The
RADIO ENGINEERS'
DIGEST

JUNE 1945 VOL. 1., NO. 11

CONTENTS

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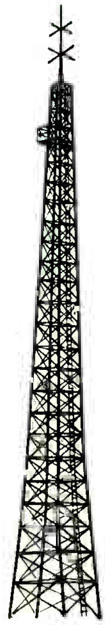

THE RADIO ENGINEERS' DIGEST

JOHN F. C. MOORE, *Editor*

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OPERATIONAL ELEMENTS OF A RADAR SYSTEM

Reprinted from Electronic Industries

By William E. Moulic
Associate Editor, Electronic Industries

The scope of applications and basic circuit elements required in Radar transmitter, receiver and antenna array

RADAR is an application of basic radio principles to the many problems of determining distance between the radar equipment and an object which will reflect radio frequency energy. These same principles employed by radar have been applied to ionosphere height measurements for many years.[1] The ability of radar to determine distance and direction makes it most suitable for detecting the presence of foreign objects, for example, aircraft, ships, mountains, etc. The fundamental principles involved are the constant known speed of radio wave propagation and the reflection or echo principle so pronounced and characteristic of the ultra-high frequencies (100 mc and up).

The practical usefulness of a radar system is obvious when the ever-present problems of navigation, collision prevention, enemy aircraft detection, etc., are considered. In the example of aircraft location, information is required at greater ranges and "early warning" radar is necessary. This system gives the range and approximate azimuth, then accurate reporting radar systems permit the location of the target in three dimensions. The available data secured from the radar systems may be used to direct fighter aircraft.

Radar systems can be applied to the control of gun fire and on board aircraft for locating surface ships. Airborne radar may also be used by fighter aircraft to locate enemy aircraft when visibility is poor. A simple basic radar system does not include the ability to differentiate between friend and foe. Auxiliary equipment may be synchronized with the radar apparatus to block the gunfire from friendly craft.

The usefulness of radar as a navigational aid in the prevention of collisions, and determination of absolute altitude, is very great. Allied superiority in this phase of warfare is perhaps a major factor in the winning of the war.

RADAR METHODS

Various possibilities of combining radio principles to produce a distant-object detecting system have presented themselves to inventors and engineers. Numerous systems have appeared in both American and foreign patents.[2]

One method of detecting a target by radar makes use of the Doppler effect. When rf energy, transmitted continuously, strikes an object, moving toward or away from the source of energy, part of the energy is reflected and its apparent frequency is changed. This change in frequency (the well-known Doppler effect) is familiar in the case of a train whistle changing its apparent pitch as it moves toward, then away from an observer. In the radar application, the equipment measures the difference in frequency between the transmitted and reflected waves in order to determine the speed of the moving object. This method is best applied to fast moving targets because of the small shift in frequency.

In a system which has been long used for ionosphere measurements, radio frequency energy from the transmitter is pulse modulated for short intervals from 1 to 50 μsec. The pulse ends before the reflected energy returns from the reflecting surface to the receiver, and an indicator is employed to determine the time between the initial and the reflected pulses. The output of the receiver is applied to the indicator, usually of the cathode ray variety. When all reflections have returned, the transmitter can again be pulsed and the process repeated. The pulse modulation method is the most common in current usage.

The primary advantage of radar is the result of the ability to convert a measured time interval into terms of distance. This is due, of course, to the fact that radio frequency energy radiated into space continues to travel at a constant and known velocity. Upon striking an object, there is no loss of time but merely

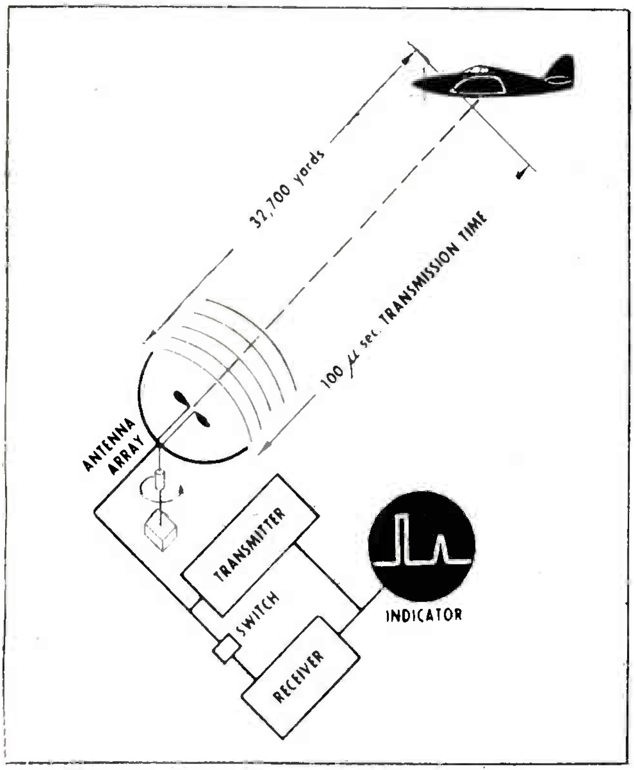


Fig. 1 The elements of ranging and direction finding by radio frequency energy echos. Familiar directional antennas give direction of transmission path to object while elapsed time between initial pulse and echo gives range.

a reradiation of part of the energy. The velocity or rate of propagation is considered to be that of light, which travels 327 yds. per microsecond. For example, in Fig. 1, if a 1 μsec. pulse from the transmitter travels toward an object 32,700 yds. away the time required for the pulse to make the trip one way is 100 μsec. The reflection will require an equal amount of time to return and the total will be 200 μsec. Since the radar indicator gives the total elapsed time it is common to figure distances (radar antenna to object) as 164 yds per microsecond of indicated time between initial and reflected pulses.

Since the fundamental quantity involved is time, the precise measurement of that quantity is essential to the accuracy of a radar system. The cathode ray oscillograph is well suited to the task, since it retains the information on its screen and also provides a time axis or scale.

Assume in the illustration Fig. 2, that the linear sweep of the cathode ray tube is 1 cm per 100 μsec. The initial and any reflected signals which might be received are applied through suitable circuits to the vertical deflection plates of the tube, thus any signal, either initial or reflected, will appear as a vertical "spike" on the CR tube screen.

Consider as an example, that a 1 μsec. duration pulse is transmitted. This pulse will appear on the screen of the receiving CR tube. This pulse will be 0.01

cm wide and during this time the rf energy will have traveled 327 yds. from the transmitter. If the target is 32,700 yds. away the pulse will arrive at the target in the time that the cathode ray spot moves 1 cm and the spot will move an additional centimeter in the same direction during the time the reflected energy returns to the receiver. The reflected pulse will appear on the screen 2 cm from the initial pulse, thus corresponding to 200 μsec.

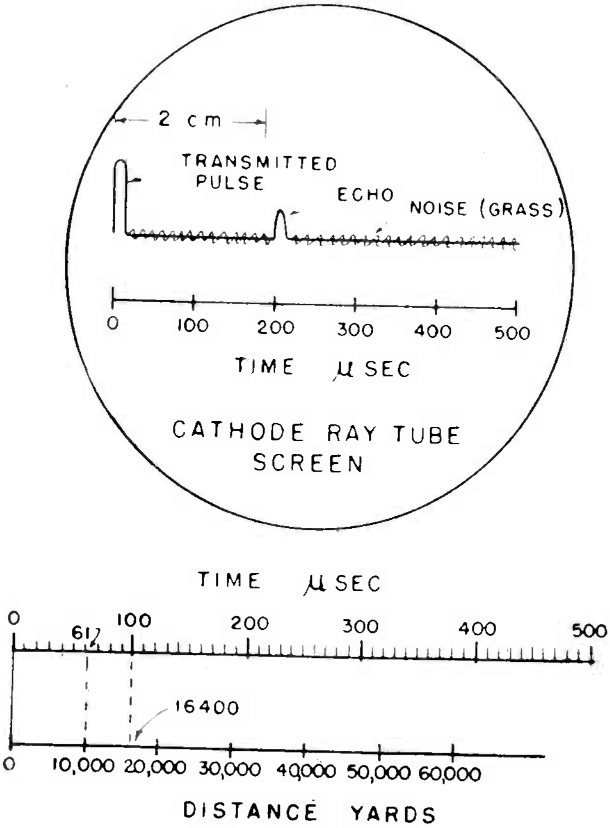


Fig. 2 A possible indicator trace where horizontal position of cathode ray is proportional to time. Initial and echo pulses appear as vertical deflections of beam. Elapsed time-distance scale is based on speed of RF propagation.

A suitable indicating scale for determining the time interval precisely can be calibrated in yards or other units. Provision is made to synchronize the cathode ray sweep with the initial pulse of the transmitter in such a manner as to superimpose successive initial and reflected waves in order to give a continuous pattern for observation. If more than one object is present at different distances, an echo pulse will appear on the screen for each of the units that can be resolved by the beam angle of the directive reception antenna equipment. A corresponding time-distance scale is also shown in Fig. 2.

DETERMINATION OF AZIMUTH

The line of radiation to an object as given by the radar system is usually presented as an angle which may be measured from true north or any other reference. The azimuth and elevation angles of the echo signal are measured by utilizing directional characteristics of ultra high frequency antenna systems.

The simplest form of azimuth determination involves the use of an antenna system which produces a single lobe radiation pattern as shown in Fig. 3. The antenna system is mounted so that it may be rotated and energy is directed across the region to be searched until a return signal is picked up. The position of the antenna is then adjusted to give maximum return signal at which position the desired direction may be determined. The azimuth sensitivity of the single lobe system depends upon the angular width of the reception pattern. If the lobe is sharp so that the signal strength changes rapidly with another angular position, accuracy is great.

An overlapped double lobe antenna pattern could be used where greater accuracy is required. The principle of the double lobe system is indicated in Fig. 4. Two lobes from the antenna system are displaced so as to overlap at one point. At this point equal signals would be produced by the two antennas for this particular azimuth. At all other positions of the array unequal signals would be received by the two antennas involved, and by selective switching or dual reception equipment the bearing of the array could be adjusted until equal signals were picked up by the two antennas.

