Radio Digest

SELECTED RADIO TECHNICAL ARTICLES

(Another RADIO Publication)

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Low Distortion

Audio-Frequency Oscillator

BY HERBERT J. REICH

(Department of Engineering, University of Illinois)

THE GOOD frequency stability and low harmonic content of the dynatron oscillator are offset by the dependence of the action of the dynatron upon secondary emission.[1] Large variations in secondary emission during the life of the tube, and differences in the secondary emission characteristics in individual tubes of the same type, seriously affect the operation and calibration of dynatron oscillators.

Several investigators have suggested the desirability of the development of special tubes which exhibit more stable secondary emission characteristics, but so far special dynatron tubes have not been made available. The improved form of the van der Pol oscillator recently described by Herold[2] represents one effort to develop an oscillator having the advantages of the dynatron without its disadvantages.

No study appears to have been made of the suitability of the "Kallirotron" negative resistance circuit of Turner[3] as the basis of a negative resistance oscillator. It is the purpose of this paper to show that the characteristics of this circuit are ideal for its use in an oscillator and to describe a low distortion oscillator based upon it.

• Kallirotron Circuit

The Kallirotron circuit is shown in basic form in figure 1. By the application of the equivalent plate circuit theorem to this circuit it may be shown that the resistance between points *A* and *B* has the value[4]

[1] M. G. Scroggie, *Wireless Eng. and Exp. Wireless*, vol. 10, p. [illegible] (1933). Includes a bibliography of thirty-five items on dynatron oscillators.

[2] E. W. Herold, Proc. I.R.E., vol. 23, [illegible] October (1935). Includes a bibliography of fifty-five items on negative resistance.

[3] L. B. Turner, *Radio Rev.*, [illegible] (1920).

[4] J. A. Stewart, [illegible] Kallirotron [illegible] June (1935).

In the first portion of this paper, which deals with the theory of negative resistance oscillators, it is shown that for small harmonic content the form of the negative resistance characteristic in the vicinity of the operating point should be such that the average negative resistance increases with amplitude of oscillation. It is then shown that Turner's Kallirotron circuit has negative resistance characteristics of the desired form.

$$\rho = \frac{2r_p}{\dfrac{r_p + R_b}{R_b} - \mu}.$$

ρ is negative if μ is greater than $(r_p+R_b)/R_b$. The current-voltage characteristics for the circuit of figure 1 were obtained by measuring the direct current, I flowing into B as the result of the application of a voltage, E, between A and B. Figures 2 and 3 obtained with a type 53 twin triode, show the manner in which the characteristics are affected by grid and plate supply voltages, E_c and E_b. Figure 4 shows how the negative resistance, found from the reciprocal of the slope at the origin, varies with grid and plate supply voltages, and with plate load resistance. These curves were found to be in excellent agreement with similar curves determined[5] from the equation above.

Since the resistance between A and B of the circuit of figure 1 may be made negative, a negative resistance oscillator can be made by connecting a parallel resonant circuit between points A and B. In figure 5 is shown a practical form of oscillator which uses a common plate supply voltage for both tubes. C_c and R_c should be sufficiently large so that the reactance of C_c is small compared to R_c at the lowest oscillation frequency. Because of the low reactance of C_c, the tuned circuit may be connected between the grids, as shown by the dotted lines in figure 5, instead of between the plates. Figure 6 shows another form of circuit in which the coupling condensers, C_c are replaced by resistors, R_c'.

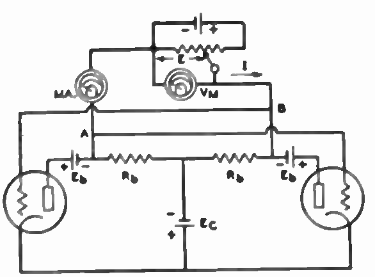


FIGURE 1. BASIC NEGATIVE RESISTANCE CIRCUIT

[5] The change in r_p resulting from the change of operating voltage with R_b must be taken into account in comparing theoretical and experimental curves of ρ against R_b.

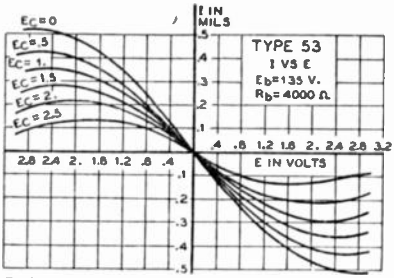


FIGURE 2. NEGATIVE RESISTANCE CHARACTERISTICS FOR THE CIRCUIT OF FIGURE 1, USING TYPE 53 TWIN TRIODES

• Amplitude Control

In order to keep the amplitude of oscillation, and hence the harmonic content, small, it is necessary to adjust the circuit parameters or supply voltages so that L/rC is only slightly larger than ρ at the operating point. As the frequency is varied by changing L or C, it is therefore also necessary to change ρ or r. r may be varied by means of a variable resistance in series with the inductance, but it has been found that an increase of r raises the harmonic content. ρ can be varied by means of the supply voltages or R_b, as indicated by the curves of figure 4. If the oscillator is to be calibrated at selected frequencies, then the potentiometer settings can be included in the calibration chart. A more satisfactory method is to use automatic amplitude control. A certain amount of automatic control is obtained as the result of flow of grid current in the circuit of figure 5 when E_c is small. When the amplitude builds up to the point at which grid current starts flowing, the grid sides of the condensers C_c accumulate a negative charge faster than it leaks off through the resistors R_c. Consequently the grids become more negative, and ρ is increased, finally becoming high enough to establish equilibrium. Much better control is obtained by rectifying the oscillator voltage by means of a diode and using the rectified voltage as grid bias for the oscillator.[6] The sensitivity is increased by the use of a 3:1 audio transformer to step up the voltage before rectification. A circuit which incorporates this type of amplitude control is shown in figure 7. Although this method does not hold the output level strictly constant, the variation is sufficiently small so that the harmonic content may be kept at a low value over the whole audio-frequency range.

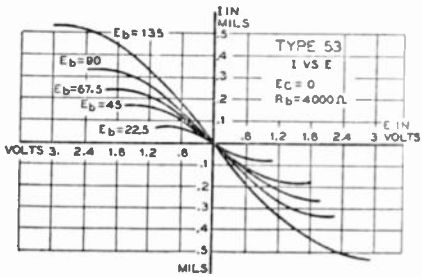


FIGURE 3. NEGATIVE RESISTANCE CHARACTERISTICS FOR THE CIRCUIT OF FIGURE 1, USING TYPE 53 TWIN TRIODES.

Diode amplitude control does not prevent change of amplitude

[6] L. B. Arguimbau, PROC. I.R.E., vol. 21, pp. 14-28; January, (1933); J. Groszkowski, PROC. I.R.E., vol. 22, pp. 145-151; February, (1934).

with plate supply voltage. For given values of r, L and C, the criterion for oscillation is satisfied for a particular value of ρ. Figure 4 shows that ρ decreases with increase of E_b. The amplitude will therefore rise until the rectified bias voltage increases sufficiently to bring ρ to the critical value. The variation of amplitude with plate supply voltage may be reduced by increasing the transformation ratio of the transformer which feeds the diode circuit. Similar reasoning shows that the amplitude of oscillation may be adjusted by means of a cathode resistor in the oscillator circuit. If the bias produced by the cathode resistor is changed by an amount $\triangle E_c$, the crest oscillator voltage will change by $\triangle E_c/n$, where n is the transformation ratio of the transformer.

- Effect of Coil Design on Harmonic Content

Tests were made with a General Radio wave analyzer to determine the effect of coil design upon harmonic content. It was found that the harmonic content increases with the resistance of the inductance coil

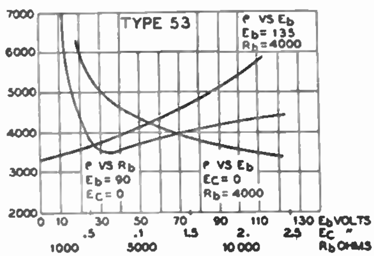


FIGURE 4. VARIATION OF NEGATIVE RESISTANCE WITH SUPPLY VOLTAGES AND LOAD RESISTANCE; TYPE 53 TWIN TRIODES

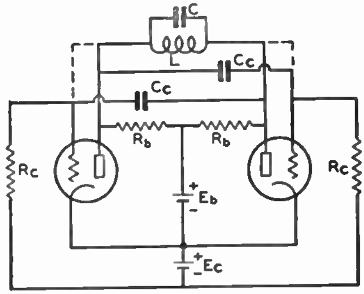
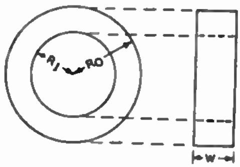


FIGURE 5. BALANCED NEGATIVE RESISTANCE OSCILLATOR WITH COMMON B VOLTAGE.

THE final part of the paper describes an audio-frequency oscillator based on Turner's circuit. The second and third harmonic content of the output may be kept below 0.2 per cent by the use of low resistance coils and diode automatic amplitude control. Higher harmonics are negligible. At a thousand cycles per second the frequency drift relative to a tuning fork oscillator does not exceed 0.04 cycle. The frequency change caused by a 22½-volt change in plate supply voltage is 0.04 cycle.

TABLE 1
Coil Design Data

Coil No.	L Henrys	R Ohms	DCC Wire No.	Wt. Lbs.	Turns	Layers	Taps	Dimensions Inches r_i	r_o	w	% H_2	% H_3	Min. freq. c.p.s.
1	11.5	2100	32	3	10,700	110	11	1.6	3.2	1.9	0.5	0.5	40
2	2.8	280	26	5	5,000	66	11	1.6	3.2	1.9	0.25	0.25	100
3	0.48	23	18	15	2,200	44	11	2.0	2.0	2.4	0.18	0.18	120



and with the resistance introduced in series with the coil or between the tuned circuit and the plates. Examination of the dynamic negative resistance characteristic by means of a cathode-ray oscillograph indicated that the increase of harmonic content results from a tendency of the circuit to unbalance because of slight differences in the two triodes. The unbalance can be partially corrected by individual adjustments in the resistors R_b. The harmonic content increases rapidly as the coil or circuit resistance approaches the magnitude of the negative resistance, and eventually the oscillation changes into the relaxation type. This is to be expected, since the circuit becomes that of a multi-vibrator if the inductance is omitted.

Using a tapped inductance, it was found that the harmonic content at a given frequency was always least when the tuned circuit contained the smallest part of the inductance with which oscillation of given amplitude could be obtained. A slight reduction of harmonic content results from short-circuiting the unused portion of the inductance. When the inductance exceeds four or five henrys a portion of the distortion results from the iron core of the amplitude control transformer, the primary of which shunts the tuned circuit.

A second advantage of low coil resistance results from the fact that the frequency stability increases with decrease of resistance. If r is small in comparison with ρ, changes in ρ resulting from changes of battery voltages will have little effect upon frequency.

Table I gives the design specification of three coils, together with the average harmonic content, and the minimum frequency at which oscillations can be obtained with a plate supply voltage of 90 volts. All coils are designed for optimum L/R ratio.[7]

The fourth and higher harmonics are negligible. It is evident from

[7] Morgan Brooks and H. M. Turner, "Inductance of coils," Bulletin No. 53, University of Illinois Engineering Experiment Station.

this table that the harmonic content can be reduced to a very low value by the use of large wire, but that reduction of harmonic content is accompanied by a marked increase of weight if the inductance is maintained sufficiently high to insure low minimum frequency. For most applications coil no. 2 represents a satisfactory compromise between low weight on one hand, and small harmonic content and high stability on the other. The minimum frequency can be reduced with comparatively little increase of harmonic content by raising the inductance of coil no. 2 by increasing the amount of wire. Tests are planned to determine the practicability of using coils with low-loss iron cores.

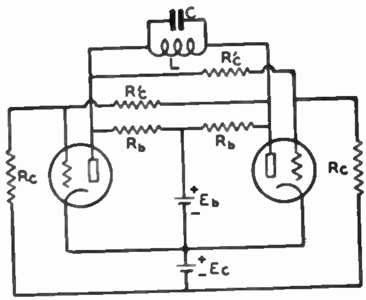


FIGURE 6. BALANCED NEGATIVE RESISTANCE OSCILLATOR WITH COMMON B VOLTAGE.

- Complete Oscillator

Figure 7 shows the circuit diagram of the complete oscillator. Type 53 triodes are used in the oscillator stage and in a stage of voltage amplification which feeds the final power stage of 45's in push-pull. Any type of tube may be used as the amplitude control diode. With coil no. 3 the audible frequency range can be adequately covered by means of a decade arrangement of condensers in four banks of 0.001–0.009, 0.01–0.09, 0.1–0.9, and 1–4 microfarads ca-

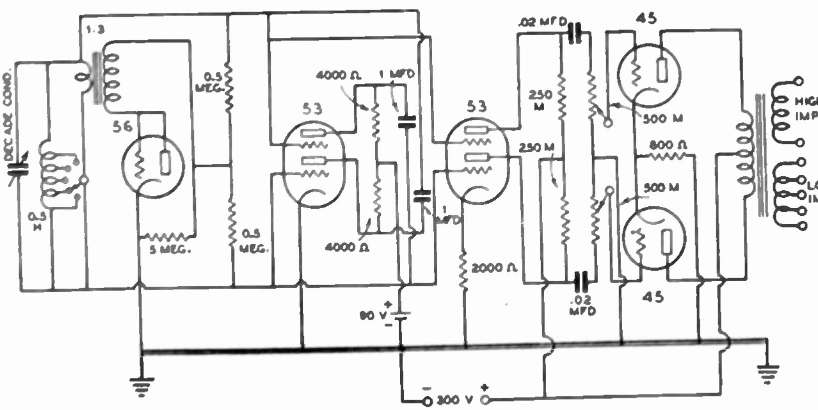


FIGURE 7 NEGATIVE RESISTANCE OSCILLATOR WITH DIODE AMPLITUDE CONTROL

pacitance. The 1–4 microfarad bank may be omitted with coils no. 1 and no. 2.

In the original design of the oscillator the plate voltage of the oscillator stage was obtained from the same power supply as that of the amplifier stages. It was found, however, that fluctuations of line voltage produced considerable variation of output level. This resulted not only from the direct effect of changes of plate voltage of the oscillator stage, but also from associated changes of grid voltage caused by the plate-to-grid coupling. The difficulty can be remedied by the use of a regulated B supply, but since the oscillator triodes draw a total current of only about 4 milliamperes, it is simpler to use two small 45-volt B batteries to supply the oscillator voltage.

The output level is adjusted by means of twin potentiometers which control the input to the power stage. The maximum power output is approximately sixty milliwatts. Because it is operated so far below its normal full output, the amplifier makes a negligible contribution to the harmonic content of the output. When the amplitude control tube is removed, the harmonic content rises to about two per cent, most of which is accounted for by the third harmonic. The power output may be increased to about 200 milliwatts by the use of a 79 tube in place of the 53 in the first amplifier stage.

To obtain a conservative measurement of frequency stability, readings were made with coil no. 1, which has the highest resistance. The frequency was adjusted to 1000 cycles, using two sections of the coil. The resistance of this portion of the coil was 320 ohms. Reduction of plate supply voltage from 90 volts to 62½ volts resulted in a frequency change of 0.04 cycle per second. The maximum frequency drift relative to a 1000-cycle tuning fork oscillator from the time of commencement of oscillation was also approximately 0.04 cycle per second.

Higher stability was obtained with coils no. 2 and no. 3. With coil no. 3 the frequency change from 1000 cycles resulting from a 22½-volt change in plate supply voltage was less than 0.03 cycle per second. In determining the frequency stability, no attempt was made to control or vary the temperature. Since the circuit elements are not compensated for temperature, it is to be expected that the frequency will change with temperature, but a test has not been made to measure the temperature-frequency stability. To insure frequency stability and calibration permanence, particularly at the higher frequencies, it is necessary to make all portions of the oscillator as rigid as possible and to shield the panel. Paper condensers have been found to be more satisfactory than mica condensers.

The distortion produced by the iron in the amplitude control transformer when a coil of high inductance is used in the tuned circuit can be prevented by taking the amplitude control voltage from the plate circuit of the first amplifier. Unfortunately this involves other difficulties.

If capacitive coupling is used, the fluctuations of plate supply voltage of the amplifier stage produce corresponding fluctuations of oscillator grid voltage, which cause the amplitude to vary. If transformer coupling is used, the output of the first stage of the amplifier falls appreciably at low frequencies. The amplitude control compensates for this by increasing the amplitude of oscillation, which also raises the harmonic content. The circuit of figure 7, using a coil of not more than three henrys inductance, has proved to be the most satisfactory.

• Conclusion

The low harmonic content and high stability of this type of oscillator have made it a valuable addition to the electron tube laboratory.

More Power for Short Waves

SOUTH AMERICAN reception of short-wave broadcasts from the United States will be greatly improved by General Electric's use of an effective carrier power of 1200 kilowatts—more than twice the power of any existing long-wave unit—for short-wave station W2XAD, together with a $120,000 a year special series of programs for foreign listeners only, established by the National Broadcasting Company.

This increase in power strength, together with the program facilities of the two companies, will provide complete coverage for all parts of South America when used with two new frequencies recently granted W2XAD by the F.C.C.

On the new frequency of 9,550 kilocycles, one of the two narrow beams will be directed at the eastern half of South America, and the programs will be broadcast in Portugese for Brazil. On the other frequency of 9,530 kilocycles, the beam will be directed to the western half of South America and will carry programs announced in Spanish for the Spanish-speaking population of Central and South America.

The new set-up will give Central and South American neighbors a short-wave service second to none. Because of the expert programming facilities of the two American organizations, the new service should not even be excelled by any of the heavily government-subsidized stations of Europe.

The two frequencies that will be used at night for broadcasting to Latin America are the present W2XAF frequency of 9,530 kilocycles and the new 9,550-kilocycle frequency of W2XAD. In the morning, Central and South America will be reached by the new 21,500-kilocycle frequency, and later in the afternoon by the frequency of 15,330 kilocycles (W2XAD).

¶ From RADIO
January, 1938

FADING..... What Can Be Done About It?

BY ELMER H. CONKLIN

THERE are a number of possibilities whereby fading can be reduced or eliminated. These, mainly, can be divided into those things which are done to the receiver, to the transmitting antenna, or to the receiving antenna. Everyone is familiar with the improvement that can often be obtained with automatic volume control on a phone signal, particularly on lower frequencies where the fading is usually general rather than selective as to frequency. This method involves holding the voice level constant, permitting the background noise to rise and fall, rather than to allow the voice intensity to fade up and down, with the gain and the background noise held constant. The method is not widely used on code where keying changes the average signal input to the receiver. It works reasonably well where the fading is not selective and where the swings are within the range of the a.v.c. action. But it is far from the last word in eliminating fading, particularly on the high frequencies.

In diversity reception two antennas spaced about 2 wavelengths or more, whether broadside to or in line with the transmitting station, will receive the signal with fading that is substantially independent in each antenna. In commercial practice, three antennas are often used, each feeding a receiver. The relative signal level automatically switches the output circuit to the receiver enjoying the highest signal level. Because all three antennas are seldomly picking up the signal in the depth of a fade, usually one part of the system delivers a useful signal. A.v.c. operating on this system eliminates some additional variation.

XE1G had an amateur installation of this type, employing two receiving channels. This diversity receiver at the time was using two horizontal antennas at right angles to each other, giving half-scale readings on the R-meter of one channel and a very low reading on the other, so the usefulness was considerably reduced from the theo-

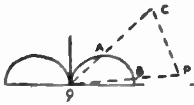


FIGURE 1

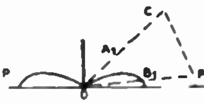


FIGURE 2

FIGURE 3

retical maximum. Where space is not available to erect two receiving antennas spaced two wavelengths or more, one antenna may be made vertical and the other horizontal if ignition noises are not troublesome on a vertically polarized antenna.

Where transmission is intended mainly for the area within a hundred miles or so from the transmitter, such as may be true on the lower frequency bands and on the normal broadcast frequencies, the useful working range is limited to the distance where bad fading is encountered. The antenna radiates at low angles and puts a "ground wave" signal directly into the receiver without a reflection from the ionosphere. Higher-angle radiation may also come down out of phase, or with shifting phase due to variations in the reflected path length, causing partial or complete cancellation of the "ground wave" at the receiver. This effect is shown in figure 1 where the curve OAB represents the relative field strength radiated at various angles in a vertical plane from an antenna O. Line OA represents the strength effective in a direction that is reflected by the ionosphere at point C and received at point P. OB represents the strength of the "ground wave" as received at point P.

The cure for the fading at P, obviously, is to eliminate one of the two possible paths, OACP or OBP, whereby the signal can be received. In broadcast practice, a concentration of radiation in a horizontal plane (OB) is used because this is readily obtainable to a degree, and nearby reception via the ionosphere path OACP is rare anyway. The current distribution on the vertical antenna is corrected so that the pattern more nearly approaches that of figure 2, in which the strength along OA is considerably reduced compared with OB. This treatment is only necessary where the power is high enough to produce a ground wave of useful strength extending to the point where the reflected path is received.

In amateur practice, horizontal antennas are generally used on the lower frequencies where this type of fading occurs, reducing the strength of the ground wave and likewise eliminating one path, even though the width of a skip distance zone, if one is present, is thus increased. The signal strength at nearby points is likewise reduced.

On our higher frequency bands, fading is generally more rapid, and often selective as to frequency rather than general. Again this is due to interference between components of the signal following paths with different transmission times, but both paths are generally through the ionosphere. When these paths are due to radiation leaving the transmitting antenna at widely different angles, a change in the directive pattern in the vertical plane might be accomplished at the transmitting antenna to reduce the fading. This would be possible by the use of sharper vertical directivity such as results from the use of the V or the rhombic (diamond) antennas if horizontal directivity is also desired, or some method of holding down the vertical angle without appreciable horizontal directivity. The Kraus Flat-Top Beam[1] arrangement may be used (end-fire in the horizontal plane) with some improvement. Vertical stacking has also been used. One station, W9SYD, has had particularly good results with stacked horizontal antennas. Change in pattern caused by stacking vertical antennas is roughly seen by comparing figures 1 and 2.

What is perhaps the most successful single method so far devised to reduce fading is "Directivity Steering"[2].

In "general" fading there may or may not be appreciable angular separation between the multiple interfering waves at the point of reception. It has been determined that with selective fading, a material path-length difference, with little question, must exist. If some method is devised whereby the antenna will receive waves from only one angle, fading will be considerably reduced. If this one angle should involve receiving one of the stronger waves, then the volume might be satisfactory.

Sharp, variable directivity itself may be difficult to obtain. However, a moderately sharp characteristic can be obtained if the vertical pattern of the proposed antenna has a steep edge and thereby discriminates against reception from some angles. See figure 3.

When the received strength is low, the edge of the diagram in figure 3 should be advanced until a large amplitude wave is encountered. The system should not have minor lobes of appreciable size.

For his tests, Mr. Bruce used a rhombic antenna arranged so that the far end could be "pulled out", expanding the axis of the diamond in the direction of the transmitting station. This required only a relatively small change to alter the angle at which the steep upper edge of the pattern will just intercept a reasonably strong wave. With this antenna, a number of observations indicated that 51% of the measurements show no reduction in fading from a comparison antenna, but in 35% there was practically no fading present. However, in 89% of the more severe types of fading, when it was most troublesome, there was a measured improvement. In only 4% of these cases could the fading be made equal to or worse than on the comparison antenna by deliberately steering to an unfavorable angle.

[1] *"A Small but Effective Flat-Top Beam," John D. Kraus, W8JK,* RADIO, *March, 1937.*

[2] *"Directivity Steering," E. Bruce and A. C. Beck,* BELL SYSTEM TECHNICAL JOURNAL, *April, 1935.*

¶ From Service,
January, 1938

$ $ $ IN AUTO-RADIO

Progressive service men are realizing extra profits by combining auto-radio sales and service with home-receiver work. Statistics show their expansion into this field are more than justified owing to the great potential market yet to be developed.
Taking a cue from the automobile industry, now showing new models, service men will also find it advisable to make contacts presently.

IT HAS BEEN forecast that radio receivers in use this past summer totaled 34,000,000 with 25,000,000 home radios equipped, an increase of 2,000,000 more radio families than the previous season. According to this report 4,000,000 supplementary receivers were to be added to the 25,000,000 radio homes. On the whole these prospects have been most encouraging to the service industry, particularly as the predictions seem to have been realized, or nearly so, at this time.

Similarly, the prospects for auto-radio sales and service have been promising though not as auspicious as one might suppose. Briefly, every fourth person in the United States owns or is paying for a car. Prompted by this fact, any curious and progressive service man will be led to investigate the statistics yet further. The figures he will find in such a search will not be unlike the following:

*Total automobiles in the United States	28,520,559
Private passenger cars	24,172,823
Government cars	200,230
Private buses	123,900
Private trucks	4,023,606

It will be further revealed that the United States has gained in registrations some 2,138,238 motor vehicles in 1937, a percentage advance of 8.1 over January 1, 1936.

Contrasted with these rather overwhelming figures is the fact that some 4,500,000 car operators now can ride while regaled by radio's

*As of July 20th, 1937: Report No. 619, Department of Commerce, Washington, D. C.

