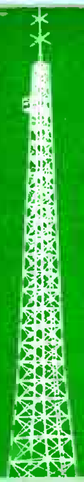
The RADIO ENGINEERS' DIGEST



November 1944 Vol. 1, No. 4

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The Open Forum

We plan in the near future to open a new department which we believe will be of service and interest to our readers.

To be known as THE OPEN FORUM, the new department will serve as a general clearing house for the interchange of engineering ideas. It will offer a service whereby engineers with problems of mutual interest may submit them for discussion and advice, and where new ideas and novel solutions to engineering problems may be presented for the benefit of fellow engineers.

We want to emphasize that this department is 100 percent by and for our readers. We will not offer any advice ourselves nor take part in any of the technical subjects under discussion.

We cordially invite our readers to submit any ideas or engineering problems which they believe will be of general interest and will see to it that they are printed in THE OPEN FORUM.

THE RADIO ENGINEERS' DIGEST

JOHN F. C. MOORE, *Editor*

Vol. 1, No. 4 November 1944

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POSTWAR FUTURE OF EMERGENCY RADIO SERVICES

Reprinted from F M and Television

By James Lawrence Fly

An Outline of Developments Which Will Require Accomodations in the Radio Spectrum

IT is a commonplace that one of the few good results from war's tragedy and destruction is the tremendous stimulus to technological development. We are bombed out of our old patterns of thinking and forced willy-nilly to explore new ways and new ideas; to leap towards new goals where once we walked.

One of the most striking instances of this war-born impetus is the advance in the art of radio communication, navigation, direction-finding, and remote control of moving objects. Some of these advances are known to even our youngsters who play their war games with "walkie-talkies." Others are merely hinted at by the military authorities or the guardians of laboratory secrets.

Americans have become more radio-minded than ever before. Our men in the services, who have developed or used radio as a weapon of war on land, air, and sea, will be quick to convert it to a tool of peace after the war.

We know that one of the most significant of the wartime advances has been the upward extension of the usable portion of the radio spectrum. Although we do not have full information, enough has been learned to arouse hopes for a greatly-increased supply of frequencies.

To those contemplating the expansion of radio for police work, fire fighting, public utilities, railroads, and aviation, this prospect of new territories in the spectrum has been an exciting incentive to postwar planning.

Before too much of a gold rush fever sets in, a word of caution is advisable—not to dampen anyone's enthusiasm but to set future prospects in proper focus, or as near proper focus as we can foresee at this time.

While it is true that more frequencies will be available, it is also true that the demand will be greater than ever before. How well these elements will balance remains to be seen.

Beside the familiar uses of radio, many new uses are anticipated. Radar will come out of its wartime mystery into peacetime applications.

Many railroads are looking to radio. As an outgrowth of the widespread interest in radio for railroads, the Federal Communications Commission held public hearings, beginning September 13, 1944, on the feasibility and necessity of using radio as a safety measure and for other purposes in railroad operations. There is no actual radio system in regular use on any commercial railway in the United States today, but since May 1, 1944, the FCC has received applications for 30 construction permits for radio stations for use at fixed locations and on rolling stock in railroad operations.

In fields where radio is already established, its use will apparently mushroom. It can be taken for granted that this nation will maintain an Army and Navy of

(*F M & Television, July* 1944)

considerable size for some time after the war. They will require a generous allotment of frequencies.

C. I. Stanton, administrator of the Civil Aeronautics Administration, has predicted 300,000 civilian airplanes in the United States within three years after the war and 500,000 by 1950. In view of the close relationship between safe flying and the use of radio for communication and navigation, think what a demand for frequencies for both planes and airports such a development will generate!

Our huge ocean-going and Great Lakes cargo fleets, the result of one of the greatest miracles of war production, will remain important users of radio communication and navigation facilities. Harbors, yachts, forest services will want radio channels.

Present indications are that FM, television, and facsimile will grow to giants after the war and frequencies for these services will have to be supplied.

In view of all these demands already on the horizon, it is plain that we will still need economical rationing of frequencies after the war and that government and industry must cooperate and plan now to achieve the goal for which we are all striving, namely, sufficient assignments to meet at least the minimum postwar needs of all legitimate radio services.

Satisfactory progress in this planning is now being made. The Federal Communications Commission, which has the responsibility of allocating frequencies for civilian use; the Interdepartment Radio Advisory Committee, which recomends frequency assignments for government departments and agencies to the President in normal times; and the Radio Technical Planning Board, composed of industry representatives, are actively studying these important problems.

As to the relatively high importance of the established emergency services in the radio realm there can be no question. Everyone responsible for planning radio's future realizes the unique and urgent requirements of these services, and will bend every effort to supply enough frequencies that they may attain their maximum effectiveness.

The fighting men who have the greatest resources of science, engineering and production back of them will be the victors

DAVID SARNOFF.

HIGH-SPEED TIME BASES

Reprinted from Electronic Industries

By William A. Stewart

Engineering Dept., Philco Radio and Television Corp.

Application of blocking oscillator produces a time base suitable for analysis of micro-second intervals.

USUAL sweep circuits have not proved particularly satisfactory for the observation and measurement of recurrent phenomena of very short time duration. For certain of these uses, it is necessary to maintain a calibration of at least 0.05 microsecond, and make possible repeatable measurements with that accuracy.

It is, of course, possible to construct the usual type of RC sawtooth generator, and with careful attention to the necessary bandwidth, build an amplifier to obtain sufficient voltage to operate the time base. Needless to say this method requires several tubes, entails considerable difficulty of design, and necessitates the use of many circuit components. After construction, even should the sweep circuit be satisfactory otherwise, individual variations of the several components with temperature, humidity, voltage, etc., make calibration difficult to maintain.

After due consideration of the factors involved in such a circuit, it would appear highly desirable to obtain necessary voltage for the operation of the time base directly from the saw-tooth generating circuit itself. Should this be possible, not only would the circuit difficulties be greatly reduced, but the calibration might prove to be much easier to maintain.

HIGH ENERGY CONTENT

Consideration of the usual means available for obtaining a saw-tooth voltage pulse of short duration indicate the necessity for a heavy current through a comparatively low value resistor, either for the period of time between sweeps or momentarily during a portion of the saw-tooth. It is obvious that the greater the voltage swing desired, the more current required through the saw-tooth generating circuit.

Hence, to use the first of the two methods would necessitate the utilization of a tube of large current carrying capabilities, and require a power supply capable of maintaining its voltage under the indicated current drain. Further, the resistor of the RC circuit would have to be capable of high heat dissipation. For example, if the resistor utilized were 1,000 ohms, the 500 volt saw-tooth required to obtain a fairly linear 300 volt sweep would necessitate a current drain of half an ampere with the voltage supply providing about 600 volts.

A cathode follower in the output would make possible the use of a higher resistor, but the added capacitance of the follower would tend to augment the nonlinearity of the saw-tooth, and hence make a smaller portion of it available for use. It appears likely, therefore, that there would be little gained. In view of the foregoing, this method appears impractical.

The second of the two methods of saw-tooth generation seems to offer more possibilities. If the plate dissipation of the tube used is taken as the limiting factor, it is evident that considerable current may be drawn for short periods. For example, if the allowable plate dissipation of a tube is five watts at one kilovolt,

(Electronic Industries, August 1944)

it would be possible to draw five amperes for a period of one microsecond one thousand times a second before the rating was exceeded.

The limiting factor here, of course, would be the peak emission capabilities of the tube. However, taking the case mentioned in a preceding paragraph, where the current needed amounted to one-half ampere, an ordinary receiving tube, such as the 6SN7, might be used, provided the repetition rate were kept within reasonable bounds.

The requirement, therefore, resolves itself into a problem of driving the grid into the positive region and holding it there for a period long enough to permit the plate voltage to reach the value indicated by the plate current and the resistor of the RC circuit. Since this period also represents the "return-trace" it should be as short as possible.

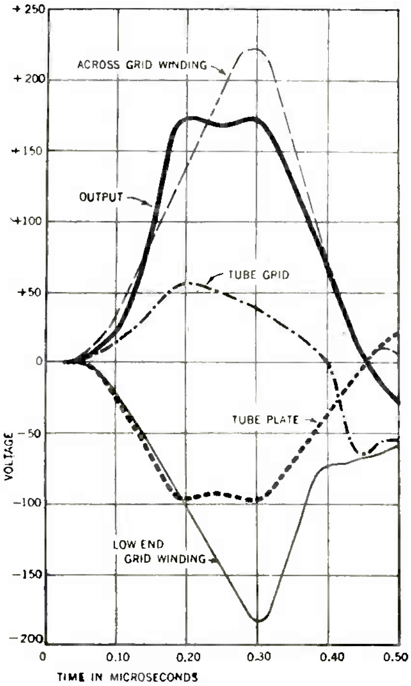
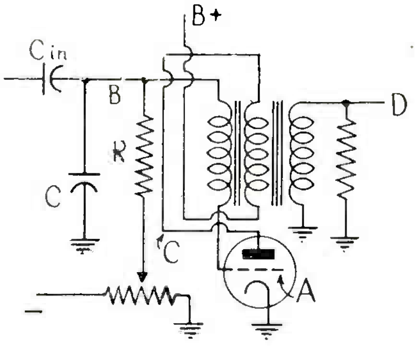


Fig. 1—Oscillogram showing blocking oscillator action giving short duration positive pulse.

Fig. 2—Experimental set-up showing circuit utilized in analyzing oscillator operation.



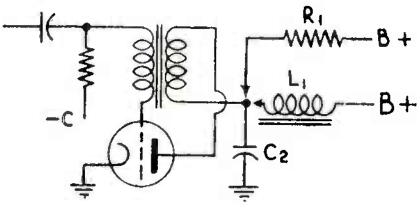
Because the tube is to be completely cut off for the period between sweeps, and during its conducting period run at saturation, an idea of the grid swing required may be obtained. If cut-off is ten per cent of the plate voltage, the grid would have to swing more than sixty volts for a plate potential of 600 volts. Probably under such conditions, a grid bias of about 70 volts would be safe, and a firing pulse of between 80 and 100 volts needed.

This firing pulse would have to be a square wave of fairly short time-duration. If the time-base of the sweep is to be two microseconds long—four inches at 0.5 microseconds per inch—it would be logical to wish the "return-trace" to be at least not more than twenty-five per cent of that period, or 0.5 microsecond. Since this will represent the time during which the tube is conducting, it will also represent the entire duration of the triggering pulse.

Thus, the requirements for the firing pulse: Total duration, from cut-off to cut-off, not more than 0.5 microsecond; amplitude of pulse above cut-off, at least 80 volts; shape of pulse, as near a square wave as posible, at least on the leading edge, while the trailing edge must not distort the linear portion of the saw-tooth. The pulse must have a maximum amplitude of sufficient duration to permit the plate voltage to drop to its minimum value.

Examination of the several circuits capable of producing a positive pulse suggests two or three possibilities. The first such circuit which comes to mind is the familiar "trigger" circuit, a modification of the multivibrator where the first grid is held below cut-off until the system is placed in operation by a synchronizing pulse. Investigation of the operation of this circuit indicates that a one microsecond pulse is about the lower limit of pulse duration obtainable due to the inherent slope of the wave generated by this circuit.

Fig. 3—Saw-tooth wave circuit, with alternate forms of output.



For pulses of approximately one microsecond at half amplitude the wave shape is about that of a triangle. Durations of less time result in a reduction of amplitude with the triangle shape being maintained. This fact more or less rules out the use of a trigger circuit directly. It might be possible to differentiate the leading edge of such a pulse, amplify the result, clip, and perhaps obtain a satisfactory firing pulse for the saw-tooth generator. The difficulties involved in such a process probably would be no less than those inherent in amplifying a saw-tooth, so it may be ruled out.