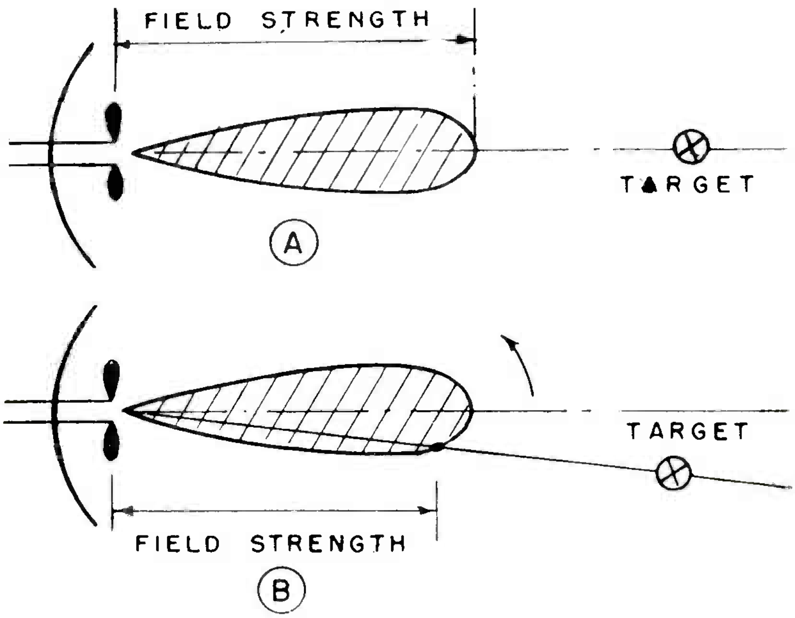


Fig. 3 Direction finding principles of single lobe antennas where amplitude of output voltage is a function of angular position. Direction to object is indicated when output of receiver is maximum. Antennas shown are symbolic and may be any of well known arrays.

The elevation of an object can be determined by the slant range and the angle of elevation of the reflected wave. A tilted antenna array can be used and the angle adjusted for maximum signal. The combination of this information with the slant range provides for the calculation of the elevation through right triangle computation. This is shown in Fig. 5. The double lobe pattern system could also be used for greater accuracy in elevation angle measurements.

FUNDAMENTAL SYSTEM ELEMENTS

Radar equipment varies greatly in detail depending largely upon the degree of accuracy involved. Principles of operation, however, are substantially the same. In general the degree of accuracy increases with the rf frequency since the microwave region lends itself to greater precision in angular measurements because of the more directional antenna arrays which can be built in a given space.

The functional parts of a pulse modulated radar system resolve themselves into six essential elements. These are shown in the block diagram Fig. 6.

(1) The timer, also known as the synchronizer, supplies the synchronizing pulses to the transmitter and the indicator.

(2) The transmitter, which generates the rf energy in the form of short, high peak power pulses under the control of the timer.

(3) The antenna system, which radiates the rf energy in a directional beam and which receives any returning energy reflected from some given object.

(4) The receiver, which detects the rf echoes and reproduces them as pulses to be applied to the indicator.

(5) The indicator, which produces a visual pattern of the initial and echo pulses in such a manner as to deliver the desired information, such as time lapse for range, angular bearing, etc.

(6) A power supply.

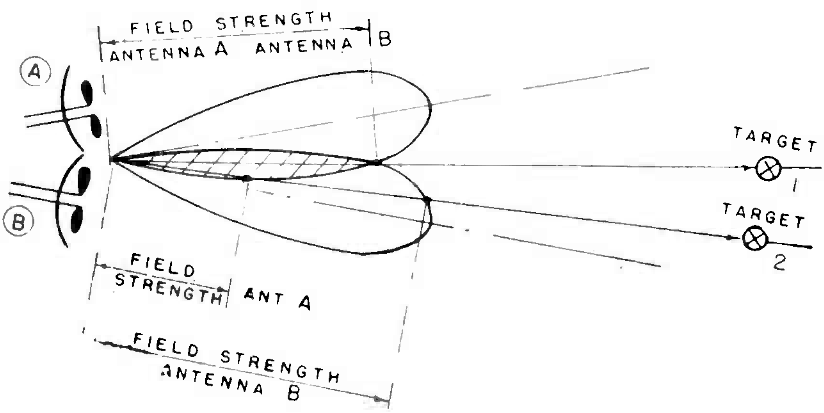


Fig. 4 Lapped antenna reception patterns may be employed for more accurate direction determination as is common in aircraft landing systems. Output of two antenna systems is equal for only one direction (target 1). Other directions give unequal outputs.

There are several methods for generating the timing or synchronizing signals. The pulse repetition frequency can be determined by a stable oscillator such as a resistance tuned audio oscillator, multi-vibrator or similar type. The output of this oscillator can be applied to wave shaping circuits to produce the required timing pulses. Fig. 7 shows a typical circuit which can be used as a pulse generator.

Through the application of familiar grid-blocking phenomena, the transmitter with its associated circuits may establish its own pulse width and pulse repetition frequency and also provide the synchronizing pulse for the other parts of the system. This action may be accomplished in the rf oscillator with properly chosen circuit components. This second method eliminates a separate timing circuit; however, the control of pulse width and repetition rate is less accurate.

The carrier frequency selected for radar purposes is a compromise between the directional advantages of very high frequencies and the difficulties encountered in producing and amplifying these frequencies. The lowest carrier frequency is normally governed by consideration of practical size for the directional antenna array. Frequencies from 100 mc to several thousand are in general use.

PULSE RATES

The repetition rate of the pulses should be such that sufficient time is allowed for an echo to return from any target within the maximum workable range of the installation, otherwise the reception of pulses from distant targets would be obscured by a repeating initial pulse. In searching, the antenna system is rotated at a constant speed, and the beam energy strikes the target for a relatively short time. During this time a sufficient number of pulses should strike the target and be returned to produce a lasting indication on the oscillograph screen. Therefore, the persistence of the screen and the rotational speed of the antenna ordinarily determine the lowest repetition rate for the pulses.

In a system in which the entire interval between transmitted pulses is used in the indicator the repetition frequency must be very stable if accurate range measurement is desired.

The shortest range at which an object can be located is determined largely by the time duration of the initial pulse. If the target is so close to the transmitter that the echo is returned before the initial pulse is turned off, the reception of the echo will be masked by a following pulse from the transmitter.

The radar transmitter is rated in terms of peak power. Since the transmitter is "off" for a time relatively long in comparison to the pulse duration, the average power is very low. With other factors remaining constant, the greater the pulse width the higher the average power, and the longer the pulse repetition time the lower the average power. Thus:

$$\frac{\text{Av power}}{\text{peak power}} = \frac{\text{pulse duration time}}{\text{pulse repetition time}}$$

The ratio of pulse time to repetition time is called the duty cycle. For example a 1 μsec. pulse repeated 1,000 times per second has a duty cycle of 10^{-3}. The ratio of the average power to the peak power is likewise equal to the duty cycle. Thus for an average power of 100 watts a peak power of 100kw would be obtained with a duty cycle of 10^{-3}. High peak power is desirable to produce a strong echo over the maximum range of the equipment. The low average power enables the transmitter tubes and associated components to be made smaller which is in keeping with the current state of the UHF art. The relationships in a rectangular pulse are shown in Fig. 8.

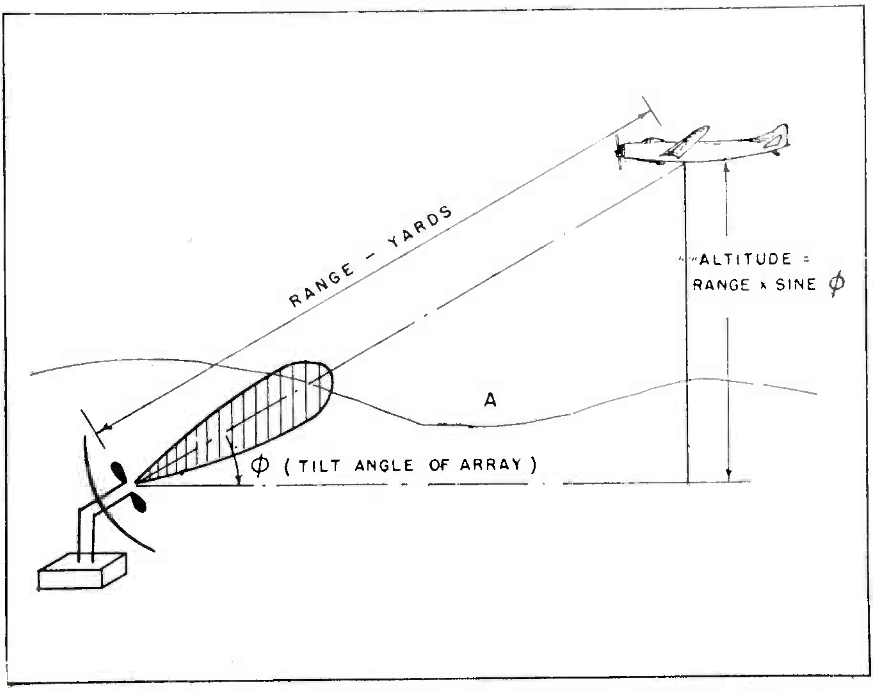


Fig. 5 Simple altitude determinations are possible by measuring range of object and vertical angle of maximum echo strength. Altitude is then a right triangle relationship.

ANTENNA SYSTEMS

The simplest radar antenna system would contain two separate arrays, one for transmitting and one for receiving. The receiving antenna would be shielded from the transmitter to protect the receiver from the powerful pulses. In general the directivity pattern is sufficiently sharp to permit close operation.

A more practical system involves a single antenna and an antenna switch capable of transferring the array from transmitter to receiver and back again at the pulse repetition frequency. Such a switching arrangement has long been common, particularly among the amateurs. Since the pulse repetition rate may be any value from 60 to 5,000 cycles, however, a mechanical switch is out of the question. Such a switch must be an electronic type, and it may take the form of an rf amplifier, resonant transformer, etc.

