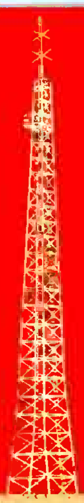
The RADIO ENGINEERS' DIGEST



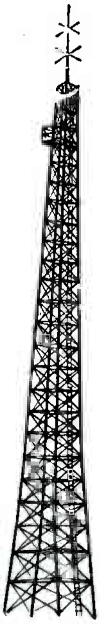
NOVEMBER 1945 VOL. 2, NO. 4

CONTENTS

7 Gehres

PUBLISHED BY REEVES-ELY LABORATORIES, INC.

www.americanradiohistory.com



THE RADIO ENGINEERS' DIGEST

JOHN F. C. MOORE, *Editor*

Copyright 1945 by Reeves-Ely Laboratories, Inc.

Vol. 2, No. 4 November 1945

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

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

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

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

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

www.americanradiohistory.com

TELEVISION SCANNING AND SYNCHRONIZATION

Reprinted from C Q

By B. W. Southwell, W6OJW

Television will doubtless play a large part in post-war ham radio. Television is no longer the simple art it was in the days of mechanical scanning. It is a science all its own, and here are a few of the fundamentals.

IN ORDER to transmit and receive intelligible visual images it is necessary that the subject picture focused on the mosaic of the iconoscope be scanned very rapidly so that a complete picture can be transmitted in a fraction of a second. It is also essential that the image be reproduced on the fluorescent screen of the kinescope exactly as it was seen by the iconoscope.

Three views of the fluorescent screen of a cathode ray tube are shown in *Fig.* 1. In *A*, with no connections to the deflection plates, the electron beam striking the screen appears in the center, midway between the horizontal deflecting plates 1 and 2, and vertical deflecting plates 3 and 4. If a potential is connected across the tube between plates 1 and 2, the beam, which consists of negative particles of electricity, will move horizontally toward the positively-charged plate 2, as indicated in *Fig.* 1*B*. Similarly, the beam can be displaced vertically upward as in *Fig.* 1*C*.

If the battery voltage is replaced by an oscillating or alternating potential on the horizontal plates, the beam will sweep back and forth across the screen. The length of this sweep will depend on the voltage applied. An alternating potential applied to the vertical plates will cause the spot to move up and down between plates 3 and 4.

SAWTOOTH SCANNING

In scanning an image it is necessary that the deflection increase linearly in respect to time. In other words, the voltage must build up linearly while the beam sweeps across the face of the screen and then reverses itself and decreases rapidly to its initial value. The waveform of the voltage produced in the output of scanning generators appears as shown in *Fig.* 2, and is known as a "sawtooth" wave.

There are two types of cathode ray tubes — the electrostatic-deflecting and magnetic-deflecting. In the electrostatic-deflecting design the outputs of the scanning generators are fed to two sets of deflecting plates. One pair sweeps the beam horizontally and the other pair vertically. In the magnetic deflecting type deflection is accomplished by varying the magnetic field between two sets of coils placed at right angles to each other around the neck of the tube just beyond the last

Copyright 1945, *Radio Magazines, Inc.*, 342 *Madison Avenue, N. Y. C.*
(*CQ, September* 1945)

www.americanradiohistory.com

anode in the electron gun. The magnetic field of one set tends to move the beam back and forth in a horizontal direction (horizontal sweep coils) and the other vertically (vertical sweep coils). The sawtooth waves produced in the scanning generator for electrostatic deflection are voltage waves, while those generated for magnetic deflection are sawtooth waves of current.

If an alternating sawtooth potential of 15,750 cycles per second is applied to the horizontal deflection plates, and a sawtooth voltage of 60 cycles to the vertical plates, the beam will sweep back and forth across the screen 15.750 times a second and up and down 60 times per second. The resultant reproduced picture on the fluorescent screen of the cathode ray tube is a scanning "raster" consisting of 525 lines.

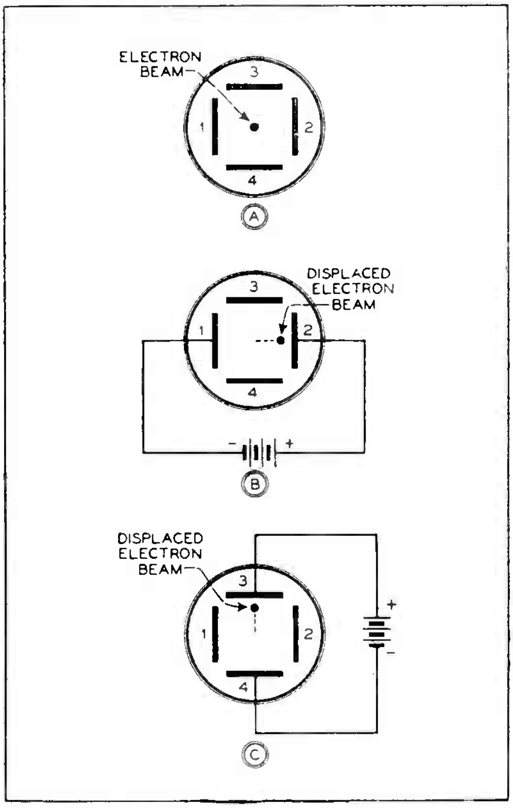


Fig. 1 Showing how the electron beam or "spot" is deflected in a cathode ray tube. A combination of rapid horizontal and vertical displacements build up the "picture"

SAWTOOTH GENERATORS

There are various types of sawtooth generators. One of these employs a two-element gaseous discharge tube. Such a tube contains two electrodes immersed in a gas at low pressure and is connected across the terminals of a capacitor. This type is of little value for television purposes due to the fact that it cannot be accurately synchronized.

The scanning generator most commonly used is a conventional three-element vacuum tube, which is free from temperature and de-ionization delay effects. This type of scanning generator, employing the multivibrator principle, is shown in *Fig.* 3. The multivibrator pulse generator circuit is very similar to that of a regular resistance-coupled amplifier. The circuit requires two triodes which are generally included in one envelope. The output of the second triode is fed back to the grid of the first triode in the right phase to sustain oscillations. By varying the grid condenser C and the grid-resistance R, it is possible to change the fundamental frequency of the multivibrator. This arrangement is very popular as it is easy to synchronize.

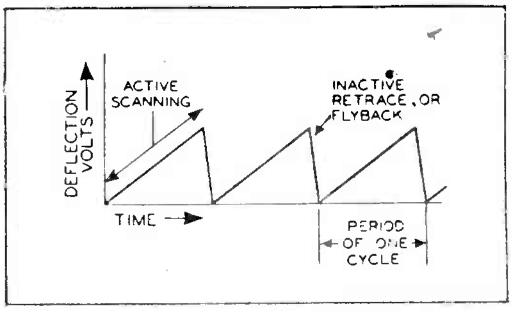


Fig. 2. The "sawtooth" of a scanning generator. In conventional 525-line television the horizontal period is 1/15,750th of a second

The blocking oscillator type of scanning generator; illustrated in *Fig.* 4 is a later development and is also reliable and simple to adjust. The oscillations are blocked suddenly when the grid is driven negative by the passage of grid current, and commence again as the charge flows off through the gridleak. A separate triode, (which in practice is generally the other half of a twin-triode type tube) is used to discharge the capacitor C. The frequency at which the blocking oscillator operates is determined by the RC combination $R_G C_G$. As R_G decreases in value, the charge leaks off C_G faster and the blocking action repeats itself at a higher rate.

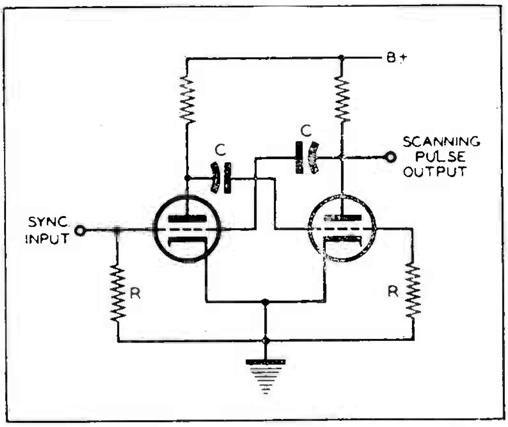


Fig. 3. Multivibrator type of sawtooth wave generator.

Sawtooth oscillators which are not blocking oscillators are generally termed "relaxation" oscillators. Relaxation oscillators are divided into two types, the symmetrical and the unsymmetrical. In the symmetrical type, a voltage wave is generated with a quick "flip-over" from extreme negative to extreme positive values, followed by a period during which the voltage decreases slowly (relaxation), until the critical value is reached and the process repeats itself in the opposite direction. The unsymmetrical oscillator generates positive and negative waves of unequal magnitude and duration. The wave-forms of these two types as viewed on a test oscilloscope, are shown in *Fig.* 5.

The frequency of horizontal scanning generators to reproduce an image of a certain number of lines is derived from the formula

$$\text{Lines} = 2\text{X}\,\frac{\text{horizontal frequency}}{\text{vertical frequency}}$$

For example, a 525-line image will require a horizontal oscillator frequency of 15,750 cycles (assuming a 60-cycle vertical sweep).

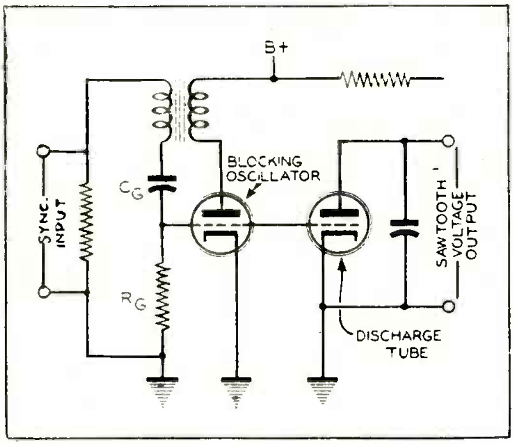


Fig. 4. Blocking oscillator generator with discharge tube

When construction of a television receiver is contemplated, it will be desirable to consider separate power supplies for the horizontal and vertical scanning generators to minimize cross-talk. When vertical deflection intermingles with the horizontal, the pattern shape is distorted. Harmonics of the horizontal sawtooth appearing in the vertical deflection circuits cause the scanning lines to become wavy instead of straight.

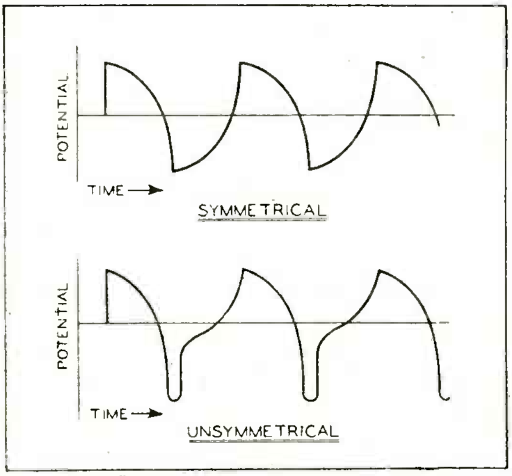


Fig. 5. Relaxation oscillator waveforms

SCANNING METHODS

There are various methods of scanning and reproducing an image by an electron beam, the best known of which are the progressive (non-interlaced) and the interlaced (preferable method). The progressive system consists of a picture

www.americanradiohistory.com

scanned by a single set of parallel, adjacent lines, as shown in *Fig. 6A*. The solid lines are the scanning or active lines, while the broken lines are the return or inactive lines. The inactive lines are blanked out so that they do not appear in the reproduced image. The electron beam is moved back across the picture instantaneously during the time of the inactive lines. At the completion of an inactive line the horizontal blanking action ceases and the beam starts to trace another active line slightly below the preceding line. The distance one line lies below the preceding one depends primarily on the frequency of the horizontal scanning generator, and the coordinated action of the vertical oscillator on the beam to bring the spot down to the start of the next line. The higher the frequency, the greater the number of scanning lines and consequently each line is closer to the preceding one. Similarly, if the frequency is low the number of lines is smaller and hence the lines are spread out from each other. The downward action of the vertical oscillator is constant during the time of the active scanning line and the blanked-out retrace. One can readily see that if the retrace were not instantaneous horizontal dark lines or bands would run through the picture.

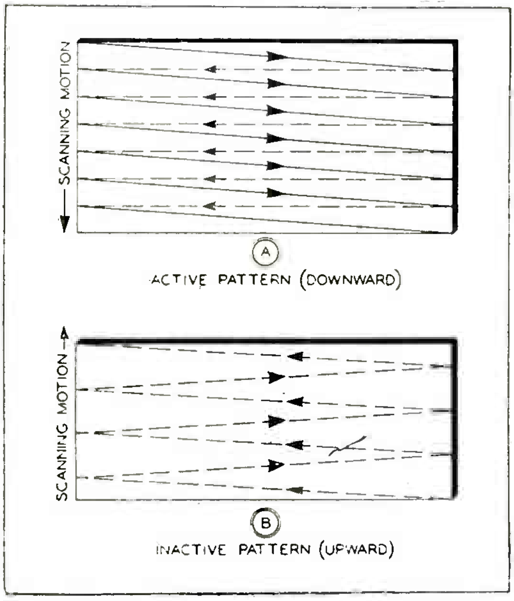


Fig. 6. Progressive scanning patterns. Inactive or return sweeps are dotted

At the end of the last scanning line, *vertical* blanking is imposed on the spot, extinguishing and returning it to the upper left corner of the picture. This return is fast compared with the downward motion and the line moves back and forth several times as shown in *Fig. 6B* (inactive pattern). These upward motions constitute the difference between the active lines and the total number of lines of the entire pattern. The number of inactive (upward) lines must be kept to a minimum. In practice, the number of vertical inactive lines is 41 or less.

Each scanning line should be just thick enough to be adjacent to the preceding one and must equal the distance between centers of adjacent lines. The line thickness is derived from the formula

$$\text{Thickness} = \frac{\text{height}}{\text{number of active lines}}$$

For a 525 line picture with 483 active lines and a height of six inches, the line thickness will be 6 divided by 483 or .0124 inches.