Another possibility lies in a thyratron. This tube will generate, when fired, a positive pulse of considerable amplitude across a resistor placed in its cathode circuit. The limitation here lies in the deionization time of the tube. However, the application could prove practical.

A third method of obtaining a pulse of the character required is the blocking oscillator. A simple circuit of this character, where the tube is run at cut-off and the operation started by a keying pulse, will depend for its pulse duration upon the inductance and capacity of the feedback transformer used, as well as upon the resistance and capacity in its grid circuit.

When the circuit is keyed by a positive pulse applied to the grid of the tube, a pulse having sufficient amplitude to overcome the bias voltage and start current flowing through the tube, the feedback action of the transformer will send the grid into the grid-current region, and the tube to saturation. Due to the inability of the plate voltage to maintain itself through the inductance of the plate winding of the transformer, the voltage at the plate will drop sharply.

PULSE POLARITY

The grid winding of the transformer, together with the effective capacitance in the circuit, will form a resonant circuit. Due to the presence of grid current, the grid-cathode resistance will be rather low, and the circuit will have a fairly high "Q". This circuit will be shocked by the voltage induced from the plate winding and oscillation will start to build up.

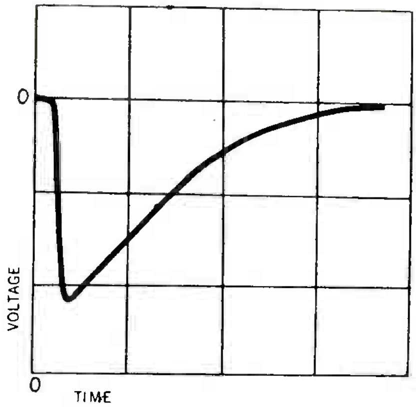
This oscillation will have its positive polarity at the grid, making the low end of the grid winding negative. When the energy supplied from the plate winding has accumulated on the capacitor, the direction of current flow in the grid winding will reverse. The feed-back action of the transformer then sends the voltage at the plate of the tube back to the level of the supply voltage, and the grid to cut off.

The action results in the generation at the plate of a negative pulse of considerable amplitude. A third winding may be added to the transformer, which will serve to invert the pulses and hence, the circuit may be utilized to supply a positive pulse having high amplitude, short duration, and essentially flat topped. The curves obtained at various points in the circuit are shown in Fig. 1.

This circuit has been discussed at some length because of its particular application in the generation of fast time bases. In the preceding paragraphs attention has been given to the usual type of circuit in which the saw-tooth generator has its own tube, while the firing pulse is supplied from another tube or tubes. Such a circuit may be set up utilizing the positive pulse generated by the blocking oscillator to fire the saw-tooth generating circuit.

However, the curves shown in Fig. 1, together with the function of the circuit as discussed, indicate that a heavy current passes through the blocking oscillator when it fires. The presence of this heavy current demand suggests its use directly in the generation of a saw-tooth. Such a circuit could be that shown in Fig. 3. The demand current is supplied by the capacitor C_2, while the R_1-C_2 combination provides the charge curve usable for the sweep. The type of curve obtained is shown by Fig. 4. The curves, Fig. 1, were obtained using the experimental set-up, Fig. 2. The trigger pulse was introduced through a capacitor "Cin", which is comparatively small, relative to "C", thereby introducing as little of the trigger voltage into the system as possible. The curves were obtained at the points indicated: "Output", from "D" on the diagram to ground; "Tube Plate", from "C" to ground; "Tube Grid", from "A" to ground; "Low End Grid Winding", from "B" to ground; and "Across Grid Winding" between "B" and "A".

Fig. 4—Saw-tooth waveform from circuit used in Fig. 3 using R_1C_2 output.



Examination of Fig. 4 indicates the presence of only approximately 60 per cent of usable saw-tooth voltage. It is entirely practicable to use a comparatively high plate voltage; the saw-tooth generated by this means, at least for short-duration sweeps, will usually run between 50 and 80 per cent of the plate voltage. Attention should be directed, however, to the fact that the plate dissipation of the tube used should not be exceeded at the most rapid repetition rate at which the saw-tooth is to be used.

It is necessary, when using the foregoing, to employ a fairly high plate voltage, and throw away a comparatively good sized portion of the saw-tooth. This suggests that perhaps some better method of obtaining a saw-tooth shaped wave might be available.

Examination of Fig. 1 suggest that the sides of the pulses, being comparatively straight for a fair sized portion of their length, might be used. Further investigation discloses that these curves are those typical of the growth and decay of current in a reactor. It appears obvious that the larger the inductance, the slower the growth of current. Further, the higher the "Q" of the circuit, the larger the straight portion of the curve. It would appear that these physical facts might be put to good use.

Requirements for the generation of a saw-tooth have been noted:

(1) Means for the momentary passage of a large amount of current.
(2) Means for the supply of this current.
(3) Means for slowing down the recovery of the circuit to a normal condition, and making that recovery proceed along a definite curve, a fair portion of which is linear.

Toward the satisfaction of these requirements, there are the following:

(1) A blocking oscillator to supply the means for creating the momentary surge of current.
(2) A capacitor to supply the current for the surge.
(3) An inductance to delay the return of the voltage to normal.

These may be connected as shown in Fig. 3 using the inductive-capacitive output connections.

Now, as the blocking oscillator is fired, the initial current for the generation of the plate pulse is drawn from the capacitor C_2; the presence of the inductance L_1 in the circuit prevents current from being drawn from the supply at this time. At the low point of the pulse, the grid cuts off, and plate voltage returns to normal, with the capacitor C_2 recharging. The delay occasioned by the presence of the inductance L_1 in the circuit results in the capacitor C_2 recharging along a combination of the curve of the growth of current in a reactor, and the charge in a capacitor.

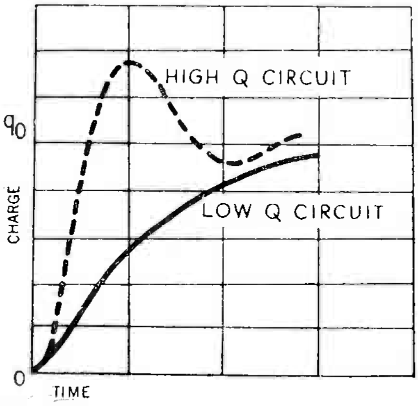


Fig. 5—Growth of charge in circuit having inductance, capacitance and resistance.

Fig. 5 shows the computed curves obtained from an inductance of 10 millihenries, a capacitance of 100,000 micromicrofarads, a resistance of 200 ohms (dotted curve), and a resistance of 1250 ohms (solid curve).

From the solution of the differential equation for a series LCr circuit, and assuming $r^2/4L^2$ to be small as compared with $1/CL$, it can be shown that the charge on the capacitor will be equal to its initial charge, q_o, after a time interval

$$t = (\theta+\pi/2)\,(1/CL - r^2/4L^2)^{-\frac{1}{2}},$$

where

$$\sin\theta = r(C/2L)^{\frac{1}{2}}$$

This then may be taken to be the approximate length of the sweep obtained in this manner. It might be noted that this time should also be that of the duration of the output pulse shown in Fig. 1, where the values are those of the grid circuit. L would be the effective inductance of the grid coil, while C would include the capacitance of the wiring, tube, etc.

It will be noted that the start of the curve is not abrupt. The linear portion, however, continues to a point well above the full charge line. This curve may be combined with the charge curve of a capacitor by placing a resistor in parallel with the inductance L_1. This will have the added effect of "damping" the oscillation shown about the full charge line. The value of this resistor may be determined by experimental means; too small a value will cause distortion of the curve. The addition of this resistor will eliminate the gradual curve at the beginning of the slanting portion of the saw-tooth.

Reference to the equation giving the time of the sweep indicates that variation of C_2 would produce a change in the slope of the sweep. However, it also will be noted that the condition of $1/CL$ greater than $r^2/4L^2$ must be maintained to obtain the linearity desired. Therefore, a limiting value for C_2 will be found for each value of L and r in the circuit, beyond which the linearity will not be preserved.

Keeping these facts in mind, however, it will be noted that a sufficient variation in the time of the sweep may be obtained with a variable capacitor to permit calibration, provided the value of the inductance L_1 is chosen carefully, and the maximum capacity obtainable with the capacitor is still low enough to permit the above condition to be maintained.

It will be noted that the saw-tooth obtained by the use of the circuit shown in Fig. 4 is negative. Inversion of the polarity by means of a tube is possible, but for very short sweeps, somewhat impractical. Consideration of the method of obtaining the sweep leads to the observation that since the delay in the inductance actually forms the curve, the magnetic field in the core must vary along the same curve. Hence, it should be possible to utilize a transformer of reasonably good frequency response to invert the saw-tooth. Further, the step-up and step-down abilities of the transformer may be utilized.

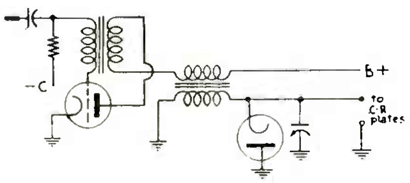
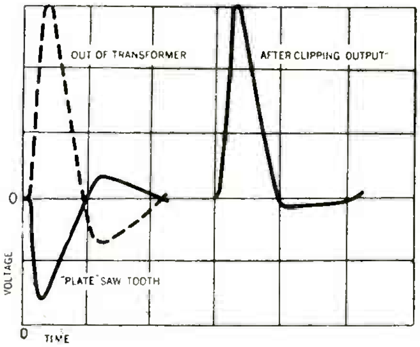


Fig. 6—High-speed sweep circuit giving saw-tooth output of waveform shown at right in Fig. 7.



Twice the saw-tooth voltage, accompanied by inversion may easily be had by this means, and further, each end of the secondary winding may be connected to a plate of the cathode ray tube.

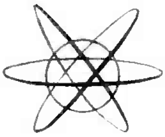
If a high-voltage tube is used for the saw-tooth generator, giving rise to a high voltage pulse, say of the order of 2,000 volts, the voltage pulse may be turned into a current pulse for use with magnetic deflection circuits by the use of a step-down transformer.

The curves shown in Fig. 1 were obtained by the writer with the aid of a sweep utilizing a step-up transformer. The oscillograph calibration was set at 0.25 microseconds per inch. The calibration has been maintained for some time without further attention. No difficulty has been experienced with "flicker" or "jitter."

The saw-tooth generating circuit makes use of a 6SN7 and a two-to-one step-up pulse transformer, the low winding of which acts as the inductance in the saw-tooth forming circuit. The high-winding of this transformer has an inductance of approximately 10 millihenries.

Another pulse transformer, having a rather straight-sided characteristic, a comparatively low inductance, and a four-to-one step up ratio between the plate and grid coils is used to regenerate the tube. The low winding is placed in the plate circuit. By this means the grid of the tube is forced to a rather high positive level, and the conductance of the tube correspondingly increased. This insures a comparatively good-sized plate swing.

The portion of the oscillation on the opposite side of the axis from the saw-tooth was clipped after inversion by a 6H6. Calibration was accomplished by a "trimmer" across the output from the transformer. It was discovered that with the inductance used in the plate circuit of the tube, the distributed capacity of the transformer and wiring was sufficient, hence the capacitor, which would be used with longer sweeps was omitted. The circuit is shown in Fig. 6, while the saw-tooth obtained is shown in Fig. 7.



