching a bulb excited from d.c. to the load lamp. This can be a fairly accurate method at low light intensities if the lamp bulbs are identical. Pilot lamps,

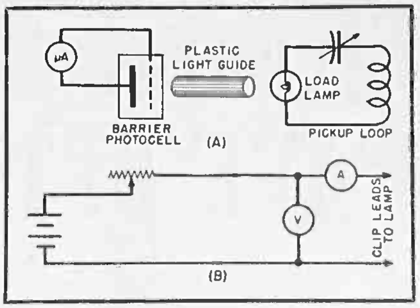


Fig. 1. Schematic diagram of (A) the u.h.f. wattmeter and (B) the calibrator.

however, vary over wide limits so that a cross calibration must be made to compensate for the difference between individual lamps. In calibration, the load lamp is excited by d.c. and the power input observed. The second lamp is matched in brilliance for a series of input powers. The voltage across the second lamp is plotted as a function of input power to the load lamp. When the load lamp is lighted on r.f. and the second bulb matched to it in brilliance, the power in the load can be read directly from the curve.

Over a period of two years in the Application Engineering Laboratory, this method has been used by many observers and, at low light intensities, has checked quite closely. The approximate deviation between readings of different observers was 5%. As the light intensity increases the divergence between readings of several observers becomes greater. A means to eliminate this human error was sought. The photovoltaic or barrier type cell offered a ready solution. Such a photocell, however, is sensitive primarily to light intensity and secondarily to color, while the eye matched color only. In color matching by eye, the distance of the

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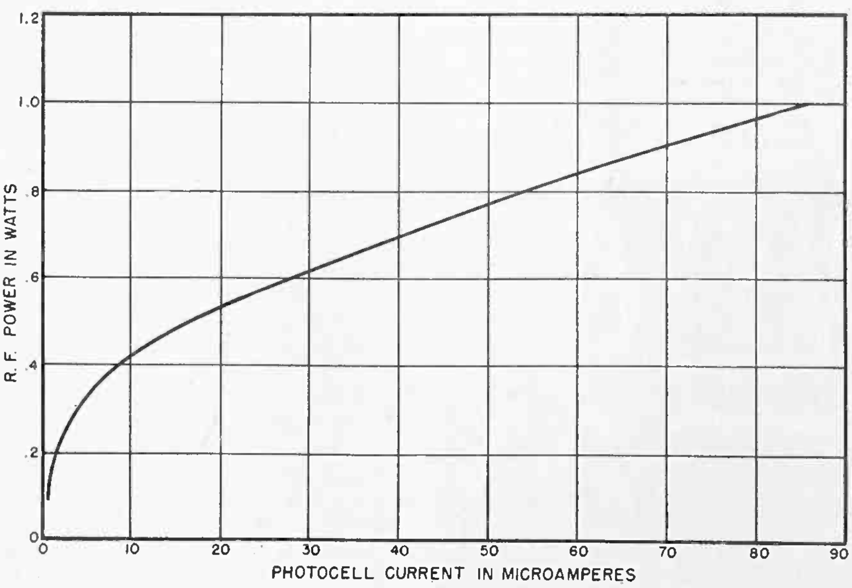
Fig. 2. Calibration curve for the probe-type u.h.f. wattmeter.



Circular STANDING-WAVE DETECTOR

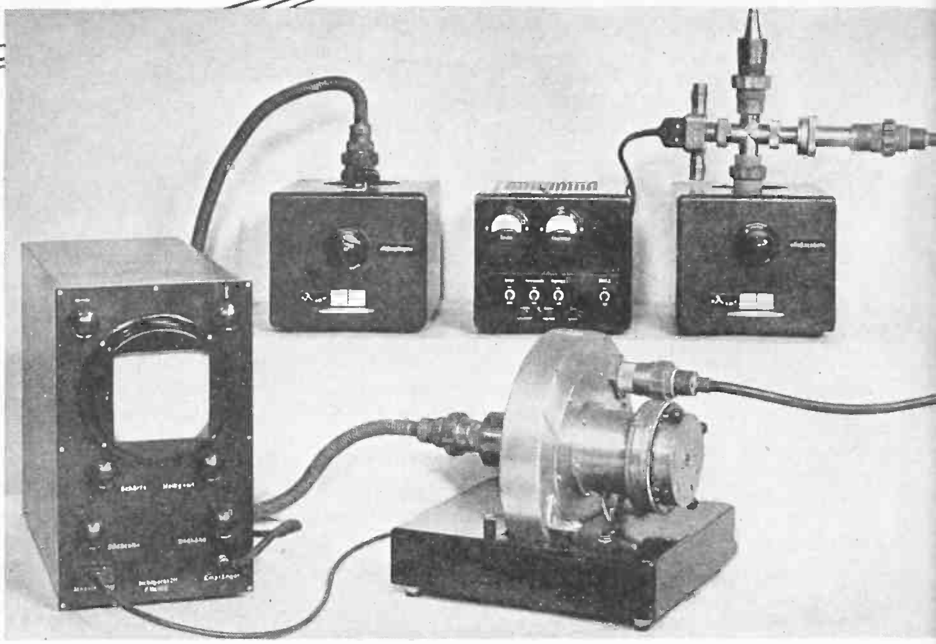


Fig. 1. Complete standing-wave detector setup. Top right, generator with attenuator and its characteristic impedance; next, power supply; then the receiver and at left, the oscilloscope. The circular standing wave detector is at the lower front.

A coaxial conductor in the form of a circle with a rotating probe for detecting r.f. in the conductor forms the basis of this instrument.

THE *Junta-Express Co.* of The Hague, Holland, has developed a circular standing-wave detector which should be of interest to engineers working with ultra-high frequencies from 250 to 1500 mc. With this new system the voltage distribution along the r.f. conductors is shown on a cathode-ray tube, making possible the direct display of high-frequency phenomena in all types of circuits.

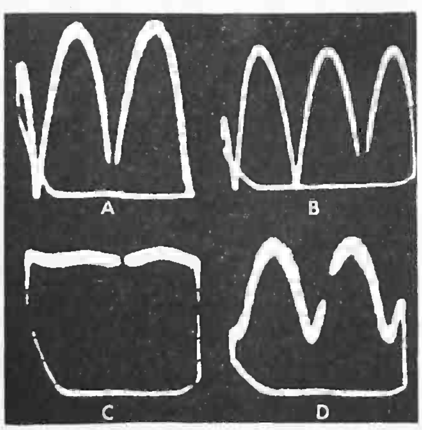
The method is especially valuable in applied research and development laboratories, where quick tests under various conditions must be made.

The circular standing-wave detector using a rotating probe described here does not make the normal parallel-wire system obsolete. The latter will remain in use for special measurements.

The method that has been developed now means considerably less work and some really new techniques, most of which are unknown up to now. It also permits an easy interpretation and rapid control of the phenomena observed.

The heart of the device consists of a circular concentric line in which an r.f. probe can rotate. A suitable signal generator having an output of about one watt with a resistive termination of 70 ohms feeds energy into one end of the circular conductor, the other end being either suitably terminated or connected to the material under test.

Fig. 2. Oscilloscope traces under various circuit conditions. (A) and (B) show standing waves in the circular system with the "dark point" at a voltage minimum. (C) represents the nearly ideal case of a traveling wave. In (D) the circular system terminates in a complex impedance.



Output of the rotating probe is fed to a receiver having a bandwidth of about 1 mc., where it is amplified, rectified, and connected to the vertical deflection plates of a cathode-ray oscilloscope. The horizontal plates are synchronized with the rotating probe, thus giving a picture of the standing waves in the circular concentric line on the scope screen.

The complete setup is shown in Fig. 1. At the top right is the generator with its attenuator and suitable termination. At the top left is the receiver and next to it the cathode-ray tube. The circular standing wave detector is in front.

The diagram of Fig. 3 serves to indicate the basic functions of the various components. At the right is a suitable signal generator terminated with a 70 ohm resistor to insure good frequency stability. A capacitive attenuator is also included, giving a variation of 18 to 90 db.

The rotating probe of the system is connected to the input of the receiver through a capacitive joint. The receiver is a superheterodyne with a diode mixer and an intermediate frequency of 3 mc. plus or minus 500 kc. After rectification, this i.f. voltage is supplied directly to the vertical deflection plates of the scope.

The synchronization of the electron-beam is effected by magnetic impulses from the rotating arm of the standing-wave detector connected to the scope deflection plates as shown in Fig. 3. The length of the sweep is equivalent to the active circumference of the circular system, which is about 320° of the total circumference.

By means of a second magnetic impulse connected at *Z* to the control or intensity electrode of the scope, a "dark spot" is produced, which can be moved along the sweep. Its exact position can be read from an engraved scale. By this simple device each point of the curve on the fluorescent screen can be accurately located and its distance from any other point measured.

Tests and measurements which may be made with this device include matching of impedances, measurement of resistances, measurement of large mismatchings, measurement of low-loss four-terminal networks, construction of impedances with any resistive and reactive components, and measurement of the band-pass curves of i.f. amplifiers and receivers, to mention only a few.

Fig. 4A shows the circular standing-wave detector terminated in a concentric line with a movable shorting plunger. The voltage distribution round the circular system is shown on the scope screen. First the amplitude of possible interfering voltages is determined by measuring the distance between maxima or minima at various positions of the shorting plunger. By comparing the distances between maxima or minima in the circular system with those on the concentric line the characteristic impedance and the network characteristics of the output system of the circular standing-wave detector can be determined. After this the concentric line can be replaced by the unknown impedance. The electrical length between the circular system and the object under test can be measured by short-circuiting the latter.

Matching of Impedances

Any complex impedance can be transformed into a resistance of 70 ohms by connecting a shortening "trombone" in series with it and using a movable shorting plunger connected to a T-piece parallel to it, as shown in Fig. 4B. It is better to carry out the measurement with small amplitudes. Finally the impedance under test is replaced by a movable shorting plunger, the length of which is varied.

Fig. 4C indicates how measurement of resistances may be made at small amplitudes. By means of the "dark point" the exact position of the nodes can be determined. By using the attenuator the maximum and minimum voltage can be regulated to the same level and in this way the quotient $m = V_{min}/V_{max}$ can be measured. A simple calculation gives the unknown resistance. This procedure has proved to be superior to the methods which were common practice until recently. Large mismatchings may be measured by the setup shown in Fig. 4D, using the capacitive attenuator. First the maximum generator output is applied and the height of the minimum on the screen is determined. Then the voltage is decreased until its maximum reaches the same value as the minimum which has just been determined. The quotient m can then be read from the calibrated attenuator.

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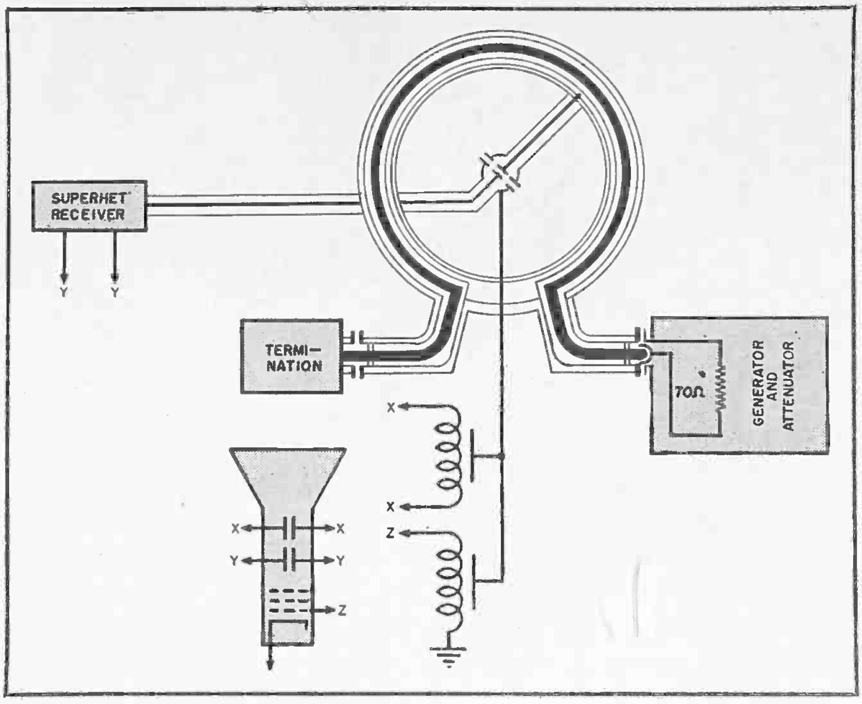

Fig. 3. Block diagram showing the essential functions of the various components used in the circular standing-wave system.