When a radar receiver is operated in close proximity to the radar transmitter a certain amount of signal inevitably gets in the receiver through stray

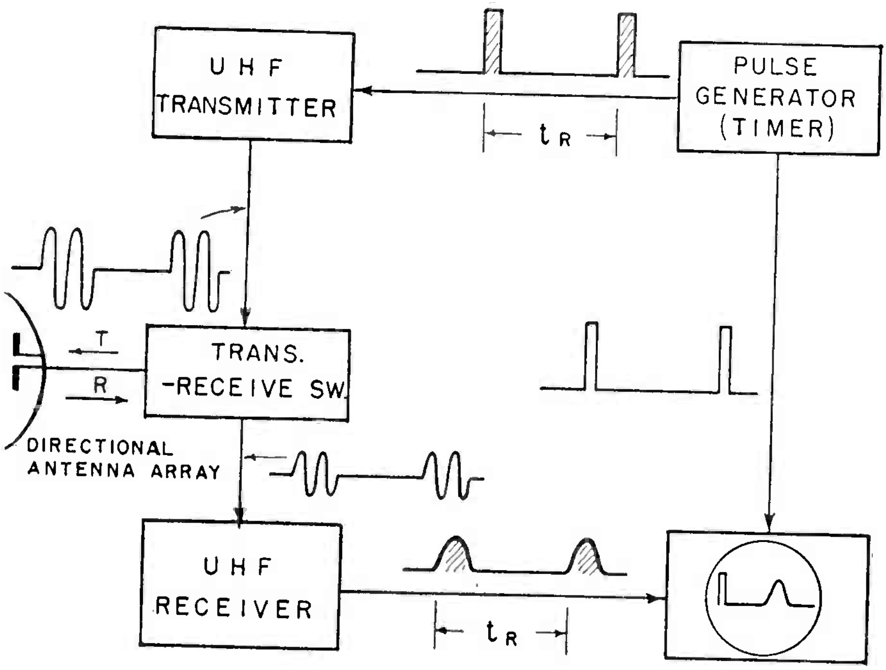


Fig. 6 Electronic components for a possible radar system showing approximate wave shapes at various points in the circuit. Time t_R is interval between pulses. Pulse generator connection to oscillograph is for sweep timing.

fields. In such instances these stray signals resulting from the main transmitted pulse must be eliminated from the output of the receiver. This is accomplished by turning off or "gating" the receiver. It is usually necessary to couple a small amount of transmitted rf energy into the receiver for timing purposes. It is important to prevent damage to the receiver as a result of the powerful pulse and likewise to prevent blocking of the receiving tubes during transmission.

A common form of transmit-receive switch embodies some of the principles of the old gas-filled antenna switch for lightning protection. The general arrangement is shown in Fig. 9. The device consists of a pair of coupled resonant circuits (in the form of cavities) shunted by a discharge gap. The cavities are sealed and gas filled. An electrode system across the narrow cavity coupling gap is charged and used to keep the gas at a near ionization state. When the transmitter is pulsed, the rf voltage surge fed to the input cavity ionizes the gas and thus forms a virtual short across the circuit. In the equivalent circuit at the right in Fig. 9, it is seen that any discharge across the gap will prevent energy from being transferred to the output cavity and consequently damaging the receiver.

Some antenna arrays suitable for radar use are stacked dipoles with an untuned reflector; a radiator with tuned reflectors; and the dipole with parabolic reflector. In the case of the parabolic reflector very narrow rf beams can be pro-

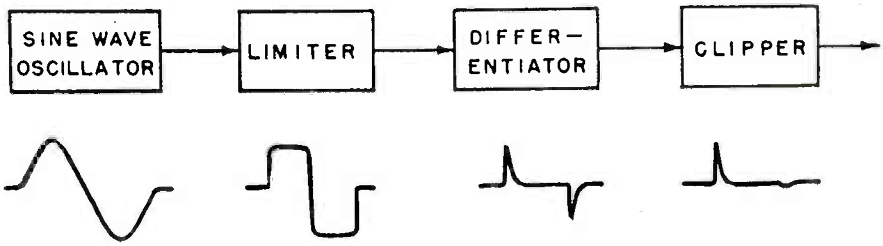


Fig. 7. Common form of pulse generator using wave shaping circuits and differentiator to produce short duration steep front pulses.

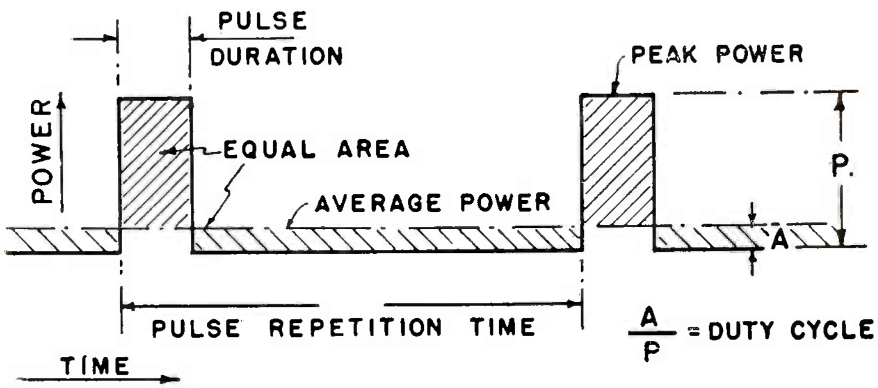


Fig. 8.. Theoretical relations in a rectangular pulse of power. High peak power is possible from tubes and circuits having low average power requirements.

duced where the diameter of the reflector is large in comparison to the wavelength. In the microwave region where wave guides are practical, the antenna may take the form of horns, or other inpedance matching wave launcher.

RADAR RECEIVERS

Since radar frequencies are high it is difficult to obtain sufficient amplification. The superheterodyne principle may be used and components of high stability and sensitivity are required. A block diagram of such a receiver is shown in Fig. 10. In general the power rf signal is fed directly to the mixer tube. The mixer and local oscillator are located close to the T junction of the transmission line in order that the received rf energy may be converted to a lower frequency before being passed on to the remaining elements of the receiver. Such a receiver is typical of UHF practice. The mixer is a non-linear element such as a diode, or mineral crystal. The frequency conversion elements must be located close to the transmission lines to minimize rf losses. Multiple frequency conversion is essential to high gain if amplifiers.

The output of a conventional second detector is fed into a wide band amplifier typical in many respects to the video amplifier in television receivers. The output of this amplifier is connected to the cathode ray indicator system.

The presentation of time intervals through the use of a cathode ray tube is fundamental. The sweeping of a cathode ray beam at uniform and accurately known velocity is standard practice, particularly in the case of television.

In radar, the simplest form of indicator is a cathode ray tube, horizontal sweep generator and provision for synchronization of the sweep. The output of the wide band amplifier in the receiver is connected to the vertical deflection system of the CR tube. The initial and echo pulse are then delineated and appear as in Fig. 2. Locally generated precise-timed pulses can be superimposed on

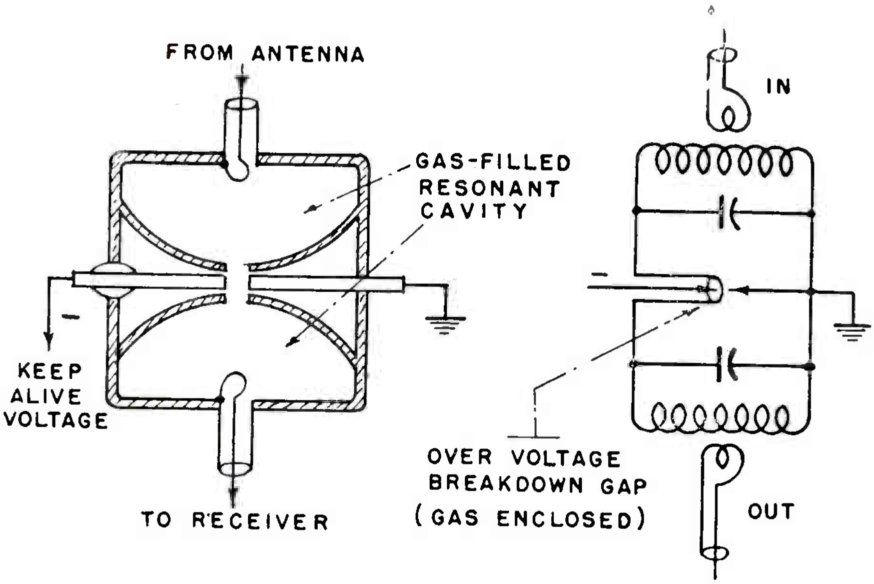


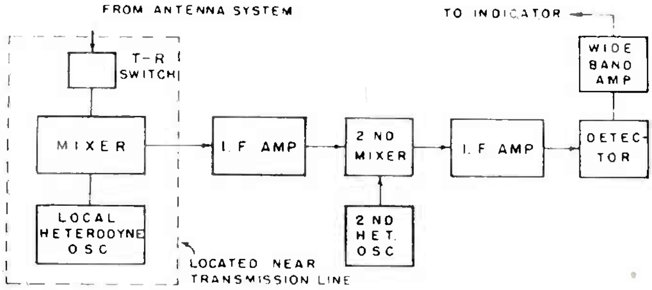
Fig. 9. Possible protective switch for receiver consisting of gas-filled resonant cavities which are short-circuited when transmitter pulse ionizes gas. Principle is similar to neon filled lightning arrestors.

the screen for accurate determination of the echo delay interval, (and thus the range).

Another possible indication system to combine range and azimuth or range and elevation could employ the raster pattern of television. For example, the CR spot motion in one direction can be used to indicate range as just described. The spot deflection at right angles can be synchronized with the angular movement of the antenna beam. Any echo pulse from the receiver is then used to modulate the grid of the CR tube and thereby produce a bright spot at the range and azimuth position where the reflecting object is located. An example of this system is shown in Fig. 11. A similar raster coordinate system with target spots controlled by grid impulses has been used for television studies.[3]

A block diagram of the essentials of a radar indicator system is given in Fig. 12. In many respects it is identical to the horizontal synchronization and deflection circuits of a television receiver. The indicator gate is a rectangular pulse

Fig. 10. Block diagram of a suitable UHF Superhet for reception of radar echo pulses. High carrier frequencies usually require double frequency conversion as illustrated,



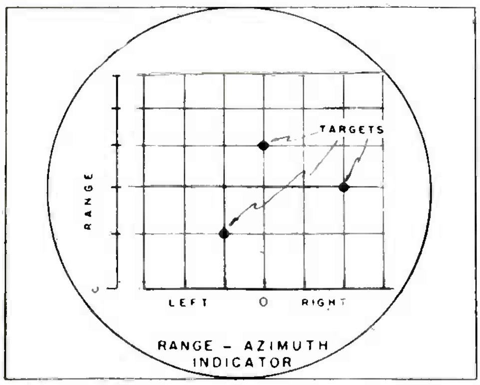


Fig. 11 Television scanning raster could be employed to combine two elements of target position even as it is for picture element location. Grid modulation of CR tube by signal produces bright spots on co-ordinate system of desired factors.