EXPANDS ATOMIC RESEARCH

The electron mirco-analyzer, developed in 1943 reports on atomic composition of submicroscopic particles of matter. It tells about particles too minute to be seen by microscopes!

ANTENNA BOTTLENECK

Reprinted from Television

By T. R. Kennedy, Jr.

Reception problems are analyzed with special emphasis on crowded metropolitan areas. Getting to the top of the trouble, a master-antenna system is presented as an all-wave remedy for the ghostly difficulties of video-minded apartment dwellers.

LET us begin with a few assumptions—the war is over, the television industry is embarked on a receiver-building program, say 1,500,000 sets the first year, double that the second and so on. Half of the receivers are earmarked for big-city sales where most of the people live in apartment houses—hundreds under a single roof.

Let us assume that television shows are so attractive that dealers everywhere are glutted with orders, that 500,000 sets will be sold in metropolitan New York as soon as deliveries can be made. It isn't too much to expect. The broadcast-set census in the same area is nearly 5,000,000 receivers.

Could we operate that number of television sets in New York apartments as soon as they can be delivered and installed. The answer is *no!* Not any more easily than we could serve the same householders with electric lights and power without electric-light wiring in the apartment buildings, which would be impossible.

Television reception free from annoying interference is possible for a limited number of people, almost anywhere in the greater city areas, by erecting on the roof-tops proper types of antennas called television doublets. The doublets are small, they do not disfigure the skyline any more than ordinary broadcast-antenna wires. But television is an extraordinary service and extraordinary precautions must be taken to receive the signals clearly. Trouble begins when a number of video-set owners install television doublets on the same roof. They do not get along well with each other. They interact and cause wave reflections that result in interference patterns on the viewing screen. In a city like New York, the television waves bounce from walls and buildings anywhere within the range of the waves. In addition, walls, towers, water tanks, metal roofs, the television receiving antennas themselves and a variety of other objects contribute to the general wave chaos. The result is something like an amusement park's *Hall of Mirrors.* Every bounce brings a new set of troubles to the video-viewing screen, and the greater the number of television antennas on a single roof the greater is the problem.

As a result, *ghost* images, perhaps any number from two to 10, may be visible on the screen. A performer in the television studio may hold up his finger. The home televiewer may see a finger for every ghost.

Take a hypothetical apartment house with 100 prospects for immediate installation of television receivers. Under the best arrangements possible today, no less than about 25 separate television antennas would be necessary to serve them all—four receivers to one antenna. It would be utterly impossible to get the best results from 25 antennas on the roof, more or less closely grouped to take advantage of the best spot for reception from all local television stations.

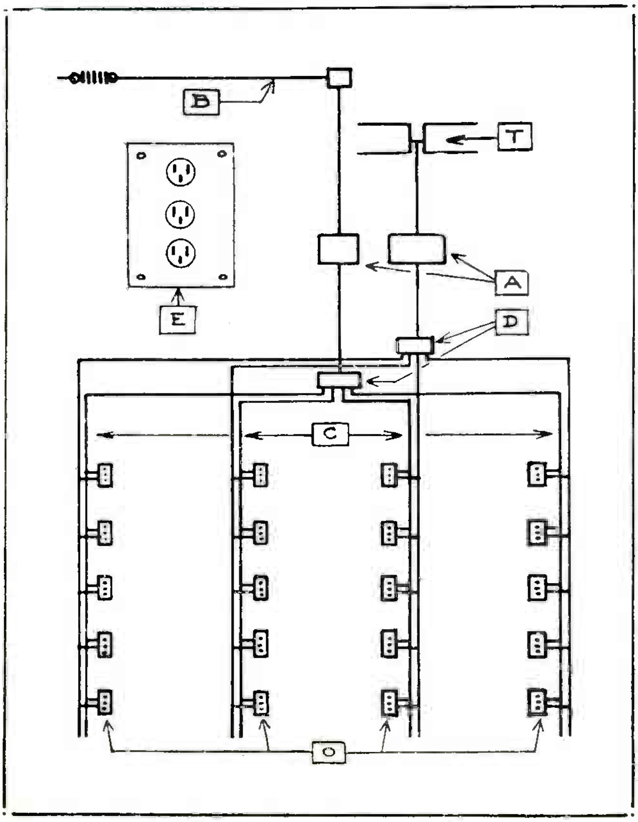
What then? The sole means of doing such a job would be by the installation of a master-antenna system—one excellent pickup doublet, an all-wave electric repeater installed in a convenient location and turned on and off by a clock, and a network of wires conveying the received and amplified programs to outlets in every apartment. It can be done at moderate cost—say about $40 per outlet for television, FM, short-wave and broadcast reception. Each apartment outlet would comprise a three-receptacle plug-in device—one receptacle for broadcast and short wave, one for FM and one for television.

Careful installation of the television receiving doublet or *dipole* invariably pays in clearer reception of images. An 18- or 20-foot pole should be selected and the dipole affixed so it may be adjusted up and down. Best reception may not be at the top. Actually, it may be half way up or even near the bottom. There is likely to be a rather well-defined spot on the roof where the clearest signals are received from all local television stations. Often the final location must be a compromise between best locations for different stations. Best signals may be had with the dipole tilted one way or another.

LOCATION FINDER

The best spot and tilt can be located quickly if the experimenter has access to a portable television receiver. With all stations on the air—test patterns are best—the best location for all can be found in an hour or less. Without the portable outfit it may take weeks, as the test dipole is moved from place to place during the few hours when test patterns are radiated.

The same support for the television dipole may also be used to support one end of the broadcast-short-wave-FM antenna if the outfit is to be an all-wave system



Block diagram of the complete all-wave antenna system—B is the broadcast, short-wave and FM wire. T is the television dipole. Both may be mounted on the same supporting mast or pole. A is the respective amplifier and repeater, both untuned and designed to cover very broad bands. D is the distributing transformer. C is the series of cables installed throughout the building. O is a series of apartment outlets. E is an enlarged view of a proposed outlet.

in every sense of the word. Furthermore, if the system is to supply many apartments in a large building, it will look something like the accompanying block diagram of a complete all-wave receiving system from antennas to apartment outlets. The separate broadcast-FM-short-wave and television antennas shown at the top of the pole feed separate broadcast-FM-short-wave and television untuned amplifier-repeaters. The whole broadcast-short-wave-FM band is accepted by one antenna combination, passed on for amplification by its respective repeater, then fed into a series of cables installed in the walls of the building and terminating in the apartments.

Similarly, the whole television band from 50 megacycles up to at least 100 is similarly treated by the television part of the antenna system.

The repeaters (A) can be located anywhere inside the building or on the roof in a special housing. The point of distribution (D) to the various cables may be at the repeaters or some distance from them, as shown in the diagram. Points D are special *distribution transformers.* All sets of cables may be run in the same conduit throughout the building. The amplifiers may be designed to supply a great number of branch lines throughout a large building, or an amplifier for each branch, or any practical or economical arrangement where several hundred or more outlets are required.

The all-wave master system pictured is a combination of the well-known design evolved a few years ago by Amy, Aceves and King, New York consulting radio engineers, plus a television all-wave system now under design in the laboratory. It is expected to be ready for use by radio manufacturers as soon as materials are available.

AIDS HUNDREDS

From the foregoing, it is seen that a wide-range system can be designed to do for hundreds of apartment dwellers what the single all-wave system does ideally for the suburbanite. As to cost, the 100-apartment installation job, based on prewar dollar values, may be installed from antenna to outlets for about $4,000. Television alone would cost about $30 per outlet, or $3,000 for 100 apartments.

Yes, the radio-antenna engineers of the country are getting ready for postwar television on a wholesale basis to back up the intended wholesale production of receivers by the million. But the production of antenna systems and receivers alone will not solve the formidable problem of how to get apartment-house owners to install the needed equipment. Anyone who has had experience with such problems knows the size of the task ahead. Property owners cannot be expected to spend money for master antennas unless it will repay them to do so. How to sell them on the merits of the project is a matter for the whole radio industry, many leading radio men believe.

We have been hearing something about the possibility of constructing home television receivers with *built-in* antennas. Undoubtedly, such receivers would relieve some of the pressure on those whose job it will be to make sure television grows at a rapid pace after the war. Built-in antenna television receivers, according to leading radio experts, can be expected to operate quite satisfactorily only when their pickup systems are directly exposed to the waves from the television transmitters. Otherwise, television will have to use housetop antennas. It is estimated that for every built-in television antenna that will operate satisfactorily in a city of steel like New York, there will be 100 or more that will not. Remember, caution the radio experts, television reception is a much more serious problem than ordinary broadcast reception.

Certainly, it is a problem that must be fully solved in one way or another before television can hope to match or surpass the rapid growth of broadcasting after World War I.

PAPER CAPACITORS AS MICA CAPACITOR SUBSTITUTES

Reprinted from Radio Service Dealer

By The Engineering Dept., Aerovox Corporation

War-time conditions made mica capacitors unobtainable for civilian radios. Methods for substituting available paper capacitors are discussed in this timely article.

AS A MEANS of meeting the shortage of mica capacitors, various capacitors of other types have been proposed as alternates. Included among the suggested substitutes are the inpregnated paper capacitors of both tubular and molded-bakelite construction.

Paper capacitors of several types have been tested by the capacitor manufacturers to determine their suitability as mica condenser substitutes. Among the electrical characteristics investigated are the *Q*, power factor, insulation resistance, temperature coefficient of capacitance, and working voltages. In determining the suitability of substitute capacitors, it has been necessary to keep in mind the particular applications in electrical circuits in which mica condensers have distinguished themselves, and to respect size requirements already set by mica capacitor dimensions.

TYPES

Bakelite-moulded paper condensers usually resemble standard molded mica units in shape; and their sizes are not much different from those of mica capacitors. The capacitor sections may be of "stacked" construction or may be "wound" and flattened. The molded paper condenser may be impregnated with oil or wax.

Special tubular paper capacitors for mica substitution resemble standard tubular units except for their reduced size. These condensers are generally oil-impregnated and are provided with cylindrical metal containers with or without an outer insulating sleeve.

Substitute paper condensers of both types cover a wide range of capacitance values. While it is desirable to replace as many of the mica types as possible, it is particularly important that alternates be provided for the larger condenser value units which employ the greatest amount of mica. Prominent in the later class are units with capacitance ratings of 0.002 *mfd.*, 0.005 *mfd.*, and 0.01 *mfd.*, which are employed in various coupling, blocking, and by-passing positions in radio and electronic circuits.

SIZES

Bakelite-molded paper capacitors can be found with approximately the same dimensions as corresponding mica condensers up to 0.01 *mfd.* These units are usually molded in black bakelite in accordance with tentative specifications of the *American Standards Association.*

Special small-sized oil-impregnated paper tubualar condensers up to 0.01 *mfd.* capacitance are obtainable in overall lengths from 1" to 1 13/16" and diameters from 5/16" to 7/16". Outer insulating sleeves add 1/16" to length and 1/32" to the diameter. These small sizes should enable direct replacement of mica units mounted in close quarters.

(Radio Service Dealer, July 1944)

ELECTRICAL CHARACTERISTICS

The electrical characteristics of substitute paper condensers depend upon the material employed as a dielectric (at least as far as dielectric constant is concerned), and the properties of the oil or wax impregnant.

In general, a low Q value (10 to 30 at 10 *Mc.*) may be expected. Power factor will be approximately 0.5% at 1000 cps. Insulation resistance will be of the order of 8,000 to 10,000 megohms at 500 volts *dc.* Residual inductance will depend upon the type of construction and lead length, and is usually of such magnitude that the resonant frequency of the 0.01 *mfd.* unit occurs in the vicinity of 10 megacycles.