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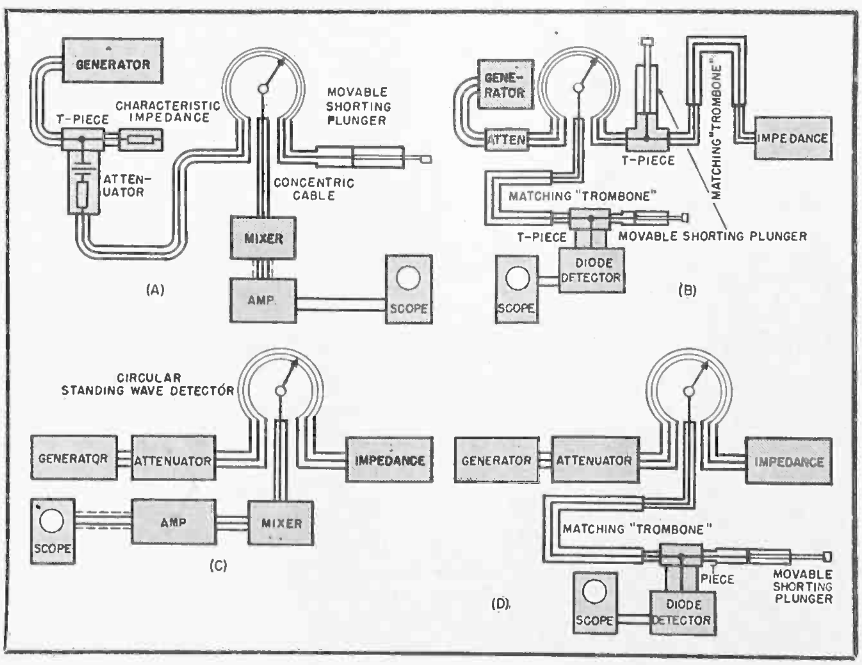

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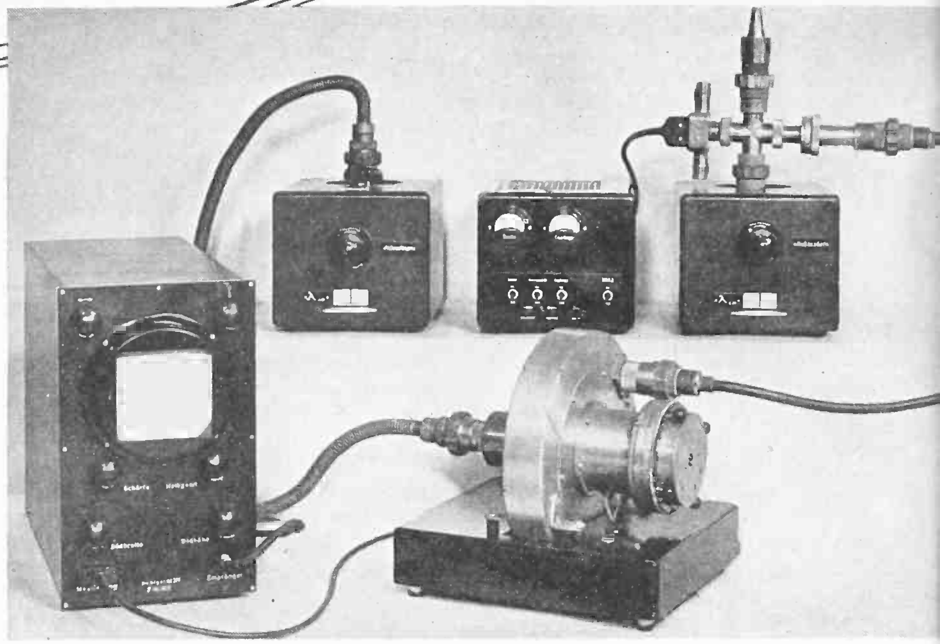

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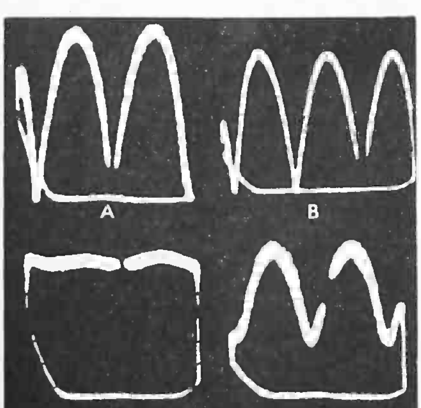

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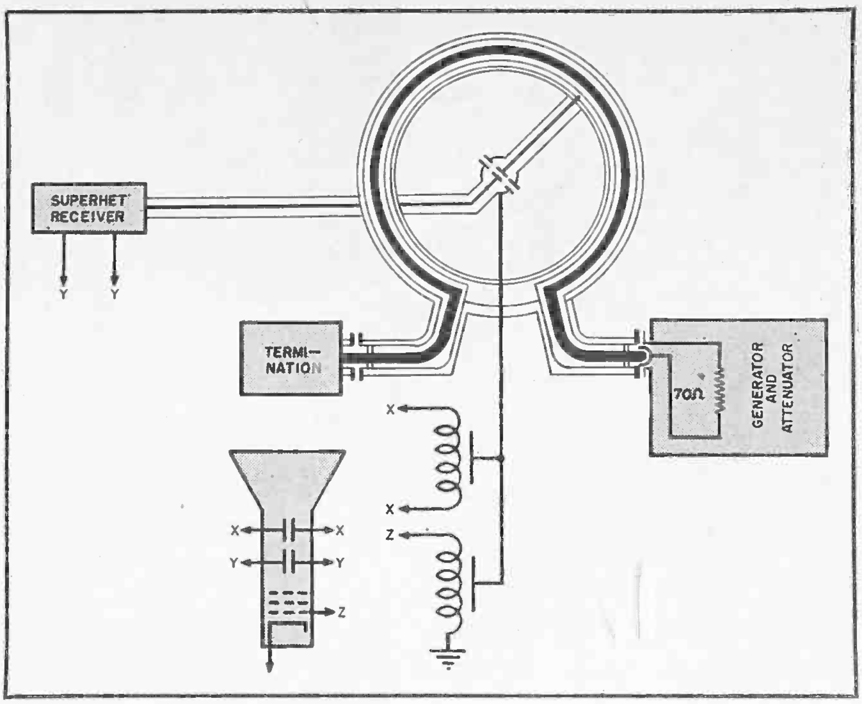

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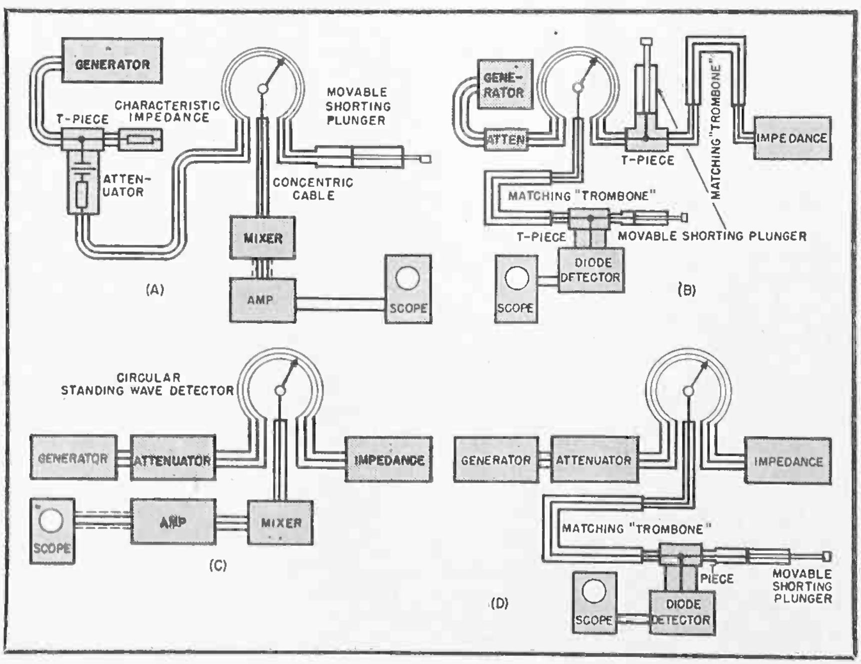


Fig. 1. Quartz plate with growth in zone of density change.

GROWING QUARTZ CRYSTALS

By
E. BUEHLER
and
A. C. WALKER
Bell Telephone Laboratories

A summary of progress made in the artificial growth of quality quartz crystals at Bell Labs.

RESEARCH on the artificial growth of quartz crystals has been stimulated in recent years by our dependence on a single source of high quality natural quartz, and by the large quantities of quartz needed by the electronics industry in both war and peace. Further stimulation has been brought about by reports of the successful growth of quartz crystals by Professor Richard Nacken in Germany.[1]

This report summarizes progress that has been made by *Bell Telephone Laboratories* engineers since research on this project was begun in March, 1946. Several methods of growing large single crystals of quartz have been under investigation.*

One of these has been brought to a state of development recently whereby clear crystals weighing up to nearly one quarter of a pound have been grown in the brief period of twenty days. (See cover picture.)

The process by which this crystal was grown is illustrated by Fig. 7. Enclosed in a steel tube, or "bomb," having relatively thick walls to withstand the great pressure developed within it, are the three elements needed. These are a "seed" of clear quartz free of inclusions, misoriented areas, and other defects; a layer of broken quartz in the bottom serving as nutrient SiO_2 for seed growth; and sufficient alkaline aqueous solution to fill the free space within the bomb at room temperature to about 80 per-cent of its capacity. Long before the liquid is heated to the operating temperature indicated—400° C at the bottom of the bomb and 380° C at the top—the liquid expands sufficiently to completely fill the free space, and the pressure then builds up to about 15,000 pounds per square inch. The bomb is hermetically sealed at top and bottom with suitably welded steel plugs and is placed on a hot plate. The bomb and hot plate are enclosed in a well-insulated oven, and this simple arrangement is left to "cook" for several weeks. Growth takes place on the seed in an orderly manner according to the following procedure: The broken quartz dissolves rapidly at the very bottom of the bomb in the hot alkaline solution, consisting of 5 per-cent sodium carbonate, and forms a strong sodium silicate solution, substantially saturated with silica at 400° C. Motion by convection in the liquid is very rapid, and the dissolved siliça is quickly transmitted to the slightly cooler region in the vicinity of the seed, where the solution is then supersaturated with respect to silica. This is a basically important condition necessary for crystal growth, and silica deposits out on the seed. Because of continuous motion in the liquid, the growing surfaces are constantly bathed in fresh supersaturated liquid and the partially depleted liquid is carried down to the bottom, where it is again saturated at the higher temperature. This process is sufficiently rapid to transmit surprisingly large amounts of silica, and the flow across the growing surfaces is uniform enough to produce the clear growth seen in the cover picture.