INTERLACED SCANNING

The interlaced method of scanning is a different story. The lines are scanned in the order 1, 3, 5, 7, etc., followed by 2, 4, 6, 8, etc. The time for covering the picture area is reduced from 1/30th to 1/60th second so that in the first field in which the odd numbered lines are scanned, the spacing between lines (center to center) is doubled. The second field in which the even numbered lines are scanned must fall accurately so that the lines of the second field are half-way between the lines of the first field. The interlaced pattern is shown in *Fig.* 7.

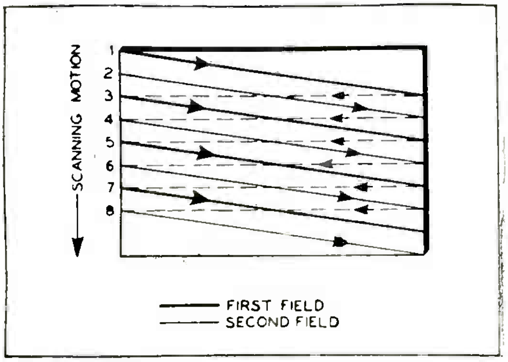


Fig. 7. Odd-line interlacing. Return or inactive lines are dotted. Vertical return is shown on the right

There are two methods of interlacing — the odd-line and even-line systems. In the odd-line method the total number of lines is an odd number. It is simpler than the even-line system and is the method most commonly used. In the even-line method (*Fig.* 8) the total number of lines is an even number. The difficulty lies in accurately forming up and down motions of unequal length in the required succession. Since it is superseded by the odd-line system we shall not discuss it further.

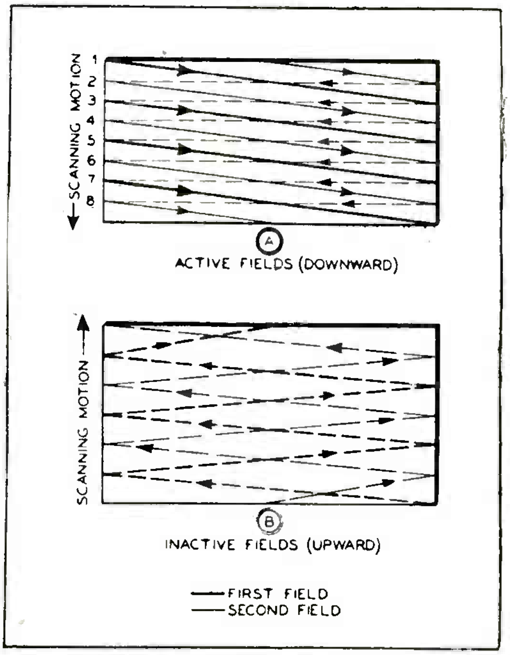


Fig. 8. Even-line interlacing

www.americanradiohistory.com

With odd-line interlacing, there are 262.5 lines in each successive field. Every up and down motion must be precisely the same length in order that interlacing be preserved. At the start of each field, in order to avoid "pairing" the spot must be one-half line distant and exactly on the same level as the start of the previous field. (Pairing will be described later.)

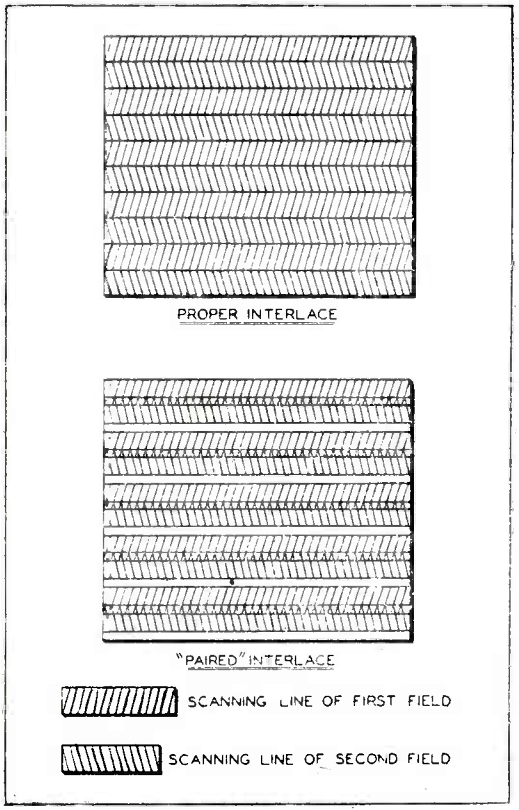


Fig. 9. Showing "pairing" of lines in successive fields due to improper timing of vertical scanning generator

There are other methods of scanning in less general use. Sinusoidal scanning uses simple deflection circuits, which are relatively free from distortion as well as inexpensive. Spiral scanning makes maximum use of a circular cathode ray screen, but is wasteful of screen area in rectangular pictures. Like sinusoidal scanning it is difficult to synchronize. Another method is velocity scanning which produces brighter high lights and need no synchronization. Its principle is brightness inversely proportional to scanning velocity, but requires an excessive vertical blanking period.

In interlacing, the simple two to one is the easiest form to obtain and is employed in the odd-line system. While greater detail is available with a higher ratio interlace, it is difficult to synchronize accurately to avoid pairing, and interline flicker becomes apparent due to lower frequency.

SYNCHRONIZATION

The method by which the electron beam in the receiver is kept in step with the scanning beam in the iconoscope at the transmitting position is called synchronization—or familiarly "sync." The synchronizing signal is applied between the grid circuit and the ground of each scanning generator.

If, in each scanning cycle, the timing is not the same as the preceding cycle, the picture elements in the cathode ray tube will be displaced in the reproduced

www.americanradiohistory.com

image. The picture elements in one line are displaced to one side or the other, relative to the next line, if the horizontal synchronization is faulty. On the other hand, if the vertical scanning synchronization is out of step, lines in one interlaced field will be displaced vertically with reference to lines of the preceding field. The lack of vertical sync will cause what is known as "pairing," as shown in *Fig.* 9. There are two important frequencies in synchronizing:

1—The free or natural frequency of the scanning generator itself which is governed by the constants of the circuit (resistance and capacitance values, tube constants, etc.).

2—The synchronizing frequency, which is the frequency of pulses applied to the grid of the scanning generator tube.

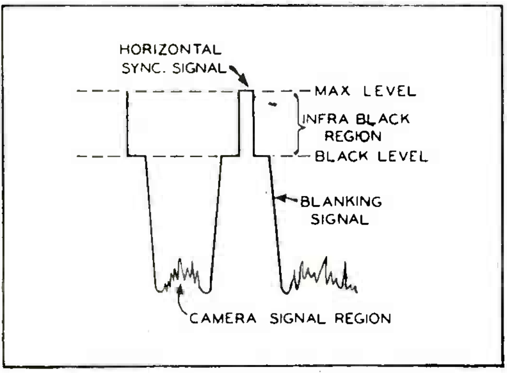


Fig. 10 Horizontal synchronizing pulses

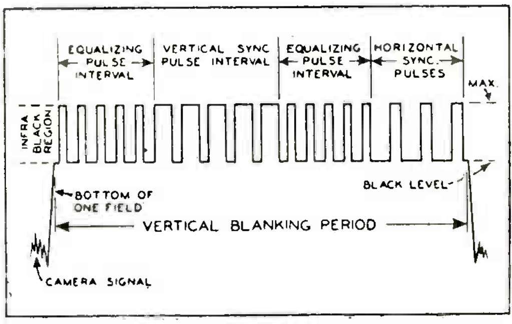


Fig. 11. Vertical synchronizing pulses

When the sync pulse is approximately the same frequency as the free frequency, the scanning generator then operates at a forced frequency, which is equal to the sync frequency whenever an image is being reproduced. Viewed on a test oscilloscope the sync pulse appears to be riding on the top of the horizontal blanking pulse as in *Fig.* 10. It is not desirable to have the sync frequency and the free frequency exactly the same. The general rule is, to set the free frequency far enough below the sync frequency so that they cannot become equal, but not so far as to cause the sync circuit to lose control. If the free frequency were set above the sync frequency the period between pulses occur during the time a line is being scanned. Setting the free frequency below shortens the period between pulses, and the oscillator is held back continuously because the sync pulses always appear at the end of the scanning of each line.

Horizontal pulses occur at the end of each line and "lock in" each of the successive transmitted lines. These are sharp, nearly rectangular pulses (see *Fig.* 10) which occur 15,750 times per second for a 525 line picture. For every 262½ horizontal sync pulses, there must occur one vertical sync pulse. This vertical sync pulse has the same amplitude as the horizontal sync pulse and is prolonged to en-

www.americanradiohistory.com

dure through some 3 or 4 horizontal sync pulses. The vertical sync pulse does not wipe out these horizontal sync pulses, as this would cause the horizontal generator to slip out of sync while the vertical pulse is present. In order to preserve the continuity of the horizontal pulses, the prolonged vertical pulse is broken up into a series of smaller intervals, each serving as a horizontal pulse. A series of "equalizing" pulses of twice the line scanning frequency is inserted before the vertical pulses to make the effective shape of each vertical pulse identical, after separation. These pulses occur during the time the scanning beam is blanked out. The vertical sync pulse and equalizing pulses ride on top of the vertical blanking pulse as shown in *Fig.* 11. The ideal shape of any of the sync pulses (plotted against time) should be rectangular. They are, however, trapezoidal in shape, as the rise to the level of control voltage is more or less gradual rather than instantaneous.

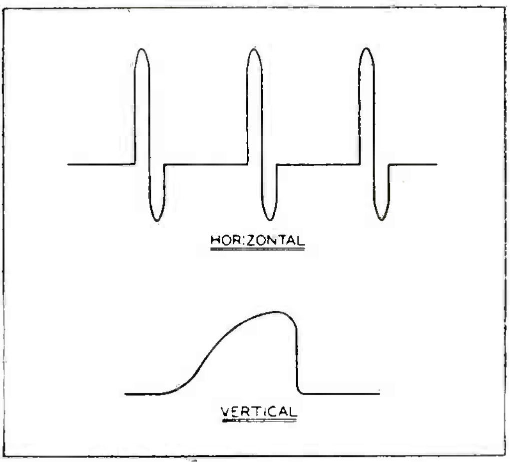


Fig. 12. Oscilloscope waveforms showing separated "sync" signals

The synchronization pulses are generated in the sync generator at the transmitter location and are used to initiate the horizontal and vertical sawtooth scanning generator oscillations. They are combined with the picture and blanking signals which modulate the transmitter. These signals are separated from the picture and blanking signals in the receiver, where they are fed into the scanning generators to lock them in with those at the transmitter. By doing this, the picture on the screen of the cathode ray tube is an undistorted reproduction of the image focused on the iconoscope mosaic.

SEPARATING SYNC PULSES

When the combined sync signals are received it is necessary that they be separated so that there is no interaction between the horizontal sync pulses and the vertical sawtooth generator, and similarly between the vertical sync pulses and the horizontal generator. This separation is accomplished in a circuit called the "sync separator" stage. After separation, the wave-forms of the sync signals when viewed on a test oscilloscope are as shown in *Fig.* 12. The signals illustrated are those occuring with progressive scanning. Sync signals of the interlaced system appear as in *Figs.* 10 and 11.

The sync signals occur in the region which is called the "infra-black" or "blacker than black." Since this region of amplitude is above the black level, the synchronizing signals cannot produce light in the received image. If the peak amplitude of the radio-frequency television signal is taken as 100 per cent, the National Television Systems Committee in 1939 designated as standard the use of not less than 20 per cent, nor more than 25 per cent of this total amplitude for synchronizing pulses.

www.americanradiohistory.com

4 CHANNEL MIXER FOR YOUR AMPLIFIER

Reprinted from Radio News, Radio-Electronic Engineering Edition

By David A. King

THERE are many amplifiers in use today, both of professional and home constructed types, that have been designed with a single input terminal. These amplifiers are entirely adequate for any purpose where it is desired to amplify sound from only one source at a time. For those who desire to make more elaborate sound pick-ups for such purposes as moving picture sound-tracks and other home recording ventures, the electronic mixing panel described herein will prove of real value.

In designing this mixer it was proposed to develop a unit which, while retaining all or most of the advantages enjoyed by expensive professional equipment, still used standard receiver parts. Many of these parts, as in the case of the amplifier, can well be salvaged from discarded radio receivers.

Many volume controls designed for use in home radio sets are somewhat noisy when used ahead of a high-gain instrument where even minute variations in voltage are amplified to the point where they will produce annoying volumes of sound in the loudspeaker.

This fault has been eliminated in the present design by removing the volume controls from the low-level input to the grid circuit of the mixer tube. This means the addition of one extra tube for each low-level channel but, in the opinion of the writer, this extra tube is more than justified by the quieter operation gained through its use.

Through the use of standard electronic mixer tubes, the use of expensive pads has been eliminated and a mixer has been provided where each channel can be set to its own level without inter-acting with any of the other channels.

The tube line-up shown is perfectly satisfactory with the circuit constants shown. The reader is referred to any standard hand-book of resistance-coupled amplifier design for constants for tubes other than those shown. The only exception to this is the variation shown in the schematic where it is noted that 6J7 tubes may be substituted for the 6SJ7 tubes used by the writer. Since these tubes differ only in a few minor respects insofar as audio frequency applications are concerned, the same circuit constants may be used with either tube. One added precaution to be used with the 6J7 tube, though, is to be sure to use a shielded lead to the grid-cap and to use one of the little cap shields over the grid-cap. In the case of a "G" tube, of either type, it will be found that a close-fitting metal shield will give a huge reduction in noise pick-up.