Figure 1

ever-broadening entertainment. One-half of these receivers are said to be more than two years old. With the aid of a little mathematics it becomes evident that the figure 26,520,559 is, theoretically speaking, the potential market for auto-radio receivers, excluding, of course, the continuous influx of new machines not yet equipped with sets. The situation is represented graphically in figures 1 and 2, whereby one may visualize readily that the auto-radio field yet offers manifold possibilities for sales and service.

• The Previous Situation

In the past, however, there have been complaints that a radio receiver in a passenger car constitutes a traffic hazard as the driver's attention is distracted and thereby may be indirectly the cause of a serious accident. Of those parts of the country taking the complaints earnestly, the proposed bill which was before the senate of Idaho is typical. Had the drafted law been passed it would have been illegal for any person or persons, either driving in or operating a motor vehicle, to listen to any sound, voice, or music as received on a radio receiver. How the RMA co-operating with the automotive interests had the proposals scrapped is well known.

On the quiet, police departments, safety and accident-prevention bureaus have investigated the matter only to find the complaint has little or no foundation. On the contrary, these groups, after due consideration, have absolved the auto radio from any part in traffic accidents, finding instead that a musical program received while on the road discourages conversation and any tendency for general "rough-housing" among the car occupants, induces a slower operating speed to permit a possible improved reception and increased attention to the same, and, finally, subjects no distracting forces upon the drivers. With nerves somewhat steadied by the music, the operator is usually more prepared for an emergency than is otherwise the case.

An analogous situation, incidentally, is the home-study periods of young students who claim they are unable to prepare their lessons until the radio is going full volume!

Moreover, in the case of car operators traveling long distances over monotonous country, the companionship of the auto-radio is considered a great factor in safety as it lessens both mental and physical fatigue and promotes a consciousness of driving in periods otherwise conducive to sleep.

With these important and widely

publicized objections eliminated, for the self-evident reasons just presented, a gradual increase in auto radio sales has been evidenced among dealers and service shops.

• Technicol Viewpoint Versus Public

Skepticism and downright opposition have met the introduction of practically every invention we have. Indeed, the development of new products springs rarely from popular demand. It requires, on the contrary, persistent persuasion to bring individuals to accept a higher standard of living. Having overcome the initial resistance to the auto-radio—a typical example of a new application—the manufacturers continue to combat the insinuation of those people who "remember when," or who recall some of the earlier sets and their varied shortcomings. Such complaints, usually outmoded at the time of expression, are registered without ever a gleaning of appreciation for progress in the admitted years of trial and error.

Be it known today, however, that no one need apologize for the quality of reception now obtainable on a standard model receiver as designed expressly for the motor vehicle. Any minor defects now present in auto-radio reception cannot be classed as real objections when one collates the quality of reception over the wide range of conditions under which a motor car must of necessity operate. Just as proper filtering and shielding were developed to overcome inherent disturbances from the motor's ignition system, so too are the remaining problems today having the attention of the best engineering minds.

Now that new and improved receivers and antenna systems are providing the motorist more entertainment value than ever before, even the perfection-conscious individuals have less of which to complain.

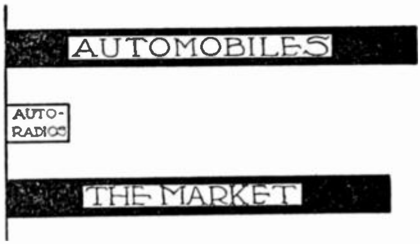


Figure 2

With increased sensitivity and further improved tone quality assisting in the gradual decrease of sales resistance, the future looks brighter. Clearly the manufacturers have done and are doing their part; it remains for service men to put over the sales and service work which will result thereby.

• The Prospects

The average service man is well prepared to make auto-radio sales having, as he does, the added advantage over the usual dealers and garages of facilities for initial installation and future servicing. His position with respect to the public makes him the most logical contact man between user and producer.

In this connection, it has been

said of one progressive service man that he keeps his auto-radio always at full volume when on the way to answer a call, thus attracting attention to his service truck and business. Upon approaching and stopping at a traffic light, he invariably modulates the tuning for the benefit of both pedestrians and any cars that might draw up at his side. Under these conditions at least two people out of every ten, whether walking or driving, would inquire for the maker's name. Should a major sports event be in progress at the time, they will inquire for the score. Obviously the next move on the part of the service man is to invite the newly-made and curious friends to see and hear the receiver by drawing up to the curb. According to his story, a sale usually results.

If the truth of this incident can be relied upon, it would appear that one's class of prospects includes all those owning a motor or intending to do so presently. Lacking the contact-on-the-go opportunities just described, one resorts to vehicle registration lists, gasoline stations, garages, friends, telephone directories, and previous clients, in compiling a prospects list.

Of one's potential customers, the most likely individuals are those who spend long hours driving. They are called professionals and include traveling business men, salesmen, truck drivers, news and movie reporters, cross-country bus drivers, long-distance commuters, doctors, and weekend travelers. The desire of these people for an auto-radio evolves from their absence from home and their accompanying inability to hear a favorite program at a given hour. Too, they wish entertainment and some degree of relaxation during a long or monotonous run over much-traveled country. Commercial travelers forced to make calls during their client's office day and to cover the intervening territory outside of hours, appreciate the company provided by the auto-radio receiver.

The obvious attack, when preparing the ground work for sales and later service, is directed at executives of concerns owning truck, bus, and passenger fleets. The safety and employee's well-being factors are stressed in a sales message to this group. Failing here, one concentrates on the individual operators themselves, the while emphasizing entertainment value on the trip. From among them, one soon learns to classify those who are news fans, sports addicts, stock-quotation pursuers, and music lovers. From a single program interest grows a desire for an auto-radio. Detect that liking and the sale is half accomplished.

Introductions to the groups of motorists mentioned above can also be made conveniently through garages and gasoline stations whose staffs come in daily contact with prospective auto-radio buyers. The sales technique here consists of canvassing the proprietors of such stations and offering them a commission on actual purchasers directed one's way.

A demonstration set mounted appropriately on a suitable display rack, prominently situated in the station, assists markedly in this direction. The usual forms of service man's literature can well be distributed by station attendants not only to the advantage of one's auto-radio business, but also for the publicity of the home-receiver servicing work. Service stations will be pleased to do this in return for the use of the demonstrator model which is at the same time suggesting its worth to persons stopping in for a change of oil or the like. Taxi drivers are also likely to be interested in a similar proposition.

For the commuter group—those spending from two to three hours a day going to or coming from work between the periods 7:00 to 9:30 a.m. and 5:00 to 6:30 p.m.—there are many instructive features being broadcast at these times. In fact, it requires little argument to make such a motorist realize the value of exercising the mind and ears while occupied in otherwise unpleasant driving.

• Friends and Clients

Just as a receiver can well be spared for advertising purposes at a nearby gasoline and repair station, so a demonstration model can be used to advantage in one's personal car, the better to exhibit a set's abilities to friends and clients. One service man of our acquaintance usually lets his car receiver continue playing as he parks it in a customer's yard and goes in to install an aerial system for the new home radio. Before the installation and minor adjustments have been completed, the customer will be inquiring about the prices on the set operating outside. Already an interest has been cultivated.

Similarly, the procedure works both ways, for when installing or servicing a customer's auto-receiver, the progressive service man will inquire how the home radio is functioning. Taking a by line from insurance salesmen's "How much of a policy do you carry?" the alert men in the service industry inquire "How many radios have you?" They argue that there is always room for one more.

When describing the virtues of the auto-receiver to a prospective client, one need not necessarily emphasize the quality of and need for reception as the automobile is in motion. Obviously the same features apply when the car is parked, a situation well illustrated by the man who has a workshop in the garage and who makes use of the radio in his car while engaged weekends on some odd job.

Others claim it a fine sedative for mowing the lawn, hoeing the garden, or raking the leaves. In fact, when concentrating on friends, one plans to drive into the neighbor's yard just about the same time the latter is working about the grounds. The ensuing conversation on flowers, gardening, and the weather usually concludes with said parties at the car side where the radio has been the while demonstrating quietly its tone quality of reception.

• Year Around Sales and Service

In the past whenever similar recommendations have been made, the spring or summer periods have been advocated as the best time of year for concentration on auto-sales and service. Basing the claim, however, on a possible dullness of season at these times of the year is not entirely justified. Witness the radical changes made by the sales departments of automobile manufacturers who have found the erstwhile fall season the preferable period of the year in which to introduce and display their latest models. The service industry can do well to imitate them in this respect and make the winter a time in which to concentrate on auto as well as home-receivers. Perchance it will then be more convenient to contact the purchasers of new cars and the buyers of old ones.

Service men who add the motor-radio to their present sales and service line of home equipment will find winter as profitable a season as the spring and summer. Actually, climatic conditions in many parts of the country permit this extra revenue source for the service shop to be an all-year proposition.

One will rightly agree that the winter-buyer-for-spring-delivery customer can well expand his budget at the same time to include the radio. Those demanding immediate possession, moreover, will appreciate a demonstration of the new radio models. Finally, those setting aside their cars as demanded by a brief winter season can see the logic of having a receiver installed at this period to avoid the spring rush. Winter's drivers already have shown that the auto-radio is at its best for sheer entertainment value when travelling. Winter is also the most mutually beneficial time for servicing a car-owner's radio.

• Technical Aids

It has been said the average service shop is well qualified and equipped to service the motor-radio. The very nature of the business necessitates a general knowledge of electrical principles that can be expanded readily to include the ignition systems of motor vehicles.

The auto-vibrator is an outstanding example of how the dissemina-

Current practice abroad offers an interesting solution to the accumulation of static charges built up on the brake drums of automobiles by friction. It has been found that a colloidal graphited grease of maximum graphite content, when injected into the existing hub grease with due care for adjacent brake linings, dissipates the charges to the frame. Perchance such a procedure will be of interest to service men in this country.

tion of information has become beneficial in this field. Interrupter and synchronous-rectifying types of vibrators for power packs have long been in use in automobiles; yet from the first, service men have regarded them with suspicion and uncertainty, feeling that all major receiver troubles in the motor-radio is attributable directly to them. Unaccountable noise and low plate voltages are the symptoms, though later tests on the vibrator in question by the manufacturer have proved it normal in all respects. With more detailed information made available, service men have come to know the vibrator, its circuits, and characteristics.

• Two Service Tips

It has been shown that high-test gasoline using lead-tetra-ethyl breaks down into by-products which deposit on spark plugs and decrease their resistance appreciably. The lowering of resistance makes the spark suppressors installed in the car interfere with the proper functioning of both the engine and radio at certain speeds. In addition, then, to checking the filters and shielding, one now makes a practice of cleaning spark plugs on every inspection job.

The demand for and the sale of motor-radios have created in the automobile sales and service stations a situation that can be solved effectively by the service man. The new sets must be installed properly and maintained. Finding it inconvenient to return a newly purchased set to the dealer for service, customers stop in at the nearest garage. They in turn attempt repairs or recommend a neighborhood radio-service shop. To meet the circumstance, auto-servicing chains have already been organized in a plan whereby any auto-radio installed by a member station is serviced completely at any other member station, free of charge, during the warranty period. The staffs of large radio-service shops are being called upon for the work. It merely remains now for the independent service man to affect a connection that meets his local conditions.

¶ From RADIO,
February, 1938

Simplified Inductive Tuning

BY CHARLES D. PERRINE, JR.

Link neutralizing—no tuning condensers—no by-passes. This revolutionary 1938 amplifier hits a new high in simplicity and economy. The one condenser is a small, fixed, vacuum affair capable of withstanding 40,000 volts. The only other parts are two coils, three links, two tuning loops, and two 250TH's. The saving in condenser costs actually pays for one 250TH.

LINK neutralization is a highly practical application of inductive neutralization. Just as link coupling improved and simplified interstage coupling in transmitters, so does link neutralizing improve the inductive type. Collins and Craft[1] first applied inductive neutralizing to amateur work by directly coupling the plate and grid coils of an amplifier in reverse phase so as to neutralize the feedback through the tube. They point out the big disadvantage of such a system: that neutralization changes with frequency. This is true for conventional capacity tuning of plate and grid circuits, but *not* for *inductive* tuning. Referring to the skeleton amplifier circuit in figure 1, let K represent the coefficient of coupling between L_1 and L_2 introduced by links L_3.

Then for neutralization:

$$K = \omega^2 \sqrt{L_1 L_2 C_{gp}}$$

where $\omega = 2\pi f$ and f is the frequency in cycles per second, C_{gp} the grid plate capacity of the tube, and L_1 and L_2 the inductance of the two coils.

But, using the resonance equation

$$\omega^2 = \frac{1}{LC}$$

ω is eliminated from the expression for K:

Thus $$K = \frac{C_{gp}}{\sqrt{C_1 C_2}}$$

[1] *A. A. Collins and L. M. Craft, "Inductive Neutralization of R.F. Amplifiers", QST, July, 1936.*

Hence K and neutralization become independent of frequency if C_1 and C_2 remain fixed and all tuning is done by varying L_1 and L_2.

Thus inductive tuning not only nails down the neutralizing adjustment but obviates the use of variable tank condensers. The actual variation of inductance is obtained by rotating a single shorted turn inside the tank, a stunt borrowed from broadcast practice. The effect of the shorted turn is to vary the coil by approximately one turn. This is more than sufficient to cover any ham band, with the possible exception of 160 meters (where it has not yet been tested). With a low resistance silver-plated or silver wire "flipper" loop, the losses in it are very low. Contrasted to condenser tuning, there are no voltage limitations to inductive tuning.

• Vacuum Tank Condenser

The use of inductive tuning immediately makes possible the use of a fixed vacuum condenser for the tank capacity. With a good vacuum, ridiculously small spacings can be used to increase capacity and reduce physical dimensions. The condenser used in the new amplifier is a somewhat experimental model made to order by Eimac. With no precedent to follow, the voltage ratings of the condenser were necessarily made high.

The condenser consists of two 750T plate stems end to end as pictured on page 53. Two concentric tantalum cylinders supported

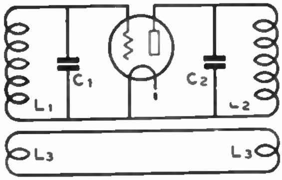


FIGURE 1
Fundamental Circuit

from the opposite ends of the condenser form the plates. The capacity turned out to be a little higher than expected, 30 μμfd., but not excessive for the contemplated frequency of 7 Mc. Due to the use of tantalum, the vacuum improves with age. The gap between electrodes is only 1/16", but as much as 40,000 volts of r.f. failed to cause a trace of arcing or ionization. The leads to the electrodes are good for at least 60 amps. Losses are nil as the only insulation is Nonex and vacuum. 30 μμfd., 40,000 volts, and 60 amps. in a 2¼"x 8" condenser show just what can be done in a vacuum.

The complete circuit of the experimental amplifier is shown in figure 2. Note the two new circuit symbols devised for the tuning loops and vacuum condenser C. The grid tank capacity is the grid-filament capacity of the 250TH's. The resulting high L/C ratio is permissible because the push pull operation keeps harmonics down. Some "Q" is coupled into the grid tank from the preceding driver plate tank. The link L_6 does the work of neutralizing by feeding back to the grid tank sufficient out-of-phase

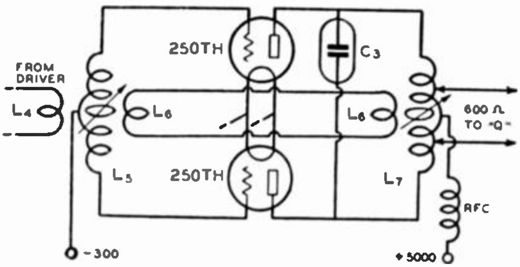


FIGURE 2
The complete circuit of the 7-Mc. push pull amplifier.

C_3—30 μμfd. 40,000-volt vacuum type (see text).
L_4, L_6—1 turn, silver-plated no. 10 wire.
L_5—35 turns, 3" diam., 6" long, silver-plated no. 10 wire.
L_7—15 turns, 4½" diam., 5" long, silver-plated no. 10 wire.
Tuning loops—One shorted turn, silver plated no. 10 wire.
RFC—High frequency r.f. choke, 500 ma.

power to neutralize the capacitive feedback. As in the past, push pull is used because it reduces harmonics and is balanced to ground, though unbalances with respect to ground do not appreciably affect link neutralization. The only balance important is that of the load on the tubes, which is controlled by the antenna coupling. An unbalanced load will cause one tube to run hotter than the other.

• Construction

Photos on pages 52-53 show the constructional details of the amplifier. The breadboard is 12"x 24" with a 5" platform at one end to bring the plate tank on a level with the tube tops. The filament transformer is located under this platform. Complete symmetry of layout is important and has been carried out in the placement of all parts. Power leads are brought out to terminals on the end of the baseboard below the plate tank. Wiring is done with no. 10 silver-plated wire.

The grid tank is on a level with the grids of the tubes. The exciting and neutralizing links are coupled to the center of the coil with just enough separation to pass the ¼" bakelite shaft that carries the rotatable, silver-plated tuning loop inside the tank. The bearing for the bakelite shaft is a midget open circuit phone jack; the sleeve provides the bearing and the spring the necessary friction to prevent free rotation. This jack is mounted at the coil-center level on a piece of bakelite attached to the top of a wooden upright. Provided with a suitable knob, this 25-cent tuning set-up tunes as smoothly as the best.

The grid and plate leads to the tubes are made of thin ½" copper strip. It is a recognized fact that the braid usually used is a poor r.f.

conductor at high frequencies. The copper strip is not only better in this respect, but also helps appreciably in cooling the tube terminals and seals.

The platform carries the entire plate tank. The vacuum condenser is supported on two insulators by short no. 12 wire leads and two large size grid clips. It must be sufficiently in the clear, as any objects near its middle might cause a puncture by arcing through the glass. The plate coil is self-supporting and arranged for a good shape (form) factor. The plate tuning loop is mounted and controlled just as in the grid circuit. The neutralizing link L_6 is placed around the center of the plate coil. The link line joining the two neutralizing links is made of two parallel no. 10 wires that can be seen running down the center of the amplifier between the tubes. The polarity of the link must, of course, be correct; otherwise it would accentuate the feedback. Proper polarity follows a simple rule: if the tanks are wound in the same direction, the links are also in the same direction and connected in parallel (no cross-over) by the link line.

- Adjustment

Neutralization of the amplifier is simplified because only one neutralizing adjustment is made, that of the neutralizing link. First apply excitation with the plate voltage off, and increase it until 200 ma. of grid current flows. Then adjust the coupling of the neutralizing link (can be done either at plate or grid ends, or both) until the grid current remains unchanged as the plate is tuned through resonance. The point of complete neutralization is quite broad and neutralization is really complete; a sensitive light coupled to the plate tank shows no trace of r.f. As a final acid test of neutralization and stability, the amplifier was operated as a class B linear with approximately cut-off bias and excitation removed. No sign of self-oscillation was present with tanks both in and out of tune.

Plate tuning is just as in any condenser-tuned rig. The antenna coupling should preferably be balanced, such as the Q feed shown. But even a badly adjusted, end-fed antenna can be coupled on to one side of the tank without bothering neutralization, though the tube loading will be unbalanced and the tubes will not heat evenly.

- Advantages

Operating advantages of this amplifier over the old type are many. For the c.w. man, it will withstand full plate voltage with the load removed (at 5000 volts this produces an 8" arc when drawn with an insulated pipe wrench). To the phone man it means no further worry about modulation peaks, as even 1/32" electrode spacing is good for at least 20,000 volts in a good vacuum.

When loaded by the low impedance grids of the 250TH's, the inductive tuning of the grid circuit and the resulting low-C produce a very broadly-tuned circuit, broad enough to cover 200 kc. at 7 Mc. without retuning with less than 10% change in grid current. As the only condenser in the amplifier is sealed in glass, dust and moisture can never make it flash over.

The amplifier described above is just one application of link neutralization. It can be used wherever neutralization is required with a great simplification of circuits. Even with capacity tuning it will be constant enough to cover about a 1% frequency change. Doing away with split tanks in single-ended stages (required for capacity neutralizing) will make band switching much easier.

Link neutralizing was applied to a single-ended 250TL amplifier on 14 Mc. and gave more complete neutralization than the old capacity neutralization. Another case was a 6L6 to be operated as an amplifier instead of as a doubler, thus requiring neutralization. It took only a moment to run a link between the grid and plate coils to neutralize the tube perfectly without any further change in the original circuit.

Station W2XOY Starts

W2XOY, G.E.'s new ultra-short-wave radio transmitter, erected on top of the state office building in Albany, N. Y., officially inaugurated its broadcast schedule February 21. W2XOY operates on a frequency of 41 megacycles or 7.31 meters with a power output of 150 watts.

It is on the air on Mondays, Wednesdays, and Fridays from 8 to 9 p.m., and on Saturday afternoons from 3 to 5 o'clock. All programs originate in General Electric's short-wave studios in Schenectady and are carried by a special wire line to the Albany transmitter.

Signals on this ultra band are supposed to travel in straight lines, the same as light waves, to be heard within a distance of 20 or 25 miles from the point of origin. However, in one of the early tests about two months ago a report was received from an amateur in Phoenix, Arizona, more than 2,000 miles distant, telling of receiving the section.

QUOTATION from a newspaper description of a radio system installed by a Southern fire department. "The receiver has built a 'noise squelcher' circuit which eliminates static. The only noise is that of a broadcast."—QST

MEN IN RADIO . . .

OLIVER HEAVISIDE—1850-1925

OLIVER HEAVISIDE, the English physicist, was a contemporary of Thomas Edison and, like Edison, was compelled to contend with the affliction of deafness throughout his entire career.

Heaviside had only a common school education. While still in his 'teens he secured a position with the Great Northern Telegraph Company at Newcastle. In 1874 his deafness became so bad that he was compelled to retire from business. He stayed at his home in Devonshire and there began the electrical research and experimentation which brought him world-wide fame.

Because of his unusual and unorthodox methods of mathematical calculation he had great difficulty in obtaining recognition for his works, and found it practically impossible to get them published. Finally, in 1892, he published them himself. His mathematical work involved the use of a term, which he invented, known as an "operator." This gave the name of his methods of "Heaviside's Operational Calculus." His methods have proven very useful and have been widely adopted.

In his "Electrical Papers," Heaviside dealt with many practical problems, including duplex and multiplex telegraphy, electro-static and electro-magnetic induction between parallel wires, and the properties of transmission lines.

Heaviside in 1902 first suggested the presence of a conducting or "ionized" layer in the upper atmosphere which prevents electrical waves from spreading out into space. The Heaviside layer, also known as the Kennelly-Heaviside layer or the ionosphere, is ionized primarily by the effects of solar radiation. In reality, constituted of several layers, the ionosphere is constantly changing in height and ionization and occupies the region from 40 to 250 miles above the earth's surface. Heaviside's suggestion was made many years before the "skip distance" effect, now made familiar by short wave radio, was known. The "skip distance" effect is so well explained by reference to the Heaviside layer as to be definite proof of Heaviside's theory.

The bending or refraction of the radio sky waves by the ionosphere returns the waves to the earth at some distance from the transmitter. This distance varies with the frequency of the wave, the angle at which it strikes the layer and the condition of the layer at the moment.

—The Ohmite News.

From Bell Laboratories Record, Jan., 1938

Higher Volumes Without Overloading

BY S. DOBA, JR.

FOR MANY years, a major problem in radio broadcasting has been how to utilize as effectively as possible the available power of a broadcast transmitter so as to render the best service to the maximum number of listeners. As one moves outward from a transmitter, a point will finally be reached where the signals received by the listener become so weak that the softer parts of the program are masked by static and other electrical noise, and beyond that point noise prevents good reception. Anything that increases the signal strength of the softer parts of the program being transmitted, therefore, extends the area throughout which good reception is possible.

For a given transmitter the strength of the loudest portions of the program is limited by the maximum level that can be applied to the transmitter without overloading it. With the maximum level thus limited, it follows that the narrower the volume range of a program the stronger will be the soft parts of the program and the farther from the transmitter is good reception possible. Most programs have a fairly narrow volume range, the loud and soft portions rarely differing by more than 30 or 40 db, but occasional programs such as symphony orchestral music may have volume ranges exceeding 60 db. It would be desirable to transmit to the listener the full volume range of a program, but in the interest of the best service to the most listeners, it is the practice to effect a compromise between volume range and noise interference at the receivers by reducing the volume range of those programs having initially the wider ranges before applying them to the transmitter. A further factor justifying limitation of the volume range is that under average conditions in a home, the transmission of a very wide range of volume would result in the soft portion of the program being submerged and lost in the room noise or set noise, even when static and other electrical noise is negligible.

In practice the volume range of

EDITOR'S CHOICE

This month Paul B. Findley, managing editor of "Bell Laboratories Record", and his associates select the material on the following pages as the "Record" article which they believe to be the most suitable for re-publication in "Radio Digest."