This relatively simple process was not achieved without considerable effort, expended not only at the *Bell Telephone Laboratories*, but elsewhere as well. In order to appreciate the significance of the progress made in this work it may be well to outline some of the important background information, and the necessary steps leading to the success thus far achieved.

Even in our first experiments using the Nacken process, clear growth was obtained on suitable quartz seeds in weak alkaline solutions. Conditions were somewhat similar to those shown in Fig. 7, in that the seed was suspended near the top of the bomb, a supply of nutrient material was placed in the bottom, and the free space within the bomb was partially filled with the alkaline solution. In the Nacken process, however, advantage is taken of a difference of approximately tenfold in the solubility of amorphous and crystalline silica in such alkaline solutions, and the nutrient used was amorphous silica. Furthermore, the bomb was kept at substantially constant temperature at or near the critical point of water, this being 374.2° C. The liquid filling was equivalent to only about 30 per-cent of the free space at room temperature, and the alkali concentrations were less than about 0.5 per-cent calculated as sodium carbonate.

Presumably the process can be carried out at constant temperature because of the large difference in solubility of the two forms of silica,

Abstracted by permission from an article by the same name which appeared in the September, 1949 issue of The Scientific Monthly.

* *Other workers on this problem have made important contributions to a better understanding of the process of hydrothermal growth. Among those with whom we have exchanged information are Brush Development Co., Cleveland, Ohio; Professor A. C. Swinnerton, of Antioch College, Yellow Springs, Ohio; Squier Signal Corp Laboratories, Fort Monmouth, New Jersey; and the Naval Research Laboratory, Washington, D. C.*

although the results seem to be somewhat better with slight, controlled fluctuations in temperature about the critical temperature, and with liquid fillings somewhat in excess of 30 per-cent, this amount being just enough to completely fill the bomb with liquid at 374.2°, and is defined as the "critical" volume. In all cases, however, the results were disappointing because, although growth was surprisingly rapid during the first few hours of operation, it was substantially completed in about eight hours and consistently dropped off to nearly zero after the first twenty-four hours. Careful study of the German reports indicated that the German experimenters experienced the same difficulty and had found no satisfactory solution. Nearly 150 experiments were performed in the *Bell Laboratories* in an effort to control the rate of solution and deposition of silica, using amorphous silica as the nutrient material. Some of the factors investigated were size and shape of bomb; solution composition and concentration; addition agents; pressure and temperature; degree of fill; agitation, such as rocking, mechanical stirring, simple convection, and cyclic temperature changes; and continuous feeding of amorphous material.

Extremely rapid, clear growth of quartz is possible under certain conditions with the Nacken process, but because of the great difference in solubility of amorphous and crystalline silica it is evident that the process cannot be depended upon to give high growth rates over long periods.

It follows from equilibrium considerations that if amorphous and crystalline silica are both present as solid phases, the solution in immediate contact with the amorphous phase must be supersaturated with respect to the crystalline phase to the extent of approximately 1,000 per-cent, due to the tenfold solubility difference. Experience with water-soluble crystals indicates that with more than about 5 per-cent supersaturation, spontaneous crystallization cannot be prevented. It appears, therefore, that the Nacken growing cycle is somewhat as follows:

Two to four hours are required for the bomb to be brought up to 375° C, and during this time the alkaline solution dissolves silica from the amorphous layer in the bottom at a continually increasing rate, but not fast enough to achieve the 1,000 per-cent supersaturation with respect to quartz. Sufficient supersaturation develops, however, to promote rapid growth on the seed crystal suspended from the top of the bomb during this period. As the operating temperature is approached, the liquid becomes more and more supersaturated with respect to quartz, and spontaneous seeding occurs, mostly around the individual particles of the amorphous material. Very quickly each particle becomes enclosed in a continuous layer of fine quartz crystals, the local high degree of supersaturation with respect to quartz falls to zero, and growth practically ceases, except perhaps for the very small temperature difference that may exist between bottom and top of the bomb.

Our experience indicated that growths of as much as 0.003 inch in thickness occur during the first four hours, about 0.006 inch in the first six to eight hours, a maximum of 0.008 inch in the first twenty-four hours, and thereafter the rate decreases to the order of 0.001 inch per day or less.

Growth Through Density Change of Solvent

To improve the rate of growth using crystalline quartz as nutrient material, consideration was given to the possibility of utilizing density changes such as are likely to occur in liquids at the critical point.[2] This temperature is defined as the point at which liquid and vapor have the same density, this being about 0.32 for water at 374.2° C. If a bomb is controlled at 372° C ± 2.5° C, the liquid density can vary from about 0.45 at 370° C to 0.32 at 374.2° C, and the vapor density will change from about 0.2 to 0.32 similarly. These are relatively large changes for a temperature difference of about 5° C, and the solubility of silica in either phase should be profoundly affected.[3,4]

Numerous experiments were performed to explore this possibility and growths were obtained (Fig. 1). Half of this seed plate was located where vaporization of the liquid occurred near the hot wall of the bomb. Appreciable growth is visible on this half, whereas the remainder is substantially unchanged from its original thickness. These density tests were not encouraging, however, because of the narrowness of the growing zone, and spurious seeds were difficult to avoid. Growth was continuous throughout the run and at a rate comparable with the Nacken process in its early stages.

Higher Pressures and Temperatures

Three important observations derived from the preliminary work indicated the direction of effort leading to the present successful procedure for growing quartz at high rates. These are:

1. Clear quartz could be deposited at rates as high as 0.03 inch per day, but only for short periods of a few hours, and in the presence of much spurious seeding, using amorphous silica as the nutrient material.

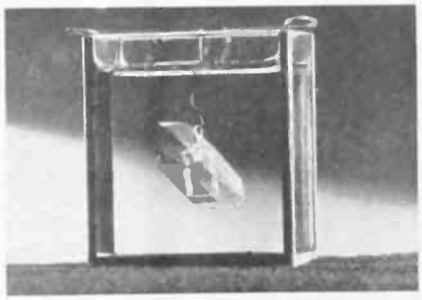


Fig. 4. Quartz crystal in liquid of like index of refraction. Growth is almost transparent.

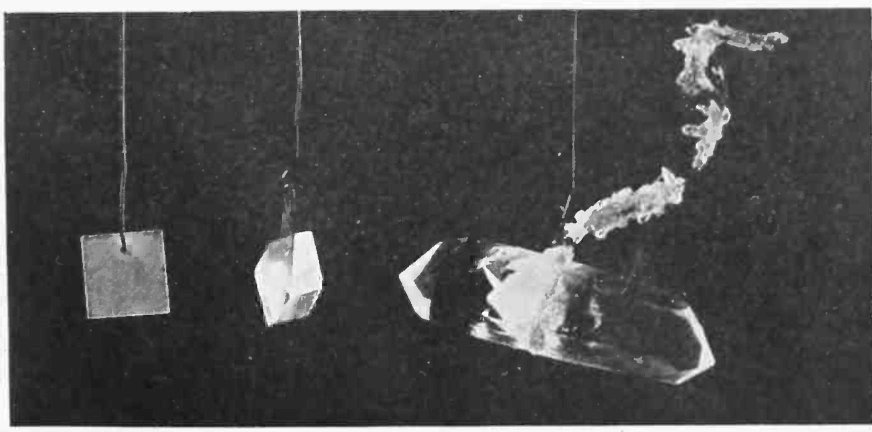


Fig. 2. Effect of bomb leak on quartz growth and spurious seeds.

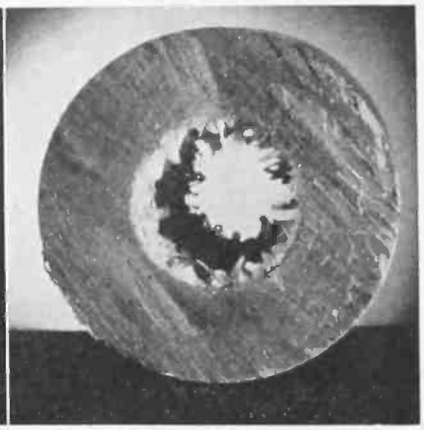


Fig. 3. Section of a bomb that leaked.

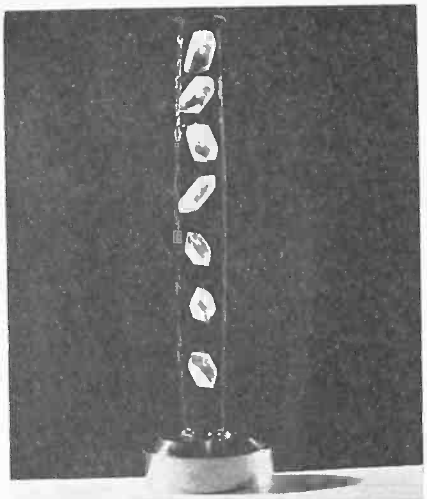


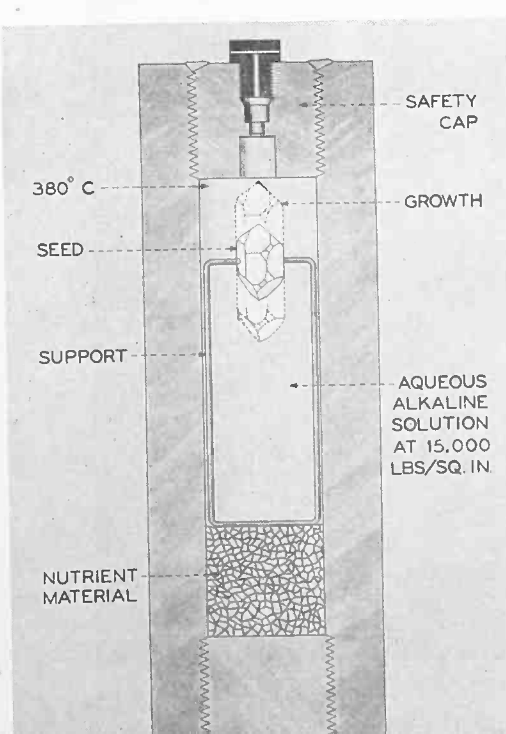
Fig. 5. Arrangement demonstrating growth of several crystals in a single bomb.

2. Growth at very slow rates, perhaps a maximum of 0.001 inch per day, could be sustained with crystalline quartz as nutrient material, and with no spurious seeds.

3. Growth at a rate of about 0.03 inch per day could be sustained with crystalline quartz as nutrient material in narrow zones within the bomb where marked density changes occurred, and this suggested that better results might be obtained at higher solution density.

To secure such higher solution densities it seemed logical to fill the bomb with more liquid, for at the same operating temperature the greater the percentage fill above that corresponding to the critical volume the greater the pressure. In addition, operating at 400° C, rather than at 375° C, better results were obtained.

Fig. 7. Section through bomb used to grow quartz crystals.



These considerations led to the experiments with liquid volumes of 80 per-cent of the free space at room temperature and with solution concentrations of 5-10 per-cent sodium carbonate. After overcoming the serious limitations in bomb design and metal creep caused by operating at 400° C, and pressures of 15,000 pounds per square inch, greatly improved rates of growth were repeatedly obtained, up to about 0.1 inch per day. As indicated in Fig. 7, the bottom of the bomb was at 400° C, and the gradient to the top was 20° C. These temperatures were measured by thermocouples mounted on the outside wall of the bomb—the internal temperature gradient between top and bottom is probably less than this but cannot be measured with any facilities now available. Tests have been made with bombs having internal diameters of 1 inch, 2 inches, and 3 inches, and essentially the same results may be expected with any size bomb when proper consideration is given to obtaining comparable temperature gradients along the length from top to bottom.