In planning your mixer panel layout remember that the usual construction rules prevail; keep all leads as short as possible and parts well spaced to prevent intercoupling. All circuits are so routed as to prevent coupling from output to input through any path whatsoever. To this end, the output of the mixer panel should be be well separated physically and the associated wiring so routed as to prevent capacitance or inductive coupling between these circuits. It will be noted

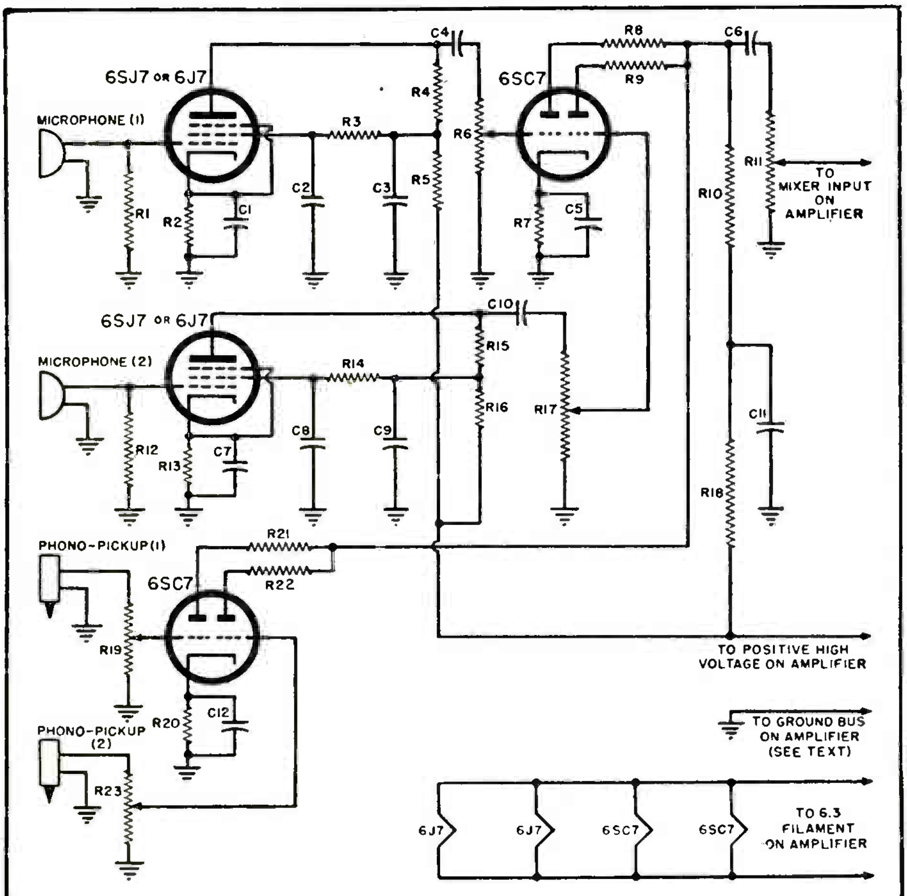
Copyright 1945, Ziff-Davis Publishing Co., 185 No. Wabash Ave., Chicago, Ill.
(Radio News, Radio-Electronic Engineering Edition, October 1945)

www.americanradiohistory.com

that de-coupling nets have been introduced into the plate-circuit of each tube. These nets were found to be absolutely indispensable in the prevention of motor-boating and other forms of instability.

As indicated in the schematic, a ground bus interconnected with that on the amplifier will be found to reduce hum and other forms of disturbances to a minimum. Carry this ground bus on mounting lugs which are carefully insulated from the chassis and do not connect this bus to the mixer chassis at any point. Bond the mixer chassis to the amplifier chassis to prevent the formation of static charges between these units. It may be found that a good connection to earth ground will reduce noise level and it will certainly prevent any chance of shock due to any stray voltage between chassis and ground.

Schematic diagram of four-tube mixer. Each input has its individual volume control.



R_1, R_3, R_{12}, R_{14}—1 megohm, ½ w. res.
R_2, R_{13}—600 ohm, ½ w. res.
R_4, R_{15}—500,000 ohm, ½ w. res.
R_5, R_{10}, R_{16}—100,000 ohm, ½ w. res.
R_6, R_{11}, R_{17}, R_{19}, R_{23}—500,000 ohm pot.
R_7, R_{20}—3000 ohm, ½ w. res.
R_8, R_9, R_{18}, R_{21}, R_{22}—10,000 ohm, ½ w. res.

C_1, C_5, C_7, C_{12}— 25 µfd, 25 v. elec.
C_2, C_8—.5 µfd, 400 v. cond.
C_3, C_9, C_{11}—8 µfd, 450 v. elec.
C_4, C_6, C_{10}—.01 µfd, 400 v. cond.
2—6SC7 tube
2—6J7 or 6SJ7 tube

In wiring this unit, bear in mind that the low-level input circuits (those marked "mic. 1 and mic. 2" on the schematic) are carrying voltages which are amplified some 7000 to 10,000 times before they are reproduced in the loud-speaker. For that reason, noise voltages which would ordinarily be negligible assume proportions comparable to program level. This latter is true since the output of high-quality microphones is so minute as to be comparable in value to the noise voltage in a carelessly laid-out circuit.

This is mentioned, not as an attempt to scare the reader, but to save him from the rather disappointing experience of finding that his mixer is a source of noise rather than a means of amplifying the speech and music it is designed to handle.

These voltages can be reduced to the point where they can be neglected by a few simple precautions. First, keep all low-level signal leads as short as possible and run them entirely in shielded wire. This applies to the grid leads of the low-level or microphone input tubes. Bond these shields carefully to the ground bus, but insulate them carefully where they pass through the chassis. Second, use some type of shielded input jack. An ordinary single circuit radio jack will do if it isn't too large physically. If a large jack is unavoidable, enclose it in its own shield to avoid pick-up. A still better input jack for the "mikes" is the regular amphenol button-contact jack. This latter may be hard to obtain, however. Third, never try to use ordinary wire to connect a high-quality microphone to any amplifier. Use regular microphone cable which is carefully shielded. Even when using cable of this type, carefully avoid cable runs longer than those recommended by the manufacturer of your microphone. This is usually about 50 feet for most makes of high-impedance instruments.

If longer cable runs are necessary, obtain a microphone with a line transformer in its case and provide a line-to-grid transformer for each microphone channel. This latter, if carefully shielded, will provide somewhat better over-all response for the microphone placed at some distance from the mixer.

One more excellent precaution, which will pay off in reduced hum level, is to make sure that all wires carrying raw a.c. (such as filament leads) are carried through the circuit as twisted pairs and pushed as far into a corner of the chassis as possible. It will be remembered that the filament circuit of the amplifier was grounded on one side to avoid hum pick-up. It would be an excellent idea to ground the mixer filament lead, as well. However, an obvious precaution would be to make sure that the *same* lead is grounded in both amplifier and mixer to avoid any chance of a short circuit.

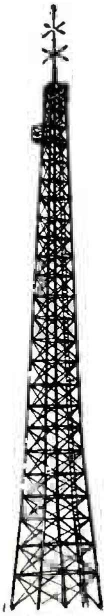
The panel layout is left up to the reader's taste with these few notes. First, if obtainable, select a panel of some metallic material such as iron or aluminum. This may, of course, be finished to suit. Second lay out the channel controls in logical sequence across the top of the panel and place the master control below them or, if preferred, place the master control near the top of the panel and line the other controls up along the bottom. This is for the sake of avoiding confusion in operation. If practicable, make all microphone and phono connections to the back of the mixer cabinet and keep the low-level tubes as far away from the panel as the size of the chassis permits. This latter is not of too much importance, however, provided shielding has been carried out as suggested.

The wiring complete, connect the mixer to the power amplifier as indicated in the schematic. Before placing tubes in the sockets, check voltages on the tube sockets with a good voltmeter if one is available. Failing this, at least check the filament terminals with a neon bulb to be sure that plate and heater leads haven't been crossed. This could cause considerable damage to the amplifier's power pack even though a tube were not burned out.

Now place the tubes in position. Place a finger on the input circuit of one of the low-level inputs and *slowly* advance the corresponding mixer control. The result should be a loud humming sound in the loudspeaker. Now turn this mixer control to zero and try the other low-level channel the same way. Now feed in sound from either a microphone or some other source of equal level and check the amplifier and mixer for quality. If instruments are at hand, an audio oscillator may be used to drive the amplifier and mixer and the over-all frequency response determined for each channel in turn.

In operation, connect each input channel of the mixer to an appropriate sound source, *i.e.*, one or two microphones for spoken commentary and sound-effects and two phono pickups for "canned" sound-effects or musical backgrounds (or both!). If possible arrange to have the microphones placed in rooms away from that used for the mixer panel. This latter is to provide an opportunity to use a loud-speaker to "monitor" the mixing results and adjust each separate channel to its proper level. Failing this, a pair of headphones may be connected into the circuit.

Nothing, in the writer's opinion, can give any person any greater satisfaction than to achieve fine results with apparatus built by his own hands. If those results are a well-planned soundtrack for a home movie film or a well-recorded sound-drama, a person has an artistic achievement as well as a scientific one to "point to with pride".



Some books are to be tasted, others to be swallowed, and some few to be chewed and digested. FRANCIS BACON

www.americanradiohistory.com

WHITHER TELEVISION?

Reprinted from Television

By Dr. Alfred N. Goldsmith

CERTAIN recently disclosed engineering methods and equipment, developed during the war period, strengthen the viewpoint expressed relative to television-broadcasting-allocations in an earlier discussion in these columns. They reinforce the conviction that present-day commercial and practical television should effectively be concentrated below 300 megacycles, and that the highly evolved television of the future should be centered above 5000 megacycles. Other considerations additionally reinforce the opinion that the number of channels presently assigned to commercial television broadcasting should speedily be increased to enable a healthy and normal expansion of that art.

It is well known that standard broadcasting is conducted commercially on 105 channels between 550 and 1500 kilocycles, though not all of these channels are available for use in the United States. Frequency-modulation broadcasting will enjoy eighty channels between 88 and 104 megacycles, and most of these will be available for use in this country. In sharp contrast, commercial television broadcasting is crowded into thirteen channels scattered in groups between 44 and 216 megacycles — a channel arrangement which obviously is not preferred from the engineering or operating viewpoint. And even experimental television broadcasting, between 480 and 920 megacycles would (with 10-megacycle channels and some subtractions from the available band) offer about forty television channels. It is significant that the Radio Technical Planning Board proposed between twenty-five and thirty channels as a compromise minimum — or about twice as many as have actually been assigned to commercial television.

For convenience of reference three types of television will be described and compared. They are as follows:

TYPE A TELEVISION

This type of television would occupy some thirty channels, each 6 megacycles wide located between 44 and 300 megacycles and, as nearly as possible, in large and adjacent blocks of channels. These channels would therefore occupy 180 megacycles out of the available 256 megacycles between 44 and 300 megacycles, leaving nearly 80 megacycles to be assigned to other services if necessary. It would seem that 150 million people in the United States might well be entitled to such a frequency assignment for their entertainment and instruction by the greatest medium of mass communication so far discovered.

Type A television would produce black-and-white pictures of entirely adequate fidelity, and of thoroughly satisfactory entertainment value. It is a type of television which is here. It can give immediate employment to tens of thousands; it can stimulate the employment of millions; and it can bring enjoyment into the homes of tens of millions. It may fairly be called "practical present-day television." It will provide sufficient channels to enable some degree of competition and to furnish service over the major portion of the United States.

Copyright 1945, Frederick Kugel Company, 600 Madison Avenue, N. Y. C.
(Television, October 1945)

www.americanradiohistory.com

It must be pointed out that the antennas are about ten feet long and that, when directional as required, are bulky. Further, this type of antenna will present problems in multiple-apartment dwellings and may compel the use of centralized-television service by the landlord on a rental basis. But there are no outstanding technical problems in all this.

In summary, Type A television deserves vigorous encouragement by the public, the government, and the radio industry. It offers great opportunities for public entertainment and instruction for large-scale employment — vital factors under existing conditions.

TYPE B TELEVISION

This sort of television, at present on an experimental basis, is located between 480 and 920 megacycles. It can offer about 40 10-megacycle channels or only about 20 20-megacycle channels). If the 10-megacycle channels are used in order to get a fairly adequate number of channels under present-day conditions, Type B television would offer color pictures of about the same detail as the black-and-white pictures of existing Type A television.

In offering radio engineers the opportunity to study experimentally the 480-920 megacycle band in its television capabilities, the Commission is furthering a clear understanding of the capabilities of this band. By such experimentation, engineers will learn more about the circuits, equipment, operating procedures, and necessary standards for any possible television in the 480-920-megacycle frequencies.

It is interesting, however, to consider whether this band of frequencies can ever be truly desirable for future commercial television operation, and particularly in the field of high-fidelity color television — a field toward which the television art should progressively advance over the years.

Equipment in the 480-920-megacycle domain has not been developed. Large-scale production of commercial color-television transmitters and receivers is clearly a long way off, for standards must be set, field tests carried out, and all defects of operation ironed out before commercial operation can be considered in any band. Network facilities are not yet available for 10-megacycle channel transmission.

So far as antenna structures are concerned, these will still be fairly bulky in the 480-920-megacycle band, being several feet in size. It would accordingly be impracticable, so far as we now know, for each tenant in a multiple-apartment dwelling to have an antenna which was directional for each of several stations. This might even be the case for persons living in their own homes.

Considering picture fidelity, antenna convenience, number of available high-quality channels, and a number of other factors, it would seem that Type B television is not free from the disadvantages of Type A television. Further, it cannot offer the advantages of immediate and dependable commercial operation such as can be obtained with Type A television.

In brief, Type B television is properly a long-term experimental project insofar as it has interest to engineers. For smooth commercial operation, on a large scale, and on an economic basis, it would appear that years of additional development will be needed followed by a prolonged period of experimental tests and standardization.

TYPE C TELEVISION

This reasoning naturally leads to what is regarded as the logical step to take at some time in the future. This is, if after a number of years of acceptable Type

www.americanradiohistory.com

A television, a new Type C television becomes commercially available, it will be logical to change over to that vastly improved system.

To be more specific, Type C television might be operated, for example, between 5000 and 9000 megacycles, occupying about 100 channels each some 40 megacycles wide. This is an adequate number of channels for a nationwide competitive service. And the color pictures produced by such a system would be of high fidelity (say 700-800 lines). Such a television system might fairly be termed the "television of the future."

Type C television has many major advantages. The antenna problem is at once greatly simplified, since the antenna structures will be metal reflectors or horns which can readily be held in the hand. Such antennas can be mounted on swivel joints and fastened, in an appropriate orientation in each case, on an ordinary pole on the roof. Five or ten of them can readily be mounted on such a pole, and their outputs can be carried by appropriate transmission lines or wave guides to the individual receiver. The need for landlord-sponsored central installations thus disappears, and a vast simplification of installation and maintenance results.