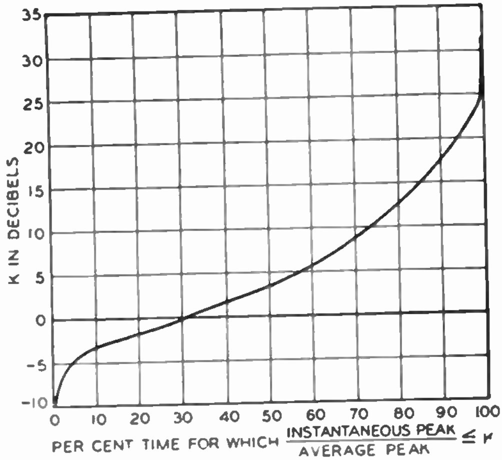


Figure 1. Time distribution of peak power of a representative 75-piece orchestra.

the programs is controlled by having an operator at the studio monitor the program and make manual adjustments to keep the program levels within certain limits. The operator listens to the program and watches a volume indicator, and makes adjustments to reduce the levels of the louder portions and to raise the levels of the weaker portions of the program, keeping the general levels as high as possible without overloading the transmitter. Very prompt action on his part is required, and he must become familiar with the most rapid and extensive changes in program loudness during rehearsals so that he can slightly anticipate them at the actual performance.

The situation is further complicated by the presence of sudden peaks of short duration that are too rapid for him to control. In raising the gain to give full modulation, he must consider these sudden peaks of power that would overload the transmitter and introduce distortion. Occasional overloads of short duration are not particularly objectionable, and the monitoring operator determines by trial some point below full modulation, perhaps 7 or 8 db, to which he may safely raise the gain for the higher amplitude portions of the program. This 7 or 8 db leeway that he allows is enough to insure, with careful monitoring, that only an occasional peak will actually overload the transmitter.

A typical variation in volume for a 75-piece orchestra is shown in figure 1, where the ordinate gives the ratio in db of the instantaneous to the average peak power, and the abscissa, the percentage of time that this energy ratio of the program is equal to or below that indicated

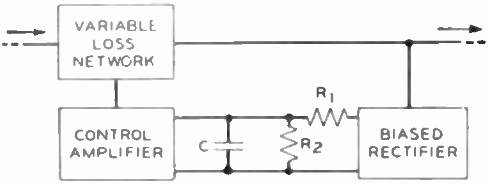


Figure 2. Simplified block schematic of the volume control circuit.

by the ordinate. Thus, for example, the instantaneous peak power is at or below the average for 31 per cent of the time, and it is not more than 25 db above the average during 99 per cent of the time. It may go 25 to 32 db above average, but this occurs only 1.0 per cent of the time. Other programs would have somewhat different curves but their general shape would be similar.

The volume at which the monitoring operator can permit the program to be transmitted depends upon the magnitude and duration of these short peaks. Obviously his work would be lightened, and a higher average signal strength could be maintained, if some arrangement could be provided for automatically limiting the amplitude of these peaks without causing serious distortion, or materially affecting the dramatic effect of the musical passage. Because of its importance, this requirement was carefully studied, and various ways of accomplishing it were considered. As a result a gain-regulating circuit was developed that seemed suitable from the standpoint of theoretical considerations, and also proved satisfactory in actual trials. In simplified block form, its circuit is shown in figure 2. There are a variable loss network in the transmission path, a biased rectifier to rectify a portion of the output beyond the loss network, a timing circuit consisting of a condenser and resistances, and an amplifier to control the loss introduced by the network.

The action of the circuit is quite simple. Up to a predetermined output of the signal, the bias on the rectifier is such that the control circuit is essentially inactive, and the loss inserted by the network remains constant at its minimum value. When the signal output exceeds this predetermined value, however, the rectifier provides a negative voltage on the grid of the control amplifier, and the decreasing current of the amplifier increases the loss in the network, and thus decreases the output. It is essential that the change in loss be slow compared to the periods of the component frequencies of the signal, but fast compared to the normal changes in amplitude of the program. It must be fast enough to follow the increases in amplitude of the program but not so fast as to follow the wave form of the lower program frequencies, since this would result in a flatten-

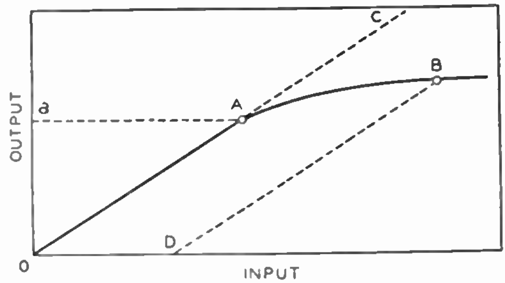


Figure 3. Input-output characteristics of the controlled network.

ing of the waves of the component frequencies, and cause distortion. The timing circuit consists of the condenser, C, the shunt resistance R_2, and the series resistance R_1, which is the effective resistance of the rectifier. The condenser must charge through the resistance R_1 before the effect of the increased signal can increase the loss, and it must discharge through resistance R_2 before the effect of a decreasing signal can decrease the loss. The two times may thus be controlled independently by properly selecting the values of R_1 and R_2.

The effect of such a device on transmission is indicated by figure 3, on which the input to the variable loss network is represented along the abscissa axis, and the output on the ordinate axis. With minimum loss in the network the input-output curve would be line OC. The point A on this curve represents the signal strength at which the bias of the rectifier is overcome and the loss in the network begins to change. For all outputs between O and *a*, therefore, there is no change in the network, and OA is the input-output curve. As the output rises above *a*, however, the loss in the network is increased, and the gain is reduced, the output following the curve AB. At the point B, for example, the loss inserted by the network is such that the input-output curve becomes the line DB. If no further change were made in the loss network after the point B was reached, the input-output curve would be DB. The curve AB thus represents the upper limits of a series of input-output curves parallel to OA, the particular curve on which the circuit is operating at any moment depending on the loss inserted by the network.

The loss network consists of four varistors arranged in a bridge network and inserted in the circuit as indicated by figure 4. The ratio of the output signal to the input signal of such a circuit is proportional to the expression $(R_1R_4 - R_2R_3)$. When used as a Wheatstone bridge, R_1R_4 is made equal to R_2R_3 for the balanced condition and the output is zero. As used for volume control, however, R_1R_4 is always considerably greater than

R_2R_3, and the output of the circuit is a function of their difference.

The resistance of these varistor units varies inversely with the current flowing through them, so that it is possible to control the output of the network by controlling the R_2R_3 and R_1R_4. This is done by sending current from a constant source of potential through a parallel-series circuit with R_1 and R_2 in one branch and R_3 and R_4 in the other. Another circuit, through the control amplifier, sends current through R_1 and R_4 in a direction opposite to, and a current through R_2 and R_3 in a direction the same as that due to the constant potential. Up to the critical value of output, the control amplifier has a minimum grid bias and its plate current is a maximum, with the result that R_1R_4 is large compared to R_2R_3, and the loss inserted by the network is a minimum. As the critical output is exceeded, the bias on the control amplifier becomes negative, and its output decreases. This results in increasing the value of R_2R_3 and decreasing the value of R_1R_4, so that the loss that has been inserted by the network increases.

These resistors and their supply circuits are connected into the circuit as shown in figure 5. The network is coupled to the input and output circuits through impedance-matching transformers T_1 and T_2, and the d.c. control current is fed to it through mid-taps on these transformers so that the current flows in opposite directions in the two halves of the winding and produces no net effect on the flux in the core. Current from the battery E_2 divides at the mid-point of a winding on T_1 into two parallel paths—one through R_3 and R_4 in series and the other through R_1 and R_2 in series. These currents, i_2, and their directions are indicated by the arrows on the diagram. Current from the control amplifier follows two paths, one leading to the mid-point of each secondary winding of T_1. One part of the control current thus passes through R_2 and R_3, and the other part through R_1 and R_4. These components of current passing through the control amplifier

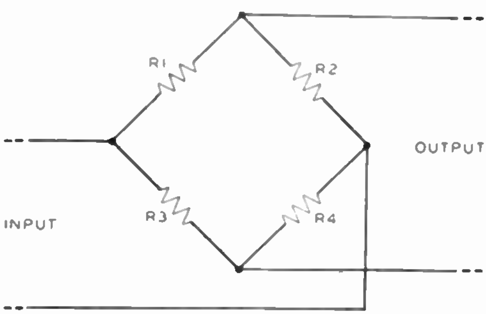


Figure 4. The four resistors are arranged in a bridge network, with provision (not shown) made for passing direct current through R_1R_4 and R_2R_3.

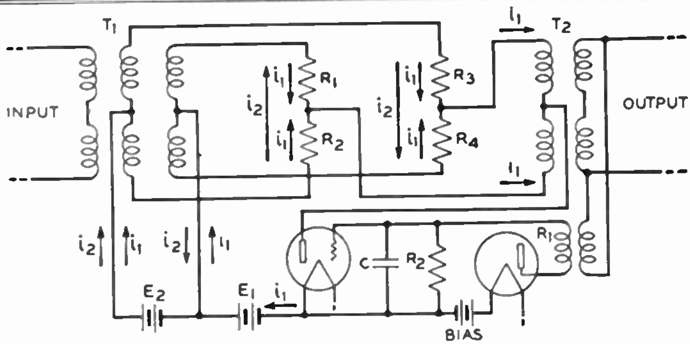


Figure 5. Arrangement of variable-loss network in the transmission circuit.

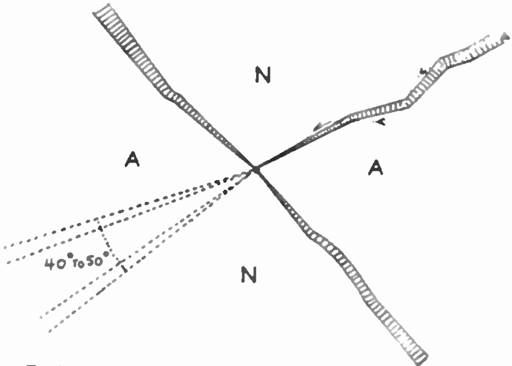
are marked i_1 on figure 5, and from the directions indicated, it will be seen that i_1 opposes i_2 in R_1 and R_4 and assists i_1 in R_2 and R_3. The relative values of R_2R_3 and R_1R_4 thus depend on the current from the control amplifier, and the greater the control current, the larger will be R_1R_4 and the smaller will be R_2R_3.

For a volume control device to be used at voice frequencies, it is essential to prevent the control current from passing into the output where it would appear as an audible disturbance. The circuit described above provides the accurate balance needed for this purpose. In addition it maintains a constant impedance for the circuit regardless of the loss it introduces. Furthermore, the bridge type circuit insures that the inherent shunt capacitances across the varistor units have a fixed effect on the loss, and their influence on the circuit can be allowed for in the original design. As a further advantage the varistors are very stable—maintaining the same values over very long periods of time. In view of its expected wide application, later models of this circuit have been designed for operation entirely on alternating current supply.

Time Signal and Musical Pitch Combined

THE CHARACTERISTIC musical tone sounded to announce the time of day by station WOR of Newark, N. J., and the Mutual Broadcasting System, is now sufficiently accurate to serve as a musical pitch standard. The WOR studios use an electrically-driven tuning fork which emits a pure 440-cycle tone with an accuracy within .002%.

The fork operates continuously, its frequency being picked up and delivered to the control amplifier when needed for a time signal announcement. Because of its musical precision, the signal may be used by musicians and by technicians as a tone or frequency standard.



Typical examples of course bending and course swinging.

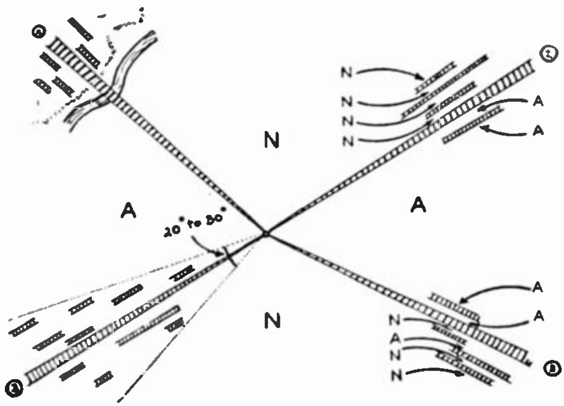
vertical and a horizontal component; the horizontal component, reflected from the Heaviside layer, is responsible for fading which affects the two figure 8 patterns unequally, causing their equi-signal zone to shift. This phenomenon is most pronounced at night, and is commonly called night effect.

The more modern TL type beacons employ four vertical antennas, operating in pairs, and transmit essentially vertically polarized fields. The night effect on TL type beacons is almost entirely absent. However, with either type of beacon it is necessary to guard against functional inequalities of the transmitting equipment, which must be carefully and frequently serviced and monitored as to frequency and antenna output.

Bending of range courses is caused by refraction of radio waves by electrical obstacles in the terrain over which they pass. Occurring chiefly in the mountainous areas, this phenomenon is commonly called mountain effect, although it is also encountered in level country where the electrical obstruction may be a river, or a railroad track, or a deposit of conductive ore. Bending occurs only when the obstruction lies obliquely to the path of the radio wave front; this change of the wave front is a constant phenomenon peculiar to the terrain involved, and although the amount of bend will vary somewhat with altitude and weather conditions, the refracted courses are fairly stable.

These permanent bends in the courses are often mistaken by pilots for course shifting; indeed, under conditions of low visibility, the changes of direction necessary to remain on course are identical with those occurring during course shifting. In either case, it is not the pilot who loses the beam: the beam loses the pilot.

The most prolific source of difficulties in radio navigation — and one most prone to lead to an accident—is the phenomenon of multiple courses. The mechanics of multiple course production are not yet completely understood, although it is logically conjectured that they are caused by reflection of radio waves, possibly combined with refraction. They are extremely irregular as to type and location,



Various types of multiple courses.

which varies with altitude, distance from beacon station, and time of day. Generally speaking, the angular arc in which the multiples occur extends as much as 10° to 15° to either side of the true course.

The accompanying diagram shows several types of multiples. On each leg a different type of multiple has been shown, although all types may exist on one single leg, and be absent on the other legs. On leg 1 are shown multiple courses bounded by the same letter on each side of the multiple on course signal. These are easily recognized and present no special danger.

Leg 2 illustrates another type of multiples, not bounded by the same letter. These are easily confused with the true course, and require considerable experience to recognize. The diagram reveals, in the *N* quadrant, a case of two adjacent multiples giving *reverse* orientation —a not uncommon and extremely confusing phenomenon.

On leg 3 is a typical multiple course arrangement likely to occur in a generally mountainous country; while leg 4 shows the appearance of multiples occurring beyond a point where there is a major change in terrain.

Generally, a multiple course can be recognized by its narrow width, in comparison with the true course; nor can they usually be flown for any great distance before they disappear. However, they present a most serious obstacle to orientation, especially when close to the station where a multiple can be interpreted as passing two beam legs. In applying the 90° system of orientation to a radio range where multiples and other phenomena exist, it is necessary to fly for a considerable distance, after making the 90° turn, and select the true course among the several encountered. It must be noted that a multiple need not necessarily be heard when approaching the true course.

Antenna design and its location on the airplane have a considerable bearing on the indicated signal. Most antennas used for beacon reception today have a substantial horizontal component, while as much vertical component as possible is provided at the same time. Even with the vertical transmitting antennas of the TL type, the horizontal component in a receiving antenna is extremely important, as the projected area of the antenna to the station will not be at a minimum when flying directly over the beacon station.

The cone of silence, in the case of the loop type beacons, is almost entirely due to the antenna design on the airplane; there is no actual cone of silence in space above the loop type beacon. A vertical antenna on an airplane will show a cone of silence effect over either the loop or the TL type beacon, while a loop (correctly mounted for the purpose) will show a cone of silence only over a TL antenna.

Antenna design also influences the apparent width of the beam, as well as the *A-N* signal ratio (on course signal) when flying a course corrected for drift. The directional effect of the horizontal component, when following a course at a drift angle, will result in a slight apparent shift of an otherwise stable course, because of the induced change of the antenna's responsiveness to the *A* and *N* quadrant signals. This directional effect has even been utilized for rough direction findings (as on the old Northrop mail ships and in the original Bureau of Standards instrument landing system).

Correct antenna design is essential for radio navigation, and the pilot must be familiar with the pecularities of the antenna array employed on his ship. In addition to following a course correctly, the antenna should be suitable for orientation, and provide easy and definite identification of the cone of silence.

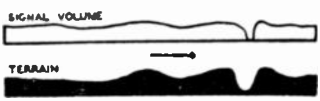
In this connection, the tests recently conducted by the TWA engineers are illuminating. These conclusively showed that the cone of silence phenomenon is a function of both the receiving and the transmitting antenna, and added materially to the knowledge of the phenomena of refraction and re-radiation of radio waves by the airplane's structure, especially the wing.

In the diagram, under *A*, is shown the cone of silence as received by a vertical antenna in space. The surges of signal intensity preceding and following the cone are equally defined. The period of absolute silence over the cone of a TL station is longer than that over a loop station, as in the former case both the station and the airplane's antenna gave an additive result.

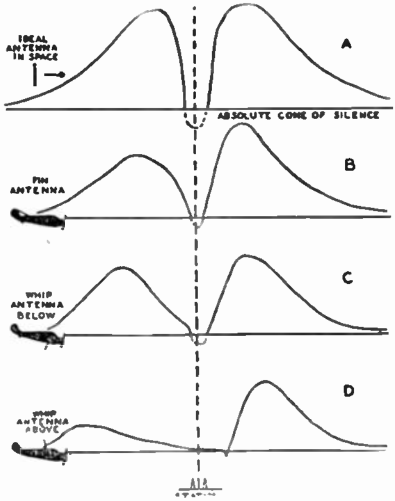
The standard fin antenna, in *B*, will give a smaller and more gradual surge in approaching the beacon because of the smaller projected area of the antenna to the station; the effect on the surge after the beacon is passed is opposite for the same reason. With loop type beacons, the cone of silence will be observed slightly before the station is reached; the logical conjecture that over a TL beacon two cones of silence should be heard (one due to transmitting station, the other to the receiving antenna) was borne out by observation. The two cones occur almost simultaneously; the antenna cone of silence is rarely distinguishable from the deeper beacon cone of silence which immediately follows.

A most satisfactory type of aircraft receiving antenna is shown in *C* — the "whip" antenna mounted beneath the fuselage, maintaining in flight approximately the curved shape shown. It is free from refraction effects of the wing, and having but a small horizontal component (and therefore a good cone characteristic of its own) it gives a longer sustained cone of silence effect when passing over the station; the horizontal component present is sufficient to level off somewhat the signal surges before and after the beacon is reached, requiring less volume control adjustment.

The same whip antenna, mounted above the fuselage (at *D*) is unsatisfactory; the reason for its poor performance is apparent from the diagram. Considerable refraction takes place and the wave front is



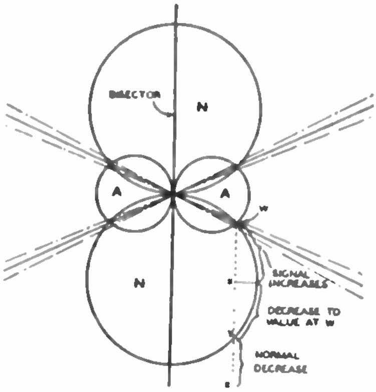
Typical effect of terrain on the volume of received signal. Arrow shows direction of flight.



Effect of antenna design on reception of the cone of silence phenomena.

distorted and tipped as it comes over and around the wing. The approach surge is low and badly defined, and the indicated cone of silence occurs at a point well past the beacon station (34° from vertical in tests). This may be taken as proof that the oft-discussed swaying of the cone of silence actually does not take place but is wholly a function of the airplane's receiving antenna.

Inequalities in the received signal intensity may be construed as an indication of the terrain over which the airplane passes. There is a definite relation between signal level and the topography; unfortunately, it is not definite enough to be of practical value. In flying away from a station and toward an increase in ground elevation, the signal level will have a tendency to



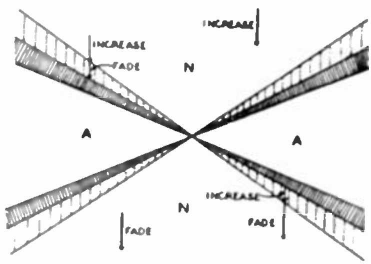
How signal level reversal occurs in orientation on squeezed courses.

rise; if a sharp irregularity in the terrain, such as a canyon, is encountered, the signal level will momentarily drop to inaudibility. This false cone of silence usually occurs when passing over the far rim of the canyon, and should not be confused with the true cone because the surges before and after the silent period are small and seldom require adjustment of the receiver volume control.

Although such variations in the signal level are not necessarily confusing in following a course, they must be reckoned with in solving orientation problems. After making the 90° turn, the course must be maintained until a definite rise or decrease in the signal level is observed. A typical case of signal level reversal over electrically-good terrain is shown on these pages.

When orienting in the wide quadrants of a squeezed radio range, the signal will obviously show a fading following the initial increase, just before a course is reached; conversely, when flying away from the course on a line substantially parallel to the wide quadrant bisector the signal will first rise. Again, the necessity for maintaining a course until the signal level change is established beyond doubt is clearly demonstrated.

The phenomenon of apparent signal reversal on an otherwise stable course occurs only when the receiver is operated at its maximum output. It is due solely to the blocking of the receiver. All receivers have an overload point beyond which increase in volume control does not result in increase of audible signal. When this overload



Signal level reversal effect.

point is reached, the radio tubes are blocked out of their normal operation, and upon increasing the volume further the signal level actually decreases. Thus, approaching a radio range in the *A* quadrant with the receiver overloaded, further rise in the strength of the received *A* signal will manifest itself in reduced audibility, allowing the background *N* signal, as yet below the overload point, to predominate.

◖ From Electronics,
January, 1938

Reviewing THE VIDEO ART

●

Members of R.M.A. Committee on Television, meeting at Rochester, reveal status of work now in progress here and abroad.

●

BEHIND the scenes of television development in this country there is no more important a group than the R. M. A. Committee on Television, which for the past three years has been active in formulating tentative standards and in evaluating progress made by various companies engaged in television research.

In 1934, when cathode ray television began to emerge from behind locked doors, there was no agreement among the various companies on what constituted a good television picture. In fact, there were as many different ideas on television standards as there were experimenters.

Now, scarcely four years later we find the industry, the technical part of it at least, presenting a solid front on television standards, and with such good effect that their recommendations have been accepted, substantially, by the Federal Communications Commission in setting up the allocation for the ultra-high frequencies. This achievement may be credited almost exclusively to the work of the R.M.A. Sub-Committee on Television Standards, reporting to the R.M.A. Committee on Television, in whose meetings many differences of opinion have been ironed out, and which is at present engaged in collecting information which will permit standardization on those points now the subject of discussion.

As evidence in this data-collecting program the R.M.A. Committee, of which A. F. Murray is acting chairman, held a meeting during the Rochester R.M.A.-I.R.E. Convention with the purpose of reviewing the status of work being done by the various organizations represented and to report the results of visits in foreign countries made by members of the committee. At this meeting eleven short reports were presented, seven regarding work being done by organizations in the United States and four on visits to Europe. The following report of that meeting is presented herewith.

• Synchronizing Problem Stressed

D. E. Harnett, reporting for the Hazeltine Service Corporation, stated that in its program of television receiver development, Hazeltine has found that the British type of signal (discussed in the October issue of *Electronics*, p. 32), presents, in the company's experience, better synchronizing performance than the type of signal radiated last year by the Empire State station.

It was revealed that a type of frame-synchronizing impulse has been developed in Germany which differs both from the American and British systems. In brief, the synchronizing pulses which initiate the beginning of each line in the image are omitted for a short interval at the end of each half frame. The frame-frequency oscillator is then tripped by the appearance of the next line impulse. During the interval between half-frames, the line impulses pull the line circuit oscillator back into synchronism before the beginning of the next half-frame. While the Hazeltine experimentation with this system is incomplete, the company has found that it offers considerable possibilities of smooth synchronizing performance.

Following Mr. Harnett's statement, E. F. Kingsbury of the Bell Telephone Laboratories reported briefly on the present status of the coaxial cable development. Mr. Kingsbury described the experimental television test of this cable.

One interesting fact revealed by Mr. Kingsbury is that the steel scanning disk used for generating the pictures in the coaxial cable system is slightly cup-shaped when stationary and hence the lenses in the disk must be focused while the disk is in motion, since at high speed the disk flattens out, changing the position of the lenses relative to the film.

F. R. Lack of the Bell Laboratories pointed out that the demonstration of television over the coaxial cable was not primarily intended as a demonstration of television but was rather a test in the frequency-band carrying capacity of the cable itself.

• Modulation System and Synchronizing Impulses

F. J. Bingley briefly reported work carried out by Philco during the past year, emphasizing particularly the subject of synchronizing signals, advocating the "narrow-vertical" type, and reporting the successful operation of the wide band modulation system which permits modulations of all frequencies from zero to above 4.5 megacycles in a standard television transmitter. Mr. Bingley also reported that progress has been made in the development of materials for cathode-ray screens, stating that some good black and white materials had been obtained.

• Propogation Study Reports

E. W. Engstrom of RCA revealed

that studies have been made by RCA of horizontal versus vertical polarization with relation to the noise picked up by the receiving antenna. These studies have revealed definitely that horizontal polarization produces the strongest signal in relation to noise and is freer from signal variations.

Mr. Engstrom reported that experience at the boundary of a service area where noise is strong in relation to the signal, indicated that the "serrated" type used by RCA and the British Broadcasting Company produced better results than other systems tested by RCA, of which there were six or eight examined in the past two or three years. He stated a preference for d.c. transmission, i.e., the variation of average carrier power in relation to the background light level of the picture, which would permit obtaining the bias value for the cathode ray tube directly from the output of the second detector of the receiver. This is in accord with present British practice.