Beyond the resonant frequency, the condenser is generally considered as unsuitable for by-passing in high-frequency circuits. However, this is not entirely true. Stating the matter in engineering terms, the reactance of the capacitor does become inductive at frequencies higher than the resonant point, but an inductive reactance can be as efficient a by-pass path as a capacitive reactance, as long as the reactive path is considerably lower in ohmage at the operating frequency than is the by-passed path. This will be true except when phase angle of the feed-back voltage is of importance. Thus, for instance, an inductive reactance of 1 ohm or thereabouts might by-pass effectively a tube cathode resistor of 500 ohms. At a certain high frequency beyond resonance, the inductive reactance will become equal to the resistance of the by-passed component and its by-passing ability, accordingly, will be destroyed.

FIG. 1

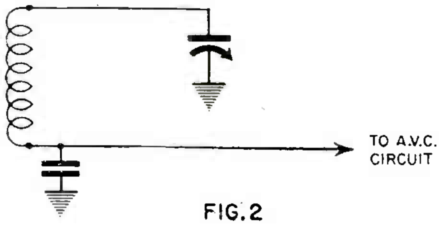


FIG. 2

Temperature coefficient of capacitance for the 0.01 *mfd* metal- encased tubular substitute paper unit will be positive and of a low value. Temperature coefficients of both capacitance and power factor are governed by a number of factors which are of special concern to the manufacturers and some servicemen.

Capacitance tolerances of substitute paper units up to, *but not including* 0.01 *mfd* capacitance, are —20 to +50%; for units of 0.01 *mfd* capacitance, the tolerance is —10 to +40%.

Common working voltages for the substitute paper condenser are from 300 to 800 volts *dc* for capacitance values between 0.001 *mfd* and 0.01 *mfd.* Some of the types have already given good account of themselves on life tests conducted by the manufacturers as well as their customers.

Ability of the substitute units to withstand water immersion according to any standard specifications is a function of the condenser casing, rather than of the type of element or impregnant. This is important in moist locations.

APPLICATIONS

It has been common practice to employ mica condensers in certain critical positions in r.f. circuits where equivalent series resistance of the unit must be of a low magnitude. One such application is the fixed-capacitance series padder in tuned *L-C* circuits in radio receivers, r.f. oscillators, and electronic test instruments (See *Figure 1*).

In order to prevent broadening of the selectivity curve of such a circuit, it is necessary that the equivalent series resistance of the padder condenser be very low. Another manner of stating this requirement is by saying that the capacitor Q must be very *high*. Heretofore, mica condensers have met this requirement with no difficulty. However, the low-Q characteristic of the substitute paper condenser renders that unit *totally unsuitable for use in high-frequency tuned circuits.*

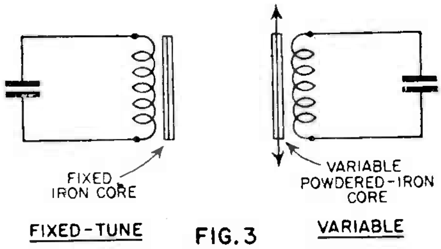


FIG. 3

Certain receiver circuits in which automatic volume control is incorporated employ a fixed condenser in series with the grounded end of the inductor of a tuned circuit, as shown in *Figure 2*. Here, as in the first case, the fixed capacitator is effectively connected in series with the coil and the variable condenser and will reduce the circuit selectivity unless the fixed unit posseses low equivalent series resistance. Present substitute paper condensers do not exhibit a sufficiently high Q to replace mica capacitators in this application.

Similar tuned or padded circuits containing only fixed capacitors (*Figure 3*) are employed occasionally at the high Q values imperative in r.f. circuits. Tuned audio amplifier plate and grid tanks, a.f. wave filters, and tone-control circuits are examples of this application in which the new substitute paper condensers are entirely satisfactory, provided they show low power factor at 1000 c.p.s.

The paper units can be used, also, for by-passing in r.f. circuits operating at frequencies up to the capacitor resonant point, and as far beyond as the ratio of reactance to by-passed-circuit resistance will permit. They are satisfactory for by-passing in audio-frequency circuits.

Figure 4 shows an ordinary superheterodyne receiver circuit in which permissible positions for substitute paper capacitors have been indicated.

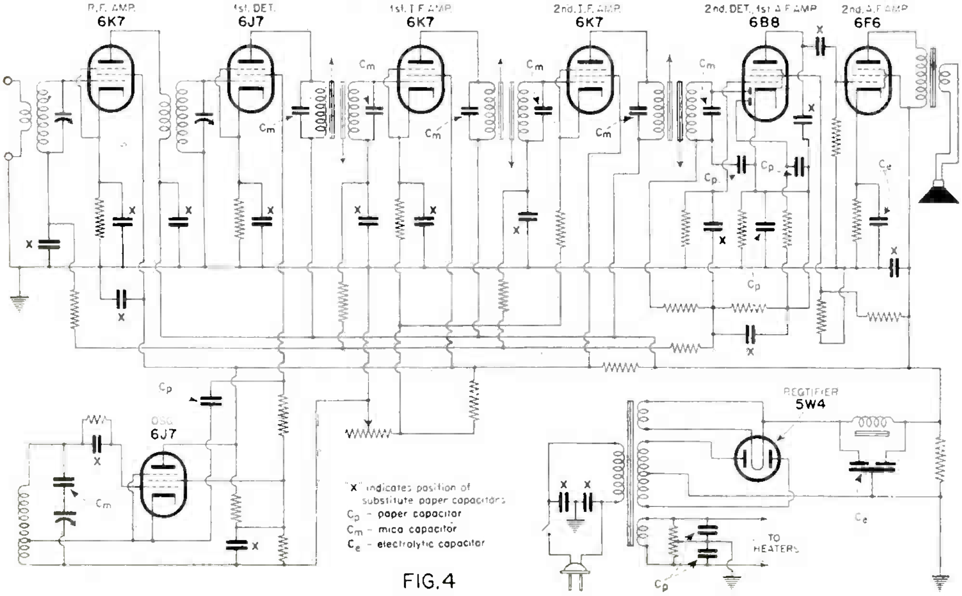


FIG. 4

Illustrating where paper capacitors may be substituted for micas in a super-het circuit.

THE VOLTAGE DOUBLER

Reprinted from Radio-Craft

By Jack King

A GREAT deal of interest is centered in voltage doublers. These circuits have been used in civilian and are being used in military equipment, although military applications, of course, are secret. Many ordinary radios use voltage doublers, yet more than a few servicemen are not too certain about the underlying principles. A half-wave voltage doubler is shown in Fig. 1-a. An alternating voltage having an essentially sine-wave form is applied between terminals 1 and 2. A 50Y6 or 25Z5 can be used in such circuits.

METHOD OF OPERATION

The circuit is easy to understand. Fig. 1-b shows the equivalent diagram when the line voltage is going through the positive half of the cycle. Point 1 is positive, point 2 negative. Condenser C1 is charged up almost to the full peak value of the line voltage, or a maximum of about 115×1.41 volts. The P_1-K_1 section of the tube conducts during this part of the cycle because P_1 has a positive charge and the negative electrons of K_1 are attracted to it. There is in effect a low resistance path through the tube between P_1-K_1, but not through P_2-K_2. During the next part of the cycle when point 1 is negative and point 2 is positive, there is a positive charge on P_2 and an electronic path through P_2-K_2, so that C_2 is charged up. The potential in the circuit is that of line plus the stored voltage in C_1. The basic circuit is shown in Fig. 1-c. A simplification of this circuit is shown in Fig. 1-d, permitting easy visualization of the action.

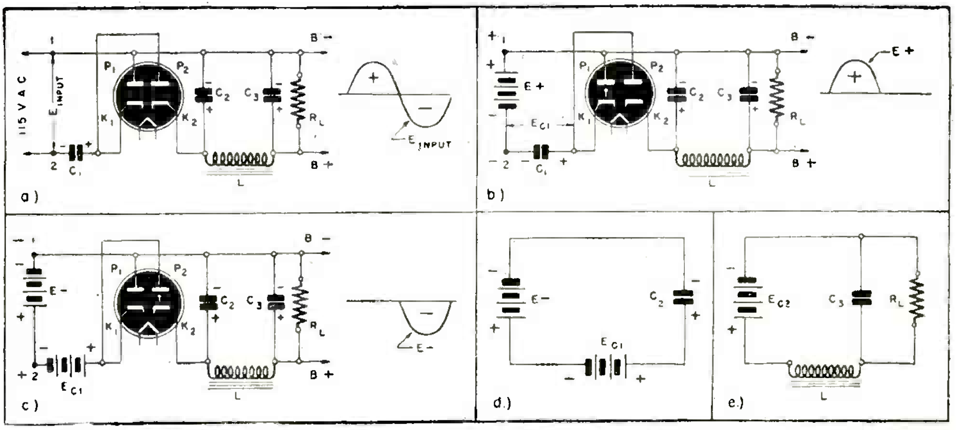


Fig. 1—How a voltage doubler works may be seen from the above diagram. Actual and equivalent circuits of a half-wave rectifier are shown.

Note that the charging of C_2 occurs when point 1 is negative and 2 positive, during one-half of the cycle of operation. Therefore, the replenishing of the charge of C_2 takes place only during half of the cycle. The voltage across C_2 may be made substantially constant by proper circuit design. If the load draws only a small current on C_2, the voltage of C_2 will not drop greatly between charging times. Choke L assists in stabilizing the output voltage because it can store energy and

(Radio-Craft, September 1944)

return it to the circuit as needed. Therefore, this choke should be of good quality and have sufficient inductance. It should have a large enough iron core so that it will not saturate on current peaks.

The voltage rating of C_1 must be sufficient to withstand the peak line voltage and C_2 should have a voltage rating that exceeds twice the peak value of the line voltage. A 450 volt commercial rating is satisfactory. A 250 volt rating may be used for C_1. The equivalent circuit is shown in Fig. 1-e, with Ec_2 about twice the line voltage, or 230 volts in typical sets.

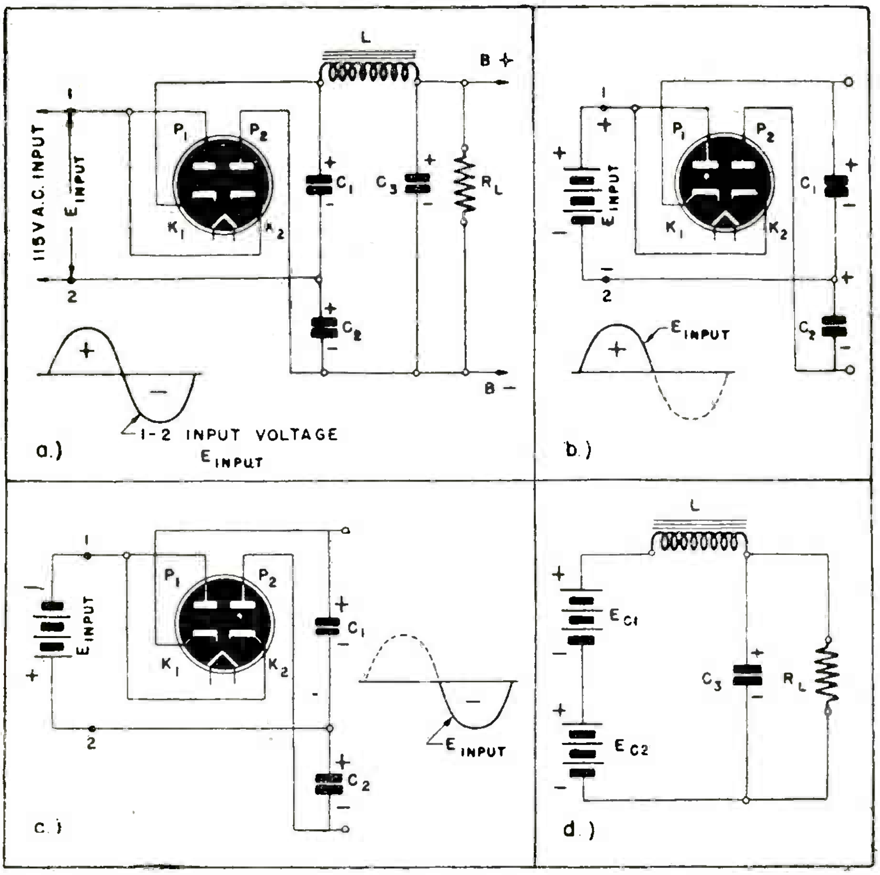


Fig. 2—Schematic representation of the operation of a full-wave voltage-doubling circuit.