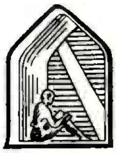
Relay systems will similarly operate in a practically static-free series of channels. And it may be possible, if necessary, to utilize frequency-modulation transmission methods.

The highly directional antennas which can conveniently be used for type C television would minimize ghost images and improve service. The channels assigned to Type C television would be resonably likely to be usable for many years without change.

Broadly considered, Type C television above 5000 megacycles should prove, after development, to be the individual citizen's "free television system." It should be capable of serving the entire country and of fostering healthy competition between television broadcasters.

SUMMING IT UP . . .

To summarize, it is the opinion of the writer that Type A television is here and should be commercially authorized; that Type B television need not be considered for adoption even as an interim system; and that Type C television should be a subject for experimental development over a period of years with the thought that it will constitute the next great step forward in television after its development is succesfully completed, thereby superseding Type A television. These opinions are believed to be shared in considerable measure by eminent engineers active in diverse television broadcasting directions. It is not known whether they represent the viewpoint of any organization or engineering body. It is however, urged that they be seriously considered at this time before steps which may be prejudicial to the future development of broadcasting in the United States shall have been taken. A position of leadership in television is offered to our country; let us act wisely before our great opportunities are lost.



Misspending a man's time is a kind of self-homicide. SIR GEORGE SAVILE

www.americanradiohistory.com

FREQUENCY AND PHASE MODULATION

Reprinted from *FM* and Television

By Ralph S. Hawkins[*]

Explaining Similarities and Differences Between Amplitude, Frequency, and Phase Modulation

> In this article, Ralph Hawkins has cleared up a point which has caused much confusion, sometimes further confounded by the use of "PM" to identify equipment which might better be described by what has become the generic term: "FM."
>
> The explanation here shows that both frequency and phase modulation are present in any "FM" transmitter, and that which ever is used as the cause, the other is the effect.
>
> Incidentally, it should be pointed out that Major Armstrong did not intend that his invention should be called "FM." But that name stuck in the beginning, and is now too firmly established to change it now.

IN THIS discussion of fundamental relations between frequency modulation and phase modulation, it will be assumed that the modulating audio frequencies and the modulated radio frequencies are sine waves, in order to avoid unnecessary complications.

It is fundamental that frequency modulation produces an equivalent phase modulation, and that phase modulation produces an equivalent frequency modulation. This should be kept in mind so as to understand that either may be the cause, and the other is always the effect. Furthermore, the deviation cycle of the equivalent modulation is also sinusoidal, but 90° out of phase with the deviation cycle of the direct modulation.

A clearer picture of the situation is given by showing how a phase modulator can be employed in place of a frequency modulator, by making use of the equivalent frequency modulation produced by the phase modulator. If a phase modulator is to be used as a frequency modulator, it is obvious that the equivalent frequency modulation deviation must be directly proportional to the amplitude of the modulating wave and independent of its frequency, as is required for frequency modulation. However, in a phase modulator, the phase deviation is directly proportional to the modulating wave amplitude and the equivalent frequency deviation is related to the phase deviation as follows:

$$\Delta F = f\Delta\theta$$

This equation indicates that the above requirement is not fulfilled in that the equivalent frequency deviation depends directly on the modulating frequency. This situation can be remedied by passing the audio modulating wave through a de-emphasis circuit before application to the phase modulator so that the amplitude of the wave actually applied to the modulator is inversely proportional to frequency.

---

[*] Engineering Department, National Company, Inc., Malden, Mass.

Copyright 1945, *F. M. Company*, 511 *Fifth Avenue, N. Y. C.*

(*FM and Television, September* 1945)

www.americanradiohistory.com

This combination still produces a phase-modulated wave, but the amplitude of deviation of the equivalent frequency modulation is independent of the modulating frequency, and directly dependent on the modulating wave amplitude, as is required for frequency modulation. Also, for these conditions, the amplitude of the phase deviation produced is inversely proportional to the modulating frequency and directly proportional to modulating wave amplitude, which is characteristic of the equivalent phase modulation of a frequency modulator. These statements are based on the relation between maximum phase or frequency deviation and the equivalent frequency or phase deviation which for sinusoidal modulating and modulated waves, is:

$$\Delta\theta = \frac{\Delta F}{f} \text{ or } \Delta F = f\Delta\theta$$

It should not be forgotten, however, that the modulator in this example is fundamentally a phase modulator and, therefore, the cycle of phase deviation is in phase with voltage applied to modulator, and that the cycle of frequency deviation is not in phase with the voltage applied to the modulator, as would be the case if a frequency modulator were actually used. This phase difference is, of course, 90°. If a particular modulating wave shape can be represented by a sinusoidal wave and its harmonics then, for the fundamental and each of the harmonics the same 90° (relative to the frequency of the harmonic involved) phase difference between the frequency and phase deviation cycles exists. And if in the de-emphasis circuit the phase shift caused in the modulating wave is directly proportional to frequency, then the shape of the deviation cycle of the equivalent frequency modulation produced by the phase modulator with de-emphasis is therefore exactly the same as the shape of a cycle of the particular modulating wave involved.

The phase modulator with de-emphasis is, therefore, able to produce a frequency-modulated wave which, even for a complex modulating wave, is the same as would be produced by a frequency modulator except for the phase shift due to both the de-emphasis circuit and the 90° phase difference between the direct and equivalent modulation.

In a similar manner a frequency modulation discriminator can be used as a phase modulation detector because the discriminator will respond to the equivalent frequency modulation of the phase-modulated wave. The amplitude of the equivalent frequency modulation deviation cycle is given by the expression:

$$\Delta F = f\Delta\theta$$

Thus the amplitude of the equivalent frequency deviation depends directly on the modulating frequency as well as the amplitude of the modulating wave. This fact indicates that the amplitude of the recovered audio wave will also depend directly on the modulating frequency as well as the amplitude of the modulated wave. This situation can be corrected by a de-emphasis circuit in which the response is *inversely* proportional to frequency, and the phase shift is *directly* proportional to frequency. The amplitude of the audio wave, recovered from the discriminator and de-emphasis circuit combination, will be independent of the modulating frequency and will depend directly on the modulating wave amplitude. Such an arrangement is, therefore, capable of demodulating a phase-modulated wave, even when a complex modulating wave is employed. It should be remembered that the recovered audio will not be in phase with the audio frequency modulating wave due to both the 90° relation between direct and equivalent modulation and due to the phase shift in the de-emphasis circuit.

In the preceding discussion, it was of course assumed that the linear operation capabilities of the modulator or discriminator were not exceeded.

In circuits linking the modulator and demodulator, the carrier and side bands, which must be considered, are exactly the same for either frequency or phase modulation. The number of side bands and their amplitude and the carrier amplitude depend only on the value of modulation index β. The frequency of the side bands for either type of modulation related to the carrier frequency is the same and de-

www.americanradiohistory.com

pends only on the modulating frequency. The resultant sum of the carrier wave and all the side bands is, of course, equal to the frequency- or phase-modulated wave, as the case may be. The phase deviation cycle of this resultant wave for phase modulation and the frequency deviation cycle of the resultant wave is in phase with modulating wave for frequency modulation.

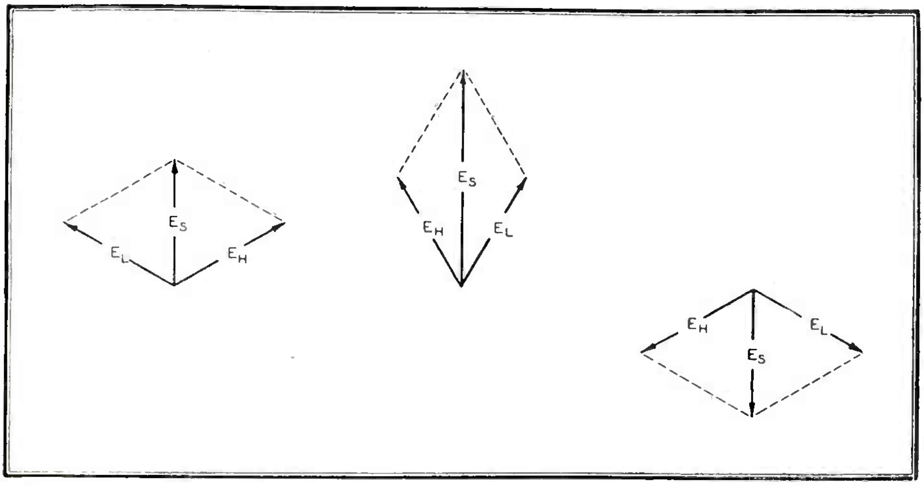


Fig. 1. Pair of AM side bands at three successive instants during angular rotation

In reviewing the fundamental relations for amplitude modulation with sinusoidal modulating and modulated waves, it will be remembered that the amplitude-modulated wave can be considered as composed of a sinusoidal carrier wave and a pair of sinusoidal side bands. The carrier wave is of constant frequency and amplitude. The side bands are of equal amplitude, and the amplitude is directly proportional to the amplitude of the modulating wave. It will also be remembered that for amplitude modulation the frequency of the higher-frequency side band is equal to the carrier frequency plus the modulating frequency, and that the frequency of the lower-frequency side band is equal to the carrier frequency minus the modulating frequency.

Inasmuch as somewhat similar relations also hold true for frequency and phase modulation, some of the features of AM, FM, and PM are readily illustrated by means of vector diagrams when sinusoidal waves are involved. In the cases to be considered, the maximum amplitude of the radio-frequency waves considered will be of a greater interest than the instantaneous amplitude, which makes it expedient to use vector diagrams in which the carrier wave is represented by a stationary (i.e. not rotating) vector.

The reader can, if he chooses, think of the paper on which the vectors are drawn as rotating in a clockwise direction with an angular velocity in radians per second of 2π times the carrier frequency in cycles per second. In this type of diagram, therefore, the higher-frequency side band is represented by a vector which rotates in a counter clockwise direction with an angular velocity of 2π times the modulating frequency, which corresponds to the difference in frequency between the side band and carrier frequency. Similarly the lower-frequency side band is represented by a vector which rotates in a clockwise direction with an angular velocity equal to 2π times the modulating frequency.

For ease of reference to the vector diagrams to be considered, the following notation will be employed:

E_C = Vector representing the carrier
E_H = Vector representing the higher-frequency band
E_L = Vector representing the lower-frequency side band

E_S = Vector representing the sum of the higher- and lower-frequency side band pair
E = Vector representing the amplitude-, or frequency-, or phase-modulated wave as the case may be, which in any case is equal to the sum of the carrier and all of the side band pairs involved.

The vectors shown in Fig. 1 represent a pair of AM side bands and their sum at three successive instants during their cycle of angular rotation.

These vector diagrams indicate that the sum of the side band waves E_H and E_L is a wave, E_S, which is of constant frequency, equal to the carrier frequency involved, as the vector E_S does not rotate. It should be noted, however, that the maximum amplitude of E_S changes and that each time the maximum amplitude passes through zero, the relative phase changes by π radians (i.e. 180 degrees). These vector diagrams also illustrate the well-known fact that, for AM, the maximum amplitude of E_S varies in a sinusoidal manner. It is also true for AM that the instantaneous maximum amplitude and relative phase of E_S depends directly on the instantaneous amplitude and polarity of the modulating wave. These facts are not, however, shown directly by the vector diagram.

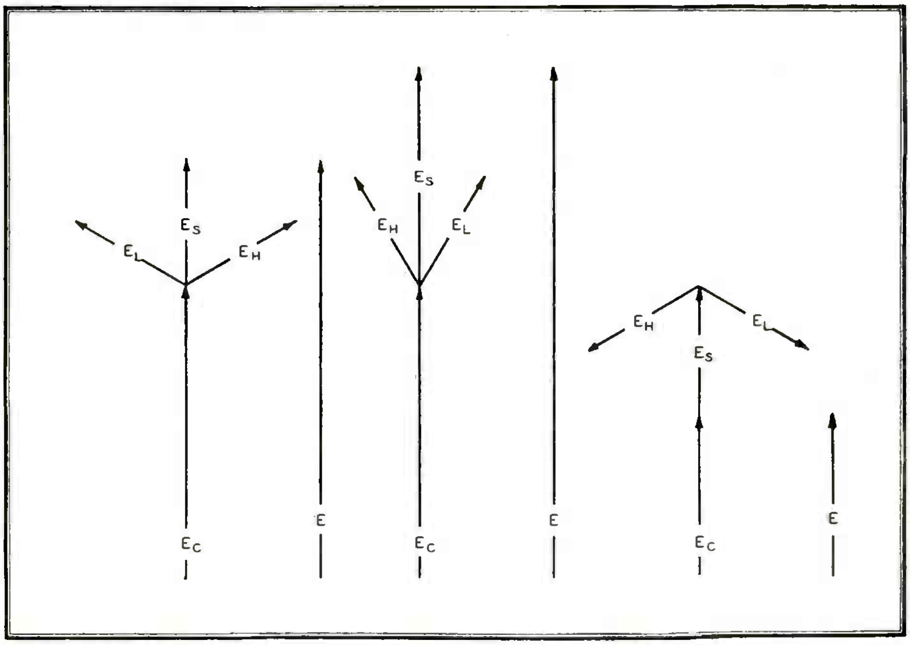


Fig. 2. Here an AM carrier plus the side band sum is represented by "E"

The vector diagrams shown in Fig. 2 illustrate the carrier and side band relations for AM if a carrier represented by a vector E_C is added to the side band sum E_S with a relative phase such that E_S either adds directly to or subtracts directly from E_C depending on the relative phase of E_S. These conditions are illustrated in Fig. 2 which also shows the resultant amplitude-modulated wave E, which is the sum of the carrier and side bands.

In Fig. 2 it should be noted that the frequency and relative phase of the resultant amplitude-modulated wave E are constant as the vector E does not rotate, and also that the maximum amplitude of the amplitude-modulated wave E varies in a sinusoidal manner relative to the maximum amplitude of the carrier E_C.