Decision on the polarity of transmission seems to hinge on methods of automatic volume control in receivers. RCA preference, in the event that a choice should be made immediately on the basis of systems now available, would be for negative transmission, i.e., an increase in carrier amplitude corresponding to a decrease in light. Work is now being carried out by RCA to determine whether or not there is any difference in performance between single and double side band reception, when multiple path transmissions are encountered because of the presence of buildings, etc., in or near the path of transmission. Work on this aspect is not sufficiently complete to report.

- CBS Prepares

Dr. Goldmark, in charge of the television activities of the Columbia Broadcasting System, reported that during 1937 CBS completed an experimental television transmitter operating on 52.5 Mc. which had been designed and built for the standard of 441 lines and 30 frames per second. The video signal is obtained from a film scanner using a dissector tube of the Farnsworth type, including a 9-stage electron multiplier. The film is moved continuously past the scanner. Two type 806 tubes operating in push-pull providing a 50-watt output are used.

Dr. Goldmark remarked that two standard RCA test patterns used as a basis for the signal had been resolved to about 90 per cent of their total content without appreciable phase shift.

A considerable portion of Dr. Goldmark's report had to do with the new television studios now being installed at the Grand Central Terminal in New York. This studio measures 60 ft.x130 ft. and will be equipped with two types of studio equipment (RCA and Farnsworth), mounted side by side. A film channel of the RCA type and two of

CBS design will be employed. Some time this year the high power television transmitter purchased from RCA by CBS will be installed.

Robert Morris, in charge of the operation of the NBC television system, discussed the complete overhauling of the equipment to change from 343 lines to the RMA standard of 441 lines. This work, started in December, 1936, is not yet complete; it involves adjusting all of the channels of eight or nine local monitors and five camera chains with their associated amplifiers, to a band width of 3½ to 4 megacycles.

• British Practices

H. M. Lewis of Hazeltine, who wrote on British television in the October issue of *Electronics*, reported briefly on his trip to Great Britain. The outstanding features of the British television images, according to Mr. Lewis, are their stability, freedom from faulty synchronizing, and their wide contrast range. The faults were a tendency of some receivers to exhibit weaving of interlace, and the shading effect present in the Emitron cameras. What projection tubes he saw he considered to be of inferior performance. The best results were obtained from mechanical scanning of film and with cathode ray tube reception.

• Recounts Foreign Impressions

Mr. Lack of the Bell Laboratories, reporting on his recent trip to Europe, emphasized the advantage and superiority of mechanically-scanned film.

In Berlin he saw 180-line mechanically-scanned film which appeared to have greater detail than pictures of many more lines shown in this country. This he attributed to the excellent contrast range present in the mechanically-scanned picture.

He agreed with Mr. Lewis that projection images in general were not satisfactory. At the Radio Show in Berlin, Dr. Lack had the opportunity of comparing equipment made by various manufacturers which were operating in adjacent booths. The best picture at this show, in his opinion, was produced by a very simple arrangement: Film, mechanically-scanned, produced a signal in a multiplier photocell, the output voltage of the multiplier photocell being sufficiently high to operate directly the grid of the reproducing cathode ray tube, that is, without any intervening amplifier. This picture, which had excellent contrast and detail, was given as an ideal which more complex systems, including amplifiers, transmission lines and transmitters, will have to approach.

Mr. Engstrom, also speaking of his visit to Europe, concurred with many of the statements made by the other speakers. He attributed the technical excellence of the British system to the good job done on the transmission systems and to the uniformly excellent performance of the transmitter and studio equipment. Of the receivers he saw, not all produced good performance with relation to interlacing, but several receivers did do so. It is believed that this question is one primarily of engineering design, requiring a fundamental understanding of the problem.

The concluding report was presented by CBS's Dr. Goldmark. In England he was impressed with the sensitivity of cameras employed and with the strength of the signal. The impression was that the non-mechanical transmissions of film were inferior to those of the direct pick-up. A demonstration of the Scophony mechanical projection system, which impressed Dr. Goldmark favorably on his visit, was reported by an executive of the CBS company to have been used on a 405-line, interlaced picture using the transmissions of the BBC. According to the report of this executive, the picture was of very high quality, surpassing all other types in brilliance, definition, gradation and size.

In Germany, Dr. Goldmark viewed a 6-ft. wide picture projected from a cathode ray tube operating with an accelerating voltage of 20,000 volts. The 441-line image had excellent definition, gradation and freedom from geometrical distortion. The iconoscope type of camera developed by Fernseh A. G., according to Dr. Goldmark, does not show any shading effect and seems to have excellent sensitivity. Most of the German experimenters are employing scanning discs for the transmission of film, in conjunction with multiplier type phototubes.

Among the recent demonstrations of television viewed by the editors was that of RCA-NBC (for the ARRL) December 8. This program, the longest ever attempted by the NBC staff, included a full-length Sherlock Holmes play, acted in the studio, and shorter interludes of film and "live talent." The entire performance lasted one hour and was easily the best demonstration from a technical and artistic point of view yet given by this organization.

The Kolorama Laboratories of Irvington, N. J., demonstrated a projected picture of about 3 by 4 feet, formed by a mechanical scanner and Kerr-cell arrangement. Only film subjects were shown, and no technical details of the system were released. The detail of the picture was less than that of other demonstrations.

The Peck Television Corporation has combined television methods with facsimile in their recently demonstrated "Television Bulletin Service." A message typed on transparent tape, is scanned by a lens disc, and converted into a video signal of low definition. The signal is then placed on conventional land wires and sent to the receiver which recreates the image by means of a Kerr cell and lens disc, projecting the image on a translucent screen.

From QST*
February, 1938

Inexpensive Coaxial R. F. Transmission Line

(See Page 50 for Photographs)

BY DOUGLAS A. SMITH

THE PECULIAR situation at W2BZR prompted the use of coaxial transmission line.

The biggest drawback to the coaxial lines commercially available was cost. In one instance 250 feet of line would have cost $250. The lowest-priced cable we could locate was a few cents less than a quarter per foot — this still ran into too much money. So we decided to build the line ourselves.

• Brass vs. Copper

Most commercial lines are made of copper tubing; we actually bought 250 feet of this ⅜-inch thin-walled tubing in 50-foot coils, and found it filthy on the inside. At least a good tablespoonful of muck and copper filings was swabbed out (in the same manner as cleaning a gun), and we realized that this type of tubing would never do for high-frequency work. So we lugged it back to the metal supply house, and while trying to get a line on cleaner copper tubing with fewer irregularities in the inside, we saw some thin-walled brass tubing. The inside of this brass tubing was as clean and shiny as the inside of a shot-gun barrel. It fitted our 5/16-inch Isolantite beads perfectly, with only about 0.01-inch play between the bead and the tubing. One disadvantage (we thought, before asking the advice of a Bell Laboratory man) was that the brass tubing only came in 14-foot lengths. Another question we had in mind was whether the brass would be as efficient a conductor as copper. This fear also was quelled by our Lab friend.

But how about bending this hard-drawn brass tubing? The answer is to use right-angle coaxial joints. With such a gadget, geometrical layout of the line is possible. However, it is possible to obtain a good deal of flexibility when the line is completely assembled. Our line wends its way between trees and bushes and through the brow of the knoll much like a long snake—

**Journal of the American Radio Relay League, Inc., West Hartford, Conn.*

underground of course, about six inches.

Those unfamiliar with concentric-line construction can readily get the idea from figures 1 and 2. The inside conductor, a piece of no. 12 wire with Isolantite beads crimped into position every two inches (approximate eye measurement), is slid into the brass tubing. The resulting line has a characteristic impedance between 72 to 75 ohms, which is approximately the impedance at the center of a half-wave antenna.

The advantages of this type of line over open-wire lines are many. With coaxial cable the impedance is constant. Second, the losses are negligible at frequencies up to 14 Mc. Even at 28 and 56 Mc. the losses are so trivial over the average length feeder that they might as well not be considered. However, for the sake of those who really want the facts the tabulation below is taken from information compiled by Bell Laboratories:

LOSS IN DB FOR VARYING LENGTHS OF COAXIAL LINE (3/8" O.D.)

	Per Mile	Per 1000 Ft.	Per 100 Ft.
2 Megacycles	8.5 db	1.6 db	.16 db
4 "	12.0 "	2.2 "	.22 "
7 "	16.0 "	3.0 "	.3 "
14 "	22.0 "	4.1 "	.4 "
30 "	34.0 "	6.4 "	.64 "
40 "	40.0 "	7.5 "	.75 "
56 "	56.0 "	10.6 "	1.06 "

Third, with a coaxial line complete grounding of the outer conductor can be obtained, either by a typical ground connection at one or both ends or at the middle, or by burying it underground. Thus there is no possibility of transmission line radiation and its attend ant highly undesirable features.

Now for the actual construction of the line. Figure out how many feet of wire will be needed and get a little extra. Use hard-drawn or semi-hard no. 12 bare copper wire; the impedance will be off slightly if enamelled wire is used. Next procure the Isolantite beads or spacers. For 3/8-inch outside diameter 0.02-inch wall brass tubing, a bead approximately 5/16 inch in diameter should be used. The tubing and bead sizes are readily available and will give an impedance of 75 ohms, according to Handbook formula for designing coaxial lines.

String the beads loosely on the wire. If you have a long length to work, it is best to construct two reels, winding the wire on one and having the other available for the finished beaded wire. The problem is to crimp the wire on each side of the individual beads to keep them from slipping, and yet not break or distort the wire. After about two weeks of experimenting with all sorts of gadgets, a 50-cent pair of pliers (Woolworth's best) as shown in figure 2 was decided upon.

Simply file the cutting edge to a point where the pliers will no longer cut wire. Leave a slight space, of the order of 0.01 inch, between the edges. Then procure a key file at the local hardware store and file two square notches opposite each other in the two old cutting edges, these notches to be just a hair or two less in width than the diameter of the no. 12 wire. The depth should be such that when the wire is squeezed in the notches it will have a tendency to be flattened and two little bulges will fill out at either side of the notches into the 0.01-inch gap left between the old cutting surfaces. These bulges will keep the beads from sliding along the wire.

The "crimps" as they are termed, must be made on each side of the bead, and should be as close to the bead as possible to keep it from sliding back and forth. Be sure the notches in the "crimper" are filed square and not round. It is not necessary to take the temper out of the 50-cent pliers before filing; they will file very easily "as is."

After a few evenings spent crimping the beads on the wire you are probably either ready to call the whole thing off, go to the doctor to have your thumb cured of arthritis—which happened here!—or else you're ready to slide the brass tubing on.

I say "slide" because that is exactly what we did here. We kept our center conductor (250 feet) all in one piece and slid the 14-foot sections of tubing, together with the necessary fittings, over the beads already crimped on the wire. Not a single bead chipped or broke. This method makes for higher efficiency since no soldering is required to connect the center conductor wire from 14-foot lengths into the required footage.

Of course before any tubing was put on we had soldered the center conductor of the end seal to the center conductor of the line, and the first piece of tubing on the wire was made fast to the end seal with gas-tight fittings. In our particular case spark plugs (Y-4 Champions) were used for end seals. As they are threaded for ⅜-inch threads it was easy to ta~ and cut one of the brass fittings in such a way as to allow the small plug to be coupled.

However, as it is rather a ticklish job to take out the spark plug's center conductor without cracking the porcelain, we suggest procuring end seals now made available by several manufacturers. Simply ask for an end seal for a ⅜-inch outside diameter concentric or coaxial line.

With gas-tight lines in automobiles and refrigeration units, it is not necessary to sweat joints—heretofore the customary method of connecting sections of tubing in coaxial lines. In sweating such joints solder often would leak into the line and cause shorts or arc-overs. Don't solder the line together if you want trouble-free operation.

• Right-angle Joints

Assuming that the line is completed as far as the wall or window where it is to be brought into the transmitter, perhaps it is necessary to make a sharp bend to make a neat installation. Being brass tubing, the line refuses to bend, so now you use a right-angle coaxial joint, figure 2. This joint, believe it or not, maintains the 75-ohm impedance even though the center conductor is bent at a 90-degree angle.

These joints are made of brass stock 5/16-inch thick by 1 inch wide. Two squares of this stock 1 inch to the side are clamped in a vise and drilled and tapped for whatever thread size you have available, one section being drilled and the other tapped so that when screws are inserted and tightened the two blocks will fit together snugly. This must be an accurate job, and we would suggest you have it done by a local machine shop unless you are well equipped to do it.

Next, place the two sections in a vise and drill, accurately, ⅜-inch holes through two sides halfway through the two sections. You then have two ⅜-inch holes drilled at a 90-degree angle to each other, meeting in the center of the two sectional blocks of brass.

Now coat the inside surfaces between the blocks with Duco cement, bend the wire accurately so it does not touch either wall of the right-angle hole, insert the ⅜-inch brass tubing into each hole about ¼ inch and tighten up the four screws holding the two brass sections together.

• Preventing Moisture Condensation

An end seal must be used at both ends of the line. Outlet and inlet fittings and a 0-80 pound pressure gauge should also be mounted in the line if it is to be filled with nitrogen gas. However, we have had no occasion to use gas in our line, and it has been lying six inches underground now for three months. Gas is used in these lines when they are installed for broadcast stations, but we know of many ultra-high-frequency police installations that have been operating perfectly for many months without gas.

The purpose of the gas (nitrogen drawn off through oil) is to give the line a greater voltage-breakdown factor between center and outer conductor, and also to keep out water and prevent condensation within the line. The average pressure maintained should be in the vicinity of 25 pounds.

A much easier system to use for clearing out condensation (if you ever do get any—we haven't yet) is to fill a Mason jar not quite full of calcium chloride. Push a brass or copper tube down through a rubber stopper almost to the bottom of the jar. Then put another brass tube through the stopper so it just projects on the other side. This is bent over and similarly connected to a second Mason jar filled with cotton batting. This tubing goes to the bottom of the second jar. A third tube goes down through the stopper of this jar to the top of the cotton batting and is then connected to the line.

The first tube is connected to a bicycle pump and air is pumped into the first jar through the calcium chloride out into the next jar up through the cotton batting and out through a hose to the coaxial line. You then have air free of moisture content pumped into the line's inlet valve and out through the outlet valve near the end of the line. Any moisture in the line will be dried up.

Thus, you have a workable coaxial line. Any radioman can build it. Except for the coaxial joints, which were made in a local machine shop, no tools are required other than those ordinarily found in any amateur station, plus a couple of wrenches out of the "flivver's" tool kit.

Coupling the coaxial line to the antenna is simple. Merely anchor each section of the antenna to the pole and run flexible copper braid of soft-drawn copper wire leads neatly from the end seal connections at the end of the coaxial line. One side of the flat top is soldered to the brass tube, the inner conductor going to the opposite half. No fanning is necessary.

Coupling to the transmitter is likewise easy; use a coupling coil at the cold end of the tank inductance or, in the case of push-pull stages, at the center of the inductance. Tune the final stage to resonance before coupling the coaxial line, then connect your coupling coil to the line and vary the number of turns until the proper amount of plate current is drawn by the tube or tubes.

●

Broadcast Engineers Conference

SUCH names as those of George H. Brown, W. L. Everitt, H. H. Beverage, J. H. Dellinger, W. H. Doherty, George M. Nixon, J. F. Byrne, A. E. Thiessen, H. L. Oleson, H. M. Hucke and P. C. Sandretto were found on the roster of those leading discussions at the broadcast engineering conference held from Feb. 7 to 18 at Ohio State university. The school's department of electrical engineering sponsored the sessions, which were attended by leaders in the industry from United States and Canada.

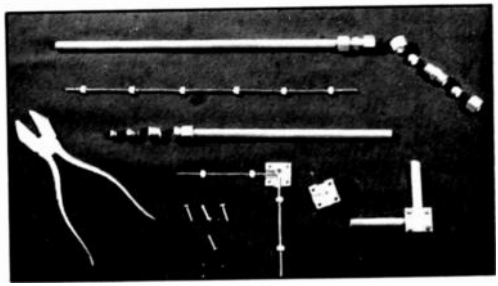
Byrne was scheduled as group leader for the talks on field strength surveys; Beverage, ultra-high-frequency propagation; Everitt, coupling networks; Dellinger, propagation of broadcast frequencies at night; Nixon, studio acoustics; Brown, broadcast antenna design; Doherty, high power radio frequency amplifiers; Thiessen, modulation and distortion measurements; Oleson, indicating instruments; Hucke, snow static effects on aircraft, and Sandretto, aeronautical ground radio station design. Everitt conducted demonstrations of phenomena of interest to radio engineers.

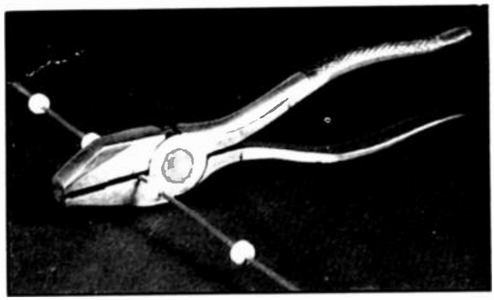
—Condensed from COMMUNICATIONS.

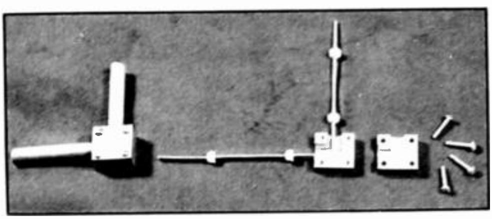
Low-priced Coaxial Transmission Line

(Photographs Courtesy QST)

Tools for building Coaxial Cable







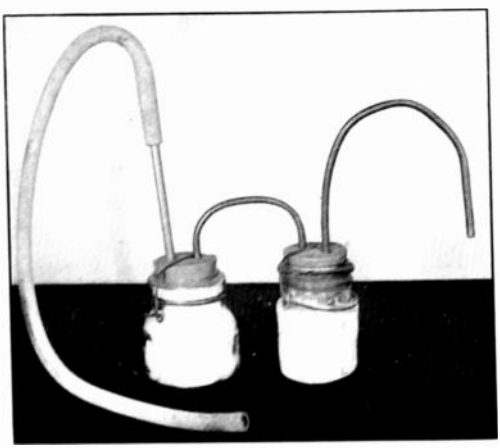
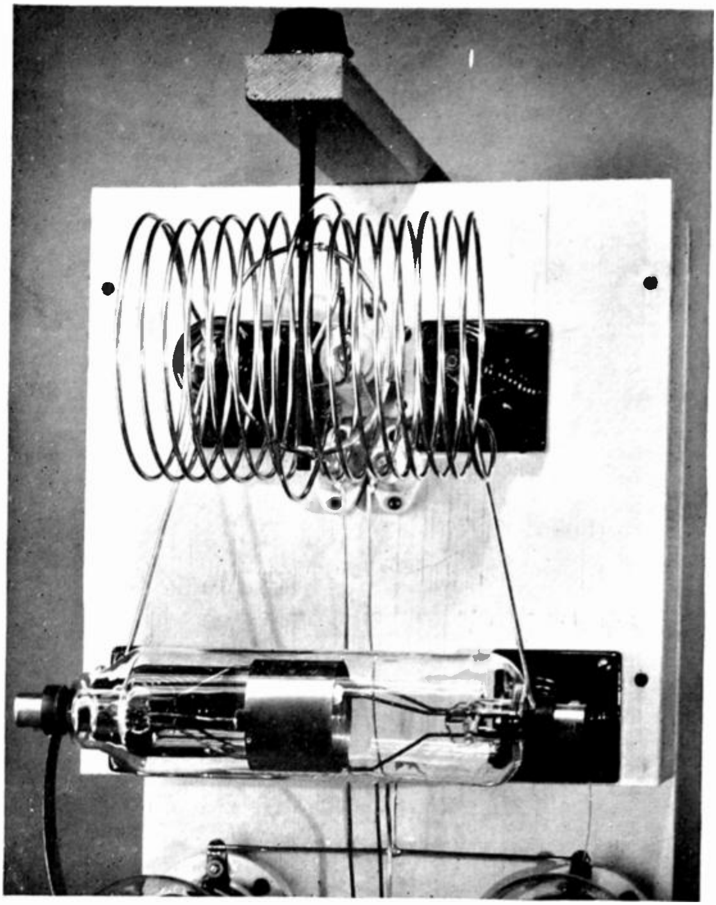


Figure 1. Gadgets used in constructing the line.

Figure 2. The crimping tool ready to take a bite.

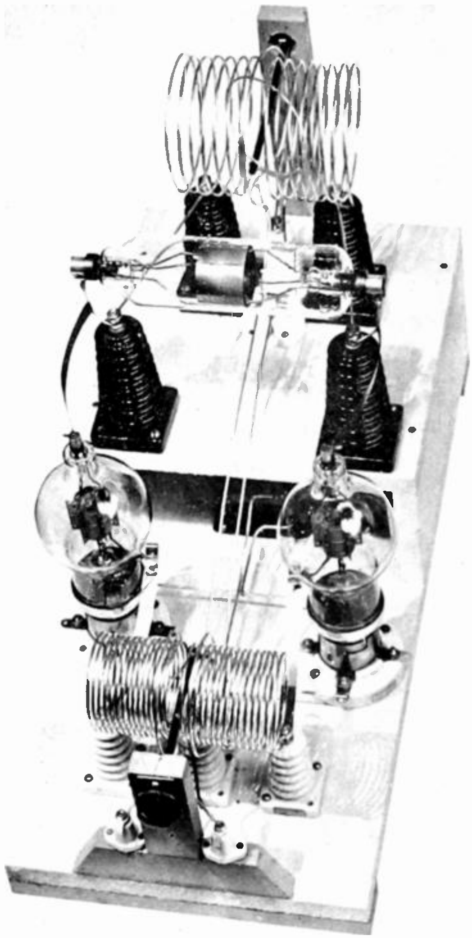
Figure 3. Left: completed right-angle coaxial joint. Right: the joint ready to be assembled.

Figure 4. The air-drying apparatus.



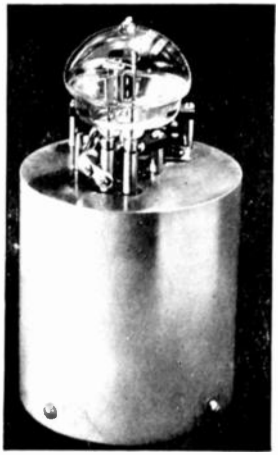
Something Different . . . . .

The business end of the fixed-capacity final described on page 22. The "tube" is a high-voltage fixed tank condenser. The link is part of the neutralizing circuit and the shorted loop resonates the plate circuit.



The experimental amplifier utilizing inductive tuning and linked neutralization.

...in Amplifiers

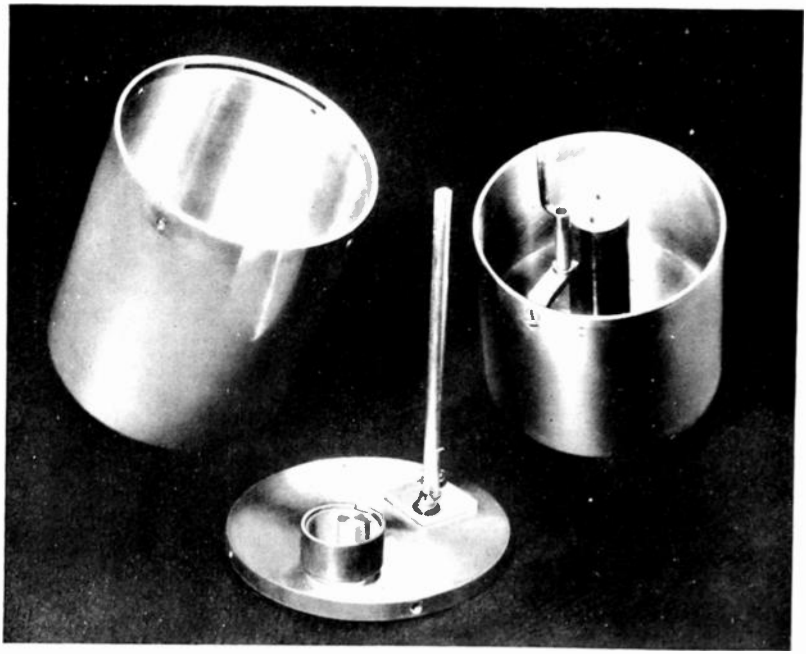


U. H. F. OSCILLATOR

Figure 1. The complete oscillator, consisting of tank circuit and vacuum tube. Overall height is 7 inches.

Figure 2. The concentric-element tank circuit taken apart. The outer brass shell is shown on the left, the inner copper cylinder on the right. The brass disc in the foreground closes the brass cylinder after the copper insert has been placed in position.

(Photos, drawing courtesy General Radio Co.)



¶ General Radio Experimenter,
October, 1937

A Highly Stable Ultra-High-Frequency Oscillator

BY ARNOLD PETERSON

The widening field of usefulness for ultra-high frequencies in radio communication has naturally stimulated the development of equipment for making measurements at those frequencies. Measurements of such factors as reactance, resistance, dielectric constant, permeability, and power factor are necessary both to prove the acceptability of existing designs and to provide a basis for the development of new designs and the application of new materials.