THE FULL-WAVE CIRCUIT

The full-wave voltage doubler is shown in Fig. 2-a. Assuming that point 1 is positive and point 2 is negative during the half of the cycle under discussion, the equivalent circuit is that of Fig. 2-b. There is an electron movement from the cathode K_1 to plate P_1, but P_2-K_2 is not a conducting path. Condenser C_1 is charged up to almost the peak value of the line voltage. On the next part of the cycle, point 1 is negative and point 2 is positive. The circuit is then equivalent to Fig. 2-c. P_2-K_2 is now an electronic path, but P_1-K_1 is not. Condenser C_2 is charged up.

The operation repeats itself as the input wave goes through its cyclic alternations. The net effect is that stored voltages in C_1 and C_2 add up to give a useful output potential. Fig. 2-d shows this effect. A voltage output of about twice the peak value of the line may be obtained, but the output voltage of course is dependent on the circuit design and load requirements. Voltage regulation is better if the load resistance is high and the current is small.

The condensers C_1 and C_2 should have the same voltage ratings. Each may be rated at 250 volts, but 450 volts is better. Condenser C_3, taking the total voltage output, must be a 450 volt unit. A good quality choke with a husky iron core will improve filtering and assure better voltage regulation. By voltage regulation we mean the securing of a fairly constant output voltage from the power supply under normal working conditions.

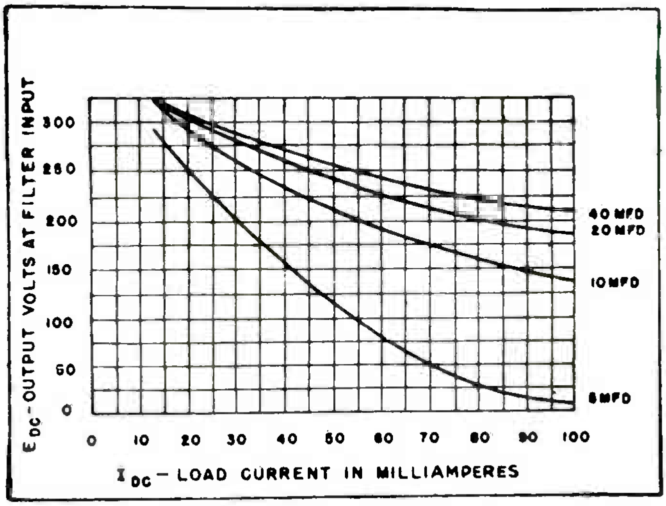


Fig. 3—Output voltage plotted against load current for the half-wave circuit.

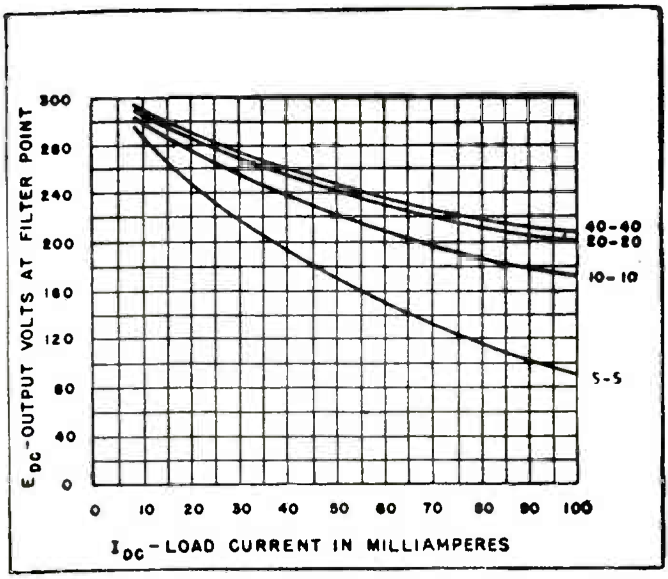


Fig. 4 Regulation is much better with the full-wave rectifier, especially with small filter condensers.

FAIR VOLTAGE REGULATION

Fig. 3 is a curve which shows the operational characteristics of the 25Z5 used as a half-wave voltage doubler. A curve showing the characteristics of the 25Z5 full-wave voltage doubler is given in Fig. 4 and a diagram of a typical radio receiver using a voltage doubler arrangement appears in Fig. 5. The voltage regulation is indicated by the curves. For example, in Fig. 3, using a 5 mfd. condenser for C_1 the output is 50 volts for a load current of 70 Ma., but decreasing the current demand to 20 Ma. results in a voltage rise of 200, and the new output is 250 volts at 20 Ma. Using a larger value of capacitance, the voltage regulation is improved. If a 10 mfd. value is chosen for C_1, the slope of the curve becomes less steep and an output voltage of roughly 185 volts is obtained at 70 Ma., with a voltage rise of 115 and an output of 290 at 20 Ma.

If a full-wave doubler is used, the curve in Fig. 4 for the 25Z5 indicates the regulation. At 70 Ma. demand, the output voltage is about 130 using 5 mfd. condensers. At 20 Ma. the output rises to 250, the rise being 120 volts. If 10 mfd. units are used, the voltage shift upward is 80 volts, changing from 200 at 70 Ma. to 280 at 20 Ma., which shows the voltage regulation of the full-wave voltage doubler to be better than that of the half-wave type. In servicing voltage doublers it is important that the polarity of the condensers be kept correct. It is easy even for an experienced man to make a mistake because the wiring is often confusing. Generally it is found helpful to use separate units instead of multiple type condensers.

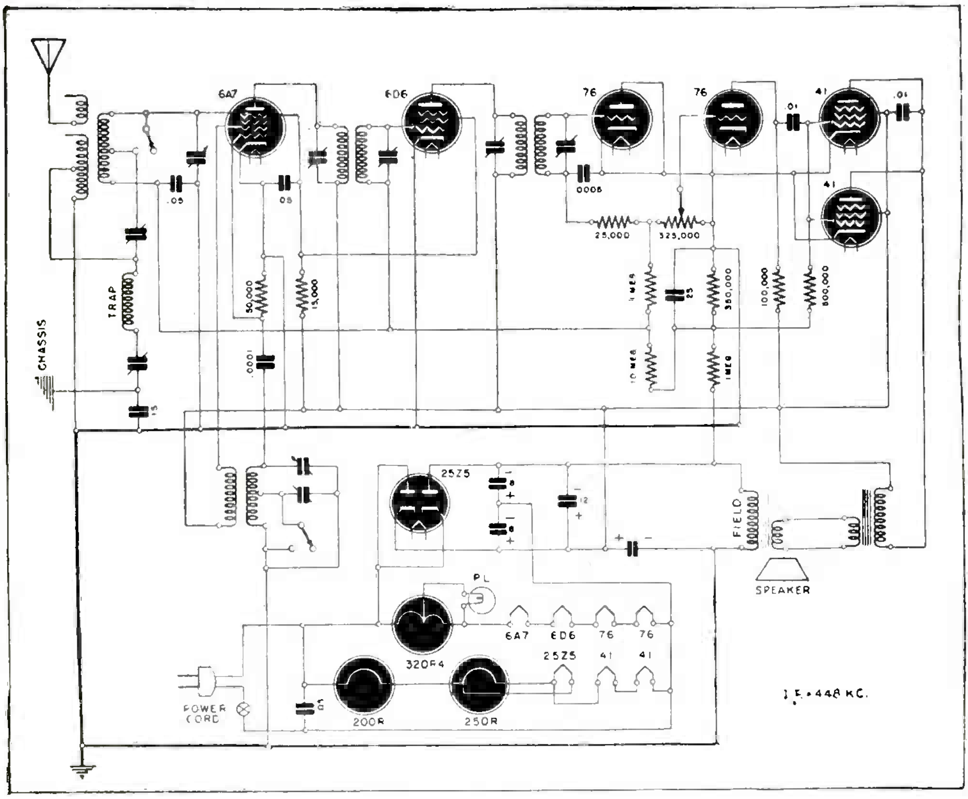


Fig. 5—The international Kadette 1019, a standard broadcast receiver which uses a voltage-doubling rectifier circuit of the full-wave type.

COLOR IN THE AIR

Reprinted from Television

By Peter C. Goldmark

Virtues of the Columbia Broadcasting System's video color device are explained by the inventor, who is also the network's chief television engineer. Holder of a doctorate in physics from the University of Vienna, he has also done practical television work in England. With CBS since 1936, he is presently engaged in the web's communications research connected with the war effort.

MUCH that has been stated or published in recent weeks on the subject of color television puts me in mind of the legend of Rip Van Winkle. How else explain the not uncommon belief that color television is still on the list of things to be accomplished at some future date? How else account for the prevalent misconception that color television cannot be transmitted except on ultra-high frequencies?

Transmission and reception of television in natural color were successfully demonstrated by CBS for a period of nearly a year prior to April, 1942, when war work required the full-time attention of laboratory personnel. Critical appraisal at that time, both lay and professional, declared CBS color television superior in quality to the black-and-white pictures broadcast on the same frequencies.

The color television that has been developed by CBS is a fundamental system, applicable to electronic as well as to mechanical methods. As demonstrated before the war, it was a three-color system, employing a rotating disk at the receiver and a rotating drum at the camera. Research has been seeking practical electronic methods for providing the color synthesis, but so far nothing as satisfactory as the color disk has been found.

Color-television receivers used in prewar demonstrations contained a 15-inch diameter color disk. Yet the observer could not detect its existence while in operation. It was almost silent and for long periods of time required neither adjustment nor replacement. Interesting and, perhaps, significant is the fact that the mechanical parts of these color receivers, even in their crude preliminary form, held up better than the electronic components under similar test conditions.

If a satisfactory form of all-electronic color television is developed after the war, it will not mean the instant obsolescence of receivers using rotating color disks. For color-television standards are such that they are equally appplicable to mechanical and electronic methods. This, of course, applies only to the color equipment in the receiver; it assumes that other standards such as lines, frames and band widths remain unchanged.

Once wartime restrictions have been removed, there is no reason why color television should not move forward as rapidly as black-and-white. At that time, work and experiments will be resumed on new color standards of 525 lines, 60 frames and 10-megacycle band width. Plans are now ready for the introduction of color receivers employing a small projection tube and a color disk approximately seven and one-half inches in diameter. The disk, with an automatic synchronizing and phasing unit, will be protected in a dust-proof capsule.