If the carrier E_C has been added to the side band sum E_S so that E_S is at right angles to E_C then the vector diagrams would illustrate a combination of amplitude and phase modulation. Fig. 3 illustrates these conditions.

www.americanradiohistory.com

It should be noted that both the maximum amplitude and relative phase of the resultant wave E change, which indicates that both amplitude and phase modulation respectively occur in this case.

For AM to be eliminated, the amplitude of the resultant wave E should not change. That is, the tip of the vector E should follow the circumference of a circle (shown dotted in Fig 3) with radius equal in this case to E_C. Also, for pure phase modulation to be obtained, the relative phase angle θ between E and E_C must be directly proportional to the instantaneous amplitude and polarity of the modulating wave. From Fig. 3 it can be observed that the relative phase angle θ between E and E_C is dependent on the maximum amplitude and relative phase of E_S which, in turn, is directly proportional to the instantaneous amplitude and polarity of the modulating wave, because the side bands being considered are produced by an amplitude modulator. It can be observed also that the change in maximum amplitude of E is dependent on E_S.

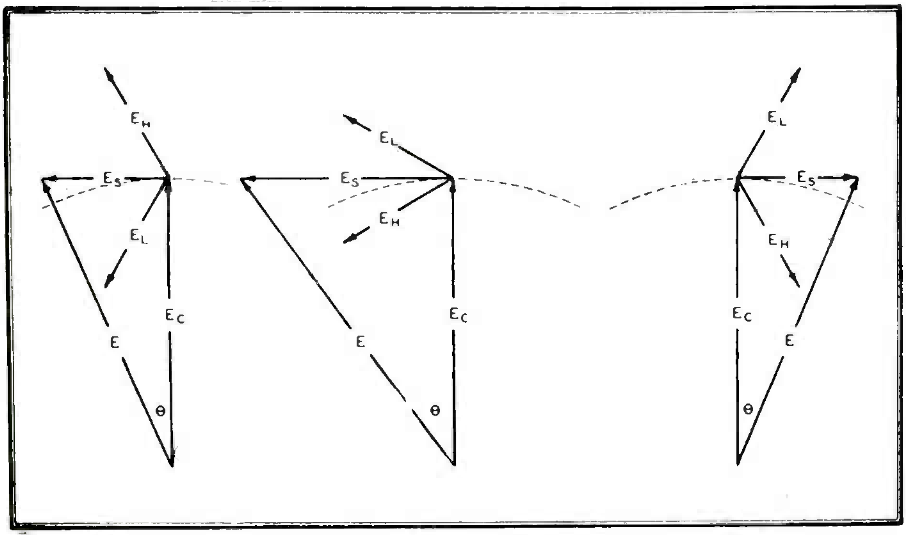


Fig. 3. Diagrams showing a combination of amplitude and phase modulation

If the ratio of E_S to E_C is restricted to values of 0.2 or less, the amplitude modulation is essentially eliminated. Also essentially pure phase modulation is obtained for these restricted conditions, because the phase angle in radians between E and E_C, which is the phase deviation, is equal to the tangent of the angle θ which, in turn, depends directly on the instantaneous maximum amplitude and relative phase of E_S, and this, in turn, depends directly on the instantaneous amplitude and polarity of the modulating wave.

This basic method for the production of a phase-modulated wave has been used in practical transmitters. The relatively small phase deviations produced under these conditions can, of course, be increased by the use of frequency multipliers. The phase modulator can be used as a frequency modulator by making use of the equivalent frequency modulation as previously described.

When modulation index β is equal to .2 or less, only one important side band pair is produced, and this agrees with the foregoing discussion. If, however, a phase modulator is employed which is capable of producing phase deviations of greater than 0.2 radian without distortion, then other side band pairs become involved. The wave which is the sum of the second side band pair produced also has a frequency equal to the carrier frequency and a relative phase such that the wave either adds directly to or subtracts directly from the carrier, E_C.

www.americanradiohistory.com

As the deviation is increased, more and more side band pairs are produced and the wave which is the sum of any side band pair has a frequency equal to the carrier frequency, and the relative phase is such that the sum of each pair adds to the carrier alternately at right angles and directly as in the cases of the first and second side band pairs. Also for pure phase modulation, the maximum amplitude and relative phase of the side band pairs and even of the carrier are dependent on the maximum deviation. The sum of the carrier and all the side band pairs must, of course, add together in such a manner as to result in the phase-modulated wave. It has been shown by well-known investigators in the field that the amplitude of the carrier and also of the side bands can be calculated by means of Bessel functions[1] from a knowledge of the maximum deviation.

The relations between the carrier and side bands involved for phase modulation are readily seen by means of vector diagrams which show the sum of each important side band pair added to the carrier, and also the resultant phase-modulated wave. The vector diagram in Fig. 4 show this addition for a phase-modulated

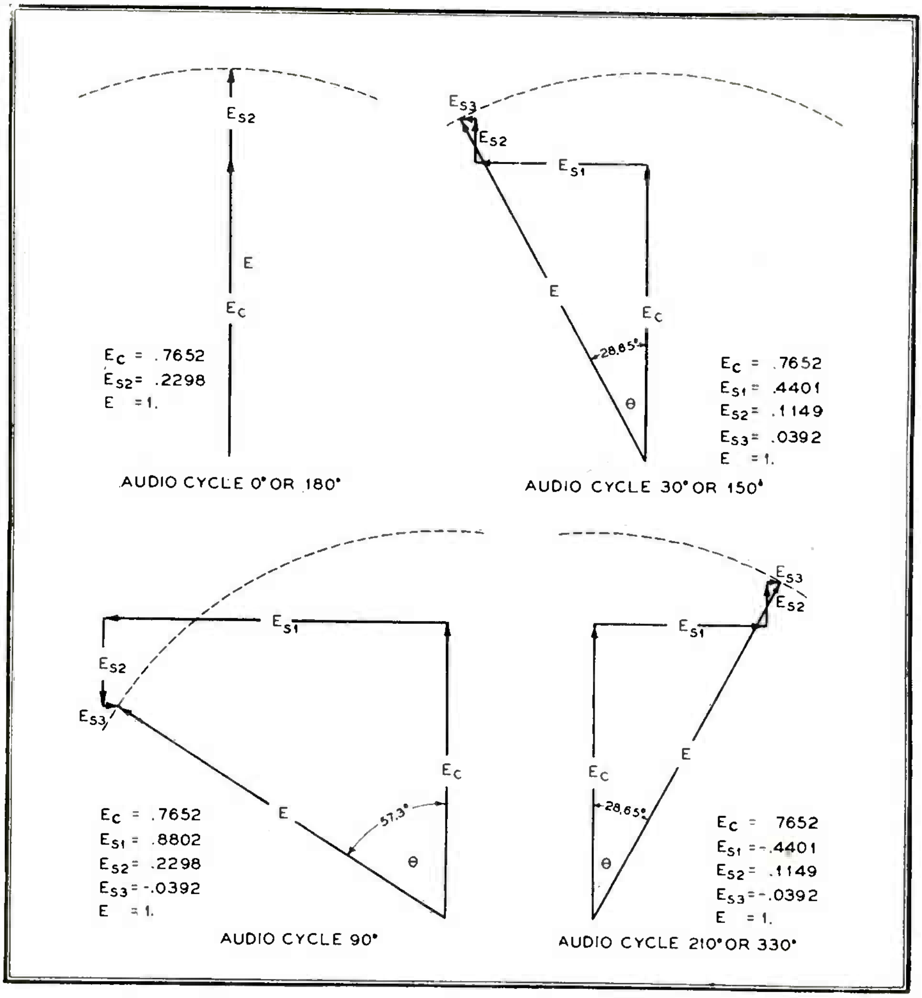


Fig. 4. Relative phase for a phase- or frequency-modulated wave

---

[1] See "FM Broadcast and Communications Handbook" Chapter 1, *FM* AND TELEVISION, February, 1945.

www.americanradiohistory.com

wave of unit amplitude at 0°, 30°, 90°, 150°, 180°, 210° and 330° during a *sinusoidal* audio modulating cycle. Vectors E_{S1}, E_{S2} and E_{S3} represent respectively the sum of the first, second and third side band pairs. A maximum phase deviation of 1 radian was chosen as this deviation results essentially in only three important side band pairs. The magnitudes of the carrier and side band sums were calculated by means of Bessel functions.

In Fig. 4 it should be noted that at 0°, 180°, and also at 360° during the sinusoidal audio modulating cycle, the amplitudes of E_{S1} and E_{S3} are equal to zero. It should also be noted that at similar deviations throughout the audio cycle the same vector diagrams apply, as might be expected.

For example, at 30° and 150° during the audio cycle the same phase deviation is obtained and the same diagram applies, as the Sin of 30° and also of 150° is equal to $+ 0.5$. The deviation is equal to .5 times the maximum deviation or $0.5 \times 57.3 = 28.65°$. Also for 30° and 210° the same deviation is obtained except for the sign, as the Sin of 30° is $+ 0.5$ and the Sin of 210° is $- 0.5$. Vectors E_{S1} and E_{S3} for 210° are both drawn in the opposite direction from E_{S1} and E_{S3} for 30°, thereby producing a negative deviation of $- .5 \times 57.3°$ or $- 28.65°$.

The type of diagram shown in Fig. 4 illustrates directly the relative phase at any instant for a phase- or frequency-modulated wave, but does not show directly the frequencies at corresponding instants. This limitation does not detract from the usefulness of the diagram if it is remembered that a sinusoidal direct phase modulation causes an equivalent frequency modulation which is also sinusoidal but 90 degrees or $\pi/2$ radians out of phase with the phase deviation cycle. To be more specific concerning this 90-degree phase difference, it should be noted that *sinusoidal* direct phase modulation causes *cosinusoidal* equivalent frequency modulation and similarly *cosinusoidal* direct frequency modulation causes *sinusoidal* equivalent phase modulation.

The diagrams shown in Fig. 4, therefore, also illustrate a particular case of frequency modulation. Inasmuch as Fig. 4 shows the position of the vector representing a *phase*-modulated wave at 0°, 30°, 90°, 150°, 180°, 210°, 330° and 360° during the cycle for a *sinusoidal* modulating wave, it also shows the position of the vector representing a *frequency*-modulated wave at 0°, 30°, 90°, 150°, 180°, 210°, 330° and 360° during the cycle for a *cosinusoidal* modulating wave. The modulation index β for the frequency modulation case illustrated in Fig. 4 is also equal to 1, as for the phase modulation case.

These relations clearly indicate the similarity of phase and frequency modulation which results from the physical fact that in order to change the relative phase of a wave the frequency must be changed also. More specifically, for either phase or frequency modulation the phase deviation cycle lags the frequency deviation cycle by 90 degrees.

It may seem to the reader at first glance that it is somewhat round about to compare amplitude and frequency modulation by comparing each to phase modulation, but a closer view of the situation will show that this method actually gives a clear picture of the relations involved. With the relations shown in Fig. 4 in mind, a better understanding of some of the preceeding paragraphs can be obtained.

POUND OF WIRE: 62 MILES

Wire of cobweb consistency, only a third as thick as human hair, is used in instruments that measure electronic circuits. A pound of the wire stretches 62 miles.

www.americanradiohistory.com

FM-TELE STANDARDS

Reprinted from Electronic Industries

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

FOUR classes of television stations will be established in the United States under proposed engineering standards adopted by a joint FCC. Because FCC relies almost unequivocally upon its engineering staff for technical recommendations, it is practically certain to approve them. Proposed engineering standards for FM, embracing allocations, topographical data and transmitter location, operating practices, antenna systems were also sanctioned by a group of approximately 100 FCC-industry engineers with one feature decision that the ratio of desired to undesired signals of 10 to 1 for stations operating on the same channel and 2 to 1 ratio for stations in adjacent channels, 200 kc removed, were adopted. The allocations for television had not yet at our press dead line been definitely decided by the FCC, but every indication was that the Commission would approve the allocations plan proposed by the Television Broadcasters Association.

400 MAJOR TELE CHANNELS

The television plan calls for assignment of channels for 400 stations in Class A, B and C in 125 of the 140 metropolitan districts of the United States and several hundred Class D stations will be available to serve the remaining metropolitan districts and other areas.

The three-day hearings before the Commission en banc on the economic and social prospects for FM at which the executive heads of the three networks and over a score of other leaders in broadcasting, including Major E. H. Armstrong, FM inventor, and former Commissioner T. A. M. Craven who is now executive vice-president of the Cowles Broadcasting Co., testified, developed the consensus that in the postwar era standard (AM) broadcasting will be replaced entirely by FM except for a few scattered clear channel stations serving remote rural areas.

The broadcasters' spokesmen in general supported the single market plan of horizontal competition in FM which was advanced by CBS. The networks indicated that they do not plan to charge for service to the FM stations until this new form of broadcasting is fully established. There was general opposition to FCC's proposal of requiring two hours of unduplicated programs for FM because of the expense during the AM-FM transition period, but the FCC asked all networks to submit schedules of programs capable of high fidelity transmission and reception. One network president, Mark Woods of American Broadcasting System, predicted that there would be 4,000 FM stations within five years after the war and that it would take three years for FM to break even financially.

Under the TBA plan, each of the 13 television channels is designated for certain metropolitan districts except Channel No. 1 (44-50 mc.) which will be reserved for low-powered stations serving small communities. Class A stations which may use Channels 2-13 inclusive would be assigned to metropolitan districts with large populations with limited geographical separations in the northwestern region of the nation; Class B stations go to cities with smaller populations; Class C stations will

Copyright 1945, *Caldwell-Clements Inc.*, 480 *Lexington Avenue, N. Y. C.*
(*Electronic Industries, September* 1945)

www.americanradiohistory.com

have minimum separation of 170 miles on co-channel basis and 85 miles on adjacent channels from Class A and other C stations and may be assigned Channels 2-13; and Class D stations will serve cities not having adequate service from other classes of outlets.

Under the proposed TBA allocation plan, New York and Chicago each will get seven channels for Class A stations — Channels 2, 4, 5, 7, 9, 11, 13. Los Angeles will get the same channels for seven Class C stations and San Francisco will secure six Class C stations using channels 2, 4, 5, 7, 9, 11. Philadelphia is to obtain four Class A stations using Channels 3, 6, 8, 10 and Detroit will get the same channels plus Channel 12 for Class A stations.