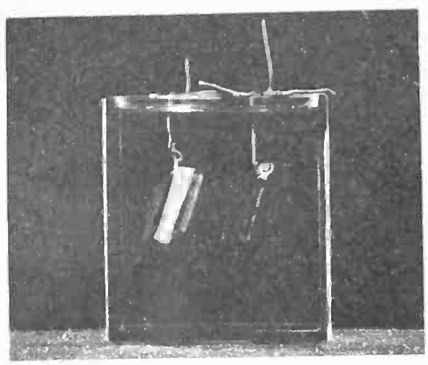


Fig. 6. Crystal on right shows effect of sodium oleate on growth—more growth and less veiling of seed plate.

Nacken reported best results with several alkaline media in this order of excellence: sodium oleate, sodium stearate, sodium carbonate. In our early work, concentrations of these substances in water ranged from about 0.001 per-cent to 0.5 per-cent by weight, and in all cases the clarity and smoothness of growth seemed best in the sodium oleate solutions. At concentrations above 0.5 per-cent, heat decomposition of this sodium oleate seems to seriously interfere with the growth operation. Attention was therefore turned to solutions of sodium carbonate in concentrations up to 10 per-cent—in some cases with additions of small amounts of sodium oleate below 0.1 per-cent.

With these conditions, clear crystals weighing up to six grams were grown in fourteen days and with rates as high as 0.028 inch per day. All the dissolved silica was transported and deposited where desired. Trials made with amorphous silica as nutrient material, for comparison, invariably resulted in a coating of the inner wall of the bomb with spurious seeds, and some such seeds were embedded in the growing crystal.

Fig. 6 shows crystal grown with and without the addition of sodium oleate. The crystal on the right was grown in a solution containing 5 per-cent sodium carbonate and 0.01 per-cent sodium oleate; the one on the left, without the oleate addition. The seed plates from which these were grown were ⅜ inch square by ½ inch thick, cut with the major faces approximately parallel to one of the natural pyramid faces (they are designated in quartz processing terminology as "CT" plates). In general, clear growth takes place only on surfaces cut parallel or nearly so to natural growing faces, and for quartz these are the major and minor rhombohedral faces; therefore the amounts of growth on these two crystals, formed under comparable conditions of time and temperature, may be seen as the relatively transparent amounts on either side of the thin seed plates, shown edgewise in the picture. It is evident that the crystal grew somewhat longer in the presence of the oleate than in its absence, and furthermore the "join" of the grown material with the original seed is much clearer and better in the test employing this addition agent.

More recently we have grown the crystals shown in Fig. 5. Seven plates, each ⅜ inch square by ½ inch thick, were mounted one below the other in a 1-inch diameter bomb, 12 inches long. The surprising result shown here is that growth in substantial amounts occurs on all these crystals, even on the lower one suspended just above the layer of nutrient material in the bottom of the bomb. Thus it is clear that the entire free space within the bomb above the nutrient material may be used to grow crystals. Furthermore, these crystals grew to lengths of 13/16 inch to 1 1/16 inches in ten days, starting from plate thickness in this case of 0.05 inch. The rate of the largest crystal was of the order of 0.1 inch per day, and that of the slowest, near the bottom, was slightly more than 0.07 inch per day.

The growth in this test is clear and unmarred by spurious seeds. This is shown by Fig. 4, a photograph of the top crystal in Fig. 5, immersed in a liquid having the same index of refraction as quartz, and suitably illuminated. The original seed is plainly visible in outline, but the portions added to each major face are substantially invisible, indicating the clear and perfect quality

(*Continued on page* 27)

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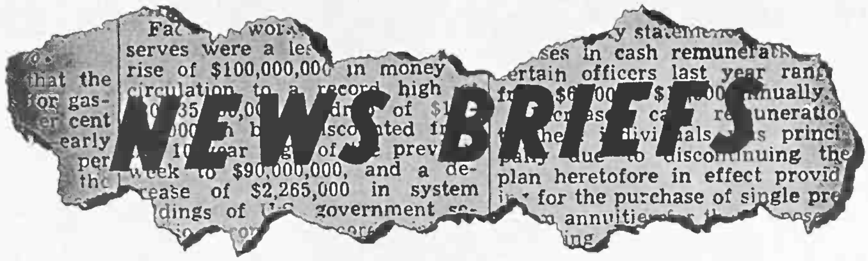
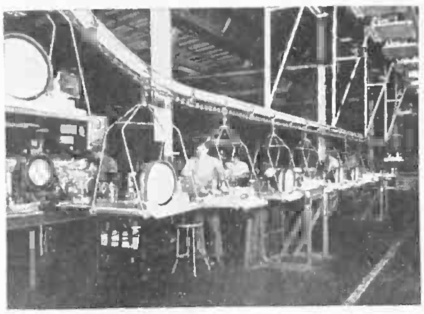


DEDICATE DU MONT TV PLANT

In a recent ceremony with such dignitaries as Governor Alfred E. Driscoll of New Jersey and Dr. Lee De Forest, radio pioneer, Dr. Allen B. Du Mont dedicated Du Mont's new TV assembly plant in East Paterson, New Jersey.

The huge 480,000 square ft. structure is said to be the largest and most modern television assembly plant in the



world. The plant is located on the 58 acre site of the former Wright Aeronautical Plant and it is reported that at full capacity the plant will be able to produce one television receiver approximately every 22 seconds.

The plant has more than 1¾ miles of conveyor systems and once a chassis is placed on the assembly line it does not require any manual lifting during the entire assembly and test operation. Special conveyors (above) are shown bringing receivers to teletest section from the end of the assembly line.

SYNTHETIC SOUND ON FILM

Robert E. Lewis, an associate physicist at Armour Research Foundation of Illinois Institute of Technology, has correlated all the theoretical data on synthetic sound on film and his work has now brought the process to its first commercial application.

Although it is by no means a reality yet, Mr. Lewis reports that the musical composer of the future will sit down to the console of a typewriter-like machine, manipulate the keyboard and compose a symphony of straight, diagonal, wavy, and saw-tooth lines of varying widths and lengths on a strip of paper flowing through the roller assembly of the machine. When the composition is completed, a technician will take the strip of paper with its pattern of lines and shaded areas and transfer it, using ordinary photographic methods, to the sound track of a conventional motion picture film. Then, by the same means now used to reproduce sound in motion picture houses, the composition can be played as if by a full orchestra of all the conventional instruments, some new ones, and with the composer's own interpretation as to tone, timing, and amplitude.

BUILD LARGE LOW BAND TV ANTENNA

The Transmitter Division of *General Electric* has shipped the largest heavy-duty low band TV antenna ever built to station KRLD-TV, Dallas, Texas. Manufactured at Electronics Park, the 6-bay antenna is 99 feet long and weighs 10,000 pounds. It is designed for 50-pound per square foot wind loading corresponding to a 150-mile-an-hour wind velocity.

The station will use *GE's* newly developed 2000 megacycle television relay equipment, portable camera equipment and a television mobile truck for on-the-spot telecasts.

NEW BROADCAST SIGNAL AT CRPL

Effective November 1st, a new broadcast signal of the National Bureau of Standards radio station WWV will warn of unstable conditions in the ionosphere. Heretofore two grades of propagation conditions have been recognized in the notices given through station WWV by the Bureau's Central Radio Propagation Laboratory.

The letter "N" repeated several times has signified normal conditions, while the letter "W" has constituted a warning that disturbed conditions were present or expected within twelve hours. A third category indicating unstable conditions and denoted by the letter "U" will now be used when the forecasters at the CRPL's warning center expect satisfactory reception of short wave communication or broadcast services employing high-power transmitting equipment operating on the recommended frequency, but poor results on less well-equipped services.

The propagation disturbance notices, broadcast in International Morse Code, primarily refer to the North Atlantic radio circuits.

FORM GROUP ON QUALITY CONTROL

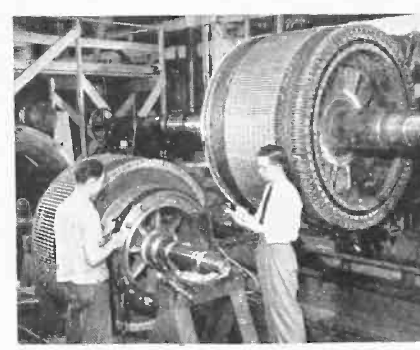
The Professional Group on Quality Control, recently formed by The Institute of Radio Engineers, elected the following officers at the initial Administrative Committee held at the IRE headquarters: Chairman, R. F. Rollman, Quality Control Section, *Allen B. DuMont Laboratories*, Passaic, N. J.; Vice Chairman, B. Hecht, Manager, Quality Control Section, *International Resistance Company*, Philadelphia, Pa.; and Secretary-Treasurer, Dr. Victor Wouk, Chief Engineer, *Beta Electric Corporation*, New York City.

This group has as its major interest quality control of components and entire systems in the fields of radio, communication, television, electronics, and allied subjects.

PROFESSORS BRING PRACTICAL EXPERIENCE TO CLASSROOM

Professors from seventeen different colleges and universities spent their summer vacations working with the men and women who design and build electrical apparatus at the *Westinghouse Electric Corporation* plants in an effort to present practical experience to their students.

Their work was arranged so that each could specialize on the subject he



teaches but, at the same time, get a comprehensive over-all view of the company's operations.

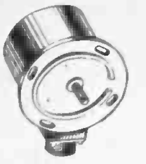
Shown jotting down details on the construction of a rotor for a steel mill motor is Kenneth Fegley of the University of Pennsylvania who received his electrical engineering degree at Penn and has been teaching there for two years.

NEW LITERATURE

New System of Electrical Measurement

A booklet describing the new system of electrical measurement using "absolute" units adopted by the International

(*Continued on page* 31)



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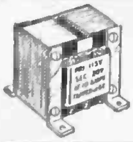

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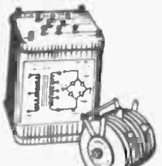

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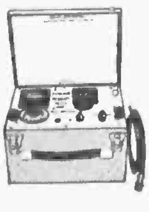

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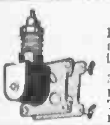

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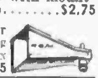

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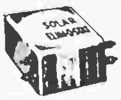

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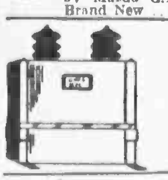

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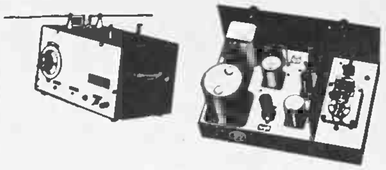

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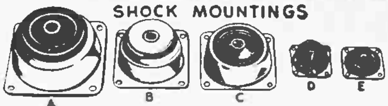

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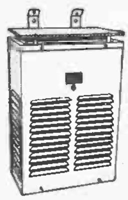

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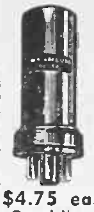

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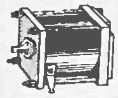

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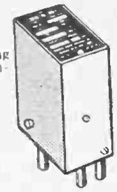
TWO-IN-ONE CRYSTAL UNITS
Bendix type MX-9E



Each unit contains 2 crystals differing in freq. by 455 kc. Following frequencies available:

2457-2912	4287-4742
2481-2936	4310-4765
2530-2985	4360-4815
2539-2994	4435-4890
2560-3015	4702.5-5157.5
2562.5-3017.5	4713-5168
2407-2862	4930-5385
2945-3400	4935-5390
3820-4275	4975-5430
3860-4315	5080-5535
4002.5-4457.5	6485-6940
4175-4630	6515-6970
4242.5-4697.5	