A prerequisite for measurements at any frequency is a satisfactory power source such as the one herein developed by the author.

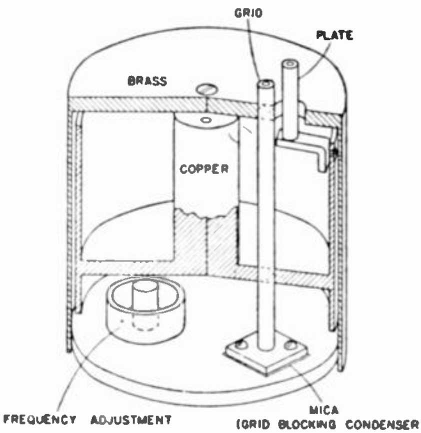


Figure 3. Sectional view of the tank circuit showing details of assembly.

VACUUM-TUBE oscillators for operation at ultra-high frequencies have received considerable attention in the last few years. Improved vacuum tubes have permitted the use of circuits which govern the frequency of oscillation to a much greater degree than is possible at these frequencies with the older and more conventional tubes. Several tank circuits for frequency stabilization have been developed, notably the parallel-wire and coaxial transmission lines and the Kolster toroid. None of these, however, meets all the requirements for a satisfactory laboratory source. These requirements are as follows: (1) A high degree of frequency stability under varying external conditions, (2) a confined electromagnetic field, (3) ample output for use as a source for high frequency measurements, and (4) a convenient physical size. A good compromise between these conflicting require-

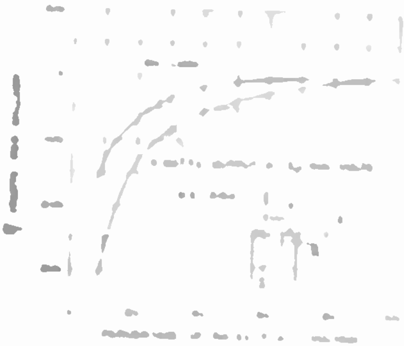


Figure 4. Change in frequency produced by a variation in applied plate voltage. The upper curve is taken at no load, the lower with a load of [illegible] watts.

[illegible]ments has been achieved [illegible] oscillator [illegible] tube especially designed for the ultra high frequencies coupled to a lumped concentric [illegible] circuit.

This tank circuit consists of an outer [illegible] cylinder with [illegible] cylindrical [illegible]. Referring to figures [illegible] and [illegible], it is perhaps simplest to consider the oscillatory tank circuit as a [illegible] circuit whose capacitance is that formed by the outer cylinder and the large inner copper tube and whose inductance is that obtained by the field surrounding the inner copper rod. The dimensions of the tuned circuit are sufficiently small in comparison with the wavelength to permit its treatment as a lumped circuit.

The effectiveness of this oscillatory circuit for frequency stabilization [illegible]

[illegible]

[illegible]

types of oscillators for this frequency region.

Because of the method used in the measurement of these changes in frequency, these results contain no appreciable drift effect and can be considered as essentially dynamic measurements. That is, the effect of physical changes in the oscillator as a result of varying thermal conditions was minimized in order not to mask the effect of dynamic changes in the tube parameters.

A rapid variation of the applied filament voltage produced only a very small shift in the frequency. However, a slow variation in the filament voltage which permitted the thermal equilibrium of the filament to readjust itself produced a change in frequency opposite in sense to, and somewhat greater in magnitude than, that produced during the rapid variation of the plate voltage shown in figure 4.

The ambient temperature coefficient of frequency of the oscillator has been made less than the temperature coefficient of expansion of the individual metals which are used in the tank circuit. This reduction has been accomplished by the proper utilization of the differing temperature coefficients of expansion of brass and copper to produce a tank capacitance with a negative temperature coefficient which approximately balances the positive temperature coefficient of the inductance. By this means, an ambient temperature coefficient of frequency of less than 5 parts per million per degree Centigrade is readily achieved.

The drift in frequency of oscillation during the warming-up period for the unit illustrated is given in

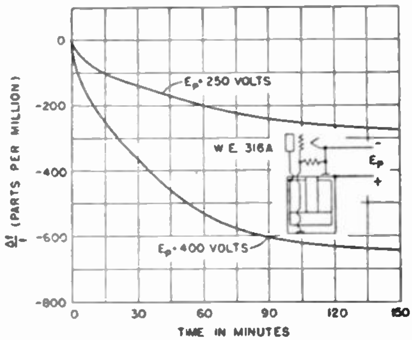


Figure 5. Drift in frequency of oscillation during warming-up period at plate voltages of 250 volts and 400 volts.

figure 5. This drift, which is approximately proportional to the input power to the plate circuit, is primarily a result of changes in the spacing of the tank condenser because of the temperature differential developed in the oscillator. By a change in the design of the given tank circuit, this drift can be materially reduced. However, to accomplish this reduction, the physical size should be increased, or the resultant frequency stability during varying electrode voltage conditions will be lessened. Thus, for a given application of this type of oscillator, unless compensation means are used, a design which effects the best compromise for that application should be adopted.

¶ From Television,
Vol. 2

Television Problems . . .

A Description For Laymen

BY ARTHUR VAN DYCK

Manager, RCA License Laboratory

PART 2. See January-February, 1938, RADIO DIGEST for Part 1 in which transmitters are discussed.

SO FAR, we have not considered the receiver specifically. That, to most people, is the most interesting part of the system. So let us now consider the receiver, but let us do so with clear understanding that it is only part of a *system,* and that it must have and maintain an intimate, accurate relationship to the rest of the system.

The television receiver antenna is energized by the travelling waves, which cause corresponding currents to flow from the antenna to the receiver. The receiver is tuned to the particular frequencies to be received in order to maximize the ones desired and to minimize undesired ones, just as in a sound receiver. These currents, even when tuned in to maximum, are very small, and are fed into vacuum tubes to be amplified. After this operation they are large enough to operate a device designed to convert them into light images. This device is called the "Kinescope", and is the inverse of the "Iconoscope".

The tiny electron beam in the "Kinescope", whenever it is not moving and therefore strikes the screen in one spot, causes a bright glowing spot on the screen at the point of contact. This spot is about the size of a pinhead. Although the glow is really on the inside of the tube, it is visible on the outside because the end of the tube is clear glass, and the screen of flourescent material is very thin. The brightness of the spot depends upon the strength of the electron beam, and

Condensed from a lecture given before the Brooklyn Institute of Arts and Sciences (February, 1937). Complete text appears in Volume 2 of TELEVISION, *published by RCA Institutes Technical Press.*

varies as the strength of the beam is varied. That spot of light is used to reproduce each spot of the picture, one at a time, by moving it around all over the picture area. It must be moved in exactly the same way that the "Iconoscope" beam at the transmitter is moved, which in modern systems is in horizontal parallel lines from top to bottom. So this beam will be very, very busy too. It is going to move all over the picture in regular fashion, and repeat the travel thirty times per second. Furthermore, while moving, it is going to vary in brightness continually as it "paints" the lights and shadows of each tiny element of the picture. To our slowly reacting human eyes, the *spot* will not be visible because it is moving so rapidly, and the screen will appear to be illuminated evenly all over the picture area, but we must remember that actually the light and the scenes are caused by one tiny spot of light, flying over the screen, and varying in brightness as it goes.

MUCH receiver apparatus is for controlling the movements of the beam, and feeding to it the currents which have been received from the transmitter, in order to vary the strength of the beam and therefore the brightness of the flying spot. Of course there are many engineering problems associated with this apparatus. The most interesting ones are those associated with what is called "synchronization", or the necessity of keeping the flying beam of the "Kinescope" in perfect step with the flying beam of the "Iconoscope", even though they may be miles apart with only a tenuous radio connection between. Obviously these two must be kept together very accurately, even though they are moving very rapidly over the picture. It would not do at all to have the beam at the transmitter picking up the sparkle of highlight in the eye of the beautiful television lady artist, while the receiver beam was working where her nose was supposed to be!

The object to be attained may be stated simply. It is merely that the electron beams of the "Iconoscope" and the "Kinescope" are to be kept in perfect step with each other. Each is to travel across its plate or screen in horizontal lines. Each is to start at the upper left corner, let us say, move across the first or top line at the proper speed, quickly jump back to the left and start on the second line just below the first line, complete that, jump back for the third, and so on until it has covered all 441 lines, finishing at the lower right corner. Then it must jump up to the upper left corner and begin again on the top line. Perhaps we should note here that the method of scanning actually used in modern systems does not move the spot in quite such a simple regular fashion, but has a more complex movement such as doing lines alternately, all the odd-numbered ones first, and then the even-numbered ones. This is known as "interlaced scanning" and provides several important technical refinements and benefits.

The beams in each case are made to move by magnetic fields produced by currents in coils mounted on the sides of the "Iconoscope" and "Kinescope". If the right currents are fed into these coils at the right times, the beams will move as desired. At present this is accomplished by making the generators of currents at the transmitter into masters of the situation. They are arranged to send out short timing signals, called synchronizing signals, and there are two of them, one for keeping the beams together horizontally, and one for keeping them together vertically. These signals are additional to the picture signals, so that a television transmitter sends out three different signals, one describing the picture, and two to keep the beams in step horizontally and vertically. Of course, if they were all sent out simultaneously, they would interfere with each other. Therefore the synchronizing signals are sent out very quickly during the short time intervals when the beams are not being used for the picture, but are occupied in jumping back from right to left preparatory to starting a new line of the picture. This means, in effect, that each receiver of all those which may be "looking-in", is continuously receiving instructions and assistance, from the transmitter, by means of which it is enabled to keep its "Kinescope" picture beam exactly in step with the scanning beam at the transmitter.

SYNCHRONIZATION is one of the television problems which has been solved. It is a considerable triumph that we are able to control apparatus at a distance with a precision measured in fractional millionths of a second.

A problem always noticed by the layman, is that of size of the reproduced picture at the receiver. At present there are two standard sizes, one about five by seven inches, and the other about seven by ten inches. Scenes of any size can be televised by the transmitter merely by using the appropriate optical lens to focus them on the "Iconoscope". At the receiver, the size of the picture is determined definitely by the size of the screen on the end of the "Kinescope". There is a limit of physical size beyond which it is impracticable either to build these tubes or to house them in cabinets of reasonable size for the home. It seems to be general experience that the most desirable size of picture for television or motion pictures is that where the height is about one-fourth the distance between the screen and the observer. Such a size seems to give the maximum of realism or emotional appeal. In the home, the desirable viewing distance is at least eight or ten feet, so that the picture height should preferably be at least two feet. There is good promise of eventual accomplishment of this goal, but at present it seems probable that the television receiver which is "just around the corner", will have a picture about seven by ten inches. Often it is asked why this picture cannot be increased simply by optical means with a lens to magnify it several times. This could be done insofar as size is concerned, but the brightness of the picture would suffer in proportion, or actually even more than in proportion, and the original amount of light available from the fluorescent screen is not enough to permit so much speading out.

Only one problem remains to mention. It is one which is encountered by television workers more frequently than any other. It is the question "When will we have television?" That is one problem which has *not* been solved! A simple answer is not possible, because the question is not simple without several definitions. We have television right *now*, under the definition of technical possibility. We will probably have it in a year or two if we limit the definition to include only those people who live within a few miles of a station, with only two or three stations in the country. However, if we mean when will television service be available to most of the people of the country, it seems safe to say that the years between then and now will be goodly in number.

•

World Radio Conference Organized

ORGANIZED by the Institution of Radio Engineers of Australia, a world radio convention will be held in Sydney, from April 4 to April 14, during the final period of the celebrations commemorating the 150th anniversary of the foundation of Australia.

It is believed that this is the first world radio convention ever held anywhere to discuss all phases of radio engineering and to embrace all persons interested in radio. Hitherto when radio conferences have been held in various parts of the world, the majority of them have only included governmental delegates to discuss frequency allocations and general control.

Technical subjects to be considered are wave propagation; telecommunication on land and sea and in the air; broadcast transmission; broadcast receivers; sound projection in talking pictures, recording and amplification; electromedical; television, and general and allied subjects.

Among notable radio figures planning to attend are Sir Noel Ashbridge, chief engineer of the British Broadcasting corporation, and David Sarnoff, president of the Radio Corporation of America. The Marchesa Marconi, widow of the late Guglielmo Marconi, will be another guest of honor.

¶ From The T. & R. Bulletin, July, 1937

NEW IDEAS *for a 56 Mc. Superhet*

BY E. G. INGRAM (GM6IZ)

IT IS quite evident that a great deal more information about the qualities and vagaries of 56 Mc. signals would be forthcoming if properly stabilised transmitters and receivers were used and while at the present time there are several good superhets which perform remarkably well, the writer has for a long time been considering the possibility of producing a receiver for this frequency which would be as stable as a modern broadcast superhet, and as easy to tune.

To those who are keen on the subject from a theoretical standpoint, the following may be of interest, but others must be warned that the idea has not been practically treated by the writer and he cannot vouch for the effectiveness of the project. The circuit is not drawn in all its details as the writer does not wish to fall foul of the many technicians amongst *Bulletin* readers and, in any case, the details are really an unknown quantity until practical tests have been made.

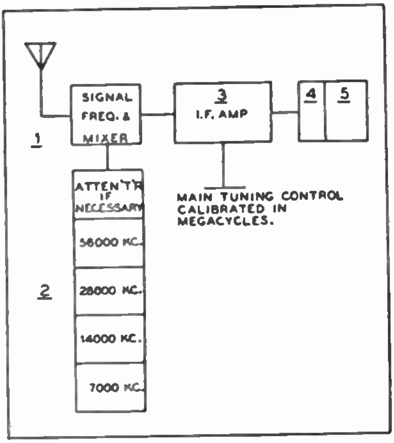
Briefly, the description is as follows:

The first stage is simply the signal frequency input circuit which may be a plain mixer or an h.f. valve, followed by a mixer. Since most of the gain will take place in the i.f. stage, the writer would be in favor of leaving out the h. f.

Coupled to the mixer is the local oscillator, the frequency of which is fixed and is crystal controlled. It should not be difficult even with a 7 Mc. crystal followed by two twin triodes, to get an output of .5 to 3 volts on 56 Mc.

The reason for crystal control here is, of course, to do away with the usually nasty job of tuning the local oscillator on this very high frequency, and also to provide an absolutely stable i.f. signal when receiving a crystal-controlled transmission.

The third stage is the i.f. and while this in the main follows conventional design, it is exceptional in the fact that it is tunable over a range of, perhaps, 500 to 700 kc. The reason for this is that, as the local oscillator frequency is fixed, the i.f. must be made variable to



allow the receiver to tune over part of the band, i.e., with a fixed local oscillator frequency of 56,000 and a variable i.f. of 500 to 700 kc., reception of signals will be obtained on frequencies from 56,500 to 56,700. Naturally, the two (or more) condensers tuning the i.f. stage can be ganged and the dial calibrated directly in Mc. This can be done easily from a standard broadcast frequency meter, knowing the exact frequency of the local oscillator. The i.f. stage would require to be highly selective, but it should not be a difficult matter on this frequency, especially if regeneration is applied.

The fourth and fifth stages are the second detector and the output stage. Nothing needs to be said except that the former could be with or without a.v.c., and the latter suitable for individual requirements.

The writer would advise separate and thorough screening for the various stages, as this will definitely improve the signal to noise ratio and minimize interference between harmonics of the oscillator section and the i.f. section. The i.f. stage would give a more even gain over the range if the coils themselves were resonant, say, about 1500 kc., padded up to 700 kc. and tuned with 200 μμfd. condensers to 500 kc.

From the figures given it will be noticed that the receiver would only tune over a small part of the band, but that disadvantage would be outweighed by the stability and accuracy which would be possible. It should be obvious that any portion of the band can be covered by choosing a suitable crystal for use in the local oscillator.

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In India . . .

Approximately one-half the ham stations are owned by schools or military organizations.

Fix-tuned receivers, pre-set to one broadcast station, are now in vogue.

¶ Condensed from RCA Review,
January, 1938

INTERNATIONAL RADIO CONFERENCE
in Cairo

BY C. B. JOLLIFFE
Engineer-in-charge, RCA Frequency Bureau

NOW IN session in Cairo, Egypt, is the much-talked-about and much-planned-for international radio conference and international telegraph and telephone conference. Approximately 80 nations are represented at the meetings.

The first named conference is considering revision of general radio regulations and additional radio regulations, while the second group is taking up the revision of the international telegraph regulations and telephone regulations. Representatives of the governments to one conference are the same, for the most part, as the representatives to the other conference.

Regulation of all forms of radio which are capable of causing international interference is based on the international telecommunications convention signed in Madrid, Spain, Dec. 9, 1932, by practically all nations of the world. Agreements made at this Madrid meeting replaced those of the international telegraph convention of St. Petersburg, 1875, and the international radio convention of Washington, 1927.

All rulings relating to electrical communications are combined by the Madrid convention under one document. These laws are authorized and annexed to the convention as separate documents, namely: general radio regulations, additional radio regulations, telegraph regulations and telephone regulations. A nation may accept one or more of the regulations as it desires, provided it also adheres to the convention. Since the United States is a party to the convention and the general radio regulations only, it will participate in the general radio regulations conference as a fully accredited member, but in the telegraph and telephone rules conference, it just has the status of an observer.

The official language for all documents of the conference is French, and the French draft is the official text of the final documents. For the purpose of discussion in the conference, the use of both French and English is authorized by the convention, a speech made in one language being immediately translated into the other.

The secretarial work incident to the operation of all international conferences on communications is carried on by the international telecommunications bureau, the offices of which are located in Berne, Switzerland.

THE preparatory work for the Cairo conferences has been going on for several months. All the nations which desired to do so have submitted their proposals for changes in the various regulations. These proposals have all been combined in a single volume for radio and a single volume for telegraph and telephone by the international telecommunications bureau and these volumes have been circulated throughout the world.

These proposals constitute the basis of an agenda for the meetings in Cairo. Each country uses these as a basis for study prior to the departure of the delegations for the conference and they are used as bases of discussion by the conference itself. The countries are not precluded from making additional proposals, and supplements to the books of proposals are issued from time to time. Proposals will probably be made by the various delegations during the course of the conference, too.

- Principal Problem

The principal problem being faced is that of allocation and use of frequencies by the radio stations of the world. The allocation of bands of frequencies to services is the heart of the general radio regulations. The present allocation, which was arrived at after much deliberation at the conference in Washington in 1927, was changed in only minor particulars in Madrid in 1932. Since the original allocation of 1927, radio has developed and expanded, especially in the use of high frequencies for long-distance international services. New services have developed and older ones have changed.

Many nations have become conscious of the usefulness of high frequencies (6,000 to 21,000 kc.) for the purpose of broadcasting to persons living at great distances. Many of the receiving sets now in use permit listeners to hear broadcasting from all parts of the world. This service was practically unknown in 1927 and did not reach its present development until about 1934. The amount of frequency space which was originally allocated to broadcasting was relatively small and with its development the number of stations which have been crowded into this small frequency space has resulted in a great amount of interference, which threatens to destroy the service. Some countries, not finding interference-free space within the broadcast bands, have assigned frequencies to broadcasting stations in the bands allocated for fixed service or mobile service, thus causing interference to long-distance international services in these bands.

The Cairo conference, or some subsequent conference, must find a solution to this problem so that broadcasting can be properly regulated and made useful on high frequencies without destroying other very important and useful services.

The entire use of the higher frequencies for aeronautics, both in the United States and in other countries, has developed since the 1927 allocation, and radio has proved itself a necessary adjunct to aviation. Because of the dependence on radio and the high speed of travel of modern airplanes, it is necessary that radio for aviation be given primary consideration. Whether this may be done best by providing exclusive bands of frequencies for aviation or fitting the needs of aviation into the bands allocated for mobile services in order that the operation of aircraft, particularly over the sea, may be coordinated with that of surface craft capable of giving them aid in time of distress, is one problem which must be given careful consideration and to which an answer must be found.

• Ships at Sea

It is of primary importance that ships at sea be able to communicate with each other and with shore stations all over the world for the exchange of messages and in order to insure the safety of life and property at sea. Consequently the operation of maritime radio stations must be under international regulations. The first radio conference in 1903 recognized this principle and since that time the general radio regulations have governed how the radio services of ships must be conducted for the exchange of messages and how operations must be carried on in time of distress in order to minimize interference and insure the best communications possible under very adverse circumstances. The distress signal is specified by the regulations and given the protection which it deserves. Experience has shown that the regulations surrounding distress have in general functioned properly and there are few proposals for changing this operation.

The general radio regulations of 1927 established an alarm signal which was required to be sent in advance of the distress signal. The purpose of this signal is to operate automatic devices, installed on other ships, which may be in the vicinity of the ship in distress and call the operators on these ships. This makes possible the participation in distress cases of many ships which are unable to maintain a continuous radio watch and thus might miss a distress call entirely. Experience with this alarm device has shown it to be very satisfactory.

Amateur radio is a service which is considered quite important by the United States government and the United States has always taken the lead in protecting the frequencies assigned to this service. Radio regulations have a minimum amount of regulation of the amateurs, leaving each country free in most respects to apply such laws as it sees fit. The American amateur has justified the freedom which he has been given in the use of the frequencies and undoubtedly the United States will again endeavor to protect this service against inroads by other nations.

In order that operators on board ships which go into foreign ports may not be subject to individual examination or that their qualifications may not be questioned, the convention sets forth in considerable detail the requirements for the examination of radio operators. This portion of the regulations is always subject to careful scrutiny to be sure that the operators upon whom may devolve great responsibility for the safety of a large number of persons in times of distress may be properly qualified to operate radio equipment. The basic requirements have become practically uniform throughout the world and operators are capable of communicating from ship to ship regardless of the nationality of the operators.

One of the primary requirements in the operation of radio service in a medium which is used in common by all the nations of the world is that all nations use equipment built and operated in accordance with good engineering principles. Since it is quite difficult to determine in an administrative conference, which is invariably pressed for time, what is good engineering practice, the regulations have set up the international radio consulting committee (CCIR) for the purpose of studying technical and allied problems. This body assembles between the administrative conferences and studies various technical problems submitted to it by the various administrations.

Other answers, however, are recommendations for regulations and need to be considered by the administrations from the standpoint of whether or not they should be inserted in the general regulations. An example of this latter type is the tolerance which will be permitted to a station when operating on an assigned frequency. The last meeting of the CCIR, held at Bucharest in 1937, recommended that there be inserted in the regulations certain permitted tolerances for various classes of stations. It now becomes the duty of the administrative conference to decide whether or not it desires to accept or reject this recommendation or modify the proposal.

THE United States government is not a party to the international telegraph regulations and these regulations are not applied by the government to the communication companies. However, the communication companies which operate circuits jointly with administrations or companies of countries which are parties to the telegraph regulations must, in general, apply the provisions of these regulations in order to provide uniformity.

While these regulations do not establish the basic rates between two countries, they do set up the relation between the rates of various classifications of messages and the basic rate and the regulations under which the various classifications of messages are handled. These relationships between the rates for the various classifications of messages and the regulations concerning their handling are extremely vital to American communication companies and to American business firms which provide a large portion of the international communication business. The United States submitted as a proposal to the telegraph conference in Cairo a "Proposal in Principle" which would govern the basis for adherence or non-adherence of the United States to the telegraph regulations. Following is a quotation of the portion of this proposal:

> "An examination of the International Telegraph Regulations discloses that they contain certain provisions, such for example, as those of Article 10, the subject matter of which is of interest to the Government of the United States in view of its increased regulatory activities. On the other hand, they contain numerous provisions, such for example as those of Article 35, having to do with operation and management of the communication services, by which the Government of the United States would not consider it proper to bind itself.
>
> "If a satisfactory segregation of the provisions of the International Telegraph Regulations into these two classes be effected, the Government of the United States can give serious consideration to the signing and acceptance of those that are of direct interest to this Government, subject to modifications and changes in existing language designed to meet conditions in the United States. This segregation could be accomplished by drafting two sets of telegraph regulations corresponding to the two sets of radio regulations. If this be not practicable, the segregation may be accomplished by arranging the provisions of the telegraph regulations so that those the Government of the United States can accept are placed together in a first part and the remaining articles in a second part. If the latter alternative is adopted, a separate protocol could be drafted in accordance with which the Government of the United States might accept only those provisions contained in the first part of the telegraph regulations.
>
> "The Government of the United States recognizes that conditions in other countries may make it unnecessary or undesirable to observe this distinction within their own jurisdictions, and to this, of course, it has no objection; nor can it object to the inclusion of provisions not of concern to the Government of the United States, such as those applicable to the European Regime, in the portion of the regulations which it does not sign."

This is a basic proposal concerning not only the form, but also the applications of the regulations.

The development of international regulation of electrical communications over a period of many years has kept pace with the development of communication and each international conference has brought the regulation into line with development. This work has always been constructive.

¶ From Broadcast News, November, 1937

Press Mistakes About Marconi

Some common mis-statements made in newspapers and magazines about the late Guglielmo Marconi, one of the best known figures in the world of radio, are herein corrected by an acquaintance of the Italian scientist.