The same set will be able to receive programs in color and in black-and-white. Use of color in television will always depend to a certain extent on the amount of color contained in the subject, as well as on light conditions. There will be times when it will be desirable to follow a color program in black-and-white. Under such circumstances, the set owner can turn from color to finely detailed black-and-white by the simple process of pressing a button on his receiver. Moreover, a scene, which contains nothing but black-and-white, can be transmitted on color standards and received as black-and-white. The switch button on the receiver is provided in order to make full use of a frequency band which, in the absence of color, can be used for added geometrical definition in black-and-white.

The added cost of color in television receivers may fairly be compared with that of a standard automobile accessory, which costs the same installed in a Chevrolet as in a Cadillac. In a projection receiver, color might amount to no more than 10 per cent of the total cost. In a less expensive table set, on the other hand, the cost of color might account for as much as 20 to 25 per cent of the total cost of the set. It is my opinion, however, that the added enjoyment of seeing programs in color will, in the public's judgment, more than offset the added cost.

300% *PRODUCTION SPEEDUP*

X-raying of airplane propeller blades by electronic control, to find defects, speeds up inspection time 300 per cent.

100,000 MILE NETWORK

Reprinted from Air Transport

By Devon Francis

Army Airways Communications System shepherds military planes of Allied Nations, U. S. airlines, and, on occasion, even the British Navy.

A WORLDWIDE airways communication system is in operation today that promises to make tomorrow's peacetime transport flights routine in almost any kind of weather. Like many other developments born of the war that await the stilling of the guns to be adapted to consumer use, for security reasons it can be described more readily in the results achieved than in the way it works.

The Army Airways Communications System, covering 100,000 miles of world air routes, inclusive of a network in the United States, is one of the phenomena of World War II. Through it, for instance, 98.5 percent of the Army aircraft that have essayed the North Atlantic in both directions have reached their destinations safely. A special safety system has led to the rescue of many of the crews in the remaining 1½ percent.

LOST PLANES SAVED

The AACS in numerous instances has saved aircraft hopelessly lost in adverse weather conditions. At Munda in the South Pacific the AACS enabled Army planes to land almost immediately after Marines had taken the beachhead. AACS men rode in, with their equipment, in the second wave of the assault boats. In one instance the AACS brought to a safe landing a flying student suddenly afflicted with a rare type of blindness, and in another it was responsible for "talking in" a pilot whose forward visibility was cut to zero by a shower of dirty oil on his windscreen.

The AACS makes use of time-tried communication and navigation devices such as radio ranges and oral conversations between plane and ground, but it also uses other devices, known to the public only in backstairs gossip. It is the Army's spectacular and widespread employment of over-ocean radio ranges, homing transmitters, marker stations and special blind-landing equipment that bodes such good for postwar commercial air transport. Landings under zero-zero conditions and the extraordinary high frequency of weather forecast transmissions are pregnant with meaning not only for future transoceanic but also domestic transport operations.

It would be unfair to agencies other than the Army, that carried on research work in peacetime, to say that the AACS has been pure innovation. Radio navigation by triangulation, employed on the Army airways, was in common use, for instance, in blue-water flying before the war. It was routine on routes of Pan American Airways. The AACS homing device is no novelty, nor is its adroit handling of heavy local traffic by control tower.

It is in the highly imaginative use of standard equipment, plus the adaptation of equipment that must remain secret for the duration, that the 20,000 AACS personnel have written themselves a gallant chapter in the annals of this war. Part and

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(Air Transport, June 1944)

parcel of their story has been the establishment of a communications network under conditions that frequently appeared impossible.

This network belts the United States and Canada transcontinentally no less than four times. It races southwestward from San Francisco to Hawaii and thence south to Christmas Island, and forks out to cover all the Southwest Pacific area. It skirts the Jap-infested islands of the Dutch Empire, and ribbons over India, the Middle East and the continent of Africa. It covers the North and South Atlantic on five different routes. It splays through Alaska and out along the bleak Aleutian chain.

Its almost 1,000 stations in the U. S. and 52 foreign countries and territories operate over a distance of more than 2,000,000 circuit miles. The north Atlantic segment of the system alone handles between six and seven million words a month. AACS not only shepherds planes of the Air Transport Command and of the Army Air Forces proper but all commercial planes flying overseas as well. The U. S. allies, including incidently the British Navy on occasion, use its services.

NETWORK IS ELABORATE

Hourly weather reports and route information are the ordinary ingredients of the day's work for the AACS. It is in case of emergency that the elaborate network functions at its best. If an airplane is blown off course over the ocean, the jungle, deserts or the uncharted wastes of the Artic, its pilot asks for a bearing. Two or more stations train on his signals; they exchange compass readings, his position is plotted, and within two minutes he knows precisely where he is in space in relation to the map. He can have in addition a course to fly to reach the station originally called. If he must make a forced landing, the last act of his radio operator before ground or sea contact is made is screwing down his key so that direction finding stations can establish an accurate bearing on him.

The AACS is building up a history that will make rich reading after the war. A C-87, caught in a snowstorm and with a useless radio, was forced to abandon an attempt to reach its destination. The pilot had less than an hour of fuel left. The field of original intended arrival flashed word of the plane's predicament to other fields in that general area. Two attendants at one of those other airports heard the distressed ship circling. The airport lights and all the emergency lighting equipment available brought the plane, ice-laden, into port.

A fighter pilot found himself with heavy weather on all sides. To the control tower at his takeoff point he called a message asking for help. All the airports in the vicinity were advised. But difficulty was encountered in establishing the pilot's position. To a staff sergeant on duty at one field that meant only the need for more resourcefulness. He spread the alarm to neighboring anti-aircraft units to watch for the plane and report its position. A bearing was obtained. Still the pilot could not find his way to a haven. The sergeant telephoned the AA batteries that searchlights nearest the plane be switched on and pointed toward the airport. That did the trick.

AACS personnel have had their share of the war as it is known to the infantry. During the early days at Henderson Field on Guadalcanal an AACS tower continued to operate in spite of bombings that ultimately damaged it so badly it had to be rebuilt.

In many of the stations the isolation is complete. The personnel who man them sit weeks on end in Alaska, the Yukon Territory, Labrador, Greenland and Iceland, their only contact with the outside world their radio equipment. Crews in the Far North, incubator of much of the world's weather, have a particular function to perform. Meteorological reports from their areas, digested and analyzed, are delivered to bomber stations on the island airdrome that is England.

At AACS headquarters in Asheville, N. C., the story is told of the hardships encountered in establishing a station in Labrador. Under command of Maj. Harry A. Mackley, the installation crew nosed to a landing along the coast in a 104-ft. boat. The tiny vessel was loaded with equipment and supplies for a year's operation.

The site chosen for the station was rocky and snow-covered. Winds averaged

65 miles an hour. The thermometer sank to as much as 50 deg. below zero. To men from warmer climes this looked like good Eskimo weather. Maj. Mackley propositioned the resident Eskimos. He would pay them well if they would help with the installation. They shook their heads. It was too cold. Maj. Mackley shrugged and hunched his shoulders against the wind. Antenna poles had to be erected and wire had to be strung. The AACS fell to. One pole was ripped out by a 125-mi. wind.

Maj. Mackley commented, "The Eskimos thought we were crazy for thinking of going out in such weather, but when we did, they knew we were."

In some instances in the Far North it has become so cold inside the quonset huts housing the equipment that radio keys have frozen to the operators' fingers. In one case warm air generated by a kerosene stove condensed on the ceiling and froze. When the weather moderated the ice melted. Down it dripped on the radio equipement. The station had to go off the air but only for a short time.

HARDWARE STORE WANTED

The AACS has its own kind of jokes. In another location where a new station was being built, personnel meticulously unpacked boxes of radio equipment. Some parts were missing—screws and bolts. Some instructions were attached. They read that the screws needed could be purchased at any hardware store. The nearest hardware store was 3,000 miles away.

Like most everything else in this war that has taken to the air, the AACS has had to depend on air transport frequently to bring in supplies. A diesel power plant needed for a station in the mountains of India was transported to an air-head by plane. But there it had to be loaded in turn on to a railroad car, camels, elephants and finally the backs of native laborers before it arrived at the site.

To do its job, to speed the movement of huge quantities of supplies, the AACS employs technicians in a large number of categories. The thousands of trained men—and women, too—include tower personnel, radio station operators, radio and teletype operators, radio maintenance men, radar experts, diesel mechanics, communications security personnel and clerical and administrative help.

Among them they are responsible for the smooth movement of a colossal aggregation of operational messages. Departures, arrivals, passenger lists, loading lists, warning messages, cancellations, follow-ups and administrative messages—apart from the messages between plane and ground—mounts into a word-traffic that is equivalent to all the words in the Bible every ten hours.

Every letter of it must be coded.

McCLELLAND IS HEAD

Heading the AACS and responsible directly to Brig. Gen. H. M. McClelland, air communications officer for Gen. Henry H. Arnold, is Col. Ivan L. Farman. Col. Farman is not only a communications expert but a command pilot as well.

Forty-two years old, he is a graduate in science of the California Institute of Technology. He got into the Army as a flying cadet and was given his wings at Kelly Field in 1929 as a bombardment pilot. In 1938 he became an instructor in radio communications at Chanute Field, out in Illinois at Rantoul. Nothing if he is not thorough, he returned to his alma mater in 1938 to obtain his master's degree in meteorology.

In 1941 he was made a major and was put in Newfoundland in connection with Ferry Command operations. That was before Pearl Harbor. He had a great deal to do with the establishment of communications over the North Atlantic route.

The insigne of the AACS is a globe with a plane trailing red telegraphic ribbon around the equator.

In Asheville they are fond of explaining a cartoon sent back to headquarters by an AACS man in the South Pacific. The cartoon depicts an AACS tower operator, sequestered in a palm tree, waving away a plane intent on landing.

"You see," the AACS explains with more truth than apocrypha, "this is the way the Army's communications system works: the operator is already established in the tree but he is waving the plane off because the Marines haven't captured the landing strip yet."

U-H-F COMMUNICATIONS RECEIVER

Reprinted from Radio

By Albert H. Carr

Chief Engineer, Fada Radio and Electronic Co., Inc.

The design and construction of an airport communications receiver to cover the frequency range of 109 to 144 mc, is discussed.

EFFICIENT radio communication facilities are the backbone of modern airway network operation. In view of the tremendous strides that air transportation has taken during the past few years, authorities have felt the need for a more comprehensive, reliable and practical air traffic control system. Control over approaching aircraft has always constituted an active problem. Additionally, it has been further aggravated by the introduction of new elements of physical hazard due to increased size and weight of aircraft and increased numbers approaching a limited landing area.

Many of the disadvantages prevalent in present-day systems present definite limitations to the extent of the expansion of this control, which in turn would present a limitation to the expansion of air traffic itself. Thus a great need was created for the type of equipment about to be described.

LIMITATIONS

Basically, some of the limitations experienced with the present operating setup were:

1. Limitation of the number of channels available because of the frequency ranges employed.
2. An increase in the number of stations operating in this frequency range would result in an unendurable state of interference between different control towers, operating on the same frequencies, even though widely separated.
3. Inherent troubles experienced in this frequency range due to atmospheric noises could not be tolerated if reliable liaison was to be maintained.
4. Reliable communication demanded the employment of equipment from which fading, echo and other similiar atmospheric effects were completely absent.

It was felt that these disadvantages could be overcome by operation within the ultra-high frequency range and although it presented some problems, of course, in so far as design was concerned, it had the following points very definitely in its favor:

1. Complete localization of transmissions. Inasmuch as this range is governed entirely by line of sight, the waves are not inclined to follow the curvature of the earth nor are they subject to deflection to the extent which the longer waves are.