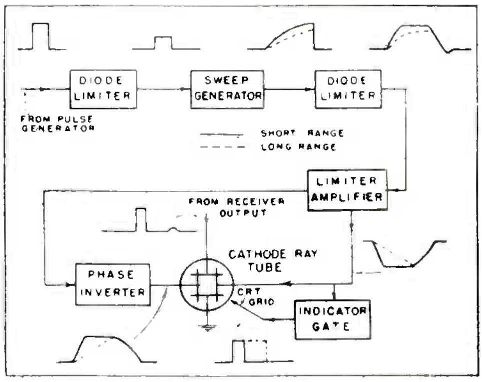


Fig. 12, Circuit elements of a pulse indicator with typical wave shapes at several points. Note the similarity to television sweep and synchronizing circuits. Two-range sweep wave shapes are shown. Sweep is triggered by timer pulse.

applied to the CR tube grid when the forward sweep is made. The spot is biased to cut-off at all other times. Horizontal and vertical blanking signals do a similar job in television.

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Revista Telegrafica, Enero, 1944.
Observaciones de la Ionosfera en la Plata—Malverez—p. 19.

2 Einrichtung zur Bestimmung des Abstandes reflektierender Flächen, insbesondere zur Bestimmung der Flughoehe von Luftafahrzeugen. DRP 726461. Filed Sept. 24, 1938, issued Oct. 14, 1942 (Siemens & Halske.) Patzold & Ernst.

3 A Method and Equipment for Checking Television Scanning Linearity.
V. J. Duke—RCA Review, Oct. 1941, p. 190.

RELAYING BY RADIO

Reprinted from Radio Age

By C. W. Hansell
RCA Laboratories, Rocky Point, L. I.

Towers Spaced Across the Nation Will Act as Repeater Stations to Carry Television and Other Services—First Tests Begun in 1923

SLENDER towers standing like lighthouses on the peaks of high hills and stretching in parade-file over flatlands hold promise today of becoming the means by which television programs will be made available to the entire nation. Using this medium, television signals comprising the sound-and-sight entertainment of the future will be "bounced" by radio from one tower to another, leaping gaps of 20 to 50 miles at each jump. Now that research scientists and engineers have brought television to a point where it is ready to create a new American industry, the planning and erection of these repeater stations is the next logical step.

For the past twenty years, the Radio Corporation of America has conducted experiments in radio relaying. Beginning with a radio carrier frequency of 182 kilocycles, research and development have gradually increased the utilized frequency to 500 megacycles. At the same time modulation bands have increased in width from 2000 cycles to four megacycles.

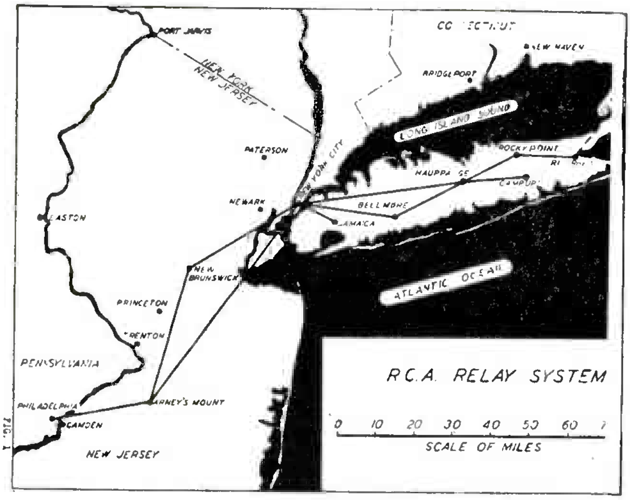
In 1923, RCA began the development of a radio relay station at Belfast, Maine. Its purpose was to intercept longwave transoceanic telegraph signals at a location where directional reception would reduce interference from lightning storms and to relay intercepted signals on another frequency to the RCA receiving station at Riverhead, Long Island. A year later, a second relay transmitter was completed at Belfast to operate on frequencies around 3 megacycles. This transmitter is believed to be the second one in the world equipped for quartz crystal frequency control, and the first to be put to practical use. By means of this unit the first broadcast programs were brought from London to New York for rebroadcast purposes. For RCA, it marked the beginning of shortwave equipment development and propagation tests which contributed to the present world-wide networks for international radio communication.

FOUR FIRMS COOPERATE

Soon thereafter, an experimental station was installed in the Empire State Building in New York City. It was at this stage of progress that the ultimate necessity for a television network, with which to carry programs from city to city, became apparent. Consequently, RCA and NBC, in cooperation with the General Electric Company and Westinghouse, undertook in 1932 the development of a relay station to carry experimental television from New York to Camden, New Jersey. A site on Arney Mount near Mt. Holly, New Jersey, was selected for the repeater and its 165 foot tower.

Although the apparatus was demonstrated successfully in 1933, using images with a fineness of 120 lines, tests soon convinced engineers that the relaying of television transmissions would have to be done at far higher frequencies than could be utilized at that time due to the lack of suitable vacuum tubes.

However, by the end of 1939, enough progress had been made in the development of new vacuum tubes for use at very high frequencies, and in the correlated development of radio repeaters and relay stations, to permit the establishment on Long Island of several radio relay stations operating in the vicinity of 450-500 megacycles. This relay system, which repeatedly "hopped" signals from the Empire State Building to a receiver in the RCA Laboratory at Riverhead, accommodated the full band-width permitted by television standards then in force.



Extensive radio relays operating between New York, Eastern Long Island and Camden, N. J., in 1939, laid the groundwork for nation-wide relays now in prospect.

Later the addition of a third repeater station at Bellmore, Long Island, made it possible to relay signals from New York to Riverhead and back to Radio City.

A striking characteristic of properly designed radio relay systems, operating on frequencies above 500 megacycles, is that they require much less amplification in a given distance than concentric cable systems, when both are required to meet the present and future television modulation band-width requirements.

As television broadcasting moves to the higher frequency portions of the spectrum and as it becomes possible to include color, it is natural that the band-width required for transmission will be increased. For this reason it seems probable that radio relaying will receive greater recognition as the most promising means, technically and economically, for the distribution of television programs.

In establishing a radio relay system, a major portion of the cost is represented by sites and towers. It is a fortunate circumstance that no development foreseen at present will destroy the value of these investments. Moreover, it is anticipated that future developments will make it possible to utilize higher radio frequencies thus providing more perfect reproduction of modulations without requiring substantial alterations in sites and towers.

Before the war the development of vacuum tubes and repeaters had been carried far enough to make it practical to utilize frequencies for television relaying in the range of about 300 to 1000 megacycles. It is anticipated that as soon as restraints due to the war are removed, the frequency range will be extended upward until eventually, frequencies of 3000 megacycles or more may be used.

SOME APPLICATIONS

Since the only justification for investing large sums of money in radio relay systems, and for getting involved in the toils of technical development, business promotion and government regulation, is the usefulness of the systems, it is appropriate to consider some of the applications.

Radio relays have so many outstanding technical and economic advantages for television distribution that eventually they should be regarded as essential for this service. However, the costs of adequate radio relay systems are substantial and, unless the outlay for relay station sites, towers and facilities can be spread over a number of channels and services, the financial burden may delay the initial spread of television service.

In holding unit costs down, it is essential that the relay stations be designed and equipped to provide several television channels, all utilizing the same towers. It is also essential that investment and operating expenses be shared with as many secondary services as possible.

In general, relay stations will occupy the highest points of land or buildings and provide the highest towers in each community. They are therefore the natural choice for location of radio broadcasting stations. By combining relaying and broadcasting, where this is possible, both can benefit.

HIGH TOWERS ARE ATTRACTIONS

High towers are natural gathering places for pleasure seekers and the curious. In many cases observation platforms, television theatres, restaurants and other entertainment facilities might be installed at the top of the relay towers to give a greater public service and to help in paying the costs.

One of the most natural secondary services, from a technical standpoint, will be that of facsimile communication, the transmission of any sort of picture or message which is to be recorded at the receiving end as a copy of the original. An adequate television radio relay circuit has a potential speed of transmission of 108,000 pages per hour.

There are as many uses for facsimile service as there are for existing telegraph and mail services. It is a means for giving the services with far greater speed and less effort. Soon, for example, facsimile could provide nationwide newspaper delivery faster than papers can now be printed.

There is another probably important use for future radio relay systems which is closely related to the struggle just beginning to obtain the use of frequencies above 30 megacycles. It is that of providing radio services to airplanes.

As airplanes increase in number, the demands for aviation radio service will increase to such a degree that it will be unreasonable to expect that radio frequencies and facilities can be provided so that all airplanes flying over land may communicate by radio over long distances. Furthermore, as the speed and efficiency of airplanes have increased, it has become more unreasonable to equip planes with either large protruding antennas, or powerful equipment, both of which are needed to operate on the frequencies required to reach great distances.

LOOKING TO THE FUTURE

Looking ahead it seems inevitable that much of the communication with aircraft must be limited to short distances and carried out on higher frequencies with more compact equipment and without protruding antennas. This will require a large number of ground stations, spread out along the air routes, and because these same routes will be followed generally by the radio relay systems, radio relay stations are natural sites for airline radio ground stations.

Railroads, long distance bus and truck lines and portions of the traveling public have communication needs similar in character to those of the airlines. Radio relay systems might very well contribute to the fulfillment of these needs.

To make radio relaying a great new American industry requires a more general understanding of its value; a well-defined and stable licensing policy; a relaxation of restraints which not only dampen the hope of expansion and profit but discourage joint action by those in need of relay service, and a few promoters who have caught the vision.