In the proposed engineering standards, the rules for television transmitters and associated equipment follow very much along the lines of the suggestions of the Radio Technical Planning Board in its reports to the Commission. The television interference standards are virtually the same as existed under the old FCC rules, while the standards on the service area of stations were only refined and clarified from the previous rules. The field intensity measurement standards, which had not been definitely specified in the present rules, were spelled out in definite detail in the proposed standards to conform with the methods proposed for FM.

In the case of FM, two phases of the standards have been left for further decision by FCC. These included the question of booster or satellite stations and horizontal polarization. In the case of use of a limiting or compression amplifier, the provision of not more than 3 decibels being employed is to be changed as some felt there should be a lower limitation than 3 decibels. The consensus was that there should be a final determination in favor of horizontal polarization in the interests of uniformity, although the discussion at the conference was that it would be better to leave it flexible with permission for vertical polarization for further experimentation. It was also felt that FM profiles up to 10 miles rather than eight miles should be sanctioned.

TECHNICAL STANDARDS

The most important Engineering Standards for Television, proposed by the FCC, and agreed to, were those on Transmission standards which follow:

(1) The width of the television broadcast channel shall be six megacycles per second.

(2) The visual carrier shall be located 4.5 mc lower in frequency than the aural carrier.

(3) The aural carrier shall be located 0.25 mc lower than the upper frequency limit of the channel.

(4) The visual transmission amplitude characteristic shall be as shown in Appendix II.

(5) The number of scanning lines per frame period shall be 525, interlaced two to one.

(6) The frame frequency shall be 30 per second and the field frequency shall be 60 per second.

(7) The aspect ratio of the transmitted television picture shall be 4 units horizontally to 3 units vertically.

(8) During active scanning intervals, the scene shall be scanned from left to right horizontally and from top to bottom vertically, at uniform velocities.

(9) A carrier shall be modulated within a single television channel for both picture and synchronizing signals, the two signals comprising different modulation ranges in amplitude.

(10) A decrease in intial light intensity shall cause an increase in radiated power.

www.americanradiohistory.com

(11) The black level shall be represented by a definite carrier level, independent of light and shade in the picture.

(12) The pedestal level (normal blank level) shall be transmitted at 75 per cent (with a tolerance of plus or minus 2.5 per cent) of the peak carrier amplitude.

(13) The maximum white level shall be 15 per cent or less of the peak carrier amplitude.

(14) The signals radiated shall have horizontal polarization.

(15) A radiated carrier power of the aural transmitter not less than 50 per cent or more than 150 per cent of the peak radiated power of the video transmitter shall be employed.

(16)* Variation of Output — The peak-to-peak variation of transmitter output within one frame of video signal due to all causes, including hum, noise, and low-frequency response, measured at both synchronizing peak and pedestal level, shall not exceed 5 per cent of the average synchronizing peak signal amplitude.

(17)* Black Level —— The black level should be made as nearly equal to the pedestal level as the state of the art will permit. If they are made essentially equal, satisfactory operation will result and improved technics will later lead to the establishment of the tolerance if necessary.

(18) Brightness Characteristics — The transmitter output shall vary in substantially inverse logarithmic relation to the brightness of the subject. No tolerances are set at this time.

In the case of FM, the following Electrical Performance Standards of Transmitters and Associated Equipment have been set forth:

(1) Standard power ratings and operating power range of FM broadcast transmitters shall be in accordance with the following table:

Standard Power Rating	Operating Power Range
250 watts	250 watts or less
1 kw	250 watts— 1 kw
3 kw	1— 3 kw
10 kw	3— 10 kw
25 kw	10— 25 kw
50 kw	10— 50 kw
100 kw	50—100 kw

In case any manufacturer decides to produce a 100 kw rating or any power rating not listed above, he must give notice to the Commission, which will release by Public Notice the manufacturer's name and the standard power rating of the transmitter to be produced at least six months prior to the delivery date or completion of such transmitter.

The operating power of any transmitter not listed above shall be from one-third standard to standard power rating.

Composite transmitters may be authorized with a power rating different from the above table, provided full data is supplied in the application concerning the basis employed in establishing the rating and the need therefor. The operating range of such transmitters shall also be from one-third of the power rating to the power rating.

The transmitter shall operate satisfactorily in the operating power range with a frequency swing of ± 75 kilocycles, which is considered as 100 per cent modulation.

---

* These items are subject to change but are considered the best practice under the present state of the art. They will not be enforced pending a further determination thereof.

www.americanradiohistory.com

(2) The transmitting system shall be capable of transmitting a band of frequencies from 50 to 15,000 cycles. Pre-emphasis shall be employed in accordance with the impedance-frequency characteristic of a series inductance-resistance network having a time constant of 75 microseconds. The deviation of the system response from the standard pre-emphasis curve shall lie between two limits. The upper of these limits shall be uniform (no deviation) from 50 to 15,000 cycles. The lower limit shall be uniform from 100 to 7,500 cycles, and three db below the upper limit; from 100 to 50 cycles the lower limit shall fall from the three db limit at a uniform rate of one db per octave (four db at 50 cycles); from 7,500 to 15,000 cycles the lower limit shall fall from the three db limit at a uniform rate of two db per octave (five db at 15,000 cycles).

(3) At any modulating frequency between 50 and 15,000 cycles and at modulation percentages of 25 per cent, 50 per cent and 100 per cent, the combined audio frequency harmonics measured in the output of the system shall not exceed the root-mean-square values given in the following table:

Modulating Frequency	Distortion
50 to 100 cycles	3.5%
100 to 7,500 cycles	2.5%
7,500 to 15,000 cycles	3.0%

Measurements shall be made employing 75 microsecond de-emphasis in the measuring equipment and 75 microsecond pre-emphasis in the transmitting equipment, and without compression if a compression amplifier is employed. Harmonics shall be included to 30 kc.

It is recommended that none of the three main divisions of the system (transmitter, studio to transmitter circuit, and audio facilities) contribute over one-half of these percentages since at some frequencies the total distortion may become the arithmetic sum of the distortions of the divisions.

(4) The transmitter output noise level (frequency modulation) in the band of 50 to 15,000 cycles shall be at least 60 decibels below the audio frequency level representing a frequency swing of ± 75 kilocycles.

(5) The transmitter output noise level (amplitude modulation) in the band of 50 to 15,000 cycles shall be at least 50 decibels below the level representing 100 percent amplitude modulation.

(6) Automatic means shall be provided in the transmitter to maintain the assigned frequency within the allowable tolerance (2,000 cycles).

(7) The transmitter shall be equipped with suitable indicating instruments for the determination of operating power and with other instruments as are necessary for proper adjustment, operation, and maintenance of the equipment.

(8) Adequate provision shall be made for varying the transmitter output power to compensate for excessive variations in line voltage or for other factors affecting the output power.

(9) Adequate provision shall be provided in all component parts to avoid overheating at the rated maximum output power.

(10) Means should be provided for connection and continuous operation of approved frequency and modulation monitors.

(11) If a limiting or compression amplifier is employed, precaution should be maintained in its use and connection in the circuit due to the use of pre-emphasis in the transmitter.

www.americanradiohistory.com

F-M LIMITERS

Reprinted from Service

By J. George Stewart

FOR PROPER operation of the discriminator in an f-m receiver, the signal applied to it must be of constant amplitude. Not only must the signal have constant amplitude, but it must also be of some exact, predetermined value. In Fig. 1 appears a characteristic curve of a discriminator for two different values of input voltage. Curve *A* represents the voltage characteristic for a given value of voltage input to the discriminator. Curve *B* shows the characteristic curve for a smaller value of input voltage. As we can see, the audio response and amplitude fidelity of the receiver is dependent on an input of constant amplitude to the discriminator, with its exact value determined in the original design.

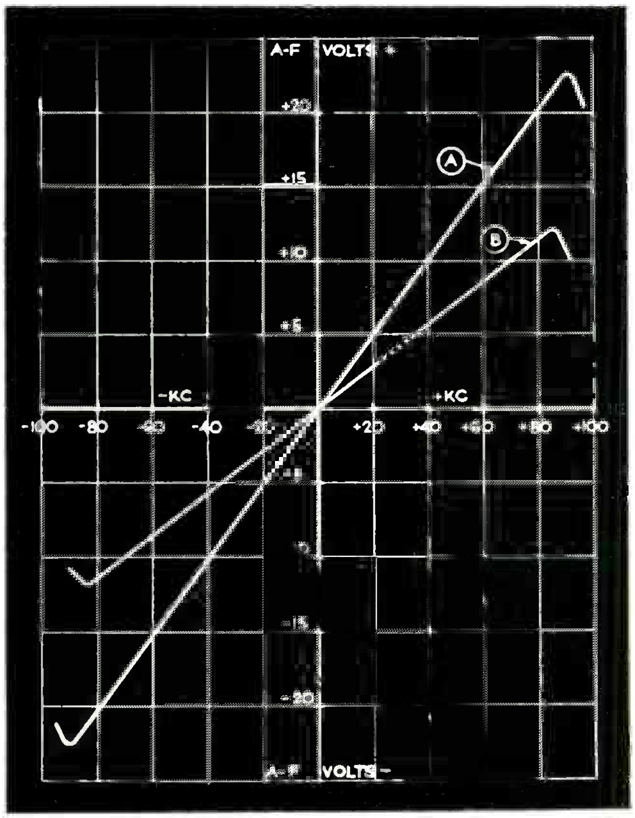


Fig. 1. Typical characteristic curves for an f-m discriminator. The curves represent the differential audio voltage output in terms of the frequency swing; curve A represents the characteristic for a given value of input; B shows the curve for a smaller value input. Note that the output voltage is a direct function of the input voltage.

Copyright 1945, *Bryan Davis Publishing Co., Inc., 52 Vanderbilt Avenue, N. Y. C.*
(Service, September 1945)

www.americanradiohistory.com

Since the field strength of the various f-m transmitters will vary, depending on their location with reference to the receiver, some means must be provided in the receiver for delivering a uniform input to the discriminator, no matter what the signal strength is at the antenna. This function is served by the limiter.

Simply stated, a limiter is a device which delivers uniform output for a wide range of input voltages. In addition, it also helps to reduce the effects of static crashes and loud local noise signals. In this respect, it is very similar to the peak noise limiter used in some a-m receivers.

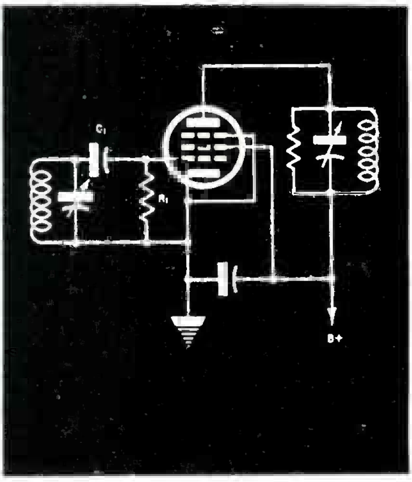


Fig. 2. A typical limiter stage. No bias is used, and its action is dependent on the value of plate and screen voltages applied.

TYPICAL LIMITER

A typical limiter is shown in Fig. 2. In some respects it is similar to an i-f stage, in others, it closely resembles a grid-leak type detector. Its operation is dependent on the proper selection of screen-grid and plate voltages, and the values selected for the grid leak and condenser.

GRID-LEAK CONDENSER ACTION

The action of the grid leak and condenser, R_1 and C_1 in Fig. 2, is the same as in the usual detector. On the positive half of the input cycle, the grid draws current. since there is no cathode bias on the tube. This current develops a bias voltage across the grid resistor, which reduces the plate current. Since there is no r-f bypass condenser in the plate circuit, the input voltage waveform appears also in the output. To limit the voltage developed in the plate circuit, low plate and screen-grid voltages are used. The low plate and screen-grid voltages, usually on the order of 45 to 75 volts, limit the peak value to which the developed signal in the plate circuit can rise, since large values of input signal only cause plate saturation. Thus, once the input signal exceeds some given value, the output from the plate circuit remains constant.

Since reduction of static and noise interference is also a major consideration in the design of limiters, the time constant of the associated *RC* networks is important. Small time constants reduce static and noise best, but also tend to weaken the constant-output characteristic of the limiter for high value inputs. Larger time constants are better for good regulation, but permit static crashes to influence the signal. Since both systems cannot be used in the one circuit, some compromise is necessary where a single limiter is used.

TWO LIMITERS

Where the maximum in both features is desired, two limiters are used, one for best regulation, the other for best noise limiting. Thus, in Fig. 3 the first limiter reduces static and interference by the use of a small time constant for R_1C_1, and the second limiter uses a larger time constant in the $R_2R_3C_2$ network, thereby increasing the voltage regulation characteristic of the limiter system. In addition, some stage gain is realized, usually about 2 to 6, which increases the effectiveness of the receiver for weak signals.

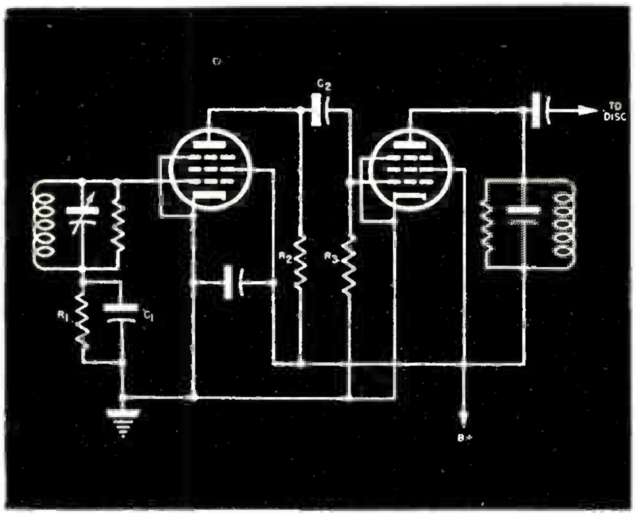


Fig. 3. A double limiter stage. One limiter is used to reduce static and interference, the other to improve the voltage regulation characteristic.