2. Complete freedom from atmospheric disturbances as well as elimination of the fading and echo effects which at present are encountered on the more conventionally employed frequencies.

The advantages realized from these features are that a number of control towers may operate simultaneously on the same band of frequencies without interference to each other if they are located with a separation of 100 or more miles between them. This results in a definite localization of the sphere of control to within the area over which the control tower is the supreme arbiter. The reliability

(*Radio, September* 1944)

of air-ground liaison is definitely enhanced by the elimination of atmospheric disturbances, as well as fading and echo effects. Materially, this should result in increased safety of operation as well as greatly increasing the control facilities which a single control unit may reasonably and efficiently handle.

Basically, the model RUP Radio Receiving Equipment is designed to cover the frequency range of 109 to 144 megacycles, inclusive, in one continuous tuning range covering approximately 500 dial divisions.

DESIGN CONSIDERATIONS

When this design was embarked on, considerable consideration was given to the employment of the super-regenerative type of receiver for operation within this frequency range. It was felt that there were many advantages of this type receiver which were desirable, namely, extremely high sensitivity in consideration of the number of tubes employed as well as the general ease of operation and construction of this type of equipment. However, it was felt that if proper care was given to the design, a superheterodyne receiver, which presents of course many additional advantages, could be satisfactorily operated within this tuning range with a consequent reduction in the number of tuning controls employed as well as much more stable operation. The much greater selectivity of the superheterodyne type of receiver was also a very large factor in determining the type of equipment ultimately to be designed. Therefore, it was felt that if proper care was given to the elementary phases of design the advantages of the superheterodyne type would far outweigh those of the super-regenerative type. Considerable advantage in noise reduction is of course achieved in this type of equipment as well as much greater frequency stability. Both of these factors also influenced the initial decisions.

Fig. 1—Front view of experimental model of receiver.

GENERAL DESCRIPTION

The equipment is designed for mounting a standard cabinet type relay rack. The main chassis of the receiver and power supply is formed of .062 steel, which is seam-welded to present a very rigid type of construction. The finish applied to the chassis has proved to be of some importance in the radio frequency section because of the frequency range employed. The initial finish consists of .002″ cadmium plate, followed by .002″ of copper plating. This has resulted in very good surface conductivity of the chassis and has served to keep the entire chassis at a more uniform potential. The exterior finish of blue glyptal is applied to protect the copper from corrosion.

The receiver as well as the power supply are mounted on a standard seven-inch relay rack panel which in turn, carries all operating controls. The power supply for the receiver is an integral part of the chassis and is located in the left rear portion of it. The entire unit is enclosed within a dust cover which may readily be removed for inspection and maintenance. The speaker panel, which may be mounted either adjacent to or remote from the receiver portion of the equipment, is a separate seven-inch relay rack panel on which is mounted a six-inch permanent-magnet type dynamic speaker, together with the output coupling transformer. The receiver itself is a thirteen-tube superheterodyne of conventional design, but modified to meet certain rigid CAA specifications. Two voltage regulator tubes are employed in the equipment bringing the total number of tubes used to fifteen. Rugged construction together with excellent mechanical design and construction make this a piece of equipment which is capable of withstanding the arduous requirements of control tower operation. Front, top and below deck views of the equipment are shown in *Figs. 1, 2 and 3.*

CONTROLS

The following controls are provided on the receiver front panel:

1. Tuning Control
2. R-F Gain Control
3. A-F Gain Control
4. Power on-off switch
5. Indicator Light
6. A.V.C. on-off switch
7. CONS, on-off switch
8. Phone Jack
9. Two fuse receptacles.

The gain controls are equipped with bar type nobs and switches are all of the standard toggle type.

CIRCUIT DESCRIPTION

The circuits, both tuned and untuned, employed in the type RUP receiver are fundamentally those of the conventional superheterodyne receiver, encompassing such modifications as are necessary for high-frequency operation and to conform to CAA specifications. In the original model of this equipment, "haipin" type single-turn inductances were used in all radio frequency circuits. These were, however, replaced in later models by this use of a more conventional spiral wound inductance. The radio-frequency circuits, of which there are four, including the oscillator, are tuned by means of a single gang condenser which is back-geared through a

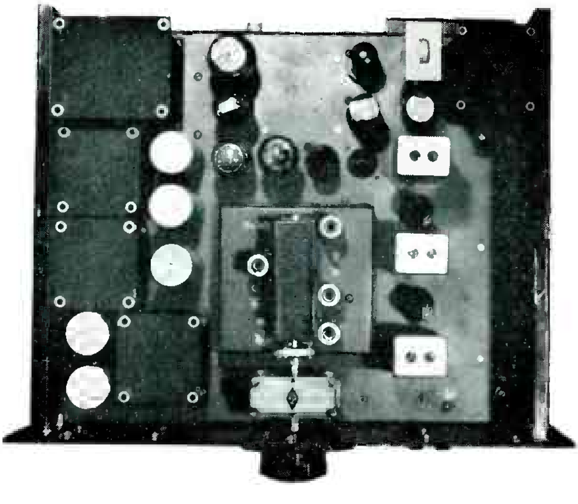


Fig. 2—Top view of new u-h f communications receiver (experimental model).

National NPWO gear reduction drive to the 500-division National dial employed for tuning the equipment.

The intermediate-frequency amplifier circuits are of conventional design which, however, feature extremely high sensitivity coupled with an exceptional order of stability. Output circuits of the receiver are designed to feed into a 20,000 ohm load, which may consist of the speaker previously mentioned or a suitably loaded headphone circuit tapped at 600 ohms. A relay is provided in the output circuit to allow remote control of the output of the equipment. This relay is operated from a six-volt d-c source. A jack is provided for the headphones, which should be of the low-impedance (600 ohm) type to match the output circuit provided for moniting purposes. The schematic diagram of the complete equipment is shown in *Fig. 4.*

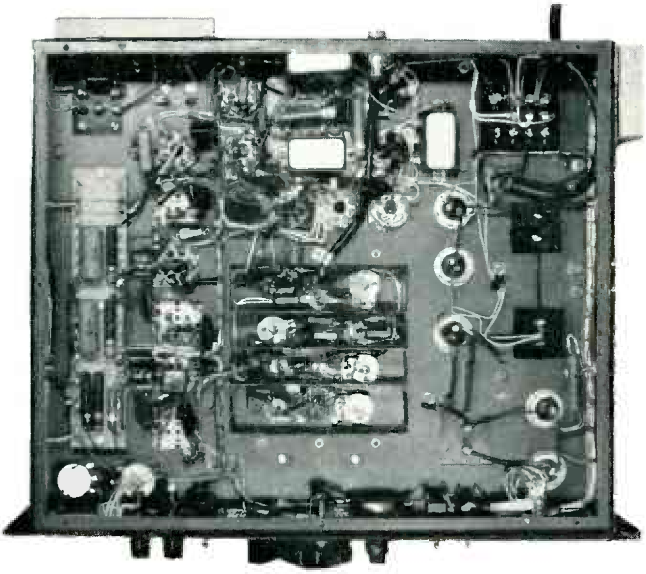


Fig. 3—Under chassis view of experimental model of set.

The following tubes are employed in the equipment in the positions designated below:

Circuit Position	*Type*	*Function*
V-1	9001	First R. F. Amplifier
V-2	9001	Second R. F. Amplifier
V-3	9001	Converter
V-4	9002	Oscillator
V-5	6AC7	First I. F. Amplifier
V-6	6AC7	Second I. F. Amplifier
V-7	6SL7	Detector in CONS
V-8	6SL7	First Audio & Noise Peak Limiter
V-9	6V6	Output
V-10	6SJ7	AVC
V-11	6SL7	CONS Control
V-12	84	Rectifier for output stage
V-13	80	Main Rectifier
V-14	VR-150	Voltage Regulator
V-15	VR-105	Voltage Regulator

RADIO FREQUENCY CIRCUIT

Two radio-frequency amplifier stages are employed in the receiver in order to acheive the desired sensitivity, which is in the order of five microvolts for an output of ½ watt. The first radio-frequency amplifier, *V-1*, employs a 9001 pentode, and the radio-frequency signal is fed from a 70-ohm concentric line, which is plugged into *J-1*, the input of the receiver. A trimmer condenser is provided across this input circuit so that the circuit may be tuned to resonance within the frequency range of the receiver.

The output of the first radio-frequency amplifier is coupled by means of a tuned circuit *L-2*, *C-6*, to the grid of the second radio frequency amplifier stage through a coupling condenser *C-19*. Resistors *R-5* and *R-6* are provided in this circuit in order to properly load the circuit to provide uniform amplification over the entire tuning range.

A sensitivity control *R-4* in the cathode circuit of *V-1* is provided in order to control the sensitivity of the receiver circuits and to provide for the adjustment of the sensitivity to a constant or reference value at any frequency within the range of the receiver.

The second radio-frequency amplifier *V-2*, which is similar in most respects to the first radio-frequency amplifier, is coupled to the converter *V-3* by means of a coupling condenser *C-20*.

The converter circuit and its associated components, which include a Hartley oscillator (*V-4*) circuit, comprise the frequency-conversion portion of the equipment. Here the incoming radio frequency signal amplified through *V-1* and *V-2* is fed into one portion of *V-3*, while the local oscillator signal generated by *V-4* is fed into another portion of *V-3*. Screen-grid injection is employed and every effort has been made to maintain the value of the oscillator voltage constant by means of slight loading of the circuit through the medium of the relatively low impedance of the cathode-coupling point on the oscillator coil.

Complete and satisfactory single-dial tuning operation is achieved through the medium of the four-gang condenser and the National NPW dial through its associated gear box. No additional tuning controls for bringing any receiver circuits or input circuits to resonance are provided. Careful alignment of all radio-frequency circuits, as well as the excellent design achieved therein, make this type of operation entirely feasible within this frequency range.

Frequency stability is a particularly outstanding feature of this receiver. After a preliminary warm-up period of four hours, the resonant frequency does not change more than .01% during a period of four hours at constant room temperature and humidity, and the resonant frequency does not change more than .05% during a corresponding period with a variation in ambient temperature from—10 to +50 degrees. It is felt that this frequency stability is more than ample considering the stability of the transmitters which will be employed in this type of operation as well as the possibility of drift emanating therefrom.

I-F CIRCUITS

The i-f amplifier in this receiver is conventional in circuit design *V-5* is the first i-f amplifier and *V-6* the second.