MEASURING RESISTANCE OF HOT FILAMENTS

Reprinted from Radio

By A. K. McLaren

A simple bridge for measurements where resistance changes with temperature

A METHOD of measuring the resistance of hot filaments or other elements where the resistance changes with temperature may be valuable in cases where these elements are used in circuits requiring close voltage tolerances. Accurate measurements may be made with a small amount of equipment and little trouble if some precautions are observed in making adjustments and taking readings. A 10,000 ohm potentiometer, an a-c volt-ohm meter, a small transformer and some resistors are all that is necessary to make the measurements. A bridge circuit is used and the range is from one or two ohms up to several thousand.

The bridge is set up as in Fig. 1, and the 10,000-ohm potentiometer may be mounted on any insulated panel. Some care must be used when employing the

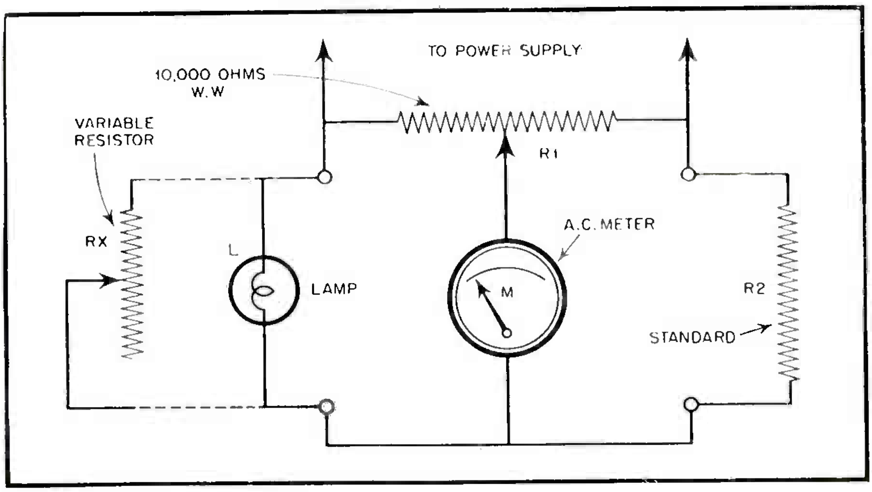


Fig. 1. This resistance bridge is simple in design and covers a wide range

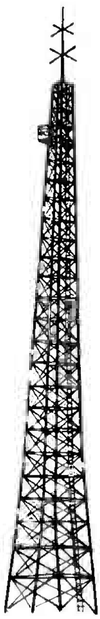
higher voltages, to prevent shock or damage due to short circuits. The power supply may be a transformer or, for the higher wattage lamps, the power may be taken directly from the 110-volt mains. A small transformer for the smaller lamps and for use when rebalancing the bridge is also required. The wattage rating of R2 must be such that it will not be overloaded for the various lamps and the watts consumed by this resistor will be about one-tenth that of the lamp being measured.

It will be seen that the lamp is connected in one side of the bridge and is lighted by the current passing through the bridge. The power is turned on and the bridge is balanced by adjusting R1 until the voltmeter reading is a minimum. It is best to use the higher voltmeter ranges until the minimum point is found and then switch to the lower ranges for most accurate adjustments. After R1 is adjusted to the minimum point it is left as it is and the power disconnected if using the higher voltages. A variable resistor is substituted for the lamp and the bridge connected to the small transformer (about 10 volts). The resistor *Rx* is then adjusted until the bridge is again balanced. Resistor *Rx* is left at this setting, disconnected from the bridge and its resistance is then measured on the ohmmeter. The resistance indicated by this reading will be equal to the resistance of the lamp.

RANGE

The range of the bridge with any standard used will be about 100 to 1: that is, with a standard of 10 ohms for R2, the range will be from 1 ohm to 100 ohms. With a resistance at R2 of 10 ohms, lamps with resistances of 1 ohms to 100 ohms may be measured. With lamps of lower current a resistance of 100 ohms at R2 will give a range up to 1,000 ohms and down to 10 ohms. However, the lower the resistance of R2, the more accurate the resistance measurements will be, due to less voltage drop in R2, and therefore less heating.

If the resistance of lamps at full voltage is required, the voltage should be measured across the lamp while in the bridge. The voltage across the bridge will have to be raised to overcome the voltage drop in R2. In measuring low voltage lamps the small transformer may be used as power supply in both balancing operations. Measurements may be made for any brilliancy of the lamp by varying the voltage input to the bridge. Several readings at different voltages may be taken and a curve drawn on cross-section paper for later reference.



Research is the department of a business which gives to the management the substance on which it grows.

HARRY P. KENDALL

PRACTICAL ELECTRONIC INDUSTRIAL CONTROLS

Reprinted from Electronics

By Paul G. Weiller
New York, N. Y.

Men who manage plants considering the inclusion of tubes in post-war products will be interested in this text telling what tubes can and can not do. Producers of packaged controls will also find it informative and some suggestions should prove helpful to engineers previously concerned with communications equipment design.

THE QUESTION, "Shall we go in for electronic control?" currently concerns many manufacturers in many fields. This article is dedicated to those men in management who have to decide. It also may serve as a reminder, to engineers who have devoted their efforts mostly to radio, of the vast difference between communications devices and those adapted to industrial control work.

It is obviously advisable for manufacturers contemplating new products to consider the application of electronic controls to their particular line. The incorporation of such controls into any piece of equipment may have important economic consequences for the maker. It may improve performance and create a new demand for an existing product. On the other hand, it may cause serious losses if it is not acceptable to the user.

ABOUT THE AUTHOR

DR. WEILLER, a widely-known consultant specializing in electronic equipment design, has had many years of experience both in the laboratory and in the field.

THAT a man whose commercial destiny is so inextricably bound up with the future of electronics should be at once optimistic about the use of tubes in industry and perturbed about possible misapplications will be understandable to many readers, as it is to the Editors.

THE PLACE OF ELECTRONICS

Let us put this newest of arts in the proper perspective with reference to other, older means of getting things done.

Industrial electronic devices are intermediate links which take power at their input terminals in one form and deliver it to the output terminals in another form. The electronic device itself can amplify, rectify, switch, time and perform other such functions but it almost invariably remains just a part of some non-electronic processing equipment. The input may be the power line or it may be a weak signal from a sensing element such as a thermocouple, pressure gage, or what have you. At the output end there is in almost all cases either a relay or a motor which actually performs the desired work. This fact precludes many of the ambitious dreams of new electronic marvels. If those responsible for final decisions on new products will keep it in mind, many disappointments will be avoided.

To make this abundantly clear, let us consider a web printing machine. Web printing machines are designed to print and cut labels in large quantities for toothpaste and similar mass-production packages. Phototube devices are often employed to make sure the machine cuts the labels at the proper place. The phototube has immensely increased the accuracy of such machines but would have been of little value had not machines been redesigned to print and cut labels faster and faster. In this case the usefulness of the phototube was contingent upon the ability of engineers to make the mechanical parts of the machine operate successfully at higher and higher speeds.

The case is typical. It is not enough to design a properly functioning electronic link for a product. It is also necessary to improve the overall performance of the device in order to achieve maximum utilization of the capabilities of the electronic link. Unless this overall improvement is possible, electronics is probably out of place.

SOME OF THE PITFALLS

Pitfalls await the novice electronic control designer. In fact, he is liable to make his first mistake right in the choice of the function of the electronic link.

There are other pitfalls in the design details. To turn out an electronic controller or an electronic instrument is an engineering job of the first order. It takes time and money and sometimes the patience of Job, and when it is all done field tests must be undertaken. These tests may show that devices which perform in a perfectly satisfactory manner during the most grueling laboratory tests will still fail in some respects in the field. They must often be radically changed before they can be put on the market with full confidence and with the assurance that the advantages they give a device over competitive products are not more than offset by faults and operational difficulties.

No doubt the employment of an electronic link adds to the sales appeal of a product. This is due to the blaze of publicity which electronics has received and because of the great assistance it has been to the war effort. Unfortunately electronics has been over-publicized.

Any appreciable number of electronic fakes, involuntary or deliberate, would discredit industrial electronics for a long time. To market an electronic device which is no better and does no more than its mechanical or electrical competitor of olden days would also result in discredit to industry even if the use of vacuum tubes in the device gives it enhanced sales appeal. Therefore, before releasing a new device embodying electronic control, be doubly sure that it has some new features which competitive devices do not have. Be sure that it is better than your previous number. At best the device will do things that have never been done before; at the very least, the advantage will be in greater convenience of operation, installation or maintenance.

If you are hesitant in the final evaluation of results, call in a competent outsider for an opinion. Then compare your opinion and his and you will learn a great deal. One is, as a rule, a poor judge of any product one has lived with a long time.

TECHNICAL ADVANTAGES

So much for sales appeal, positive and negative. Are there any great technical advantages in the use of electronics? Decidedly, yes.

Among the advantages of electronic control the almost infinite speed of response is probably the most important one. The response of the vacuum tube is instantaneous for all practical purposes. Electronic circuits, however, do have time constants though the time delay is generally negligible.

Welding timers constituted the first large-scale and exceedingly successful industrial application of electronic circuits. The task of the welding timer consists of delivering to the welder primary powers running into hundreds of kilowatts but only for a short time. Welding is commonly done at one cycle, that is, one-sixtieth of a second, and sometimes with a time period as short as a quarter-cycle. The electric energy must be perfectly synchronized so that the start is made at the beginning of some half-cycle, or at least at a definite electrical angle with respect to it. Electronic timing is indicated because it is extremely difficult to devise mechanical or electro-mechanical timers to handle the large current with sufficient accuracy and without rapid deterioration of the contacting device.

Applications requiring the high speed of electronic devices are legion. In military photography from planes, for instance, it is imperative to open the camera shutter a few microseconds after a dropped flash-bomb explodes. This can be most successfully accomplished by an electronic device. Devices for measuring the speed of projectiles were made before the advent of the electron tube but the new electronic devices are so vastly superior that they displace the old types.

The second important advantage of electronic control is its sensitivity. A multitude amplifier is not necessarily more sensitive than a fine mirror galvanometer but a galvanometer can move a pointer or a light-band up the scale and nothing more. If the power for a furnace is to be started or stopped, as directed by the galvanometer deflection, a coupling unit must be added which translates the position of the galvanometer pointer into a function of some current-making and breaking device.

The modern link between a galvanometer pointer and a contactor on the wall or an electric motor is an electronic device. Where the sensitive galvanometer pointer in itself can accomplish no work, a motor or relay can be operated by the output of an electronic circuit which is controlled by the galvanometer and yet adds no load to the galvanometer.