BY G. H. CLARK

THE DEATH of the inventor of wireless has let loose in the press of this country a mass of misinformation regarding his life. Many of these stories have persisted for many years although some are of recent origin. Guglielmo Marconi, one of whose main characteristics was an intense love of accuracy, felt very hurt by many of these manufactured stories, and did what he could to counteract them during his life. That he did not succeed is clearly shown by the press stories of his career, issued after his death had been made known.

In a letter dated March 3, 1937, he writes as follows:

> "Certain myths seem to have taken deep root in the imagination of historians, such as my having been a pupil of Augusto Righi and having frequented the Bologna or other universities. Another story, arising from nowhere, is the adversity of my father to my work; as a cautious businessman, he was not so enthusiastic, at first, as my mother; but he was not in the slightest adverse to it."

Other incorrect statements on Marconi's life, which have appeared in the press stories of his demise, are:

1. That he got the idea for using Hertzian waves when he was using a heliograph in the Italian Army, when he was 20 years old, in 1896. This has not even a shred of basis. He was not in the military service until years after. The facts are these:

a. According to Italy's conscription regulations, Marconi would have been called up for service in the army when he reached the age of twenty, and would have had to serve for three years, but there was a clause in the law whereby if an applicant passed a certain rigorous military examination, he would serve as an officer rather than as a private, and his term of service would be lowered to one year. Moreover, he would not necessarily have to begin his service at the age of twenty, but could do so at any time before attaining his twentysixth year. Marconi passed this examination, and it was not until he began his work actively in England that the matter of his military service came up. (This is from official testimony of Mr. Marconi.)

b. In 1892 Marconi made some experiments with a heliograph, while spending the summer with his parents in the mountains. These were the usual experiments of youngsters, but Marconi often has stated that the germ of his later invention of wireless communication lay in this early work with mirror communication.

2. That Marconi had "attained a distance of 120 miles before he offered his invention to the Italian government, and before he went to England to exploit it." He offered his idea to the Italian government after he had attained 1¾ miles, the limit of his father's estate, and did no more work with the idea until after he went to England. By 1899, three years after he arrived in England, the maximum distance attained was around 85 miles.

3. That he, "to put his request in due form, heralded his coming" (i.e., to England), "by sending a message across the English Channel." This is not the case. It was not until 1899, three years after arriving in England, that cross-channel communication by wireless was established.

4. That, in his famous conquering of the Atlantic Ocean by wireless, in 1901, he "heard three faint clicks in the telephone." This error is almost universal. The facts are:

a. Marconi first used a coherer, with decoherer and Morse register, in attempting to pick up the signals from across the ocean. There was so much interference from atmospherics that he could not get any readable signal — the coherer was responding almost all the time, and the Morse register was chattering in time with it. The moving up and down of the inking bar of the Morse register produced "clicks," and if he had heard the historic letter "S" on the Morse register, (in addition to seeing them printed as three dots on the register tape), the "click" myth would have been correct. But nothing of the sort happened.

b. Marconi then turned to another form of detector, with which a telephone receiver would be used. In this case, the signal from Poldhu would be heard with its characteristic note, an alternating current hum. This would to a degree be contrasted with the sharp "cracks and clicks" of static, and hence there was a chance to perceive the signal. So Marconi listened. He finally heard — not three "clicks," but three "buzzes," just as an operator many years later would hear from a spark transmitter, when using a crystal or an electrolytic detector and head telephones. Not "clicks," but buzzes!

5. That Marconi had developed a secret "death ray," by which automobiles and airplanes could be made inoperative by "pressing a button." This idea of the lethal

possibilities of wireless is as old as the art itself. In The Windsor Magazine, published in London, July, 1899, the question of wireless being able to blow up the magazines of ships during war was put up to Marconi, and with his characteristic humor he replied that if "he could get inside the magazine and place the right machine in it" he could do so. In more recent years he has definitely denied that he was planning any special device for putting out of commission automobiles or other devices of the sort, although it was well known to him, as to all other radio men, that such a device is possible today for short distance operation, and may in time be made to cover longer ranges. As a matter of fact, the creation of such a device would have been foreign to Marconi's personal desires, as he regretted that the inventive genius of the world was being employed for purposes of destruction.

There are many other "Marconi myths" extant, but the foregoing are the most persistent, and the farthest from fact.

●

Frequency Counter Checks Up Musical Pitch

PROVIDING a rare degree of accuracy, the new frequency counter or pitch standard recently installed in the Allen B. DuMont Labs. promises to have a far-reaching effect on the musical art in general.

Master tuning forks employed in this precision equipment are checked at frequent intervals against the 440-cycle tone signal transmitted daily by the Bureau of Standards through station WWV. The tuning forks are electrically driven and their respective frequencies picked up electrically, amplified and made available for any circuit. In the case of the frequency counter, the given standard frequency from the master tuning fork is caused to beat against the unknown frequency of a tuning fork or musical instrument under test. The beat note difference causes the dial of an electromagnetic counter to indicate the number of cycles of difference between standard and tested tones in any given interval of time.

Meanwhile, a cathode-ray oscillograph provides a visual indication of the beat note and shows whether the tested tone is sharp or flat with regard to the standard. If the wave pattern drifts to the right, the tested tone is sharp; if to the left, it is flat. The rate of drift indicates the degree of pitch difference.

The tested tone is picked up electromagnetically in the case of a tuning fork, or by means of a microphone in the case of the musical instrument. The main purpose of the frequency counter is to check up Resonascopes or cathode-ray musical pitch standards and comparators. However, the DuMont organization is collaborating with various musical instrument manufacturers in checking their pitch standards. The present equipment can count down to 1 cycle difference per minute. When it is borne in mind that the best the human ear can detect is 1 cycle per second, it becomes apparent that the new method is 60 times more accurate than the most critical human ear.

Condensed from Bell Technical Journal, July, 1937

THE TELEPHONE and Scientific Research

BY EDWIN H. COLPITTS

(Illustrations courtesy Bell Technical Journal)

THE TELEPHONE transmitter is a complex mechanical and electrical structure. Its general method of operation can be described qualitatively in relatively simple terms, but the operation of few structures is more difficult to define in definite quantitative terms and relationships. For example, we are concerned with acoustical problems such as those involved in the air connection between the lips of the speaker and the diaphragm of the instrument. This air connection may involve a short column of air as in those instruments which have a telephone mouthpiece. Connection between the column of air and the working parts of the transmitter may be partially closed by a perforated section. When we come to consider the operation of the instrument itself, there is involved the mechanical vibration of the diaphragm as it operates on the carbon, and further, the whole question of electric conduction in the small mass of granular carbon itself.

In the case of the receiver which converts telephonic currents into speech sounds, we have very similar acoustical, mechanical and electrical problems with the exception, of course, of the mechanical and electrical problems introduced by the carbon of the transmitter.

A large amount of research work has been carried on in the Laboratories relating broadly to the transmitter and the receiver as electromechanical physical structures. The theory of these devices as vibrating systems has been developed so that their overall performance can be related to the various structural features. Consequently, our development and design engineers are now enabled to predetermine by calculation how certain modifications in structure will affect the physical performance of the instrument. In other words, the design process has become very much less "cut and try."

Research has been undertaken and substantial progress has been made on a study of microphonic action in carbon. In order to develop a complete theory of the operation of the transmitter, it is necessary to

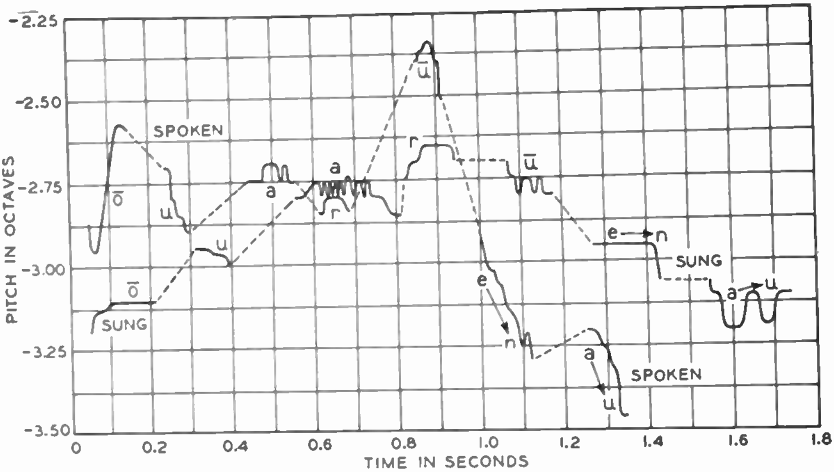


Figure 1. Melodic curves showing the variation of pitch with time as the sentence "Joe took Father's shoe bench out" is spoken and sung.

understand fully what takes place between each carbon granule in the carbon chamber.

- Speech Sounds

The source of any voiced sound is in the larynx. On both sides of this larynx there are two muscular ledges called the vocal cords. When we breathe, these two ledges are widely separated, but when a voiced sound is produced, they come close together, forming a long narrow slit. As they come close together, the air passing through the resulting slit is set into vibration producing a sound. It has been generally supposed that the pitch of the tone thus produced was determined by the natural frequency of vibration of the two vocal cords, and that by changing the tension of these cords, the pitch of the tone can be raised or lowered at will. As most of you know, their natural frequency of vibration is the rate that they would vibrate to and fro if they were plucked and set into vibration like a banjo string or an elastic band.

Our studies revealed that the natural pitch of these cords while a tone is being produced is considerably below that of the pitch of the tone. It is true that the pitch of the tone produced is affected somewhat by the elasticity of the vocal cords, but it is principally controlled by the size of the air opening between them. The little plug of air between the two vocal cords vibrates through a very much larger amplitude than the amplitude of the cords themselves and is the real source of the sound. The mass of this small plug is controlled by the size of the opening and by the elastic forces pushing it to and fro—namely, the air pressures on either side of it. It is evident that these oscillating pressures will be influenced by the size and shape of the trachea leading into the lungs on one side and by the size and shape of the tongue, mouth, and nasal cavities on the other. The mechanical action involved is analogous to the electrical action in a vacuum-tube oscillator.

The sound which is generated at the vocal cords is modified as it passes through the throat, mouth, and nasal passages. The real character of the sound which enables us to identify words is wholly dependent upon the manner in which this cord tone is modified by the changing sizes, shapes, and characters of these passages and the outlet to the outside air.

After the various speech sounds leave the mouth, they are transmitted to the ear of the listener by means of air vibration. As an example of the type of disturbance created in the air, consider the sentence, "Joe took Father's shoe bench out." This silly sounding sentence is chosen because it is used in our laboratories for making tests on the efficiency of telephone systems. The sentence, together with its mate, "She was waiting at my lawn," contains all the fundamental sounds in the English language that contribute appreciably toward the loudness of speech.

As the sound wave produced by speaking this sentence travels along, each particle of air over which it passes executes a vibration through its original or undisturbed position. The successive positions occupied by the particle as it moves in the complicated series of vibrations corresponding to a spoken sound can be visualized in laboratory investigations from oscillographic records of the corresponding telephone currents.

Each successive particle of air along the line in which the sound is traveling executes a similar complicated series of vibrations but any particular oscillation is performed at a later instant by the particle which is farther away from the source of the sound. The disturbance in the air which represents a spoken sound may then be pictured either, as was first described, in terms of the successive positions of a single particle or in terms of the displacements at any instant of each of the particles along the line of travel of the sound wave. For example, for the sentence "Joe took Father's shoe bench out," the disturbance carrying the sound *j* in the word "Joe" is about 1,500 feet from the mouth by the time the sentence is finished.

If we analyze the wave when the sentence "Joe took Father's shoe bench out" is spoken, the variations in pitch of the speech sounds can be determined from the vibration rate. Such an analysis is shown in figure 1. It will be seen that the pitch rises and falls as the various sounds are spoken. This representation of the pitch variation is called the fun-

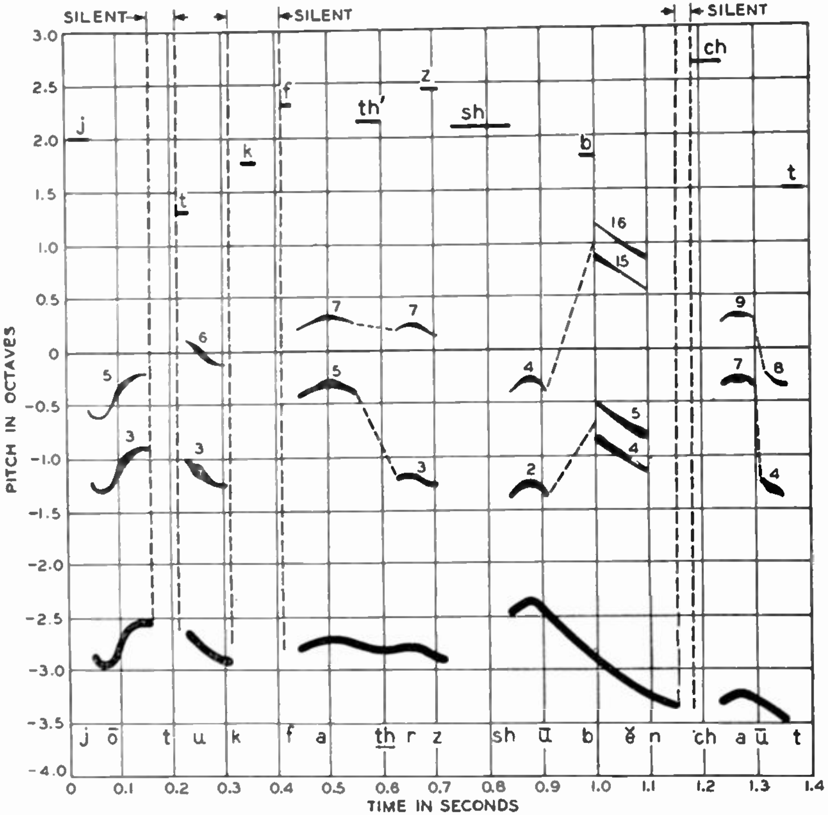


Figure 2. Melodic curves showing the variation of pitch with time as the sentence "Joe took Father's shoe bench out" is intoned on the musical intervals do, re, mi, fa, mi, re, do. The pitch changes in regular intervals rather than in irregular intervals as shown in figure 1.

damental melodic stream. It is the melody in the same sense as this term is used in music, although it is evident that the pitch changes do not take place in musical intervals as would be the case if the sentence were sung.

To show the contrast, a graph was made when the sentence was intoned on the musical intervals *do, re, mi, fa, mi, re, do*. An analysis of the graph gave the result shown in figure 1. In the case of the sung sentence the pitch changes are in definite intervals on the musical scale, while for the spoken sentence the pitch varies irregularly, depending upon the emphasis given.

TABLE I

RELATIVE SPEECH POWERS USED BY INDIVIDUALS IN CONVERSATION

Ratio of power of individual speakers to average power	Below 1/16	1/16 to 1/8	1/8 to 1/4	1/4 to 1/2	1/2 to 1	1 to 2	2 to 4	4 to 8	Above 8
Per cent of speakers	7	9	14	18	22	17	9	4	0

The pitch of the fricative and stop consonants is ignored in the musical score, and since these consonants form no part of the music, they are generally slid over, making it difficult for a listener to understand the meaning of the words.

There are two secondary melodic streams of speech represented by the second and third curves from the bottom of figure 2, which are due to the resonances imposed upon the speech sound by the throat and mouth cavities. The numbers on these curves give the number of the harmonic which is reenforced. These two secondary melodic streams are not sensed as changes in pitch, but rather as changes in the vowel quality.

Then there is fourth stream or a fourth series of interrupted sounds which are very high in pitch and are the sounds which enable us to identify the fricative consonants. The secondary melodic streams produced while speaking the same sentence are approximately the same for different persons, even for a man and a woman, while the fundamental melodic stream is usually quite different. This latter stream is not used in identifying words, but it is used sometimes to give different meanings to the same words.

As one listens to this sentence he hears the variations in loudness as well as in pitch. Loudness is related to the amplitudes and frequencies of the components of the tone, but this relationship is very complicated. It is dependent upon the action of the ear, including the nerve mechanism carrying the message to the brain. This relationship has been under study for a number of years so that we are now able to calculate from physical measurements the loudness for a typical ear and also to devise instruments for measuring approximately the loudness of any sound. The result of using such a device for recording the variations of loudness in the spoken sentence which we have been discussing is shown in figure 3. For comparison, the variations in pitch are also shown in this figure.

If the 1,500-foot wave carrying the sentence above mentioned could all be collected into an energy collector, the question arises, "How much energy would be involved?" It is not possible here to describe the devices by which we were able to measure accurately the energies and frequencies involved in speech, but the results of this research work are interesting. When this sentence is spoken fairly rapidly, it will contain about two hundred ergs of energy. About 500,000,000 ergs of energy pass through the filament of an ordinary incandescent lamp each second. This shows that the acoustic energy in this sentence is very small. Putting it in another way, it would require 500 persons speaking this sentence continuously for a year to produce sufficient speech energy to heat a cup of tea.

An examination of the wave produced by this sentence shows that the vowels contain considerably more energy than the consonants. The actual power used in producing the various sounds depends, of course, upon the speaker and the emphasis with which he pronounces the sound. The power in an accented syllable is three or four times that in a similar unaccented syllable. Measurements upon a number of voices during a conversation have indicated that the average power in the speech produced is ten microwatts (one one-hundred-thousandth watt). Some speak with more and others with less than this

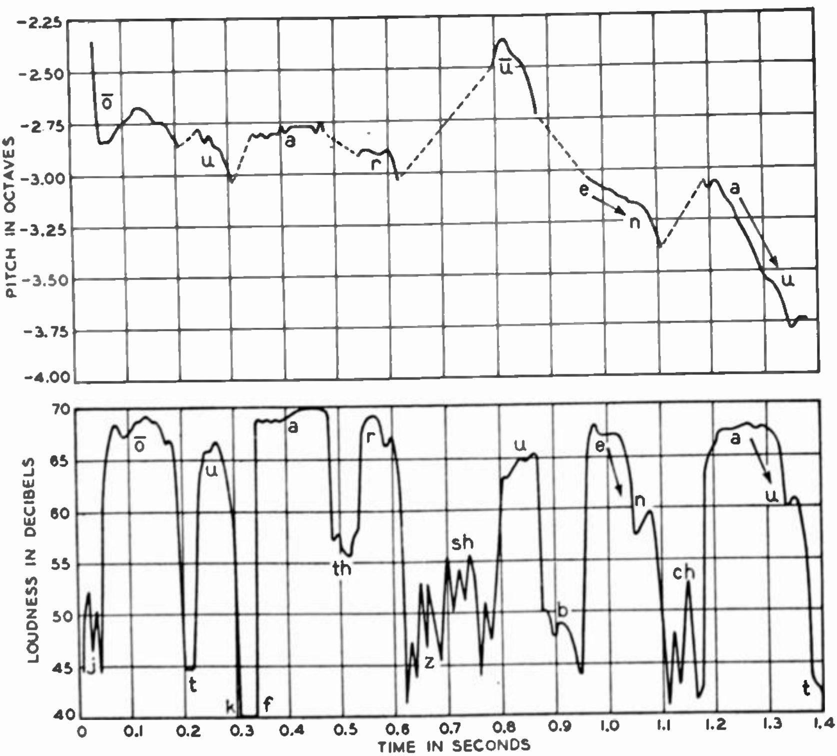


Figure 3. Graph of the loudness of the various sound elements when the sentence, "Joe took Father's shoe bench out" is spoken.

TABLE II

PEAK POWERS IN CONVERSATIONAL SPEECH

Power Boundaries In Terms of Average Power	Per Cent of Intervals
Below ⅛	12
⅛ to ¼	4.0
¼ to ½	4.5
½ to 1	5.5
1 to 2	8.3
2 to 4	12.7
4 to 8	18.6
8 to 16	17.0
16 to 32	10.5
32 to 64	5.1
64 to 128	1.7
Above 128	.1

power. In Table I is shown how various voices in a sample group vary from the average.

Now let us consider the variations for a typical speaker. As a conversation proceeds, the speech power varies from zero during the silent intervals to peak values which frequently are one hundred times the average power. Extensive measurements of these peak powers upon a number of speakers indicated a distribution about the average as shown in Table II. For example, if we should examine the speech during each one-eighth-second-interval throughout a typical conversation, we should find that for seventeen per cent of them the peak power would lie between eight to sixteen times the average over a long interval. It is seen that the most frequently occurring value of the peak power is about ten times the average.

Although a typical voice of a man and a typical voice of a woman are alike in that they use the same average power and variations of power from this average, they are different in other respects which we shall now consider. It is well known that the pitch of the voice of a woman is about one octave higher than that of a man. It was not known, however, until our experiments revealed it, that the intensity of the components having vibration rates above 3,000 cycles per second was definitely greater for voices from women than from men.

An apparatus has been devised in our laboratory which will receive the speech during a conversation and then sort out the components into groups depending upon their intensity and pitch. Those lying in each half-octave band on the pitch scale are automatically grouped together and the group power measured. Also, by means of another automatic device, a sorting process is accomplished within the group placing together all the components having powers between certain power boundaries so that they operate a particular recording meter. It was by means of an apparatus of this latter type that the results in Table II were obtained. It was found that the powers were distributed in each of these pitch bands in approximately the same manner as indicated in Table II for speech as a whole.

The relative values of the average speech power in each of the half-octave bands are shown in figure 4. Consider the half-octave from – 2.25 to – 1.75, which is the octave with its midpoint at middle "C"

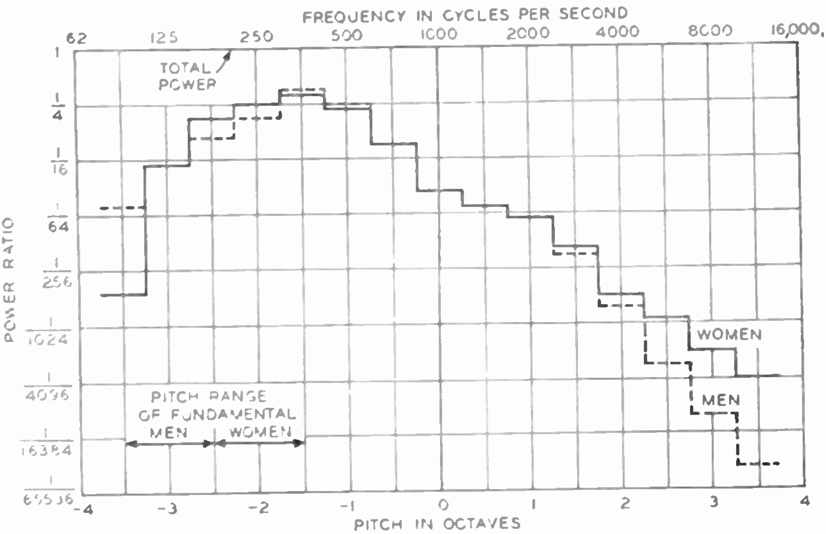


Figure 4. Distribution of speech power in fractions of the total power for half-octave intervals above and below 1000 cycles.

on the musical scale. The fraction of the power coming into this half-octave is about one quarter. It will be noted that for both types of voices the maximum power occurs in the second octave below one thousand cycles. This particular octave contains about one-half of the total speech power. The octaves on either side of this one containing the maximum power contain slightly less than one-quarter of the total power. No other octave contains more than about three per cent of the total power. It is seen that for the band of lowest pitch the voices from men contain about eight times the power of those from women. Also, as stated above, for pitches above one—that is, for tones having vibration rates above two thousand cycles per second—the voice power for women is greater than for men. For the half-octave in the region of pitch three octaves above one thousand cycles, it is about ten times greater.

For some reason which is not very evident, women use higher pitch sounds for producing the fricative consonants, and this results in the greater power shown in the regions of higher pitch. Every one who is familiar with such transmission systems knows well that these high-frequency components are nearly always eliminated. While these sounds are not of controlling importance in properly understanding speech, it is evident that the women's voices are somewhat hand-

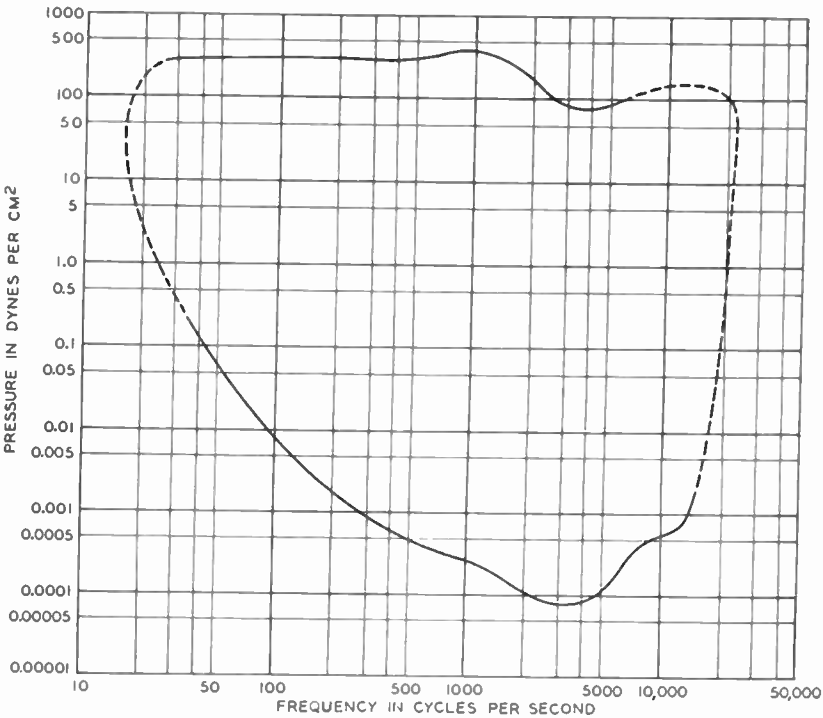


Figure 5. Auditory sensation area for the typical ear of a young adult.

icapped as compared with men in systems which eliminate them.