$1.65 Brand New

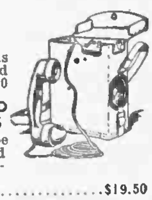
Special price in lots of 100

WESTERN ELECTRIC CRYSTAL UNITS
Type CR-1A/AR

Available in quantity—following frequencies
5910—6350—6370—6470—6510
6610—6670—6690—6940—7270
7350—7380—7390—7480—7580
9720—Kilocycles

Brand New **$1.00**

SOUND POWERED FIELD SETS
Type TP-3

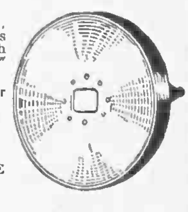


Contained in serviceable canvas cases. Brand new—export packed Per unit as illustrated......$24.50

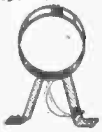
SOUND POWERED BATTLE PHONES

Western Electric Type 0 #D173312. Brand new in original cartons.
Per unit as illustrated.................$19.50

PARABOLOIDS

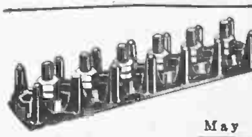


Spun Magnesium, 17½" dia., 4" deep. Mounting brackets for elevation and azimuth control on rear. 1½" x 1⅝" opening in center.
Brand new per pair $8.75



TUBE HEATERS

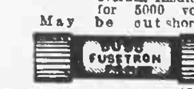
Type WAAGE 100 watts Brand new .50



High Voltage Terminal Strips

6 Terminal with bakelite barriers .10 ea.
5" x 1" x 1" high overall, Insulated for 5000 volts. May be cut shorter.

50 AMP. FUSETRONS
Bus type FRN 50



For 250 volts or less..........................15 ea.

All prices indicated are F O B Tuckahoe, New York. Shipments will be made via Railway Express unless other instructions issued.

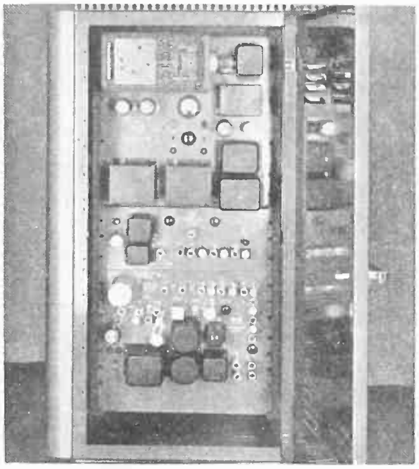
ELECTRONICRAFT
INC.
5 WAVERLY PLACE TUCKAHOE 7, N. Y.
PHONE: TUCKAHOE 3-0044

All merchandise guaranteed. Immediate delivery, subject to prior sale.
All Prices Subject to Change Without Notice

NEW PRODUCTS

MICROWAVE RELAY SYSTEM

A system of high-frequency point-to-point radio communications for pipe lines, gas companies, electric power utilities, trucking companies, forestry services, and fire and police depart-



ments has been announced by the Communications Section of the *RCA* Engineering Products Department, Camden, N. J.

The new *RCA* Type CWTR-5A radio relay equipment provides a modulation channel extending from 300 cycles to 30,000 cycles and is designed for unattended operation in the 940-960 mc. frequency band. It consists of a unidirectional system comprising transmitter, receiver, and two 4 or 6-foot parabolic antennas. Both the transmitter and the receiver may be installed complete in a single 49-inch *RCA* cabinet.

HIGH PRECISION POTENTIOMETERS

A new line of 2" high precision linear and non-linear potentiometers has been announced by the *Technology Instrument Corporation*, 1058 Main St., Waltham, Mass.

The Type RV2 potentiometers are designed for both commercial and military applications, with windings and contacts totally enclosed within a dust-free housing. Taps may be furnished when required, and units may be ganged in any desired combination without the use of cumbersome supporting structures. All insulating materials used are treated with approved fungus-resisting varnish, and mechanical parts are corrosive resisting and treated in accordance with government approved methods.

A booklet giving specifications for these potentiometers may be obtained by writing the company.

CORNER REFLECTOR ANTENNA

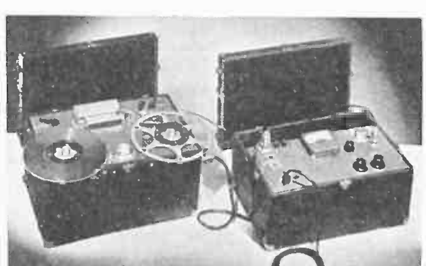
Type 3602, a Corner Reflector antenna for the frequency range 72-76 mc., is now available from *Andrew Corporation*, 363 East 75th St., Chicago 19, Illinois.

Because it is large (the sides form a square about 8 x 8 ft.) it is preferably mounted on a telephone pole or below the 100 foot level of a sturdy self-supporting tower. Type 3603 is a Corner Reflector antenna for the frequency range 88-108 mc., and is used primarily as a TTL receiving antenna in FM relaying.

Further information on the Corner Reflector antenna may be obtained by writing to the company and requesting a copy of Bulletin 84 which carries a complete description.

MAGNETIC TAPE RECORDERS

Designed to meet the exacting requirements of audio engineers, two new professional models of *Ekotape* magnetic tape recorders have been announced by *Webster Electric Company*, Racine, Wisconsin. These units are



portable for remote recording or for recording delayed broadcasts in the studio.

Model 107 (shown) consists of two compact units, one of which contains the recording mechanism, the other containing the amplifier chassis. Model 105 (not shown) consists of a single unit which contains both record and playback amplifiers in addition to the magnetic tape recorder mechanism.

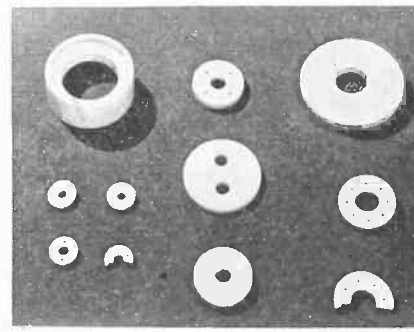
Model 107 provides a tape speed of 15" per second for a full half hour program or a tape speed of 7½" per second for an hour program. Tape speed of 7½" per second with Model 105 provides for a full half hour program.

Both units may be rack mounted.

INSULATING SPACERS AND BEADS

Crane Packing Co., 1800 Cuyler Ave., Chicago, Ill., has announced the fabrication of its new packing material "Chemlon" into highly efficient electrical insulating spacers and anchor beads.

It is reported that the electrical properties of "Chemlon" in its molded form



are low power factor and low dielectric constant. Loss factor, dielectric constant and dielectric strength do not vary with temperature changes below 400° F.

These molded "Chemlon" spacers have been successfully used as low loss insulators on rigid type television transmission lines and other forms are being applied to radar equipment because of its high electrical insulating performance.

Additional information may be had by writing the company.

CARRIER SYSTEM

A new type 33B Carrier System which provides up to seven talking circuits with associated ringdown or dial-signaling channels from a two-way radio link has been developed by *Lenkurt Electric Company*, 1115 County Road, San Carlos, California.

Spectrum utilized is 0 to 35 kc. Channel response is uniform within 5 db. or less from about 250 to 2800 c.p.s., and limiters in all modulator circuits tend to prevent overloading of radio equipment.

According to reports, it is feasible to assemble systems with fewer channels for later stacking of additional circuits without cost penalty per channel as the equipment is designed on a channel-

(*Continued on page* 26)

If it's a problem calling for PRECISION POTENTIOMETERS

Bring it to Helipot

For many years The HELIPOT Corporation has been a leader in the development of advanced types of potentiometers. It pioneered the *helical* potentiometer—the potentiometer now so widely used in computer circuits, radar equipment, aviation devices and other military and industrial applications. It pioneered the DUODIAL*—the turns-indicating dial that greatly simplifies the control of multiple-turn potentiometers and other similar devices. And it has also pioneered in the development of many other unique potentiometric advancements where highest skill coupled with ability to mass-produce to close tolerances have been imperative.

In order to meet rigid government specifications on these developments—and at the same time produce them economically—HELIPOT* has perfected unique manufacturing facilities, including high speed machines capable of winding extreme lengths of resistance elements employing wire even less than .001" diameter. These winding machines are further supplemented by special testing facilities and potentiometer "know-how" unsurpassed in the industry.

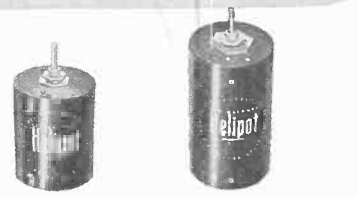
So if you have a problem requiring *precision potentiometers* your best bet is to bring it to The HELIPOT Corporation. A call or letter outlining your problem will receive immediate attention!

**Trade Marks Registered*

In this panel are illustrated standard models of HELIPOT multi-turn and single-turn precision potentiometers—available in a wide range of resistances and accuracies to fulfill the needs of nearly any potentiometer application. The Beckman DUODIAL is furnished in two designs and four turns-ratios, to add to the usefulness of the HELIPOT by permitting easy and rapid reading or adjustment.

A B C

MODELS A, B, & C HELIPOTS
A—10 turns, 46″ coil, 1-13/16″ dia., 5 watts—resistances from 10 to 300,000 ohms.
B—15 turns, 140″ coil, 3-5/16″ dia., 10 watts—resistances from 50 to 500,000 ohms.
C—3 turns, 13-1/2″ coil, 1-13/16″ dia., 3 watts—resistances from 5 to 50,000 ohms.
—Ask for Bulletin 104—



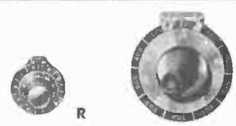
D E

MODELS D AND E HELIPOTS
Provide extreme accuracy of control and adjustment, with 9,000 and 14,400 degrees of shaft rotation.
D—25 turns, 234″ coil, 3-5/16″ dia., 15 watts—resistances from 100 to 750,000 ohms.
E—40 turns, 373″ coil, 3-5/16″ dia., 20 watts—resistances from 200 ohms to one megohm.
—Ask for Bulletin 104—

F G

MODELS F AND G PRECISION SINGLE-TURN POTENTIOMETERS
Feature both continuous and limited mechanical rotation, with maximum effective electrical rotation. Versatility of designs permit a wide variety of special features.
F—3-5/16″ dia., 5 watts, electrical rotation 359°—resistances 10 to 100,000 ohms.
G—1-5/16″ dia., 2 watts, electrical rotation 356°—resistances 5 to 20,000 ohms.
—Ask for Bulletin 105—

LABORATORY MODEL HELIPOT
The ideal resistance unit for use in laboratory and experimental applications. Also helpful in calibrating and checking test equipment. Combines high accuracy and wide range of 10-turn HELIPOT with precision adjustability of DUODIAL. Available in eight stock resistance values from 100 to 100,000 ohms, and other values on special order.
—Ask for Bulletin 106—



R W

MODELS R AND W DUODIALS
Each model available in standard turns-ratios of 10, 15, 25 and 40 to 1. Inner scale indicates angular position of HELIPOT sliding contact, and outer scale the helical turn on which it is located. Can be driven from knob or shaft end.
R—2″ diameter, exclusive of index.
W—4-3/4″ diameter, exclusive of index. Features finger hole in knob to speed rotation.
—Ask for Bulletins 104 and 114—

The versatility of the potentiometer designs illustrated above permit a wide variety of modifications and features, including double shaft extensions, ganged assemblies, the addition of a multiplicity of taps, variation of both electrical and mechanical rotation, special shafts and mounting bushings, high and low temperature operation, and close tolerances on both resistance and linearity. Examples of potentiometers modified for unusual applications are pictured at right.