The third advantage of electronic control is its suitability for remote control. There are, for example, serious obstacles in the way of using conventional thermometers and pyrometers with their sensing and indicating elements separated by great distances. The usual bulb thermometer is connected to the indicator and controller by a capillary of minute diameter. If the indicator is 200 feet from the bulb the capillary is cumbersome and not too reliable. Electronic links can be operated over almost any desired distance with conventional wiring.

There is at least one other major point of superiority. This is the flexibility of control design. The variety of tubes and other circuit elements available is almost as great as the number of combinations in a chess game. Therefore the electronic control can be given almost any characteristics. It can be fast, or time delays may be readily incorporated. It can be rugged and sensitive at the same time. It can be comparatively inexpensive or a luxury device selling for thousands of dollars.

TYPICAL INDUSTRIAL APPLICATIONS

Though the number of packaged industrial items containing electronic controls is not yet large, many successful special applications have been made. Some of the more important uses are worth specific mention.

Electronic control of d-c motors was a major industrial application of electronics. In response to electronic, electrical, or mechanical monitoring devices, tubes here regulate or change the speed of the motor in the required manner.

Electronic links have been extremely useful in stopping or starting some or all operations on high-speed machines where mechanical methods become awkward or impossible. If, for example, you wish to use some very delicate sensing device to start, stop or control heavy equipment, an electronic link will probably do the job better than anything else. An electronic device may, for instance, be designed to follow up the movement of an instrument pointer. The motorized follow-up equipment may perform almost any control function, near the instrument or miles away from it. Though the pressure of the pointer on the follow-up mechanism can not be more than a fraction of a milligram, reliable operation can be had by electronic methods. There are cases where no contact whatever between pointer and follow-up fingers is allowable. There the capacitance relay or inductive relays fills the bill.

In many devices the follow-up or control system must be actuated by the light-beam of a mirror galvanometer, by a drawn line or by the transparent or opaque portions of a template. Here a phototube relay does the job. One interesting application is the automatic cutting torch, which reproduces the pattern of a template.

When the number of instruments on an aircraft used in test flights became so large that visual observation was a nightmare, automatic recording methods were devised. The oldest consisted of photographing the instruments with one or more motion picture cameras. All instruments had to be located within the proper range of the camera and the record was available only some time after the plane had landed. Now each instrument is connected with a transducer which modulates the frequency of an f-m radio transmitter. The signals are received on the ground, demodulated and recorded on a paper strip or sound film. Results are available while the plane is in flight. The pilot can be warned by radio in case of approaching failures. If the plane crashes, the record remains intact and may give reliable information on the events preceding the crash.

Electronic devices for the inspection of metals for uniformity, soundness and size are in use in many places. Devices of this type may discover cracks, slag inclusions, voids, changes in chemical composition, faulty heat treatment, under or oven size. The devices are nondestructive and very fast. Old style tests sometimes destroy or mar the test pieces and are much slower.

Several of the newest automatic pilots for airplanes are now electronic devices, operated through follow-up systems by one vertical and one horizontal gyro. Automatic landing systems land a plane smoothly in the densest of fogs without any assistance by the pilot. Only electronic control devices can accomplish this task.

There are a large number of electronic timing devices. Some of them deliver power impulses of accurately timed duration, while others serve to measure time intervals. The various stroboscopes and also the newest of flash devices for photographic use may also be classified as electronic timers. Short-duration timing lends itself admirably to electronic methods. For long intervals other types of timers are often more suitable.

The rectifiers furnishing the current for the electrolytic cells of our new aluminum and magnesium plants and for some railroads are electronic devices. There are also electronic train controls, electronic level indicators and controls and numberless other devices, all in successful practical use.

In addition, there are many electronic instruments devoted entirely to laboratory or diagnostic work. Industrial electronics has indeed come of age technically and economically. Even before the war sales of industrial electronic devices ran into the millions.

RELIABILITY IS ESSENTIAL

We may seem to fall into the same old error of overboasting electronics. In order to correct any such impression, let it be said that many electronic devices sold to industry have ended in the factory morgue or curio cabinet after a six-week trial. Reason: the devices were difficult to use, or required too much supervision and maintenance.

The unreliability inherent even in some frequently-advocated designs is generally due to two factors. The first is the availability of a large number of possible circuits, many of which have not been thoroughly tried. There is a powerful incentive for the designer to be over-ingenious. Very few really complicated circuits are sufficiently reliable for industrial use.

A 10-percent variation in the output of a radio receiver over a period of time will be barely noticeable. Infrequent clicks will be ascribed to static. But we can permit neither static nor 10-percent variations in industrial devices. Such misoperation might cause spoiled products or even loss of life.

The second factor is the marginal erraticism of many sensitive electronic circuits, caused by a variety of characteristics of circuits and tubes which are not too well understood. For example, vacuum tubes in industrial circuits are often used on portions of their characteristic curves which are not published because they are of no importance in communications, for which the tubes were originally designed. These details may vary from tube to tube and cause difficulties. As an additional example, industrial control circuits more often than not operate on transients and transients have not been as thoroughly investigated as the usual steady-state oscillatory phenomena by the average engineer.

TYPICAL ELECTRONIC CONTROL SYSTEM

I: A detecting or measuring device or sensing element converts physical changes into electrical impulses.

PHYSICAL CHANGES

Speed, rate of flow, thickness, temperature, pressure, position, color, opacity, reflectivity, tension, slack, strain, voltage, current, resistance, etc.

DETECTING OR MEASURING DEVICES

Phototubes, thermocouples, capacitance electrodes, conductivity electrodes, thermometers, thermostatic strips or bellows, strain gages, microphones, vibration pickups, resistance elements, etc.

II: A vacuum-tube amplifier builds up the strength of the initial impulses and sometimes also selects the correct impulses needed for achieving the desired control.

III: An actuating device, responding to the amplified electrical impulses either directly or through relays or contactors, performs the action required to regulate or control the industrial machine in the desired manner.

EXAMPLES OF ACTUATING DEVICES

Electromagnets or solenoids that open or close valves, kick objects off conveyor belts, shift gates in chutes, cut off the flow of materials, etc.

Electric motors that open doors, move elevators, conveyors or cars, operate machinery, change settings of heavy valves or control handles, regulate dampers, etc.

All this emphatically does not lead to the conclusion that electronic devices are less reliable than their mechanical and electrical brethren. It means only that electronic devices require more time, ingenuity and meticulous care for the final tests before releasing the product for use.

When all faults inherent in the circuit are eliminated we still have to investigate the effects of stray magnetic and electrostatic fields, surges on power lines, radio-frequency impulses derived from arcs and sparks, and the effects of dirt and humidity. All or any of these are commonly present in industrial plants.

Electronic industrial devices are often competing with mechanical controls consisting of a considerable number of punchings or screw machine parts. Even after final machining most of these parts cost only a few cents. Electronic components are much more expensive. Therefore, there are severe limits to the number of parts which can be used if the price is to be kept reasonable.

Industrial electronics is as replete with opportunities as it is beset with traps for the unwary. We know that the harder the road, the greater the prize at its end; but let me say to manufacturers and communication engineers: Industrial electronic devices are not radio transmitters or receivers. There is a vast difference.

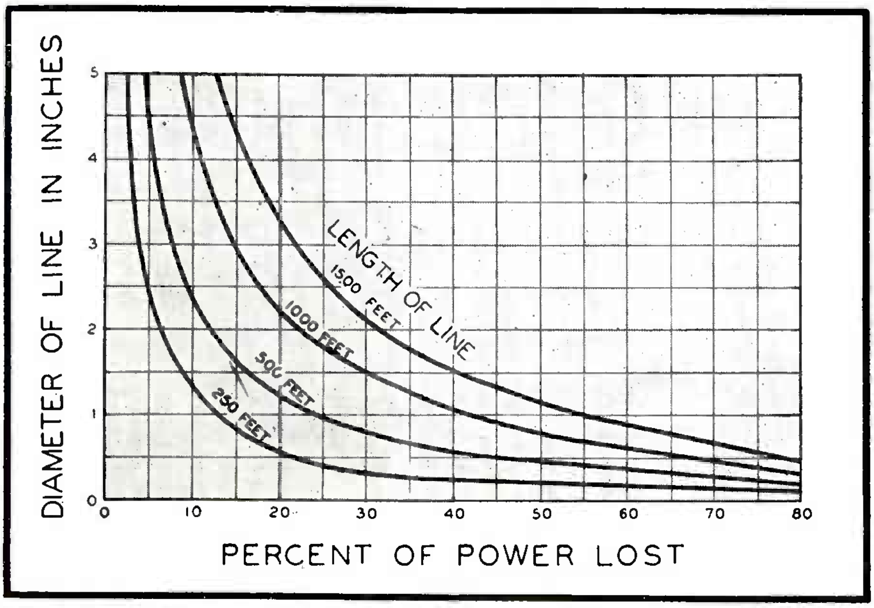
APPROXIMATE LOSSES FOR VARIOUS SIZES OF CONCENTRIC TRANSMISSION LINES AT 46 MC

Reprinted from Communications

By Wilfred H. Wood
Chief Engineer WMBG

LOSSES vary considerably with different types and kinds of concentric transmission lines at 46 megacycles. These losses depend upon the kind of materials and construction of the insulators used as well as the number used. It is also dependent on the copper used. Usually, these losses are expressed in decibels per 1,000 feet. It is, however, sometimes necessary to know the losses in power expressed in percent of power lost rather than in decibels. This is particularly true in calculating estimated coverages. These data are also useful in filling in the FCC application forms for f-m and television installations, which ask for percent of power loss.

To facilitate the preparation of these data, a set of curves offering approximate losses for various sizes of concentric transmission lines at 46 mc were prepared. They appear in the figure at the right. These curves do not represent any individual make of line, but rather an average of losses of several makes. The actual losses may be greater or less than shown.



NBC AND MADISON SQUARE GARDEN

Reprinted from Television

By Robert E. Shelby and Harold P. See

Two NBC Engineers describe operations of remote pick ups

IT SEEMS clear in projecting television's future that regularly scheduled television station operations will include adequate amounts of film presentations, live-talent studio shows and spontaneous news events and sports exhibits occuring remote from the studio. In NBC's experience thus far, the scope of program activity within the studio has made it mandatory that the film studio and field division be completely and permanently equipped.