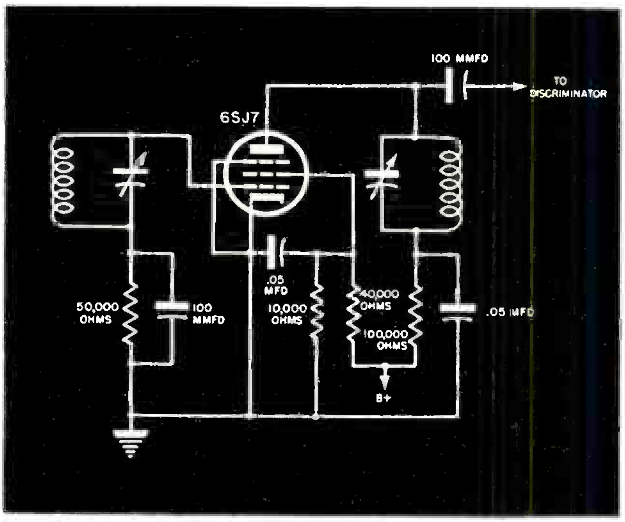


Fig. 4. A single limiter stage as used in the Freed model 40 f-m receiver. Low plate and screen voltages, and a small time constant in the grid CR circuit supply the necessary regulation

Variations of both systems, and typical circuit values are shown in Figs. 4 to 7.

FREED 40

Fig. 4 shows the single limiter used in the Freed model 40 f-m receiver. We note that the grid leak and condenser are both unusually small in value for a small time constant, and that the plate and screen-grid voltage dropping resistors permit only small values of supply voltage. When replacing defective parts in limiter circuits, it is best to use values as established by the manufacturer, since even small deviations will tend to decrease the efficiency of the receiver, or cause circuit instability.

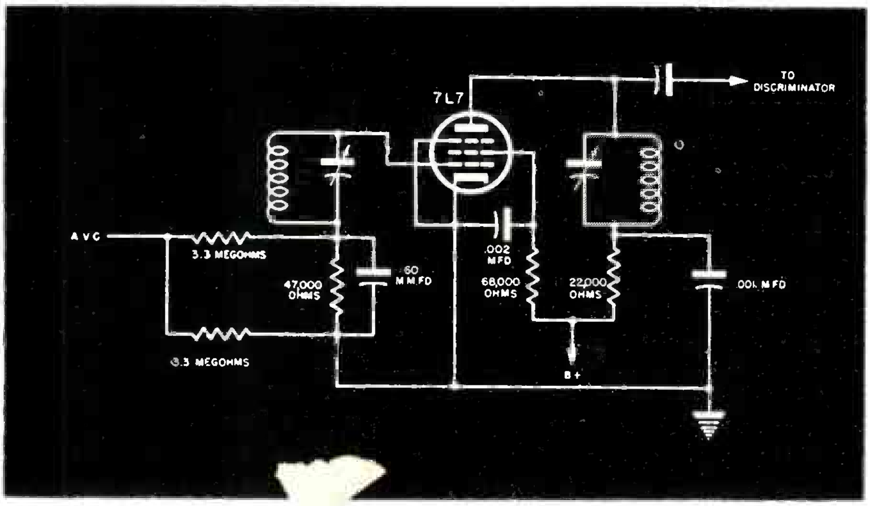
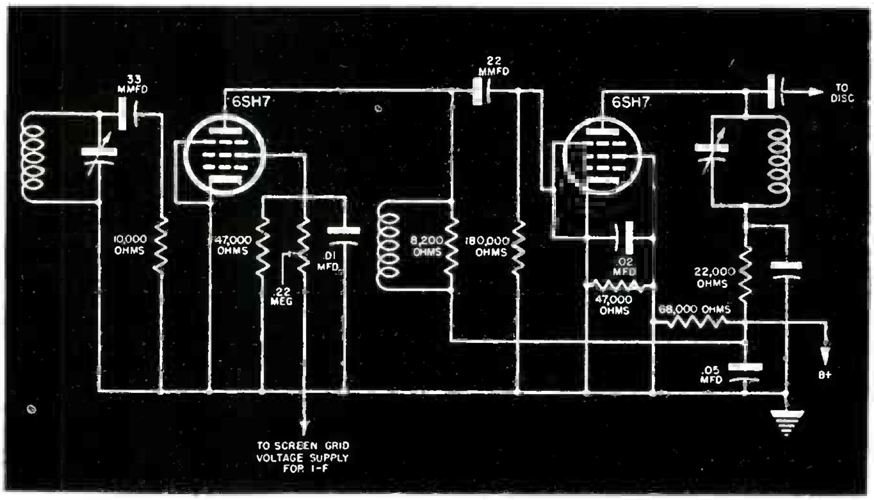


Fig. 5. (above) The Emerson FM 460 limiter. This limiter is used in the a-c/d-c model, which accounts for the low value plate and screen voltage dropping resistors

Fig. 6. (below) Cascade limiter used in the G.E. model 40. Resistance coupling is used interstage to reduce the hazard of feedback. Both limiters have almost the same time constant, since limiter 1 has already limited the range of input to limiter 2



EMERSON FM 460

In Fig. 5 we have the limiter used in Emerson's a-c/d-c FM 460. The low values of plate and screen-grid bleeder resistors are due to the low initial plate voltage. Here, the developed bias in the grid leak circuit is used for avc. Most f-m limiters use high gain tubes such as the 7H7 to improve the limiter action.

www.americanradiohistory.com

G. E. 40

Fig. 6 shows a cascade type limiter used by G. E. in their model 40. Resistance coupling is used for interstage coupling to reduce the hazards of feed-back and stage oscillation. The time constant of the *RC* network in the first limiter is .0000033 second; in the second limiter it is .0000039 second. The time constant for the second limiter does not need to be very different from that of the first, since its task has been greatly reduced by the action of the previous limiter. In other words, the input to limiter 2 is already limited in range by the action of limiter 1.

MOTOROLA FM 82

Fig. 7 illustrates the limiter circuit used in the Motorola FM 82. Here, transformer coupling is used between the two limiters. The time constant for the second limiter is supplied by the 50-mmfd capacitor and the 1-megohm resistor in the grid circuit for a time constant of .000005 second. This is identical to the time constant for the first limiter. A meter jack is also provided for measuring the input to the second limiter for alignment purposes. A low current ammeter with a 500-microampere movement or better is necessary for this operation. The signal from an a-m signal generator is fed into the i-f section, and the stages are aligned for highest reading on the meter. A quick check for oscillation or feedback in the i-f section may be made by cutting out the signal generator and noting if any reading is obtained on the meter. Any small reading is indicative of oscillation, and the i-f stage should be checked for feed-back until the meter reading is zero.

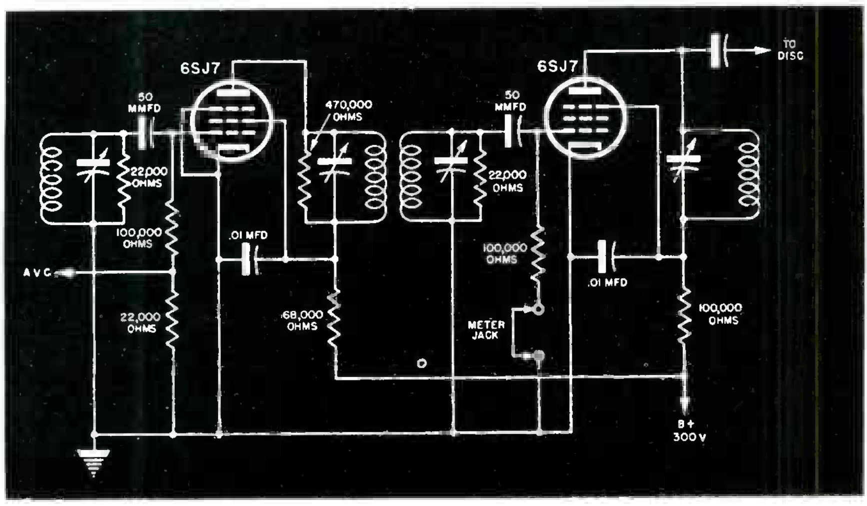


Fig. 7. Cascade limiter of Motorola FM 82. The time constants of the RC grid networks is identical for both limiters. Adequate shielding of components permits the use of transformer coupling, with corresponding improved stage gain.

ALIGNMENT METHOD

Still another method used in alignment is to convert the limiter to a grid-leak type detector. A typical circuit is shown in Fig. 8. Where an i-f transformer is used in the plate circuit of the limiter, the resistor is connected in series with the plate of the tube, and the two components bypass to ground. In aligning the G. E. 40, Fig. 6, the coil in the plate circuit of the first limiter should be disconnected, and a .002-mfd bypass capacitor should be connected from plate to ground. The output is then connected to the audio system through an audio coupling capacitor and the set aligned the same as an a-m receiver with a modulated signal.

www.americanradiohistory.com

The signal input from the signal generator must be kept at a level which does not overload the converted limiter stage. If the input signal is too high, the converted limiter stage may overload, so that increases in signal accompanying alignment will not be apparent. Incidentally, this limiting action may be checked once the set is aligned, by increasing the signal input and noting the effectiveness of the limiter action.

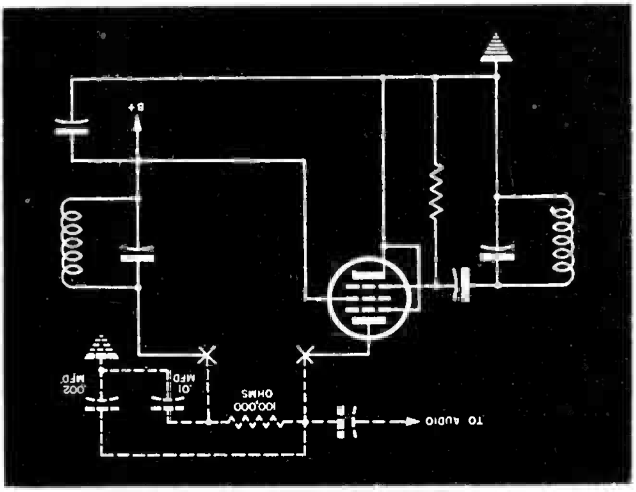


Fig. 8. A method of checking and aligning a limiter stage with an a-m signal generator. The limiter has been converted to a grid-leak type detector. The stage is then aligned for maximum output and checked for its limiting action by applying excessive input

When aligning f-m receivers, the limiter should be checked for uniform output. Receivers should deliver uniform output to the discriminator for signal inputs of 50 microvolts or more. However better performance will result if the limiter output starts to flatten off at less than 50 microvolts.

To check the limiter characteristic for amplitude modulation, an amplitude-modulated signal is applied to the input of the receiver at a level which should saturate the limiter. Very little of the modulation should appear in the output. A loud signal in the output is indicative of poor limiter action, and the circuit should be checked for abnormal voltages or improper grid-leak or grid-condenser values.

* * *

Blessed is he who has found his work; let him ask no other blessedness.
THOMAS CARLYLE

www.americanradiohistory.com

WHAT'S BEING READ THIS MONTH

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

COMMUNICATIONS (October 1945)

THE RADIO PROXIMITY FUZE........*Ralph G. Peters*

A 9-SPEAKER BATTLE-ANNOUNCING SYSTEM........*H. W. Duffield*

N. Y. NAVY YARD'S QUIET ROOM........*Willis M. Rees*

ROLE OF THE NEUTRALIZING CAPACITOR IN TUNED POWER AMPLIFIERS........*Wilson Pritchett*

PULSE AMPLIFIER COUPLING........*Sidney Moskowitz*

THE CBC H-F GLOBAL TRANSMITTING SYSTEM........*R. D. Cahoon*

SOLVING TRANSMISSION LINE PROBLEMS
(with charts of complex hyperbolic tanh and coth........*Robert C. Paine*

CRYSTAL CONTROLLED RECEIVERS FOR A-M, F-M, AND TELEVISION
(Discussion of crystal oscillator mixers for standard bands and the new V-H-F, F-M/television channels........*Sidney X. Shore*

RESISTIVE ATTENUATORS, PADS AND NETWORKS
(Analysis of their applications in mixer and fadar systems. . . Part IX)........*Paul B. Wright*

CQ (November 1945)

AN R-C SUPERHET FOR THE ULTRA-HIGHS....*Howard A. Bowman*, W6QIR

R-F UNIT FOR THE U-H-F's........*John Wonsowicz*, W9DUT *and*
Herbert S. Brier, W9EGO

WORKSHOP WRINKLES........*H. Anderson*, VE3AAZ

FUNDAMENTALS OF RADAR........*First Lieut. Robert L. Finkelstein*, W2KVY

TELEVISION PICK-UP TUBES........*B. W. Southwell*, W6OJW

420-450*MEGACYCLE TRANSCEIVER*........*J. D. Potter*, W3IKM

POST-WAR HAMFESTIVITIES

RADIO AMATEUR'S WORKSHEET, No. 6: FM DISCRIMINATORS

ELECTRONICS (November 1945)

REPORT ON WARTIME ELECTRONIC DEVELOPMENTS
What ELECTRONICS has published, and will publish, regarding military equipment.