B F

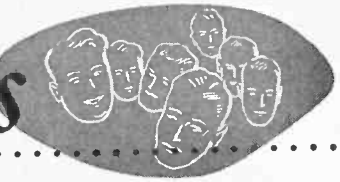
MULTITAPPED MODEL B HELIPOT AND 4-GANGED TAPPED MODEL F
This Model B HELIPOT contains 28 taps, placed as required at specified points on coil. The Four-Gang Model F Potententiometer contains 10 taps on each section. Such taps permit use of padding resistors to create desired non-linear potentiometer functions, with advantage of flexibility, in that curves can be altered as required.

A C

3-GANGED MODEL A HELIPOT AND DOUBLE SHAFT MODEL C HELIPOT
All HELIPOTS, and the Model F Potentiometer, can be furnished with shaft extensions and mounting bushings at each end to facilitate coupling to other equipment.
The Model F, and the A, B, and C HELIPOTS are available in multiple assemblies, ganged at the factory on common shafts, for the control of associated circuits.

THE Helipot CORPORATION, SOUTH PASADENA 4, CALIFORNIA

Personals



DR. JAMES G. BUCK has been named head of the cathode chemistry group at the Product Development Laboratories, *Sylvania Electric Products Inc.*, Kew Gardens, N. Y. Dr. Buck, formerly an assistant professor of physics at the University of Notre Dame, was a member of the staff of the Radiation Laboratory at the Massachusetts Institute of Technology. He is a member of the APS, the ISA, and the American Association of University Professors.

WILLIAM W. FOLLIN has joined *Radio Frequency Laboratories, Inc.*, Boonton, New Jersey as Field Engineer for the Washington D. C. area. Mr. Follin has been employed since 1946 as an electronic engineer in the Design Branch, Test Equipment Section of the Bureau of Ships, Navy Department. Prior to the war he assisted in the planning, installation, and maintenance of electronic equipment aboard naval vessels for the Bureau of Ships.

C. M. HEIDEN has been named Section Engineer of Radio Communication Equipment for the Transmitter Division of *General Electric Company*, Syracuse, New York. Mr. Heiden joined *General Electric* in 1941 and has held various positions since that time. He is a member of the IRE, the Railroad and Vehicular Communications Committee; Member of Executive Committee and Chairman of the Land Mobile Service Committee of the RMA.

DR. E. M. HONAN has joined *The Altec Companies* in the capacity of engineering manager and will have his headquarters in Hollywood where he has been engaged in research and development work in the motion picture industry since 1930. During the war Dr. Honan was in charge of numerous projects undertaken for the office of Scientific Research and Development and the Navy, for which he received formal recognition.

E. W. KENEFAKE, Assistant Section Engineer in charge of the development and design of carrier current equipment for *General Electric Company*, Syracuse, New York has been appointed Section Engineer. Mr. Kenefake attended the University of Notre Dame where he received his B.S. in electrical engineering and his M.S. degree in physics. He is Chairman of an AIEE Committee for communications and Secretary of the AIEE Committee on Carrier Current.

WILLIAM SHANNON has been appointed as an Electronic Engineer in the Guided Missile Laboratory of the National Bureau of Standards. Mr. Shannon was formerly Chief Electronics Engineer at the U. S. Naval Ordnance Plant in Forest Park, Illinois and was a design engineer with the *General Electric X-ray Corporation*. A member of Sigma Xi, Mr. Shannon received his B.S.E.E. and M.S.E.E. from the University of Illinois.

U. h. f. Wattmeter

(*Continued from page* 11)

eye from the bulb was relatively unimportant. However, if the spacing between the bulb and photocell is changed during the test, the results are meaningless. When this distance is fixed at a value sufficiently large to remove the metal of the cell mounting and microammeter from the field of the oscillator, the cell output is low because of the square law reduction in intensity of illumination with distance. This problem of loss in illumination was met by the use of a highly-polished, polystyrene rod as a light guide to conduct light from the load lamp to the photocell with negligible defocusing. In the particular model shown, the sensitivity was increased by a factor of ten through the use of the polystyrene light guide. This polystyrene light guide also gives a great improvement in the rejection of side lighting. By mounting both the load lamp and the photocell on the polystyrene rod a path of fixed length and density is provided, thus making possible the calibration of the unit as a direct reading u.h.f. wattmeter.

The use of a photocell as a light-comparing instrument eliminates the need for the second bulb used in the visual comparison method. Radio-frequency power is coupled into the load lamp with a tuned loop and the photocell current is recorded. The oscillator is turned off and d.c. power is fed to the load lamp and adjusted until the photocell current is the same as in the r.f. case. The d.c. power then equals the r.f. power and the d.c. power is easily read by the voltammeter method.

The acceptance of light matching as a satisfactory method of power measurement and of the photocell as a satisfactory matching device depends on several basic assumptions which might well be cited here.

In all methods of matching light intensities or colors as a power measurement, it must be assumed that no change in lamp efficiency or in spectral content of the light output occurs as the frequency of excitation is raised. Light output and color of light are assumed functions of filament temperature which is assumed a function of power input regardless of frequency. These assumptions neglect the possibility of ionization of the argon gas with which many pilot lamps are filled. Should any ionization be caused by the r.f. power, a change in spectral content of the light output would be expected due both to the addition of the characteristic blue of argon and to the shift toward the red of the filament color. This shift in filament color would occur as the result of the filament input power being reduced by the amount of power necessary to sustain the ionization. The human eye is quite sensitive to color changes on a comparative basis but is not capable of evaluating color changes quantitatively. A color test was therefore run using the photocell and color filters to discover if any change in light composition does occur at the high excitation frequencies encountered when making r.f. power measurements with this instrument.

White light from a pilot lamp excited by d.c. was adjusted to give a convenient value of photocell current. Various filters of different colors, but approximately the same density, were placed between the light source and the photocell. The photocell currents were then recorded as percentages of white-light current. The d.c. power was removed and r.f. power coupled into the lamp until the white-light reading agreed with the d.c. white-light reading. The filters were again placed in front of the light source and the percentages of white-light current observed. Any shift in the light content toward the red or blue would then show up as an increased reading when filters of that color were used. At power inputs within the normal rating of the lamp, no color shift was measurable. Color shift occurs on r.f. only when the load lamp is greatly overloaded and visible ionization glow is present. It is thus concluded that, within the ratings of the pilot lamp used, no spectral shift occurs over a frequency range of 0 to 10×10^8 cycles, and therefore color matching methods with lamp loads are acceptable as measurements of u.h.f. power. Inasmuch as the fundamental definition of a.c. power is based on the comparison of its heating effect with that of d.c. power; and light output, in both color and intensity, is a function only of the tungsten filament temperature, it is also safe to use matching of light intensities in lamp loads as a method of u.h.f. power measurements.

Having thus justified the method a convenient probe-like unit was constructed permitting no relative motion between the load lamp and the photocell. This unit was calibrated at d.c. levels and has shown no calibration change in several months of use. Calibration shift is possible, however, if the lamp load is operated at brilliancies high enough to cause appreciable evaporation of tungsten from the filament. Darkening of the bulb due to evaporated tungsten is a sure sign of the need of recalibration. The method of calibration is simplicity itself and thus cannot be considered as limiting the usefulness of the device.

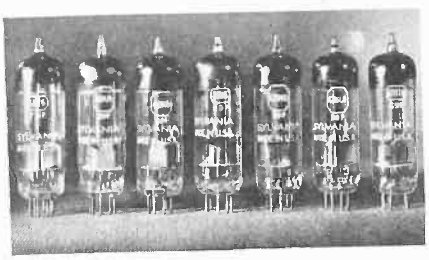
NEW TUBES

SYLVANIA TUBES

Miniature Double Diode-Triodes

The Radio Division of *Sylvania Electric Products Inc.*, 500 Fifth Ave., New York 18, N. Y., has announced seven new miniature double diode-triode radio tubes. Included in the new miniature tube group are types 6BT6 and 12BT6 with operating voltages identical with older types 6AT6 and 12AT6.

Types 6BK6 and 12BK6 replace types 6AV6 and 12AV6; and types 6BU6 and 12BU6 replace types 6BF6 and 12BF6. Also included is a new miniature, type 26BK6, having no complementary type

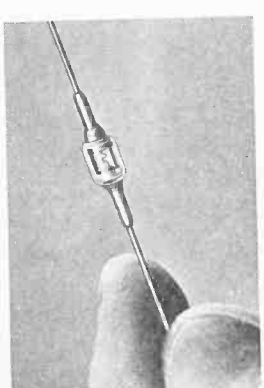


but operated at the same voltages as others in the group with the exception of its 26.5 volt, 70 milliampere heater.

Germanium Crystal Diodes

The Electronics Division of *Sylvania* has announced germanium crystal diodes which are moisture-proof and enclosed in hermetically sealed glass cartridges. The new crystals are available in two types: 1N34A, a general purpose diode, and 1N58A, a 100-volt diode.

Electrical characteristics, ratings, and prices of the new "glass" type crystals are the same as those for corresponding ceramic types marketed by *Sylvania* since the war. New terminal design



permits units to be mounted side-by-side without danger of shorting.

The many uses for these crystal diodes include: video detectors, discriminators and d.c. restorers in television receivers, FM frequency discriminators, first detectors, voltage regulators, and polarizing devices.

Miniature Pentagrid Converter

Designed especially for use in compact, light-weight portable radio receivers,

the miniature penatgrid converter tube type 1L6 is supplied with a 1.4 volt d.c. filament cathode rated at 50 milliamperes. Operated from a 90 volt B supply, it has a plate current of only 0.50 milliamperes.

High Vacuum Rectifier Tube

Also announced by *Sylvania* is a lock-in type 7X6 high vacuum rectifier tube

which is supplied with a 6.3 volt heater rated at 1.2 amperes. Maximum rated output of 150 milliamperes and separate cathode leads make the 7X6 suitable for a wide range of radio, electronic and television power supply circuits.

7-PIN MINIATURE TUBES

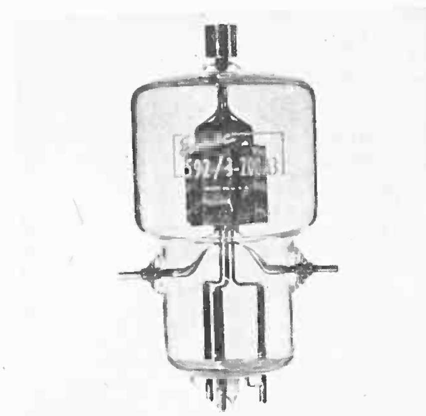
The 6AB4 high-mu triode and the 6AH6 sharp-cutoff r.f. pentode, have been announced by the Tube Department of the *Radio Corporation of America*, Harrison, N. J.

The 6AB4 features high transconductance and is intended for use in FM and television receivers as a grounded-grid r.f. amplifier, frequency mixer, or oscillator at frequencies up to about 300 megacycles.

The 6AH6 has very high transconductance and low output capacitance, making it useful in the i.f. stages of the picture amplifier and in the first stages of the video amplifier of television receivers.

V.H.F. TRIODE

Eitel-McCullough, San Bruno, California has announced a new vacuum tube directly interchangeable with the well-known type 592. This new tube is patterned after the *Eimac* VT327A radar pulse tube and is a general purpose

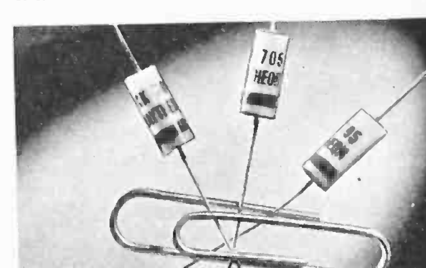


v.h.f. triode suitable for both oscillator and power amplifier service.