The pioneering work of the NBC mobile unit equipment in inaugurating over 300 remote pick-ups within a 28-mile radius of Radio City together with laboratory research resulted in the design and construction of the first suit-case type portable television equipment. This development has made it possible for NBC to pioneer in remote sporting pick-ups from such points as Madison Square Garden, where WNBT has telecast the circus, hockey matches, basketball games, track meets, ice shows, political meetings and boxing since 1939.

Since September 9, 1944, WNBT has presented from Madison Square Garden professional boxing as a regular Friday evening feature. A month later, Monday evening boxing was added to the regular NBC television schedule. The success of bringing to television homes live broadcasts of actual boxing matches needs no comment from us.

NBC television Crew

Control room in Garden

In broadcasting from Madison Square Garden a setup of portable equipment is used. It is composed of eight boxes at the control point in addition to the two cameras. The suit-case type of equipment is situated on a movable table in a small control room at Madison Square Garden. The units on top of the table are synchronizing pulse generator; synchronizing shaping unit; two camera control boxes and a master-monitor switching unit. Power supplies are on the bottom shelf. All units are shown shock, mounted for transportation and operation in a vehicle.

The synchronizing generator or "brain" of the system is composed of two boxes. The first case contains the master pulse generator. Its electronically regulated power supply is self contained. The second case includes circuits for generating the blanking and synchronizing pulses from the master pulses generated by highly stabilized oscillators contained in the first unit. These units, when combined, constitute a control system for the operation of several camera chains.

The camera control unit contains the circuits necessary for the control and operation of the camera. There is one such unit for each camera. Monitoring

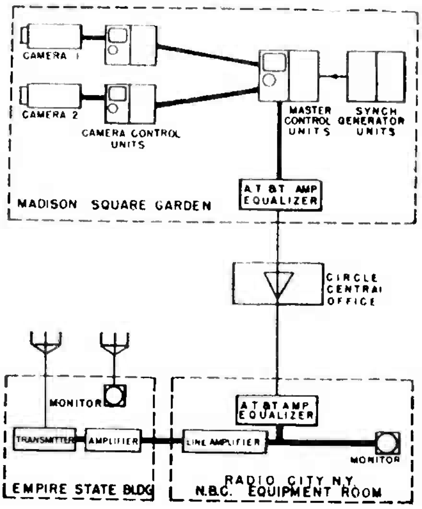


Diagram of remote circuit

is accomplished by means of the seven inch kinescope and the three inch oscilloscope built into this unit. The signal output of the video amplifier in the camera is transmitted through the camera cable (which may be up to 500 feet long), to the input of the camera control where it is again amplified by a video amplifier and fed by coaxial cable to the master unit.

The master monitor switching unit is used to switch cameras to the input of an associated transmitter or specially equalized telephone line. In this unit, the synchronizing pulse is mixed with the video signal after the camera switching position and the outputs of several cameras may be accommodated. A seven inch kinescope and a five inch oscilloscope comprise the monitoring portion of the unit.

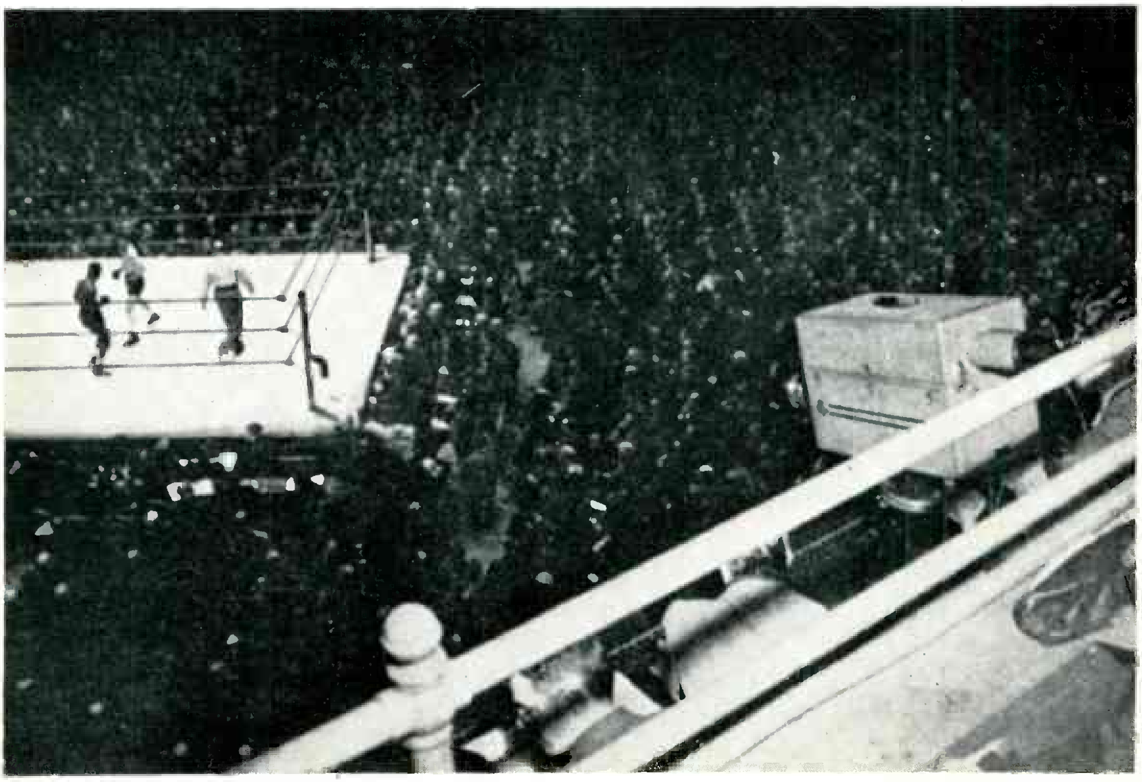
The cameras employing the "Orthicon" type pick-up tube are constructed in two main pieces. This feature greatly facilitates transportation of this unit by hand to camera locations which are many times not easily accessible. A lens plate containing an objective and view finding lens can be easily removed for substitution of different focal length lenses. A view finder permits the cameraman to follow action and change focus. The scene area in the view finder is greater than the area of the sensitized mozaic of the pick-up tube, thus affording the cameraman a wider range of view than that appearing on the monitor. Action "off scene" can be anticipated and the camera directed accordingly.

The power supply units contain electronically regulated circuits to eliminate effects produced by line voltage fluctuations. The input, nominally considered 110 volts single phase, may be adjusted through the use of a tap switch at any one of five positions. The variable input permits operations of the system at voltages ranging from 98 to 122 volts. The entire two-camera system, exclusive of a transmitter, requires an input of 3,120 watts.

The incident illumination available for the Madison Square Garden shows is provided by forty-four one and one-half kilowatt lamps located eighty feet above the floor level. Extra spot lights are used with some shows. The illumination provided by the standard fixtures is 350 foot candles at the middle of a boxing ring and an exposure meter at the camera position 70 feet from the ring shows a reading of approximately 5 candles per square foot under typical conditions.

The video signal is transmitted from Madison Square Garden to Radio City by means of a circuit furnished by the Telephone Company. This is an ordinary pair of wires in an underground telephone cable installation, but special amplifiers and equalizers are used with it. At the sending end the function of the "transmitter" amplifier is to match the unbalanced coaxial cable output of the portable equipment (i. e. one side grounded) to a balanced line. The converse of this is required at the receiving end, which in this case, is the telvision control room at Radio City. A series of variable equalizers has been included with the amplifiers. The amplifiers provide approximately zero loss and constant phase delay between unbalanced wire terminals approximately one mile apart.

This, in brief, is the method used in bringing boxing matches from Madison Square Garden to the many viewers of WNBT telecasts. The wide response from our audience indicates that these bouts play a very large part in the public acceptance of the new broadcast medium. Clearly, then, sports events of all kinds are bound to loom large in television's plans for the future.



Overall picture showing camera position and ring at Garden

INTER-AMERICAN RADIO

Reprinted from Radio News

By John W. G. Ogilvie
Dir. Radio Div., Office of Inter-American Affairs

The free exchange of information via international short-wave is one of the essentials for the maintenance of friendship and understanding between the United States and other peace-loving nations.

THE United States has reached a stage in the conduct of its foreign affairs where we must recognize that public opinion abroad is a major factor in influencing international relations. In order to promote friendships and to prevent misunderstandings, it is essential that the character, intentions, and actions of the United States be made known to the peoples of other nations.

Although all media can and should be utilized in the field of infomation, international short-wave radio broadcasting is the only medium not subject to foreign censorship and control. Further, no other medium can compare with short-wave for speed and magnitude of mass communications.

Control roof of Radio Nacional, PRE8, Rio de Janeiro. Recorded programs are an important part of daily broadcasting.

As the peace-loving nations of the world embark on the huge task of bringing about concrete realization of the Dumbarton Oaks proposals providing for a United Nations security organization and an economic and social council, it is of the utmost importance that the views of the United States, to which so many look for leadership, be freely disseminated to all parts of the world. Direct international short-wave broadcasting possesses unique virtues for such an informational operation.

The importance of future activities in inter-American as well as other international short-wave broadcasting has been emphasized by Secretary of State

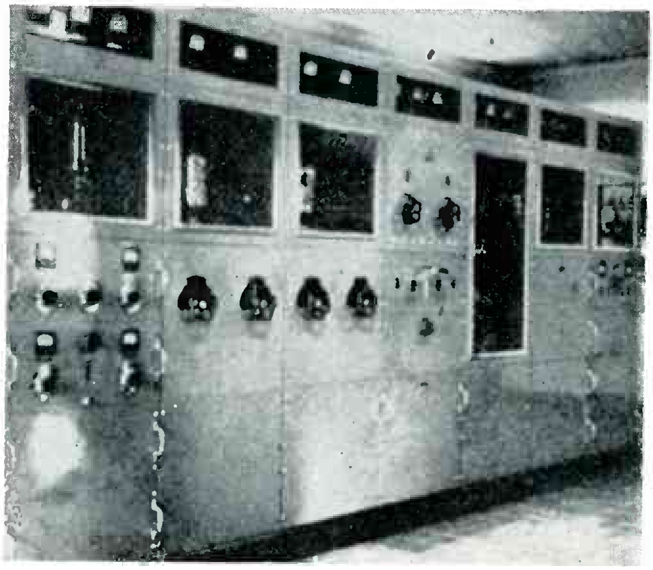
Edward R. Stettinius, Jr., who recently said: "Short-wave radio broadcasting is an indispensable instrument for creating an understanding of the United States."