- Hearing

Paralleling our research on speech sounds, an investigation of hearing has been under way in Bell Telephone Laboratories. Broadly speaking, the aim has been to arrive at an accurate physical description and a measure of the mechanical operation of human ears in such terms that we may relate them directly to our electrical and acoustical instruments. We have measured the keenness of the sound-discriminating sense, and determined what is the smallest distortion which the mind can perceive, and how it reacts to somewhat larger distortions. This information is utilized in determining a reasonable basis of design both for separate instruments and for transmission systems as a whole, to give a proper balance between cost and performance.

One of the first steps in the investigations was to determine in a quantitative way the performance of our ears as machines. It was obviously important to know how

TABLE III

DB LOSS IN HEARING WITH AGE

Frequency	60 to 1024 Cycles	2048 Cycles	4096 Cycles	8192 Cycles
Ages 20-29 (96 ears)	0	0	6	6
Ages 30-39 (162 ears)	0	0	16	11
Ages 40-49 (84 ears)	0	2	18	16
Ages 50-59 (28 ears)	0	5	30	32

faint a sound the ear can hear, and also how loud a sound the ear can tolerate. With the advent of the vacuum tube, it was possible to develop methods of accurately measuring the intensity of faint sounds and of readily producing such sounds.

Figure 5 gives the results of a large number of measurements made to determine the limits of hearing. The lower solid curve represents the minimum sound that an average young person can hear. The abscissa gives the frequency of the pure tone, and the ordinate the sound pressure in dynes per square centimeter. The top solid curve represents the maximum intensity of sound that the ear is capable of handling. This curve was determined by noting that intensity which produced a feeling sensation. Intensities slightly higher than this result in pain and in some instances serious injury to the ear. The dotted lines on either side complete the enclosure and represent the upper and lower limits of pitch that can be heard. It is obvious from this figure that the upper or lower limit of pitch is greatly dependent upon the intensity at which the sound is produced. It will be seen that near the middle range of frequencies, the pressure range is one million to one. The pitch range of pure tones is from about 16 to 25,000 cycles per second.

These results are for young adults, and it may be of interest to note that as one becomes older the hearing acuity, at the higher frequencies particularly, becomes less. In Table III is shown some measurements to determine what the effect of age would be upon the hearing acuity.

Another important measurement of average hearing is that concerned with minimum perceptible differences in pitch and in intensity. Careful measurements on large groups of people have given us reliable data of this form. In figure 6 are shown the results of such measurements. They are plotted on the auditory sensation area. The ordinates are decibels above the reference pressure and the abscissas are centi-octaves above or below a pitch of 16.35 cycles per second. A frequency scale is also given for reference purposes. The numbers within the area indicate the minimum changes in the intensity level in db that the average ear is able to detect over that region of the auditory area. It will be seen that near the threshold fairly large changes are necessary to be perceptible, while at fairly high intensities about ¼ decibel is all that is necessary for the change to be perceived.

In figure 7 are given similar data for minimum perceptible differences in pitch. The results of this line of investigation have an important bearing on the physiological theory of hearing and on the development of methods of determining the degree of impairment of hearing.

In telephony we are, of course, not directly concerned with simple sounds, but with the highly complex sounds of speech, and these are on actual telephone circuits generally associated with extraneous sounds which we may group under the broad term of noise. Further, telephone instruments are not perfect, and could be made to approach perfection only at a great expense. In order to arrive at a quantitative understanding of the importance of

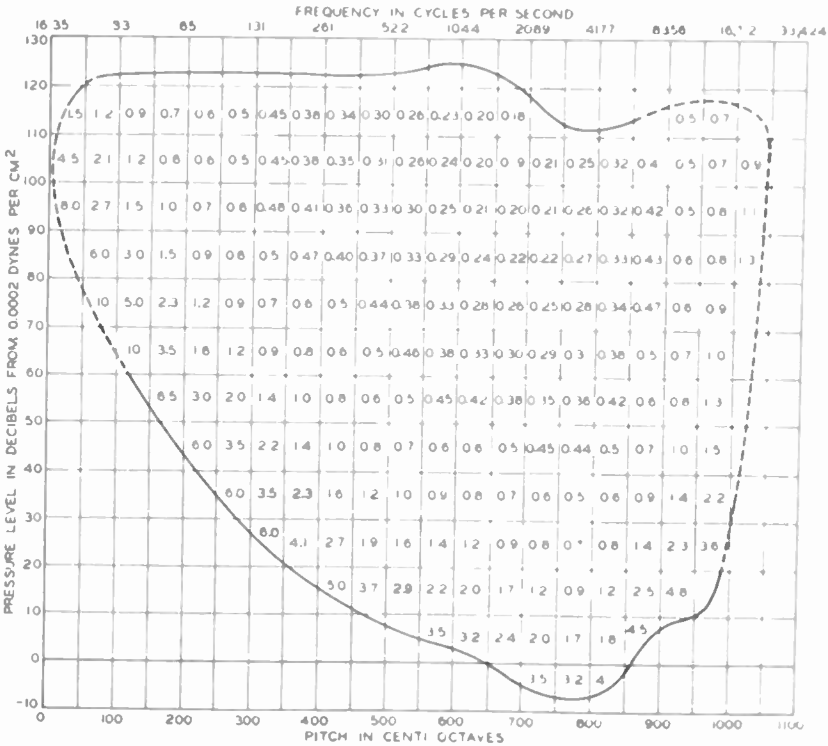


Figure 6. Minimum changes in intensity level in db that the ear is able to appreciate at various positions in the auditory area.

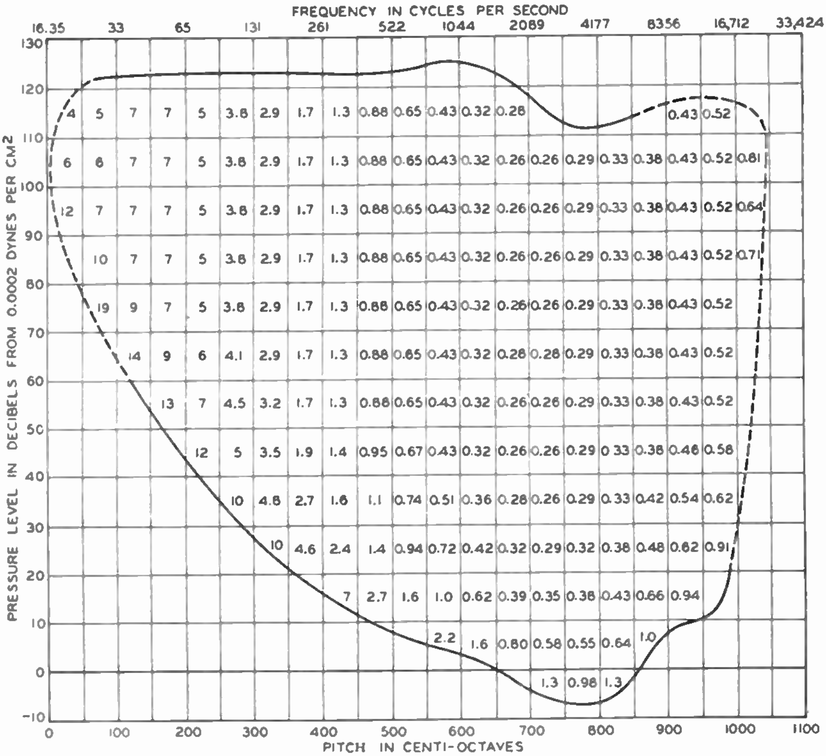


Figure 7. Minimum perceptible differences in pitch in centi-octaves for various positions of the auditory area.

departures from perfection in telephone transmission elements and conditions of use, we have in very general terms proceeded as follows: We set up transmission systems so nearly perfect that even the keenest ear could not find a flaw in their transmission performance, and then introduce measured imperfections or variations.

By this general process, we were able to determine the effect of noise of chosen intensities either as noise present in the telephone receiver or as noise in the room. Similarly, the effect of a line or other characteristic such that voice frequencies above a certain value or below a certain value were not transmitted, was determined. The effect of introducing a highly resonant element or of a non-linear element was studied. The range in loudness of speech necessary for best reception was likewise measured. As noise became recognized as a very real factor, a standard basis for noise measurement was established.

Consequently we are now able to measure noise on a telephone circuit or in a room, and state the result in terms of a standard unit.

TRENDS IN INSTRUMENT DEVELOPMENT

A new type of handset introduced in the Bell System has, in addition to a more pleasing and simplified design, incorporated a new transmitter mounted in such a way as to make fullest use of its ability to transmit efficiently over a wide-frequency band.

During the evolution of the transmitter, the knowledge which had been gained as to the importance of transmitting different widths of frequency band over commercial telephone circuits led to the establishment of the range from 250 to 2750 cycles for designs of new circuits. It was not the intention in the establishment of this range that circuits should not do better than this where it is possible without materially increasing cost, but that all circuits should be at least as good as this. The establishment of this frequency range took into account a number of factors of which a very important one is that the overall utilization of this range from the sound entering the transmitter to the sound output of the receiver provides a grade of transmission which is highly satisfactory for the reproduction of conversational material.

The establishment of this frequency range played a part not only in the design of circuits, but also in guiding the evolution of the transmitter and receiver. The transmitter last referred to meets this requirement very well. In fact, its efficiency is fairly uniform for a frequency range extending beyond 4000 cycles.

The next step in the process was to improve the performance of the receiver. A pronounced resonance at 1000 cycles was no longer necessary since means had been found to improve the efficiency of instruments in other ways than by concentrating all the resonances at one frequency. The importance of the higher frequencies in transmitting and reproducing the transient sounds characteristic of the consonants in speech led to placing more emphasis on these frequencies and attempting to produce more uniformly the band of frequencies which was set as a limit for circuits. This has now been accomplished in a practical fashion in the new receiver.

The effect of this evolution in the design of station instruments may be brought out by a compari-

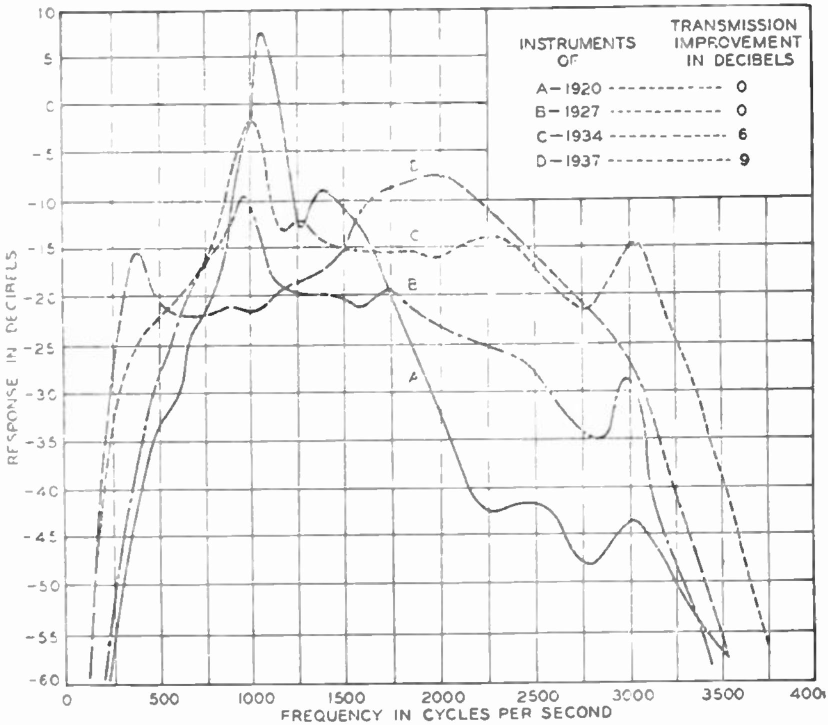


Figure 8. Comparison of the response-frequency characteristics of telephone instruments since 1927.

son of the overall response characteristic—that is, the relation of the sound delivered to the ear to the sound available at the transmitter—for a typical telephone connection having, in one case, both terminal instruments of the 1920 type and, in the other case, the terminal instruments of the new 1937 type. In this typical circuit, the trunk has been taken as free from distortion so that its effect will not influence the indicated performance of the instruments, although the circuit does include two 22-gauge loops each three miles long.

At the resonance point of the old instruments, just over 1000 cycles, the overall response in going to the new instruments is reduced by almost 30 db while the response in the range from 2000 to 3000 cycles is increased by over 20 db. In the frequency range from 500 to 2000 cycles, the circuit employing the older instruments shows a variation of overall response of over 30 db. For the new type, the variation for this same frequency range is reduced to 15 db, and, furthermore, this variation of 15 db applies approximately for the range of 250 to 2750 cycles which was mentioned as the transmission range requirement for the design of new circuits. In regard to the variation of 15 db in this frequency range, there is good indication that this response is more desirable than one of no variation, from the standpoint of having the telephone performance approach that of direct air transmission.

In addition to these improvements in frequency response and efficiency, the intensive development program on these instruments has improved materially the stability of the carbon transmitter under service conditions.

FFECTIVE April 1, the Federal Communications Commission amended in several respects Rule 443, outlining the scope of the authority granted by operator licenses. The major changes are with respect to the authority granted under the radiotelephone third class operator.

At the present time this license is generally valid for the operation of radiotelephone stations of 50 watts or less power, and with certain exceptions for other radiotelephone stations. The amended rule removes this power limitation. However, it specifically provides that stations manned solely by personnel holding a radiotelephone third class operator license must be supervised and maintained from a technical point of view by personnel holding a second class license, either radiotelephone or radiotelegraph.

The examination for radiotelephone third class operator license is limited to matters of law and regulation, and the possession of such a license gives no assurance that the holder thereof has any special technical qualifications. A number of instances have come to the attention of the Commission in which stations were involved in difficulty due to the attempts made by non-technical personnel to adjust the apparatus.

It should be pointed out that the provision of this rule does not require the person holding the second class operator license to be employed on a full-time basis or be required to stand a regular watch. It is believed that this should work no hardship on any licensee since any person who is technically capable of properly servicing and adjusting radio apparatus would have no difficulty in obtaining a radiotelephone second class operator license by examination. The setting of the effective date as April 1, should give ample opportunity for such qualification.

Other changes made in this rule do not affect the scope of authority as now existent. The rule is clarified to take into account recent changes in legislation and changes in the provisions of treaty which have become effective since this rule was first promulgated.

'Communications' Reports . . .

P-A System For Westminster Abbey

WESTMINSTER ABBEY, historic shrine of the British Commonwealth, resting place of her kings and heroes, is being wired for sound. The impression made by the extensive public-address system was installed for the Coronation ceremony in May was so favorable that work is now progressing on a permanent installation.

Six microphones and 70 amplifiers are involved. The system is regarded as one of the most complete and most modern in use anywhere. Special installation problems are being met in the placing of the loudspeakers. It has been possible to locate most of them so that they are invisible to the audience, but where this might impair the performance of the equipment, the speakers have been finished to match exactly their surroundings.

Without amplification, services are almost entirely inaudible in some parts of the Abbey—FEBRUARY ,1938.

Snow Static Detector

A SMALL device that detects and measures static is the latest development by United Air Lines' engineers in their drive on rain and snow electrical interference with plane-ground radio communication. The instrument is said to be so sensitive that it detects static not audible in the pilot's ear phones.

Designed to gauge the presence and volume of static electricity caused by electrically charged rain and snow particles, the new static meter was developed in the technical laboratory of United Air Lines. It locates static areas and measures their intensity to provide data useful in completing the elimination of this interference. Installation of two such devices has been made on United planes and production of a sufficient number to equip the entire fleet is being planned.

Pilots will report on static along with other weather conditions when they make their regular position reports at periodical intervals during flight.—JANUARY, 1938.

¶ From Communications,
February, 1938

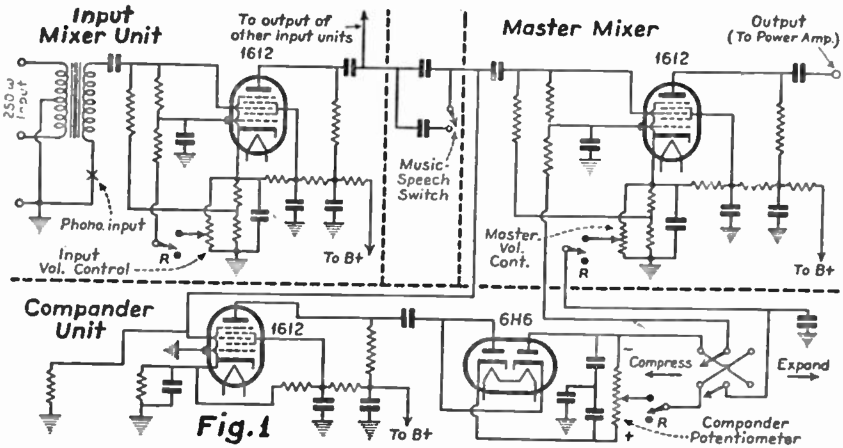
Amplifier Expansion Circuits

BY AARON NADELL

TUBE EXPANSION

FIGURE 1 gives the circuit of a volume expander plus compressor, or "compander," as its manufacturer calls it, used in one of the latest public-address systems. The circuits of figure 1 constitute the voltage amplifier (MI-4288), the expander being that portion which is below the horizontal dotted line. Figure 2 gives the expander circuit alone.

The basic action will be readily apparent on studying these drawings; a portion of the output of the first 1612 tube is detoured, amplified in another 1612, and rectified by a 6H6. The d.c. thus obtained will vary in strength proportionately



A volume expansion and compression circuit used in one p.a. system.

Expansion has just begun to creep into the public-address field; it is promised, at least, in connection with talking pictures, and has had a preliminary but hesitant introduction into the home radio receiver. Two entirely different circuits are used at the present time, each subject to minor modifications in the hands of different designers. They may be distinguished here as tube expansion and variable-resistance expansion. Tube expansion seems to be the most popular, one reason for which may possibly be that it lends itself very readily to double duty as an audio a.v.c. system, only a d.p.d.t. switch being needed to make the same circuit perform the double duty.

with the input signal. It is applied as a supplementary bias to one of the grids of the output tube. If the polarity of this supplementary bias is such that the gain of the output tube increases with the strength of the original signal, the circuit acts as an expander; if the polarity is reversed, and increased signal strength diminishes the gain of the output tube, the circuit serves as a compressor, or a.v.c. The d.p.d.t. switch needed to make the circuit perform either function is shown at the lower right of figure 1; the potentiometer that governs the extent of "compander" action is drawn just to the left of it.

That arrangements similar to those of figures 1 and 2 can readily be built into a production p.a. amplifier, so as to become an integral and scarcely distinguishable part of the unit, is shown in figure 3, some of the circuit details of which differ from those just examined. The drawing represents a 60-watt amplifier. The polarity reversing switch, shown almost in the exact center of the drawing, is triple pole. The 6H6 rectifier is drawn just below it. Part of the output of the 6N7 mixer tube is tapped off (just below the 50,000-ohm plate resistor) and coupled through a 0.01-µfd. condenser and a controlling .5-megohm potentiometer to the

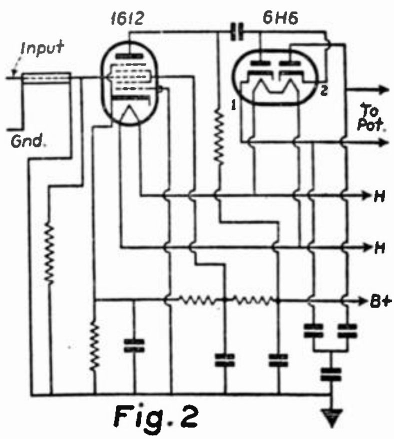


Fig. 2

The expander circuit of figure 1.

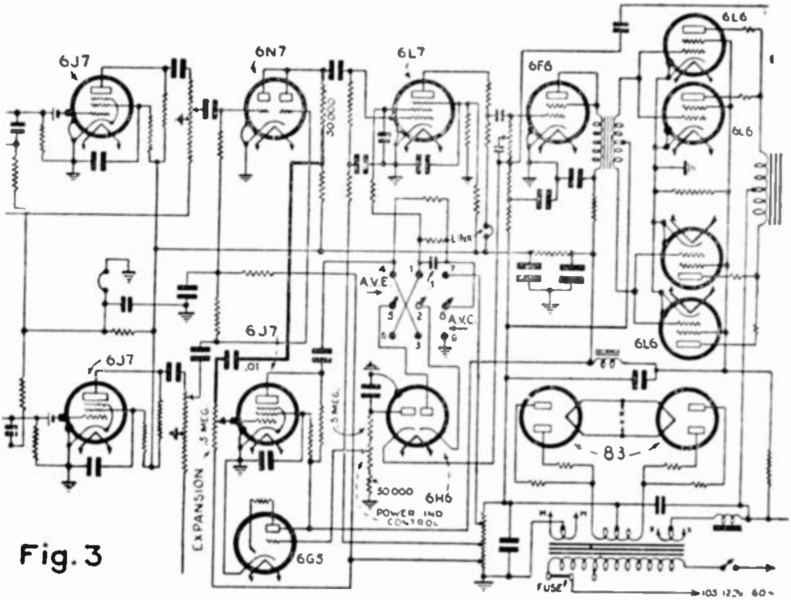


Fig. 3

Circuit diagram of amplifier employing volume expansion.

control grid of a 6J7 (drawn just left of the 6H6). Only the right-hand side of the 6H6 takes part in the action, the other half being reserved to operate the 6G5 volume indicator. The rectified output is applied to the middle grid of the 6L7 voltage amplifier.

Expansion circuits very similar to the above now find a separate market as independent units, being sold for attachment to existing public-address equipment. Two small units are shown in figures 4 and 5. They are pure expanders; compression or a.v.c. is not included. It will be noted that the 6H6 acts as a half-wave rectifier receiving plate excitation from the B+ circuits, a potentiometer in the B supply serving to govern the extent of expander action used.

The units of figures 4 and 5 are introduced into existing p.a. equipment between the phono pickup or other sound source and the amplifier input. As such, they can be used for phonograph reproduction in connection with a home radio receiver, as well as for p.a., provided that the a.c. stages and speaker of the receiver can handle the peak power. The two circuits are identical except that figure 4 is designed to receive its plate and filament power from the amplifier with which it functions, while figure 5 includes an a.c./d.c. power supply built around a 25Z6, and consequently can be added to existing equipment by any user whatever.

VARIABLE-RESISTANCE EXPANSION

A radically different circuit is shown in figure 6, in which the expander action depends upon the nature of the temperature-resistance curve of the two small bulbs, B-1

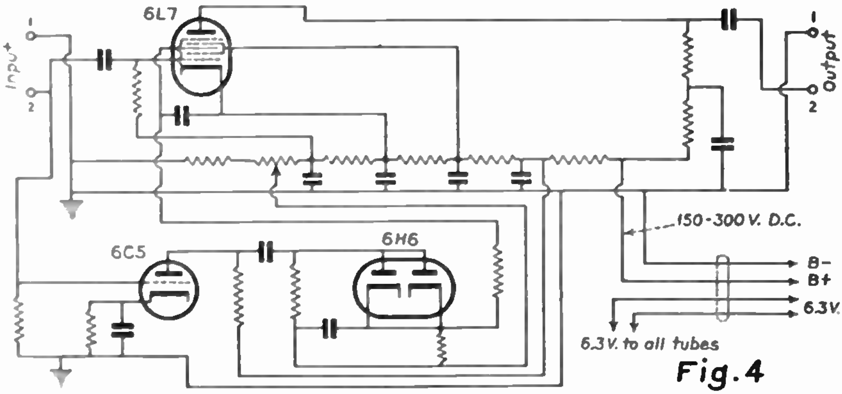


Fig. 4

Circuit of unit designed to be attached to existing p.a. equipment.

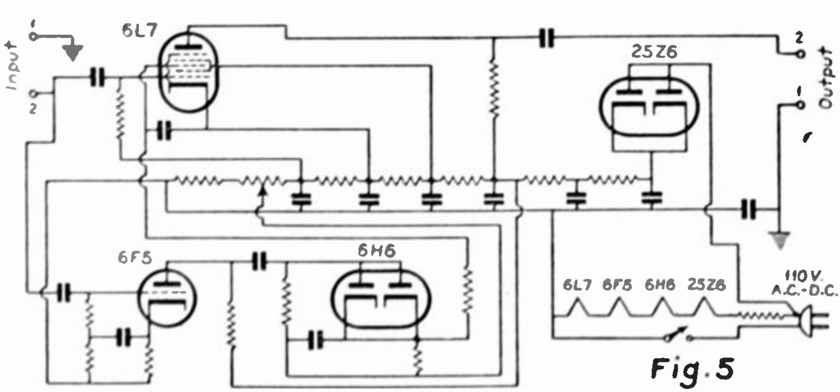


Fig. 5

Circuit diagram of another unit similar to that of figure 4.