As an oscillator, the 592 is said to lend itself well to developing medium power at the v.h.f. frequencies for industrial purposes. The construction also lends itself to power amplifier service at frequencies as high as 125 mc. The plate employs the *Eimac* pyrovac plate material which gives long life and the ability to take large momentary overloads, and non-emitting processed grid material is used.

GERMANIUM DIODES

The Special Tube Section of *Raytheon Manufacturing Co.*, 55 Chapel St., Newton, Mass., is introducing new germanium diodes which have high fre-



quency characteristics and are unusually small in size (.390" long and .160" diameter).

Types CK705, 706, 707, and 708 have a high ambient operating temperature rating of 100°C. and resistance to change in humid atmosphere. The higher temperature rating has been obtained by using only glass and metal in the basic assembly, thus eliminating the necessity of a wax filler. According to the manufacturer, in addition to total immersion this design has withstood more than 72 hours exposure to 95% humidity at temperatures from 25°C to 70°C.

Further information on these new diodes will be furnished upon request from the Special Tube Section.

A. C. C. for TV

(Continued from page 9)

trates how this control system is added to a typical receiver, the added circuit being shown in heavy lines. The two diodes may be a 6H6, 6AL5 or similar tube. Crystal rectifiers are not recommended because of the high inverse voltages and their inverse impedance, which is so low that with high contrast setting and low signal level, the a.c.c. output will drive the control grids positive. If it is desired to operate any control grids below their contact potential bias, usually between -6 and -1 volts, this can be accomplished by shunting the a.c.c. rectifier with a resistor of 10 to 20 megohms, depending upon particular conditions.

The voltage E appearing across the contrast control potentiometer will be determined by the maximum white level that the video output will deliver before loss of gradation in the white region or focus becomes evident. Generally E should not exceed 40 volts with circuits 5 and 6 or 100 volts with circuit 7. The contrast control potentiometer R may be any convenient value between five and one hundred thousand ohms. R_5 depends upon minimum contrast level desired and value of R. It is not necessary to proper operation of the circuit and may be omitted altogether, as shown in Fig. 3.

In receivers with a second detector and a.g.c. circuit as shown in Fig. 4, this system may be incorporated without the addition of a twin diode. Simply replace the second detector diode with a 1N34 crystal and use the diode as the a.c.c. rectifier.

The advantage of the automatic contrast and white level control is particularly apparent in projection and large tube receivers. Once the desired contrast and brightness has been determined for the ambient light conditions, changes in program, signal strength, background, line voltage and switching from station to station do not require any further adjustment of the receiver contrast control.

New Products

(*Continued from page* 20)

unit basis. A seven-channel system can be mounted on a single 8-foot, self-supporting equipment rack.

SPEED DRIVE

Westinghouse Electric Corporation, Pittsburgh, Pa. now has available a new fractional horsepower Mot-O-Trol

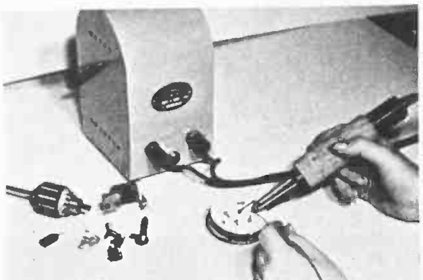
electronic adjustable-speed drive. This control starts, stops, and controls the speeds of ⅛- to ½-horsepower d.c. motors, operated from single-phase, 50/60-cycle, 220/440-volt power sources, and has a speed range of 20 to 1 at constant torque.

A small, compact control station to control starting, stopping, direction of rotation (on reversing design) and speed of the motor is supplied for separate mounting at a location convenient to the operator. Other components, used to rectify the a.c. power for the d.c. motor, are enclosed in a well-mounted NEMA Type 1 enclosure.

Further information may be obtained by addressing an inquiry to the company at Box 868, Pittsburgh 30, Pa.

SOLDERING TOOL

A new soldering tool operating on the resistance heating principle which will accommodate soldering electrodes



3/32", 1/8", and 5/32" dia. in either the single or double contact type construction is the newest addition to *Luma Electric Equipment Company's* line of soldering equipment.

The soldering heat is reported to be instantaneous and the design and construction of this tool permits it to be connected to any convenient a.c. outlet of proper voltage and frequency. The Mighty Midget Soldering Tool designated as Cat. No. 551 delivers 270 watts on a continuous basis providing ample capacity for two operators per unit with no power loss and is furnished for operation on 115 or 230 volt 60 cycle a.c. current.

Additional information may be obtained by writing the company at Toledo 1, Ohio.

SIGNAL GENERATOR

An announcement of the production of a new standard signal generator covering the extremely wide frequency range of 20 cycles to 50 megacycles by *Measurements Corporation*, Booton, N. J. has been received.

Model 82 was designed to provide in one signal generator a continuously variable signal source for most measurements at audio, supersonic and radio frequencies. Two oscillators are em-

ployed to cover the frequency range. The low frequency oscillator, continuously variable from 20 cycles to 200 kilocycles, has a metered output from 0 to 50 volts across a resistance of 7500 ohms. A radio frequency oscillator covering the range from 80 kilocycles to 50 megacycles provides output from 0.1 microvolt to 1 volt and may be modulated with the low frequency oscillator.

This instrument has individually calibrated, direct reading dials for each range, and an improved inductance type attenuator insures a higher degree of accuracy.

PORTABLE ELECTRIC TACHOMETER

A portable M1200-F electric tachometer and cutmeter which assures accuracy of better than ± ½ of 1% of full scale value in measuring either surface speeds in f.p.m. or shaft speeds in r.p.m. has been introduced by the *Electric Tachometer Corporation*, 2218 Vine St., Philadelphia, Pa.

The tachometer is completely self-contained and requires no batteries or other external power source. It has a precision-built d.c. magneto generator that produces a voltage directly proportional to the speed being measured, calibrated in conjunction with an easily-read laboratory type indicator having 4 overlapping speed ranges, and is designed for either continuous or intermittent use.

Bulletin 492 describing this new tachometer development in detail will be sent upon request.

25-50 MC MOBILE RADIO

General Electric Company, Syracuse, N. Y. has developed new 25-50 mc. mobile radio communication equipment designed specifically for use by public utilities, law enforcement agencies, highway maintenance department and others in the land-mobile radio service.

This equipment is available for 20 kc. or 40 kc. channel widths. The complete line includes 50-watt and 250-watt station combinations, 30-watt and 50-watt mobile units, remote control consoles, antenna equipment and accessory items.

Further information on this mobile equipment may be obtained from the Radio Communications Section, Transmitter Division, Electronics Park, Syracuse, N. Y.

PREAMPLIFIER AND RECORD COMPENSATOR

Two new pieces of audio equipment have been developed by *Pickering & Company*, Oceanside, L. I., N. Y.; the 130 H Preamplifier and the 132E Record Compensator.

The preamplifier is self-powered, operates with any high quality, high input impedance amplifier and installs by plugging in.

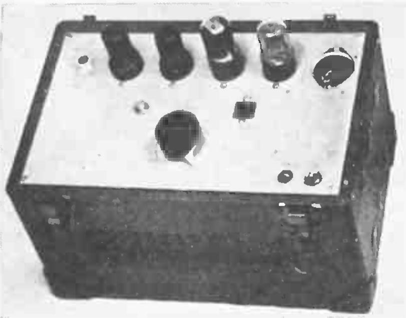
The record compensator (shown) provides the flexibility required to

equalize for different recording characteristics used by various record manufacturers. Because it uses linear elements it has no inherent distortion. It can be connected to any amplifier having an equalizing preamplifier such as the model described.

Further specifications and data on these two units may be obtained by writing the company.

CALIBRATED PREAMPLIFIER

The Model PR calibrated preamplifier, which is an all-purpose self-contained laboratory instrument and



equally suitable for portable applications, has been introduced by the *Sound Apparatus Company*, Stirling, New Jersey.

The unit has a flat response from 40 to 40,000 c.p.s., a dynamic range in excess of 60 db., a calibrated gain control in 5 db. steps from 0 to 50 db.,

(*Continued on page* 31)

Growing Quartz

(*Continued from page* 16)

of growth. The outlines of the full crystal are faintly visible because of slight etching of the surfaces which sometimes occurs during removal from the alkaline liquid in the bomb.

It now appears that the rate of growth of quartz in such bombs, utilizing quartz as nutrient material, is a function of the temperature gradient along the bomb and the size of nutrient material used. Although the true gradient cannot be measured inside the bomb, the apparent gradient as judged by thermocouple measurements made on the outer wall is sufficient criterion for control purposes. It is still too early in the development to quantitatively relate temperature gradient, size of nutrient material, and bomb dimensions to growth rate, but these factors can be correlated, and sufficient progress has been made so that it is clear that large perfect quartz crystals weighing up to one pound or more may be grown at commercially practicable rates under reproducible conditions.

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2. *Ingerson and Morey, Econ. Geol.*, 1940, 35, 772-85.
3. *Hannay and Hogarth, Proc. Roy. Soc., London*, 1879, 29, 34.
4. *Kennedy, G. C., Econ. Geol.*, 1944, 39, 25.

TECHNICAL BOOKS

"CONSTRUCTIVE USES OF ATOMIC ENERGY," Edited by S. C. Rothmann. Published by *Harper & Brothers*, College Department, 49 E. 33rd St., New York 16, N. Y. 258 pages. $3.00.

This timely volume is a compilation of articles by fourteen scientists in an attempt to bring into focus present knowledge about nuclear energy, especially its potentialities for purposes other than war. Dr. Arthur H. Compton, the Nobel-Prize-winning physicist, is represented with his article on "Atomic Energy as a Human Asset."

This is the first book which describes for the layman the uses to which atomic energy is already being put in such fields as industrial power, chemistry, metallurgy, aviation, ceramics, soil-fertilizer research, and biological, pharmaceutical, and medical research.

Written in a unified and easily understandable form and illustrated with illuminating photographs and drawings, this is a clear and comprehensive picture of the most exciting subject of today. Three appendixes have been prepared for the nonscientific reader and a glossary defines the many new words and expressions that nuclear energy has introduced into our language.

Engineers and trained technicians, already familiar with the principles of nuclear physics, will find essential information not heretofore available.

"TERRESTRIAL MAGNETISM AND ELECTRICITY," edited by J. A. Fleming. Published by *Dover Publications, Inc.*, 1780 Broadway, New York 19, N. Y. 794 pages. $4.95.

Published under the auspices of the National Research Council, this reference book is a collection of the findings of modern geophysicists in the field of terrestrial magnetism.

The earth's magnetic and electric fields, which have long puzzled and intrigued investigators, are covered, not as a textbook, but as a reference book.

This comprehensive volume, with hundreds of photographs and diagrams, presents a clear picture of magnetism itself. Various instruments for observing and utilizing magnetism are described.

According to the publishers, practical scientists and technicians in radio, mining, astronomy, physics, engineering, geophysics, meteorology and navigation will find this book the most up-to-date and comprehensive work ever published on this important subject.

TV Transmitter

(*Continued from page 6*)

might otherwise be introduced by the modulation amplifiers.

An input gain control provides adjustment of the transmitter input signal over the range of input permitted by RMA specifications. From the gain control the signal is channeled into the sync stretcher and clamp pulse generator. The function of the sync stretcher is to emphasize the synchronizing portion of the composite signal to provide the required ratio of sync voltage in the r.f. output. This is accomplished in this unit by first passing the video signal through a video amplifier and then through a non-linear amplifier which amplifies the sync portion of the signal to a much greater degree than the remainder of the signal.