The i-f transformers employed deserve special mention, however, due to their relatively high-gain characteristics which is desirable for the type of operation which it was hoped to acheive. The band-pass characteristic of this amplifier is in

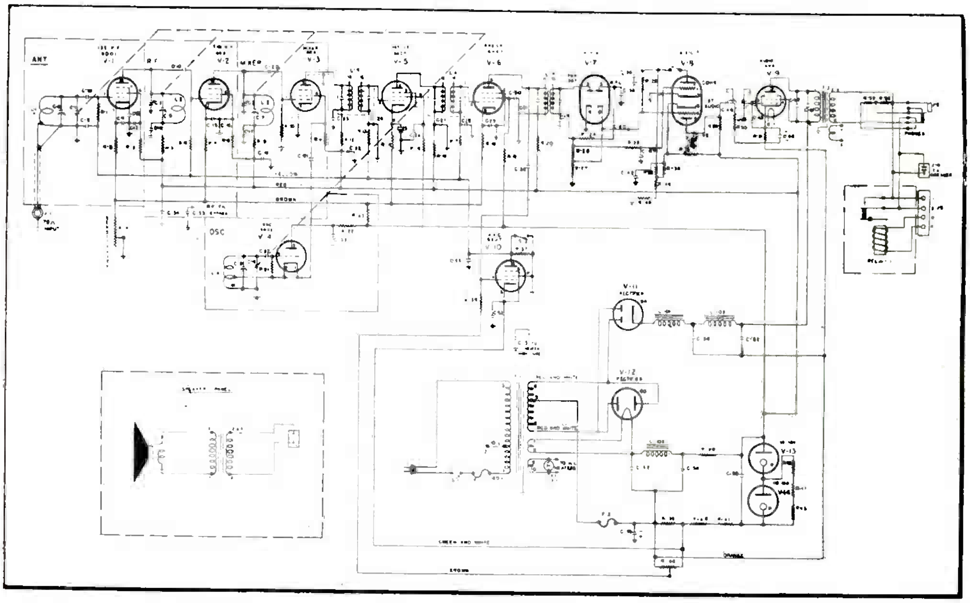


Fig. 4. Schematic diagram of communications receiver

SYMBOL	DESCRIPTION
R-1	1 megohm, ½ watt, 10%
R-2	1000 ohm, ½ watt, 10%
R-3	250,000 ohm, ½ watt, 10%
R-4	5,000 ohm, watt, 10%, ww. pot.
R-5	1,000 ohm, ½ watt, 10%
R-6	1 megohm, ½ watt, 10%
R-7	1,000 ohm, ½ watt, 10%
R-8	150,000 ohm, ½watt, 10%
R-9	1,000 ohm, ½ watt, 10%
R-10	1 megohm, ½ watt, 10%
R-11	1 megohm, ½ watt, 10%
R-12	1000 ohm,½ watt, 10%
R-13	1 megohm, ½ watt, 10%
R-14	250 ohms, ½ watt, 10%
R-15	40,000 ohms, ½ watt, 10%
R-16	1000 ohms, ½ watt, 10%
R-17	1 megohm, ½ watt, 10%
R-18	250 ohms, ½ watt, 10%
R-19	40,000 ohms, ½ watt, 10%
R-20	1000 ohms, ½ watt, 10%
R-21	47,000 ohms, ½ watt, 10%
R-22	6800 ohm, ½ watt, 10%
R-23	160,000 ohms, 1 watt, 10%
R-24	1 megohm, ½ watt, 10%
R-25	1 megohm, ½ watt, 10%
R-26	100,000 ohm, ½ watt, 10%
R-27	100,000 ohm, ½ watt, 10%
R-28	1 megohm, ½ watt, 10%
R-29	220,000 ohms, ½ watt, 10%
R-30	500,000 ohms potentiometer
R-31	250 ohms, 2 watt, 10%
R-32	20,000 ohms, 10 watt, 10%, ww.
R-33	600 ohms, ½ watt, 10%
R-34	47,000 ohms, 2 watt, 10%
R-35	200 ohms, ½ watt, 10%
R-36	100,000 ohm, ½ watt, 10%
R-37	1 megohm, ½ watt, 10%
R-38	1 megohm, ½ watt, 10%
R-39	200 ohms, 2 watt, 10%
R-40	200 ohms, 2 watt, 10%
R-41	250 ohms, 2 watt, 10%
R-42	22,000 ohm, 2 watt, 10%
R-43	250 ohms, ½ watt, 10%
R-44	10,000 ohms, potentiometer
R-45	10,000 ohms, ½ watt, 10%
R-46	1750 ohms, 20 watt, 10%, ww.
R-47	150 ohms, ½ watt, 10% ww.
R-48	10,000 ohms, ½ watt, 10%

SYMBOL	DESCRIPTION
C-1	P/O 4 section variable
C-2	P/O 4 section variable
C-3	P/O 4 section variable
C-4	P/O 4 section variable
C-5	25 mmf. variable
C-6	25 mmf. variable
C-7	25 mmf. variable
C-8	25 mmf. variable
C-9	500 mmf. 500 V., 10%, mica
C-10	500 mmf. 500 V., 10%, mica
C-11	500 mmf. 500 V., 10%, mica
C-12	500 mmf. 500 V., 10%, mica
C-13	500 mmf. 500 V., 10%, mica
C-14	500 mmf. 500 V., 10%, mica
C-15	500 mmf. 500 V., 10%, mica
C-16	500 mmf. 500 V., 10%, mica
C-17	500 mmf. 500 V., 10%, mica
C-18	500 mmf. 500 V., 10%, mica
C-19	100 mmf. 500 V., 10%, mica
C-20	50 mmf. 500 V., 10%, mica
C-21	50 mmf. 500 V., 10%, silver mica
C-22	500 mmf. 500 V., 10%, silver mica
C-23	.01 mfd. 500 V., 10%, mica
C-24	.01 mfd. 500 V., 10%, mica
C-25	.01 mfd. 500 V., 10%, mica
C-26	.01 mfd. 500 V., 10%, mica
C-27	.01 mfd. 500 V., 10%, mica
C-28	.01 mfd. 500 V., 10%, mica
C-29	.01 mfd. 500 V., 10%, mica
C-30	.01 mfd. 500 V., 10%, mica
C-31	.025 mfd. 600 V., 10%, mica
C-32	250 mmf. 500 V., 10%, mica
C-33	250 mmf. 500 V., 10%, mica
C-34	.01 mfd. 500 V., 10%, mica
C-35	250 mmf. 500 V., 10%, mica
C-36	100 mmf. 500 V., 10%, mica
C-37	.01 mfd. 500 V., 10%, mica
C-38	.1 mfd. 600 V., 10%, paper oil filled p/o 3 sect.
C-39	.1 mfd. 600 V., 10%, paper oil filled p/o 3 sect.
C-40	.01 mfd. 500 V., 10%, mica
C-41	.1 mfd. 600 V., paper oil filled p/o 3 sect.
C-42	1 mfd. 600 V., 10%, paper oil filled
C-43	100 mmf. 500 V., 10%, mica
C-44	.01 mfd. 500 V., 10%, mica
C-45	.001 mfd. 500 V., 10%, mica
C-46	16 mfd. 150 V., electrolytic
C-47	.02 mfd. 500 V., 10%, mica
C-48	Deleted
C-49	Deleted
C-50	Deleted
C-51	.01 mfd. 500 V., 10%, mica
C-52	.01 mfd. 500 V., 10%, mica
C-53	15 mfd. 600 V., 10%, paper oil filled
C-54	4 mfd. 600 V., 10%, paper oil filled
C-55	4 mfd. 600 V., 10%, paper oil filled
C-56	4 mfd. 600 V., 10%, paper oil filled
C-57	4 mfd. 600 V., 10%, paper oil filled
C-58	4 mfd. 600 V., 10%, paper oil filled
C-59	16 mfd. 150 V., electrolytic
C-60	Deleted
C-61	.01 mfd. 500 V., 10%, mica

COILS

L-1	1st R.F. coil
L-2	2nd R.F. coil
L-3	Converter R.F. coil
L-4	Oscillator coil
L-5	1st I.F. transformer
L-6	2nd I.F. transformer
L-7	3rd I.F. transformer
L-101	Filter reactor, 10 H, 125 MA
L-102	" " " " " "
L-103	" " " " " "
T-1	Power transformer, 600 V CT @ 125 MA; 6.3 v @ 4 amp.; 5 v @ 2 amp.
T-2	Audio transformer

SWITCHES

S-1	Power switch, SPST
S-2	AVC switch, SPST
S-3	CONS switch, SPST

the order of 80 kcs wide at 2 × down, which has been found ample for most communications work falling within this frequency range.

DETECTION

A conventional diode system of detection is employed in this equipment resulting in the audio output voltage being directly proportional to the percentage of modulation of the R. F. Input signal for modulations falling within the range of 5 to 100%. The noise limiter employed is of the shunt type which automatically adjusts itself to any carrier level between approximately 20 microvolts and 1 volt and is so adjusted that effective limiting action, i.e., (limitations of noise peaks) takes place when their amplitude exceeds that corresponding to 100% modulation.

AUTOMATIC VOLUME CONTROL

Automatic volume control is, of course, provided and may be cut in or out at will by means of a switch provided on the front panel. With the AVC switch in the ON position and the R-F Gain Control at maximum, the power output does not vary over three decibels when a modulated r-f signal of 20 microvolts is applied and the a-f Gain Control adjusted so that 50 milliwatts audio output is achieved, compared to increasing the input to one-half a volt. In other words, over the range of from 20 microvolts to one-half volt input, the power output of the receiver does not vary more than three decibels.

SECOND DETECTOR—CONS—NOISE PEAK LIMITER

The first audio amplifier, which employs the second section of the type 6SL7G as a noise peak limiter, is conventional as well as the output stage which employs a type 6V6 tube. The volume control placed in the input of the first audio amplifier permits attenuation of the audio amplifier from its maximum output down to 1 milliwatt or less. This gain control is so tapered that, in the absence of an AVC or CONS action an approximate logarithmic increase in audio output is achieved as the control knob is rotated clockwise.

NOISE SUPPRESSOR

The carrier-operated noise suppressor circuit employed in this receiver is conventional in design insofar as it renders the receiver inoperative until the input signal has increased in amplitude to a certain definite value. This value is of course a function of the setting of the sensitivity control; however, with the sensitivity control set for maximum gain, the noise suppressor circuit operates to allow operation of the receiver on any signal in excess of 5 microvolts on the grid of the 1st r-f tube. Reducing the sensitivity of the receiver by means of the sensitivity control causes the noise suppressor circuit to operate at a correspondingly higher value of signal input. Very sharp ON and OFF action is obtainable with this circuit with no appreciable intermediate condition wherein the receiver is partially operative and partially blocked.

HARMONIC DISTORTION

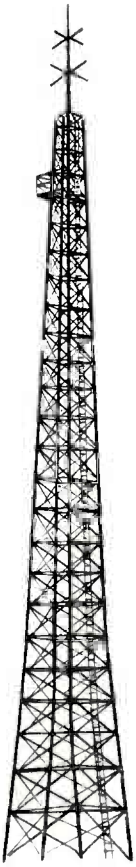
Harmonic distortion of this receiver is comparitively low considering the type of service in which it will be employed. For an output of one watt over the frequency range of 90 to 3000 cycles per second, it does not exceed 10% at any point and for its maximum rated output of three watts, the total distortion does not exceed 20%.

REGENERATION

During the development stages of this equipment some difficulty was experienced with both r-f and a-f regeneration, which finally was completely eliminated by the unique method of shielding employed in the r-f section of the equipment. It will be noted from *Fig. 2* the r-f portion of this receiver is completely self-contained on a separate small chassis measuring aproximately 5 inches × 5 inches × 1 inch deep. This chassis contains the gang tuning condenser, the four associated inductances, the trimmer condensers for each of these circuits as well as the coupling condensers which interconnect them. It is to be noted that each stage is shielded from each other stage by means of a partition which extends to the entire height of the r-f chassis and condensers employed to couple the stages extend through apertures in these shields. Proper placement of parts as well as strict adherence to fundamental principles of ultra-high-frequency circuit design resulted in a radio-frequency section of excellent frequency stability as well as one which was almost completely free from the effects of mechanical vibration.

GENERAL

The receiver has been designed to be fed from the antenna by means of a 70 ohm concentric line which attaches directly to a receptacle provided at the rear of the chassis which, in turn, is coupled to a point of proper impedance on the first r-f inductance.



Knowledge is of two kinds: we know a subject ourselves, or we know where we can find information about it.

SAMUEL JOHNSON.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