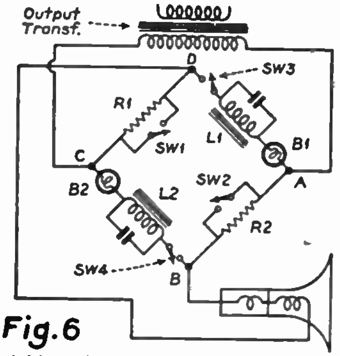


Fig. 6

Variable-resistance method of expansion.

and B-2. When switches 3 and 4 are closed, loudspeaker input depends upon the degree of unbalance of the Wheatstone bridge. Since the resistance of the bulb filaments will increase with a rise in the current flowing through them, it follows that the degree of bridge unbalance will grow more pronounced with increase of signal strength. The values of the resistors, R-1 and R-2, must of course be chosen with reference to the critical bend in the temperature-resistance curve of the bulbs used.

Opening switches 3 and 4, and closing the switches around the resistors, cuts the expander out of circuit, and the loudspeaker then functions in the ordinary way. The switches are ganged in practice.

Some of the circuits based on this principle employ ganged potentiometers in place of the bridge resistors as means of controlling the extent of expander action.

Time delay, which is needed in all expanders, and which is secured in the tube type by suitable choice of circuit constants, is naturally provided by the inherent temperature lag of the bulb filaments.

Figure 6, in which the bulb arms of the bridge include audio filters, represents this form of expander. In other variants, the filters are omitted. Their use in this circuit is based upon the well-known curve of figure 7, in which it will be noted that low-frequency sound drops below audibility (so far as the human ear is concerned) while higher frequencies of the same in-

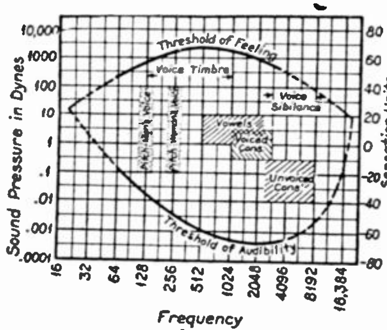


Fig. 7

Sound pressures at various frequencies.

tensity can still be heard without difficulty. Thus, it will be seen that a sound pressure of more than 0.1 dyne is needed to make 64 cycles audible, while 8,000 cycles can be heard with a pressure of less than 0.005 dyne. The filters shown in figure 6 alter the audio-frequency response of the expander, and give the results such that at maximum output volume the response is flat, but at lesser levels of output the extreme low frequencies are progressively enhanced.

BOOK REVIEWS

BOOKS submitted to the Review Editor will be carefully considered for review in these columns, but without obligation. Those considered suitable to its field will also be reviewed in "Radio".

Handbook of Chemistry and Physics, 22nd Edition. Edited by Charles D. Hodgman, M.S., published by the Chemical Rubber Publishing Co., Cleveland, Ohio. 2069 pages, $6.00 in U.S.A. and Canada.

THIS handbook needs no introduction to those who have worked in a chemical or physical research laboratory; it is the standard reference work. Although a large number of the tables will be completely useless to the radio amateur or designer, still, in 2069 pages there are an extremely large number of tables to choose from.

The handbook is divided into eleven sections, the titles of which are: Mathematical tables, 301 pages; properties and physical constants, 557 pages; general chemical tables, 200 pages; specific gravity and properties of matter, 190 pages; heat, 155 pages; hygrometric and barometric tables, 19 pages; sound, 4 pages; electricity and magnetism, 135 pages; light, 149 pages; quantities and units, 161 pages; and a section devoted to miscellaneous tables, a large proportion of which will be highly useful in radio work, 144 pages.

The mathematical tables and the ones in the miscellaneous section alone make the book well worth the purchase price; then the others are always at hand in case they should be needed at a future time.

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Short-Wave Transmitter

PROVIDING a world outlet for the 1939 Golden Gate International Exposition, the General Electric Company is scheduled to begin work at once on a short-wave transmitter at Belmont, Calif.

This 25-kilowatt station, the first short-wave transmitter west of the Mississippi, will have directional antennas of the latest type, with beams directed to the Far East and South America. Concentrating the transmitter output within an angle of 30 degrees, these antennas will provide a signal gain of approximately 300 per cent over the ordinary antenna.—COMMUNICATIONS, 1938.

THE TECHNICAL FIELD

In Quick Review

RADIO DIGEST briefly summarizes for its readers the contents of leading radio articles in current technical publications, some of which may appear later in RADIO DIGEST.

All-Wave Radio

MARCH, 1938
Manson Publications Corp.
16 E. 43 St., N.Y.C.
25¢ a copy—$2.50 yearly

THE "ONE STOP" ALL-WAVE SUPER," *by Michael G. Relsum.*—More of the features used in a communications receiver are being incorporated in the design of receivers for general short-wave listener use, such as the crystal filter, c.w. beat oscillator and bandspread tuning. The design of the receiver described in this article is applicable to the needs of any type of short-wave listener. The entire high-frequency r.f. portion is a commercially manufactured unit greatly simplifying the construction for the average user. Beside the aforementioned features, wide-range selectivity, 5 to 550-meter tuning range and ample audio output are incorporated in this modern design.

A DE LUXE HIGH-FIDELITY RECEIVER INSTALLATION, *by James Millen.*—Prefaced by a discussion of the requirements in the way of securing high-fidelity reception in the home, and a short review of means to this end in past years, the author describes a deluxe, remotely controlled installation in his own home. A relay rack located in the basement carries a number of pre-tuned r.f. amplifier channels and an automatic record changer. Push-button controls and high-fidelity speaker units are located in various rooms in the house, providing a high degree of convenience and musical quality.

A 3-BAND U.H.F. SUPERHET, *by R. H. Asmus.*—A constructional article for this type of receiver, based on standard principles as used on the lower frequencies but with the necessary adaptations for u.h.f. service. A 956 h.f. amplifier, 954 detector and 955 h.f. oscillator take care of the front end. An i.f. frequency of 4200 kc. is used. The receiver also has noise silencing using a part of the 6H6 second-detector-a.v.c. tube.

February, 1938—

SIMPLE 5-METER RECEIVER, *by Guy Forrest.*—A companion unit for the 5-meter transmitter in the January issue of AWR, matching it in size and appearance. The receiver in common with the transmitter needs only a 6-volt battery for external power. A 45-volt battery in the case furnishes the plate voltage. A 955 acorn tube is the self-quenched detector and a 38 is used for audio amplifier.

COMMUNICATIONS

Bryan Davis Pub. Co., Inc.
19 E. 47 St., N.Y.C.
25c a copy—$2.00 yearly

February, 1938

MODULATION SUPPRESSION OF A WEAK SIGNAL BY A STRONGER ONE, *by Hans Roder*—A mathematical analysis of the phenomena of the effect of a strong signal upon the modulation of a weaker one. In the British publications this is usually called "demodulation" of the weaker signal but in American usage this is commonly "modulation compression" and sometimes "masking effect".

Modulation compression is not only an interesting theoretical phenomenon, but also has practical significance because it affects the effective selectivity of a radio set. In consideration of this fact and others, the I.R.E. Standards Committee has recently recommended the "two-signal" testing method. Yet, the fundamentals of this phenomenon from a physical standpoint do not seem to be widely known nor understood, and little comprehensive treatment has so far been published.

A CRYSTAL-CONTROLLED PACK TRANSMITTER, *by Don Langham.*—The design of a pack transmitter imposes several requirements at the start, among them being weight, dimensions, and ruggedness. The one discussed is crystal controlled with the output at double the frequency of the crystal and uses tubes of the 2-volt series, a type 19 for crystal oscillator and frequency doubler, and a 1F4 r.f. amplifier. By careful design, a speech-amplifier-modulator line-up of a 1B4, 30, and a 19 furnishes enough audio for complete modulation from a low-level microphone. Constructional details of the case and data on battery life are given.

January, 1938

DESIGN OF RESISTANCE-COUPLED AMPLIFIERS, *by Edward J. Rhoad, WQXR.*—An article using the familiar derived-response equations of a resistance-coupled stage between specified limits to arrive at a fairly fast and accurate design for an amplifier. All the various factors effecting the operation of the amplifier are taken into consideration to predict more accurately the results to be obtained. The design is quantitatively treated from a mathematical point of view.

AMPLIFICATION PROBLEMS OF TELEVISION, *by F. Alton Everest.*—There is no method of actually analyzing the components of a television signal since it is continually varying in every respect from line to line and from scene to scene. Consequently, certain assumptions must be made to design properly an amplifier to operate on these signals. The article presents a summary of the methods used in arriving at the approximate frequency requirements of typical video amplifiers and of methods used in compensating conventional resistance-capacity amplifiers to fill these requirements.

PRODUCTION DEVELOPMENT OF TELEVISION TUBES.—A discussion of the methods used in the production of manufacture of television tubes; a comparison of the various types of screen materials, their methods of deposition, and their relative efficiency. Methods of cleaning, graphite depositing, and electrode aligning are also discussed.

electronics

FEBRUARY, 1938
50¢ a copy—$5.00 yearly
McGraw-Hill Pub. Co., Inc.
330 W. 42 St., N.Y.C.

THYRATRONS AND THEIR USES, by *E. F. W. Alexanderson.*—A discussion of the multitude of extremely economic uses of the thyratron tube in industry. Methods of applying the tube to frequency changing, a.c. to d.c. and d.c. to a.c. conversion, and motor control are discussed. One unusually interesting topic is the application of the thyratron to the synchronous motor, which ordinarily will operate only at the speed determined by power-supply frequency, as a frequency changer, thus allowing the motor to be used as a variable-speed device at full efficiency.

APPLYING ELECTRONIC DOOR OPENERS, *by W. I. Bendz.*—An article discussing the various things to take into consideration when installing electronic door openers. The questions: How is the door to be opened? How is it to be closed? Protective methods. Two-way traffic. How it's done. Interior doors. The various aspects of each of these considerations are covered in some detail.

these considerations are covered in some detail.

CATHODE-RAY WAVE FORM DISTORTION AT ULTRA-HIGH FREQUENCIES, *by R. M. Bowie.*—An investigation of the effects of transit-time distorion of the electron beam on the pattern produced at the end of the screen. The consequent derivation of the equations taking these effects into consideration in the measurement of ultra-high frequencies is covered.

DEVELOPMENTS IN AIRCRAFT RADIO AREA.—New developments in aircraft radio equipment to improve the useful area of operation and to make the operation more efficient and less dependent on weather conditions within the operating area. New services for both communication and navigation, on long and short waves, have permitted more regular schedules in airline operation without decreasing safety.

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January, 1938—

BATTERY RADIO DESIGN, by *Paul Marsal.*—In properly designing battery operated receivers, it is necessary to have some means of duplicating the plate, grid and filament supply conditions that will be experienced with new, somewhat used, and almost dead batteries. To assist in this design, power supplies have been designed which simulate the condition of batteries in various states of discharge. Through these artificial supplies, battery receiver designs have been improved both as to quality of operation and as to length of operating time for a set of batteries.

WIDE-BAND TELEVISION AMPLIFIERS, by *F. Alton Everest.*—Elementary theory, with practical examples, for extending the upper frequency limit of video frequency amplifiers. A number of improvements in amplifier design are given which will improve the upper frequency response. An extensive bibliography is also given.

CATHODE-RAY PHASEMETER, by *S. Bagno and A. Barnett, M.D.*—Measurements of the phase angle between different portions of the body have led to the device described by two researchers in this interesting subject. It will measure phase angles as small as 0.0005 radian; it will also measure small values of capacitance or inductance.

THE TRIOGRAPH, by *H. E. Hollman.*—A three-phase cathode-ray oscillograph for electro-cardiography which delineates the heart potentials and gives their directions in the body and their rotations during each heart beat.

A MAGNETIC RECORDER, by *T. J. Malloy.*—A practical discussion of a system for recording broadcast programs or other material on a wire. It is a portable piece of equipment that should find a multitude of common uses.

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QST *devoted entirely to*

AMATEUR RADIO

MARCH, 1938

25¢ a copy—$2.50 yearly
American Radio Relay League
West Hartford, Conn.

CQ WFCT, by *Alan R. Eurich.*—This interesting story of the further adventures aboard the yacht "Yankee" was written by the radio operator of the schooner while the ship was in mid Indian Ocean, cites a number of experiences, mainly in connection with radio receiving conditions, that were had while travelling during the voyage from Gloucester, Mass., through the South Seas to their present location.

A HOME-BUILT VELOCITY MICROPHONE, by *Norman E. Gibbs,* W1JXP.—Complete constructional details of a unit built from magneto parts, its installation and mounting, and the results obtained.

SPEECH VERSUS SINE WAVES, by *Earl I. Anderson, W8UD.*—The fact that speech waveforms contain, on the average, only about half the power contained in a sine wave has led to a number of erroneous conclusions concerning the amount of audio power needed to modulate a certain amount of class-C input. In this article Mr. Anderson gives his opinions upon the subject. Certain commonly-made assumptions are debunked.

A UNIVERSAL TEST UNIT FOR THE STUDY OF TELEVISION IMAGES, by *Marshall P. Wilder, W2KJL.*—It has always been a problem in the study of television to obtain a test signal on which to operate the equipment. The National Union Tube Co. and the Allen B. DuMont Mfg. Co. have brought out special cathode-ray tubes known respectively as the "Monotron" and the "Phasmajector" which allow the local generation of a television image. The article deals with the equipment needed to set up one of the tubes along with a standard television receiving tube for the study of television reproduction technique.

A PACK SET FOR 200 AND 300 MEGACYCLES, by *L. C. Sigmon, W9YNJ.*—A description of the remote-pickup pack transmitters as used by KCMO for broadcast service. Acorn tubes are used throughout due to their extreme operating economy as to supply voltages and due to their unusually small size.

A DOUBLE-REGENERATIVE SUPERHET, by *Byron Goodman.*—A description of a low-cost five-tube receiver that gives good stability and selectivity. The receiver has no r.f. stage, a single 1600-kc. i.f. transformer coupling the first detector to the second, and regeneration on both the first and second detectors.

February, 1938

A REGENERATIVE RECEIVER WITH HIGH AUDIO SELECTIVITY, by *Malcolm Gager and Arthur F. Graham.*—The Selectosphere, a high-selectivity, amplitude-limiting acoustical unit built in the form of a sphere, the details of which were treated in the October 1936 issue of RADIO, is here used as an integral part of a tuned r.f. regenerative receiver with several unusual circuit modifications. Another ordinary speaker is built into the set and can be used in place of the selectosphere when highly-peaked audio is not desired. The audio amplifier uses variable regenerative gain for more output, particularly when using the selectosphere. Due to the extremely sharp characteristics of the selectosphere, slight changes in the antenna circuit due to swinging were noticeable as a change in the peaked beat note, so two different forms of link coupling from the antenna coil to the grid circuit of the r.f. tuner are shown as a remedy for this condition. Constructional details are discussed and a complete circuit diagram is shown.

28-MEGACYCLE PRESELECTION, by *James Millen and Dana Bacon.*—Due to the increased images on the low end of the ten-meter phone band because of re-allocation of the U.S. portion of the band, severe interference is caused to the reception of foreign signals. This discussion deals with the improving of this condition by means of discriminating preselectors. Methods are shown by circuit diagrams for retaining a fair Q of the coils without losing much in the way of gain.

RADIO

MARCH, 1938

30¢ a copy—$2.50 yearly
RADIO, Ltd.
7460 Beverly, Los Angeles

STRICTLY 160 METERS, A 20-WATT PHONE FOR THE NEWCOMER, by *W. W. Smith, W6BCX.*—As it is designed for this one band, this small phone transmitter is extremely simplified. By tapping the excitation lead far down on the oscillator tank, there is sufficient drive for the grid-modulated amplifier. The buffer stage is dispensed with and as oscillation of the 809 cannot be sustained, there is no necessity for neutralization. A 6J7 and a 6F6 provide the audio amplification from a crystal microphone.

AUTOMATIC MODULATION CONTROL, *by L. C. Waller, W2BRO.*—Mr. Waller describes a system of automatic modulation control which effectively squelches overmodulation and gives a modulated carrier which is clean, sharp and without a trace of the side splatter which causes such heavy interference in the amateur phone bands. As contrasted to automatic peak compression, its negative control voltage is obtained from the modulator, and this system operates on the relation between the actual d.c. plate voltage and the peak a.f. modulating voltage, regardless of power supply regulation, transformer, characteristics or other factors. Photos of the complete amplifier and circuit diagrams illustrate the points discussed.

THE EFFECT OF AVERAGE GROUND ON ANTENNA RADIATION, *by E. H. Conklin.*—While the perfect-ground assumption is justified in making certain antenna calculations, the effect of average ground is of great value in predicting the results that will be obtained from the antenna after its installation. Beginning with the radiation from a horizontal antenna, Mr. Conklin discusses phase-shift, the ground as a conducting dielectric, vertical antenna radiation and comparisons of the two types over various kinds of ground and over sea water. Much of this is adapted from articles which have been published during past years in the *Proceedings* of the I.R.E. The article is fully illustrated by rectangular- and polar-coordinate charts.

A GENERAL SERVICE BRIDGING AND SPEECH AMPLIFIER, *by Raymond P. Adams.*—Although not particularly for amateur use, a bridging amplifier can be useful in modulating two transmitters from one microphone, and has uses in many other fields such as simultaneous transmission and recording, transcription duplicating, etc. A six-tube push-pull amplifier of this type is described and diagrammed, as well as another arrangement of parts for use as a regular speech amplifier with high-impedance input.

WHICH TUNING CONDENSER? *by Frank C. Jones, W6AJF.*—A treatise on air-gaps and C-L ratio considerations for various applications in which one common fallacy is debunked, namely that the tuning capacity should be one-half as great for plate neutralization as opposed to grid neutralization since the tube plate circuit is connected across one-half of the tuned circuit.

The above statement is mathematically proven and a complete review of different tank circuits is given with numerous diagrams and charts, for several values of Q.

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February, 1938—

AN ECONOMICAL PHONE AND C.W. TRANSMITTER, *by Frank C. Jones, W6AJF.*—A description of a grid-modulated transmitter using a T200 in the final stage, Pierce oscillator with a 635 and 6L6G, and T20 doubler or amplifier stages. Although designed for 10 and 20 meters this transmitter can be easily modified for operation in the lower-frequency bands. Adjustments for grid modulation are discussed and oscilloscope pictures for different conditions are shown as well as a large circuit diagram of the complete transmitter.

IMPROVED-TYPE VOLUME INDICATOR, *by Ray L. Dawley, W6DHG.*—Due to the excessive action of some types of volume indicators, recent design has a trend to a type which will follow an envelope of the highest peaks instead of every little peak and valley. This article deals with the design and construction of a volume indicator which is easily adjusted to follow every upward variation closely and to dip in several different response speeds.

IMPROVED EXCITER, *by C. M. Weagant, W7GAE.*—The original conversion exciter which appeared in the June, 1936 issue of RADIO in an experimental form is herein improved and stabilized in a highly satisfactory unit for flexible frequency control. By heterodyning a self-excited, variable frequency oscillator working in the region of 100-400 kc. against a high frequency quartz crystal oscillator it is possible to take advantage of both the stability of the crystal oscillator and the variable feature of the self-excited oscillator.

AN AMATEUR'S VACUUM TUBE VOLTMETER, *by Lloyd W. Root, W9EHD-W9HA.*—A description of a vacuum tube voltmeter that is designed to be a.c. operated, with a 0-1 milliammeter for an indicator, requiring only 1 volt for full-scale deflection and linear over its full scale, making charts and recalibration unnecessary. Complete data is given on the preliminary steps in the design. The circuit and photographs of the completed instrument are shown.

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RCA REVIEW

JANUARY, 1938
50c a copy—$1.50 yearly
RCA Institutes Technical Press
75 Varick St., N.Y.C.

DIRECT-VIEWING TYPE CATHODE-RAY FOR TELEVISION IMAGES, by *I. G. Maloff.*—A new device for obtaining large bright television images of high contrast and high definition has been developed by the RCA Mfg. Co. It is a direct viewing cathode-ray tube 4½ feet long and 31 inches in diameter. It is of the continuously evacuated type and gives a picture 18 by 24 inches in size. This paper describes the design and construction of the new tube, the reasons for the development, the difficulties which were overcome, and the results obtained.

EFFECT OF SPACE-CHARGE IN THE GRID-ANODE REGION OF VACUUM TUBES, by *Bernard Salzberg and A. V. Haeff.*—The effects of space charge in the region between grid and anode of a vacuum tube, for the case where the planes of the grid and plate are parallel, are determined from a simple analysis. Anode-current vs. anode-voltage and anode current vs. space current curves representing observations made on a specially constructed tetrode are presented by way of experimental verification of the theoretical results.

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RADIO NEWS AND SHORT WAVE RADIO

MARCH, 1938
25c a copy—$2.50 yearly
Teck Publications, Inc.
461 Eighth Ave., N.Y.C.

FIGHTING SNOW STATIC, by *Thos. Calvert McClary.*—An outline of a series of researches conducted for the purpose of discovering the true source of "snow static", that insidious interference which frequently renders a plane's communication equipment completely useless when it is needed most—under storm conditions.

COMPAK TUNER, by *Gerard J. Kelley.*—A description of an unusually compact tuner for local broadcast pickup work. A tap switch selects a pre-adjusted tuning condenser which is placed across the common r.f. coils for each of the various stations as selected from the broadcast band.

THE "10-80" X'MITTER—*for progressive construction* by *Chester Watzel and Willard Bohlen.*—Part four of a series. The three previous sections of this article on progressive transmitter construction have appeared in the past three issues of Radio News. This is the fourth section and brings the transmitter to a 112-watt phone rig. It is designed for full operation at frequencies as high as 28 Mc.

A.C. PRE-AMPLIFIER. A truly humless, a.c. powered pre-amplifier which provides a gain of about 60 db. It is compact, easy to build, and includes a switch for remote operation of auxiliary equipment such as a transmitter or p.a. amplifier.

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February, 1938—

FIRING THE "OPENING GUNS" OF TELEVISION IN THE NEW YORK AREA, by *L. M. Cockaday.*—A discussion of the television plans of the various concerns and a description of the various systems now in use throughout the country.

IMPORTANT POINTS IN DESIGNING A SET TESTER, by *Samuel C. Milbourne.*—The author, a service engineer for a concern manufacturing test instruments, cites a number of considerations that enter into the design of an efficient and easily operated test instrument. The article will be of considerable assistance to any person interested in the design of his own test equipment.

THE "HI-FI '9'", by *Raymond P. Adams.*—The design and construction of a broadcast receiver especially designed for the person interested in the reception of the programs from the local stations which broadcast high-fidelity wide-range programs. A phase inverter feeds a pair of 2A3's in the audio system of this excellently designed b.c.l. receiver.

THE A, B, C's OF ANTENNA DESIGN, by *I. Queen.*—Part three of a series, this section discusses in some detail the methods of matching the feed line to the antenna impedance; *Impedance Matching* is the sub-title given to the article.

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SERVICE

A Monthly Digest of Radio and Allied Maintenance

JANUARY, 1938
25c a copy—$3.00 yearly
Bryan Davis Pub. Co., Inc.
19 E. 47 St., N.Y.C.

GETTING ON IN RADIO, by *Bernard H. Porter.*—A discussion of the progress of radio servicing through the various stages of development from the screw-driver mechanics of the early days to the service engineers of the present time. A number of excellent book references are given to assist the ambitious serviceman to his personal betterment.

GENERAL DATA is given on the Stromberg-Carlson 260 (L, LB, P, PB) in considerable detail. Also covered is the Crosley 617 and the Stewart-Warner R-180 chassis. (Models 1801 to 1809), although these latter two are covered in less detail than the Stromberg-Carlson.

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THE T & R BULLETIN
A JOURNAL FOR RADIO EXPERIMENTERS

FEBRUARY, 1938
1/6 a copy
Radio Society of Gt. Brit.
53, Victoria St., London

RADIO FREQUENCY POWER AMPLIFIERS, by *F. Butler.*—A complete discussion of the operation of triodes and pentodes under the various conditions imposed by operation as a class-A, -B, or -C amplifier. Efficiency, output, stability, power sensitivity and allied considerations in amplifier design are considered.

FARADAY SHIELDS AND HARMONIC REDUCTION, by *E. L. Gardiner, G6GR.*—A practical discussion of the harmonic reduction effected by the installation of a Faraday Shield between the output tank circuit of a h.f. transmitter and the antenna circuit. The writer strongly urges use of Faraday screen in all transmitters where harmonic radiation has been experienced.

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January, 1938—

EXPERIENCES WITH A SIMPLE DIRECTIVE AERIAL, by *F. W. Garnett, G6XL.*—A discussion of the great improvement in transmission and reception effected through the installation of comparatively simple directive aerial systems. Quantitative results of the comparison of the various antenna systems are given.

A SENSITIVE AND SELECTIVE THREE-VALVE RECEIVER, by *J. St. C. T. Ruddock, GI8TS.*—An r.f. stage, regenerative triode detector, and a pentode audio output comprise this well-designed inexpensive receiver. The tubes shown are of European manufacture but they could easily be replaced by standard American tubes.

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