A clamp circuit is used prior to the sync stretcher stage to automatically adjust all sync pulses to the same reference level. This insures that the stretching operation will always be performed on the synchronizing pulses only, and not on any portion of the image signal. The output of the sync stretcher is then combined with the output of a two-stage video amplifier so that distortion of the signal introduced by the non-linear amplifier is greatly minimized in the combined output.

This output is then fed to the input stage of the main video amplifier which consists of a type 6AG7 tube designed for a normal input signal on its grid of approximately 0.55 volts peak-to-peak and a stage of gain of 9, giving an output for this stage of approximately 5 volts peak-to-peak.

This stage is a.c. coupled to the following stage. This is permissible because of the relatively large swing available in the grid characteristic of the type 6BG6 tube used in the second stage, and the fact that the d.c. component will be restored by clamping the signal at the grid of the modulator stage. The second stage has a gain of about 4, providing an output signal of 19 volts peak-to-peak.

The final stage of the modulator of the main video amplifier consists of four type 6BG6 tubes in parallel having a gain of 11. This provides a signal at the modulation peak of 210 volts peak-to-peak which is sufficient to fully modulate the radio frequency stage using type 4X500 tubes.

A clamp circuit at the grids of the modulator stage restores the d.c. component of the incoming signal, and eliminates any hum or fluctuation introduced in the signals up to that point, including any hum which may have been superimposed on the signal while in transmission between studio and transmitter. (Any hum that is not simply added to the signal but is cross modulated with it cannot, of course, be removed in this way.)

The positive and negative pulses required for the clamp circuits in the sync stretcher and modulator are generated by the clamp pulse generator. The input signal from the gain control is fed to the input stage of this generator which is a video amplifier using a type 6AG5 tube. This amplified pulse is d.c. restored and then fed to a type 6SJ7 tube operated as a sync clipper and differentiator. Clipping is effected in the grid circuit, while the plate circuits consist of an *L-C-R* differentiator which generates a positive pulse from the sync pulse. The differentiated output is then clipped—in a type 6SN7 tube—and used to trigger a blocking oscillator whose output is synchronized to the trailing edge of the sync pulse. The blocking oscillator is free running and, when not synchronized, has a natural frequency of 15 kilocycles. Hence in the absence of a video signal it still operates to supply clamping pulses which maintain a suitable bias on the modulator stage. A clamping circuit is used at the output of the blocking oscillator to improve the shape of the pulse. Positive and negative pulses are obtained for this circuit by means of a center-tapped transformer.

The valuable features of convenient control and fully automatic protection for failure of cooling or excessive currents or voltages in any part of the equipment have been incorporated in the transmitter. Here again standard broadcast techniques are employed to assure maximum personnel and equipment safety.

Aural Transmitter

A block diagram of the low band aural transmitter is shown in Fig. 8. The signal originates in the *Federal* "frequematic" modulator which provides for frequency modulation and center frequency stabilization. The *Federal* center frequency stabilization system is based upon the automatic synchronization of two oscillators—a crystal oscillator and a master frequency modulated oscillator—to obtain mean center frequency control. The frequencies of the crystal oscillator and the master oscillator are each divided to a common frequency and are then compared in a balanced phase detector. The integrated rectifier output of the detector is used to actuate the modulator so as to synchronize the master oscillator mean frequency with that of the crystal oscillator.

The oscillator using a type 6C4 tube is operated at approximately 4 megacycles. This signal, which is frequency modulated by the modulator using a 6AK5 type tube, is fed through a series of frequency multiplication stages to reach its final carrier frequency. One stage of frequency doubling using a type 1613 tube and two stages of frequency triplers—one stage using a type 1614 tube and the other a type 815—are used. The output of the 815 frequency tripler is used to drive a buffer stage using a type 815 tube. The output of this stage is approximately 30 watts at the final operating frequency. This stage drives a pair of 4-250A tubes in a push-pull amplifier circuit with a power output of 350 watts.

The final power amplifier consists of a pair of 7C26 tubes operating in a push-pull grounded-grid amplifier stage. The output power of this stage of approximately 3 kilowatts is delivered in a 1⅝" RMA standard coaxial line to the antenna system. In order to properly feed the antenna with both the visual and aural signals, a diplexer unit is supplied with this transmitter so that one antenna can be used for both aural and visual outputs.

The high band aural transmitter is essentially the same as the low band unit with necessary modifications to attain the 3 kilowatt output at the higher frequency. This is done through the use of an additional frequency doubler using a pair of 2C43 tubes, a pair of 4X500 tubes in the driver stage, and a pair of 5513 tubes in the final power amplifier.

All power supplies necessary for the operation of the transmitters are included in the same cabinet groups as the equipment with which they are associated. This is desirable so that each transmitter can be tested and installed independently of the other.

Transmitter Control and Monitoring Console

The transmitter may be remotely operated and its essential circuits monitored through the use of the transmitter control and monitor console. All supervisory lamps, meter start switches, overload reset buttons, and power output indicators are duplicated on this console. Monitoring facilities include a picture monitor for visual observation of the outgoing program at various stages in the transmitter and an oscilloscope for checking the visual waveform and per-cent modulation.

Fig. 7 is a functional block diagram of the console signal controls and monitoring circuits. As shown in this diagram the unit consists of two main sections—the aural and the visual. The aural section, which contains provision for checking and varying the signal level, employs conventional techniques.

The visual section consists of a gain control, picture monitor, and waveform oscilloscope. The picture monitor, which can be used to measure resolution, gradation, geometric distortion, and degree of interlacing, is a high fidelity 10 inch picture reproducer with excellent video response and amplifier and sweep circuit linearity. Accepting either composite signals or signals without sync pulses (in the latter case separate RMA driving pulses are switched into the circuit to provide synchronization), this unit can be used to check stage by stage performance of the transmitter through the use of the pushbutton selector switch.

The waveform monitor is a 5 inch oscilloscope that can be operated at sweep frequencies of 30 cycles (to show two fields), or at 7875 cycles (to show two lines). By using two fields and two lines—thereby centering the image on the screen—a complete blanking or sync pulse is presented on the scope. A modulation depth test set may be switched into this circuit to establish the zero carrier level point. This unit may also be used for stage by stage analysis through the use of the selector switch.

An auxiliary frequency monitor unit, which continuously monitors the visual and aural r.f. frequency with an accuracy of plus or minus .001 per-cent, has also been developed for use with this transmitter as required by FCC specifications. In addition to checking the r.f. carrier frequencies, this monitor, which is rack mounted, contains the following aural facilities: Meter indication of peak modulation percentage; overmodulation indication with flasher indicator; aural monitoring signal output to be fed to amplifier and speaker; and noise and distortion measurements when used in conjunction with standard noise and distortion instruments externally connected. Permanently connected to the transmitter, the monitor is a compact self-contained instrument with complete facilities for internal calibration.

Conclusion

The television transmitter described in this article is a modern, air-cooled unit employing "mid-level" modulation—a sound engineering compromise that combines the simplicity of high level modulation with the economy of low level modulation. Using a simple, dependable design, this television transmitter—in addition to meeting or exceeding all FCC and RMA recommendations—emphasizes the following additional economic and convenience features: Low tube replacement cost, a high degree of reliability based on the use of time tested components, and ready accessibility for ease of maintenance and servicing.

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News Briefs

(*Continued from page* 18)

Conference of Weights and Measures and officially instituted January 1, 1948, is now available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

Also described are the methods used in the measurements that now form the basis for the new absolute units. In addition, United States laws, important conferences and resolutions pertaining to the adoption of the new units are reproduced in this booklet.

Circular C475, Establishment and Maintenance of the Electrical Units, by F. B. Silsbee, may be obtained at a price of 25 cents a copy.

New Products

(*Continued from page* 27)

and gives a calibrated amplification into a low output impedance.

Descriptive literature will be sent upon request.

TV TRANSMITTER ANTENNA

A triangular loop television transmitting antenna which, according to reports, is simple and highly effective electrically has been developed by *Federal Telecommunication Laboratories, Inc.*, 500 Washington Ave., Nutley 10, N. J.

Both the picture and the sound transmitters are coupled to all loops of the antenna stack so the full effectiveness of the antenna is realized on both channels. Its many features include expanded coverage or service area and improved field strength at the receiver, a minimum of tuning at installation, and affords a maximum of lighting protection.

PHOTO CREDITS

3, 5, 6 . . . . . . Federal Telecommunication Laboratories, Inc.
10, 11 . . . . Sylvania Electric Products Inc.
14, 15, 16 . . . . Bell Telephone Laboratories.

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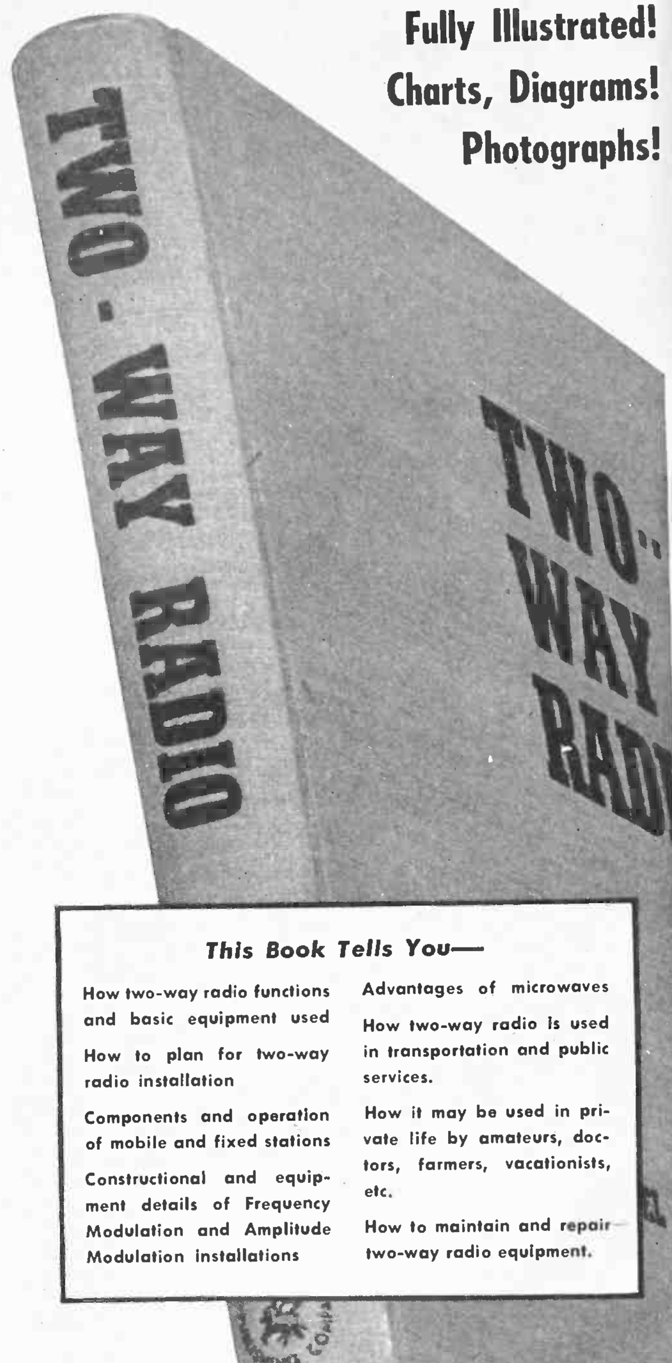

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