THE LORAN SYSTEM — PART I
Description of the most important long-range navigation system to come out of the war

NON-METALLIC MINE DETECTOR
Complete circuit, construction details, and operating theory of detector set AN/PRS-1........*T. E. Stewart*

www.americanradiohistory.com

Electronics (November 1945) (Continued)

THE SCR-584 RADAR — PART I
Specifications, conical scanning theory, operating principles, and pulse transmitting system

PROXIMITY FUZE
Description of radio-operated detonator for projectiles

GROUND-CONTROLLED APPROACH FOR AIRCRAFT
Two radars and ground-to-plane radio bring pilots down safely in zero-zero weather.......*Captain C. W. Watson*

RADAR SPECIFICATIONS
Constants of radars declassified by Signal Corps are tabulated and explained

DIELECTRIC HEATING FUNDAMENTALS
Basic theory and application formulas for industrial heating by an electric field.......*Douglas Venable*

PLANE-TO-GROUND RADIO TELEMETERING
System utilizing radio link permits reading altimeter from ground.......*David W. Moore, Jr.*

CRYSTAL-PICKUP COMPENSATION CIRCUITS
Requirements and types of corrective-coupling circuits for crystal pickups.......*B. B. Bauer*

ELECTRONIC WATTMETER
Elimination of transformers used in earlier circuit extends frequency range.......*L. P. Malling*

INDUSTRIAL X-RAY TUBES
Survey of tubes and techniques used today in plants.......*Z. J. Atlee*

SENSITIVITY LIMITS IN RADIO MANUFACTURING
Procedure for finding economical control limits for receivers coming off production line.......*A. S. Blatterman*

WOOFER-TWEETER CROSSOVER NETWORK
Flat response within 2 db from 30 to 10,000 cps, with cross over at 400 cps.......*Paul W. Klipsch*

MANUFACTURE OF SILVERED MICA CAPACITORS
New production techniques conserve mica stocks and improve quality of finished units.......*Alan T. Chapman*

ARTIFICIAL ANTENNA
Network of fixed impedance simulates antenna over specified frequency ban.......*Sidney Wald*

PERMEABILITY TUNING
Survey of applications and analysis of design factors for a-m, f-m, and television sets.......*W. J. Polydoroff*

RESISTANCE MEASUREMENT AT HIGH IMPULSE VOLTAGES
A method of measuring the effective resistance of ignition noise suppressors.......*Scott L. Shive*

MULTIPLE MAGNETIC CIRCUITS
Small magnets in parallel give higher field strength than an equivalent single magnet.......*Joseph F. Manildi*

RESISTANCE-CAPACITANCE FILTER CHART
R and C are given in terms of amount of rejection desired at a given frequency.......*Ernest Frank*

SINGLE-SIDEBAND GENERATOR
Undesired sideband is balanced out without use of filters, for power-line carrier systems.......*M. A. Honnell*

WINDING UNIVERSAL COILS
Short-cut for obtaining required self-inductance, mutual inductance, and accurate center tap.......*A. W. Simon*

www.americanradiohistory.com

ELECTRONIC INDUSTRIES (November 1945)

SILICON CRYSTALS FOR UHF DETECTION CIRCUITS

Voltage and loading factors which govern operating efficiency of modern "diodes" functioning at high frequencies.........*E. C. Cornelius*

HIGH VACUUM PUMPING

Operating principles and mechanical construction of Eimac oil diffusion pump for exhausting tubes to extremely high vacuums.

RESEARCH ADVANCES RECEIVER DESIGN

Military experience in design and production will result in better components and circuits

RATIO DISCRIMINATOR IS INSENSITIVE TO AM

By minimizing total discriminator voltage fluctuations, output is made proportional to ratio of two voltages

PAYING THE ENGINEER WHAT HE IS WORTH

Incentive compensation plans based on achievements and performance. Sales and executive pay as yardstick

RADIO FREQUENCY CORES OF HIGH PERMEABILITY

New soft iron powder of fine grain size and high efficiency insulator result in values over 50 u.................*Dr. Hans Beller and G. O. Altmann*

PT MODULATION FOR MULTIPLE TRANSMISSION

Time of occurence of carrier pulses is advanced for positive and retarded for negative portions of the signal wave

CATHODE BIASED AMPLIFIERS

Analytical methods for determining the operating point when circuit constants and supply voltages are known.................*Paul H. Hunter*

NAVY'S ELECTRONIC ORGANIZATION

Intensified research in echo technics and expansion of relations with industry projected

VECTOR ANALYSIS

Review of vector mathematics including divergence and curl for engineers dealing with wave guides and radiation............*H. Gregory Shea*

SURFACE SEARCH RADAR

Technical details of SO type light-weight equipment developed for use in PT boats — immediate commercial possibilities

THRU THE LABORATORY KEYHOLE

MACHINE TOOL CONTROL

Form and thread milling machine made fully automatic in operation through addition of vacuum tube control unit............*Ray A. Stremel*

NAVY PROXIMITY FUSE

Design and construction of VT anti-aircraft and other Naval shells automatically exploded by self-contained radio unit

INDUSTRIAL TESTING WITH HIGH VOLTAGE

Special equipment developed for military inspection purposes, permits insulation resistance determination at potentials up to 200,000 dc

GROUND WAVE RANGE CALCULATOR FOR FM

TUBES ON THE JOB

www.americanradiohistory.com

FM AND TELEVISION (October 1945)

WHAT'S NEW THIS MONTH
1-band vs. 2-band FM sets

LISTENERS' TONAL-RANGE PREFERENCES.................................*Milton B. Sleeper*

LENSES FOR PROJECTION TELEVISION.................................*John B. Taylor*

FM STANDARDS OF ENGINEERING PRACTICE
Issued by the FCC Sept. 20, 1945

CHART OF FM BROADCAST CHANNELS
FCC assignments

SELECTIVE CALLING COMMUNICATIONS.................................*Gilbert G. Brown*

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

THE I.R.E. PHILOSOPHY.................................*Ludlow B. Hallman, Jr.*

LEWIS MASON CLEMENT — BOARD OF DIRECTORS — 1945

EXPLORATIONS IN ENGINEERING EDUCATION.................................*Arthur B. Bronwell*

RADAR IN THE U. S. ARMY — HISTORY AND EARLY DEVELOPMENT AT THE SIGNAL CORPS LABORATORIES, FORT MONMOUTH, NEW JERSEY.................................*Roger B. Colton*

FREQUENCY-MODULATED MAGNETIC-TAPE TRANSIENT RECORDER.................................*Harry B. Shaper*

GLOSSARY OF DISK-RECORDING TERMS.................................*Howard A. Chinn*

THE SERVO PROBLEM AS A TRANSMISSION PROBLEM....*Enoch B. Ferrell*

A VERY-HIGH-FREQUENCY AIRCRAFT ANTENNA FOR THE RECEPTION OF 109*-MEGACYCLE LOCALIZER SIGNALS*.................................*Bruce E. Montgomery*

A PROPOSED STANDARD DUMMY ANTENNA FOR TESTING AIRCRAFT-RADIO TRANSMITTERS.................................*Chandler Stewart, Jr.*

SOME CONSIDERATIONS CONCERNING THE INTERNAL IMPEDANCE OF THE CATHODE FOLLOWER.................................*Harold Goldberg*

NOTE ON THE FOURIER SERIES FOR SEVERAL PULSE FORMS.................................*William J. Lattin*

ANALYSIS OF CURRENT-STABILIZER CIRCUITS.................................*W. R. Hill, Jr.*

DYNAMICS OF ELECTRON BEAMS.................................*D. Gabor*

THE PLANE-WAVE RESOLUTION OF GUIDED WAVES.................................*S. S. Mackeown and John W. Miles*

NOTE ON THE MEASUREMENT OF TRANSFORMER-TURNS-RATIO.................................*P. M. Honnell*

DISCUSSION ON "THE THEORY OF TRANSMISSION LINES" BY EDWARD N. DINGLEY, Jr..................................*Fred J. Heath and Edward N. Dingley, Jr.*

www.americanradiohistory.com

RADIO (October 1945)

PARALLEL TUBE HIGH FIDELITY AMPLIFIER............*Frank C. Jones*

MICROWAVE TRANSMISSION POWER REQUREMENTS............*Jay E. Browder and V. J. Young*

GRAPHICAL DETERMINATION OF THE HORIZON............*W. H. Anderson*

AUDIO SECTION DESIGN DATA FOR BATTERY OPERATED RECEIVERS........*Engineering Dept., Sylvania Electric Products, Inc.*

CHART — LOSS DUE TO SERIES RESISTANCE INSERTED BETWEEN MATCHED SOURCE AND SINK

RECENT RADIO INVENTIONS —

Antenna; Automatic Control for Locked Oscillator; Voltage Regulator; Frequency-Measuring System; Instrument Landing Guide System; Wave Length Modulation; Modlator; Balanced Frequency Modulation System; Super-Regenerative Radio Receiver; Device for Maintaining a Fixed Bias

RADIO DESIGN WORKSHEET, No. 41: NOTES ON SUPER-REGENERATION; RADIO NETWORK PROBLEM

RADIO-CRAFT (November 1945)

"FROZEN" ELECTRICITY — THE ELECTRET............*Thomas A. Dickenson*

BETATRON — ATOM SMASHER............*O. Joe Olson*

RADAR — WEAPON FOR PEACE............*S. R. Winters*

FLUX VALVE AERO COMPASS............*Raymond Lewis*

RADAR INDICATORS............*Major Eugene E. Skinner*

THIS RADIO RUNS ON GAS............*Carl R. Lawrence*

LICENSING PROBLEMS AND THE SERVICEMAN............*H. W. Schendel*

BOAT RADIO INSTALLATIONS............*Henry B. O. Davis*

TUBE REPLACEMENTS, PART V............*I. Queen*

CAPACITOR-RESISTORS............*Ernst Gulkenheimer*

EXPLORER ALL-WAVE RADIO............*Bob White*

SMALL ELECTRONIC ORGAN............*Marion Black*

RESULTS OF PHONO NEEDLE TESTS

A TRUE TONE CONTROL............*George Bertsche*

AN FM PHONO PICKUP............*Nathaniel Rhita*

DYNAMIC HANDFUL SIGNAL TRACER............*Ralph Bloom*

VIBRATOR TESTER............*Harry L. Burcham*

ELECTRONIC VOLTMETER AND SIGNAL GENERATOR............*M. E. Blaisdell*

www.americanradiohistory.com

RADIO NEWS (November 1945)

HOW MANY PROSPECTIVE AMATEURS?	*By The Editor*
HOME CONSTRUCTED 112 *Mc. RECEIVER*	*Joseph Gavin,* W9YES *and* *Sol Heytow,* W9FAL
INTERNATIONAL SHORT-WAVE	*Kenneth R. Boord*
112 *Mc. CONVERTER*	*Ray Frank,* W9JU
A SIMPLE CO-AXIAL SWITCH	*Edward Burgess*
VACUUM TUBE ANALYZER	*Leo G. Sands*
ELECTRONIC VOLT-OHMMETER	*Howard H. Arnold*
SPOT RADIO NEWS	
RADIO JOBS FOR GI JOE	*Tony Wayne*
BUSINESS RECORDING EQUIPMENT	*Robert Stone*
RADAR	
PRACTICAL RADAR	*Jordan McQuay*
SAGA OF THE VACUUM TUBE	*Gerald F. J. Tyne*

RADIO NEWS—Radio-Electronic Engineering Edition (Nov. 1945)

A GEIGER-COUNTER X-RAY SPECTROMETER	*Stuart Reiner*
RADIO GLIDE PATH FOR AIRCRAFT	*Henry I. Metz*
MOVIES FOR TELEVISION	*Salvador Patremio*
WASHINGTON TO PHILADELPHIA RELAY NETWORK	*N. F. Smith*

SERVICE (October 1945)

COMMUNICATIONS RECEIVER'S BEAT FREQUENCY OSCILLATORS	*Thomas T. Donald*
CONNECTIONS FOR UNLABELED AMPLIFIER TERMINALS (Audiograph, Bogen, Erwood, Magnavox, Operadio, RCA, Stromberg-Carlson, Webster-Rauland)	
C-R OSCILLOGRAPHS (Applications — Servicing — Part IV)	*S. J. Murcek*
F-M TUNING INDICATORS	*J. George Stewart*
INPUT CIRCUITS, PART II	*L. E. Edwards*
OLD TIMER'S CORNER	
PHOTOELECTRIC CELLS	*Willard Moody*
POSTWAR RECEIVERS	
SER-CUITS	*Henry Howard*
SERVICING HELPS	
SUPERHETERODYNE MIXERS	*Martin W. Elliott*
VOLUME AND TONE CONTROL RESISTORS (Part 8 of a series on receiver components)	*Alfred A. Ghirardi*

www.americanradiohistory.com

TELEVISION (November 1945)

DEPARTMENT STORE AND TELEVISION..........*Mary Gannon*

TELEVISION OUTLOOK IN NEW YORK..........*Frederick A. Kugel*

STATION OPERATION

THE TBA PLAN..........*Will Baltin*

LONG SHOTS AND CLOSE UPS..........*H. G. Christensen*

ONE MAN'S REFLECTIONS..........*Dr. Alfred N. Goldsmith*

www.americanradiohistory.com

The Aristocratic "SEAFARER"

IN TOUCH . . .
and in CONTROL with
HUDSON AMERICAN
MARINE RADIO TELEPHONE

Aid in emergencies; swift integration of business and orders; weather, market and navigation information—ship to ship, ship to shore, shore to ship—all these reauire contact.

The swiftest contact is radio. The fullest contact is the spoken word. The most practical contact for coastwise and inland marine operation is radio-telephone. The finest radio-telephone is Hudson American.

For detailed information write to

HUDSON AMERICAN CORPORATION
Subsidiary of Reeves-Ely Laboratories, Inc.
25 WEST 43rd STREET, NEW YORK 18, N.Y.

www.americanradiohistory.com

AMER TRAN

"WS" AND "WSB" FILAMENT TRANSFORMERS

ELIMINATE EXPOSED SECONDARY LEADS!

Simplify your rectifier circuit by installing AmerTran "WS" or "WSB" filament transformers. These ingenious two-in-one units incorporate the tube socket in the transformer body and in the "WSB", the center tap is brought out through the ceramic base. Thus, they eliminate filament wiring and save copper, promote safety, reduce maintenance and cut costs.

Because of their inherent ruggedness, these transformers are being used in ratings formerly restricted to oil-immersed apparatus. Both AmerTran "WS" and "WSB" transformers are moisture-proofed and insulated well above the average. Their test voltage is two and a half times their rated d.c. operating voltage.

Primary taps are arranged to permit close control of secondary voltage. Other features include completely enclosed windings, compound filled and full electrostatic shields. Send for Bulletin No. 14-5.

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

AMERTRAN PRODUCTS

MODULATION TRANSFORMERS AUDIO FREQUENCY TRANSFORMERS
HERMETICALLY SEALED TRANSFORMERS
TRANSTAT A.C. VOLTAGE REGULATORS
HIGH VOLTAGE RECTIFIERS WAVE FILTERS
OTHER ELECTRONIC AND INDUSTRIAL TRANSFORMERS

AMERTRAN

MANUFACTURING SINCE 1901 AT NEWARK, N. J.

Pioneer Manufacturers of Transformers, Reactors and Rectifiers for Electronics and Power Transmission

www.americanradiohistory.com