The viewpoint of the Office of Inter-American Affairs, which has engaged in short-wave broadcasting to the other American Republics, was recently expressed by Assistant Secretary of State Nelson A. Rockefeller before the Federal Communications Commission. Testifying as Coordinator of Inter-American Affairs, the office he then held, Mr. Rockefeller said:

"It is inconceivable to us, as a result of our experience, that other nations would be willing to eliminate international broadcasting. It is our unqualified recommendation that in the United States there should exist direct international short-wave broadcasting facilities at least equal to those of any other nations."

The Office of Inter-American Affairs, established in August, 1940, for the purpose of furthering national defense and of strengthening the bonds between the nations of the Western Hemisphere, began short-wave broadcasting operations in its endeavor to promote the fullest possible exchange of information among the American Republics.

At the time the Office of Inter-American Affairs entered the international broadcast field, United States short-wave was far behind that of our enemies and our allies as well. Many powerful transmitters operated by Germany had for years been beamed to the other American Republics as well as to the rest of the world. German programs were planned and directed by personnel skilled in the Nazi technique of division and conquest. Japan, too, had long been making effective use of radio as a medium of mass communication to the other American peoples. Her purposes also were to mould public opinion against democratic faith and principles.

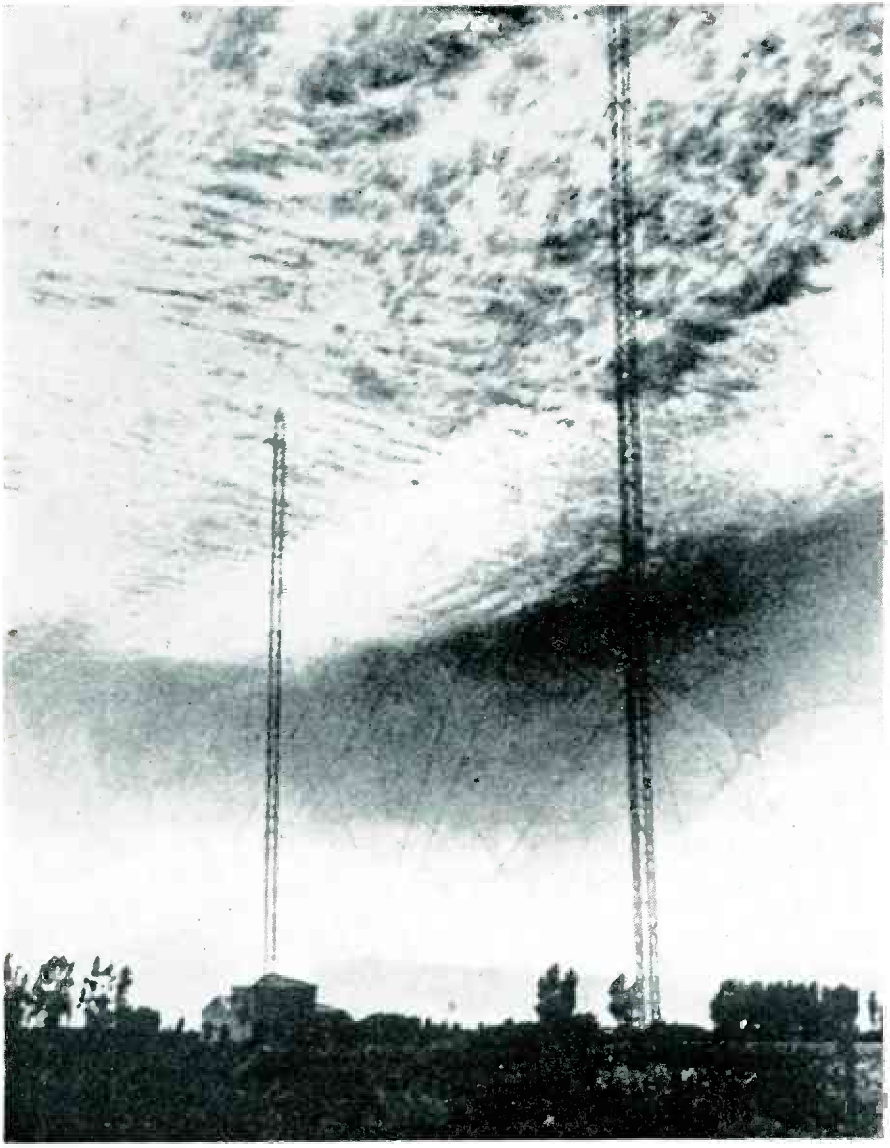


Transmitting equipment which is employed at a South American station. The design and construction are typically modern.

Our allies, long before the outbreak of hostilities in Europe, operated international short-wave transmitters, directing programs in several languages to the peoples of the Western Hemisphere.

Upon the entrance of the United States into the war in December, 1941, our short-wave service could not be compared favorably with the services of our ally Britain or our enemy Germany. We had available for use 14 transmitters, owned and operated by six licensees. Although 14 transmitters were obviously inadequate to meet the wartime problems before us, we would have been in a serious position without them. We are indeed grateful for the ingenuity and pioneering work of these licensees.

Before Pearl Harbor, short-wave transmitters were located in five cities in the United States. Stations were programmed with alternate language patterns such as English, Spanish, Portuguese, Dutch, French, Czech, etc. The Government could not request the licensees to alter their several language programming patterns and change their beam directions to cover all of the other American Republics, as this would have placed a large financial burden on the companies. Because of the concentration of population and receiving sets on the East coast of



An elaborate array of transmitting antenna towers (Radio Sociedad Nacional de Mineria, CB126) at Santiago. The rural location is ideal for foreign transmission.

South America in the vicinity of the two major capitals of Rio de Janeiro, Brazil and Buenos Aires, Argentina, the companies had concentrated on developing radio audiences in those areas.

As the licensees could not be expected to assume financial obligations to construct additional transmitters and to obtain sufficient Spanish and Portuguese language talent so that their stations could be programmed in one language throughout the broadcast day, existing transmitters were leased for exclusive use by the Government.

Leasing of available transmitters was effected in November, 1942. One-third of the transmitter time was allocated to the Office of Inter-American Affairs for short-wave broadcasting to the other Americas and two-thirds to the Office of War Information for broadcasting to the rest of the world.

These transmitters were insufficient to provide multifrequency coverage to the world, and therefore orders were placed to construct an additional 22 transmitters.

Director and assistant discuss with operator foreign transmitted program (Radio Sociedad Nacional de Mineria,CB126).

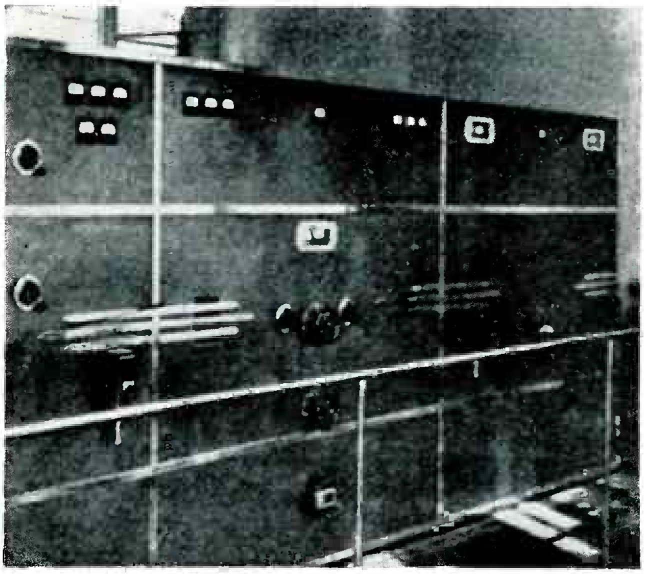
Because the Spanish and Portuguese talent available was limited, and the majority of the talent was concentrated in the Eastern part of the United States, it was decided to assign the transmitters located in the East to Spanish and Portuguese broadcasts and the transmitters on the Pacific Coast to broadcasts in English.

During the first year of Government operation of transmitters — namely, 1942-1943 — the Office of Inter-American Affairs, in cooperation with NBC and CBS, produced from the studios of NBC and CBS all Spanish and Portuguese language programs. The program plan assisted NBC and CBS in maintaining their commercial identity, as a complete Spanish and Portuguese language service was offered by each network. This was desirable, as both licensees had established local radio station affiliates in the other Americas.

In 1943, when it became evident that more frequencies were needed to improve reception and that additional transmitters could not be built quickly, it was decided to discontinue the individual programming by NBC and CBS. Therefore, in July, 1943, the two Spanish language services of NBC and CBS were combined into a single service and sent out on teamed transmitters, which provided multifrequency coverage to all areas in the other Americas. Each licensee provided the program to the combined Spanish language transmitters on alternate hours.

The Portuguese language service, likewise, was programmed equally by NBC and CBS.

In order to provide programs for the English language transmitters of the United Network located on the West Coast, commercial sponsors and domestic networks cooperated by making available their finest United States domestic programs. The Special Services Division of the Armed Forces also supplied programs especially designed for their military personnel in the Western Hemisphere. As a result, the English language short-wave service is today the finest in the world.



Modernistically designed transmitter of station Oliveria, Santiago. Many foreign broadcasts emanate from this station.

Simultaneous broadcasting of the same program in the same language by teams of short-wave transmitters had an important and beneficial result. The radio listener in the other Americas was able to select from several frequencies, and the affiliate stations in the other Americas picking up short-wave programs for rebroadcast to local audiences were also able to select the strongest and clearest signal for rebroadcast purposes.

To augment Spanish and Portuguese short-wave programs produced in the United States, radio commentators, writers, actors, and technical experts were brought to the United States from the other American Republics. Language experts were especially needed, as there is considerable variation of Spanish terminology in the various regions of the Hemisphere.

In the field of radio, the Office of Inter-American Affairs, has, since its inception, sought to encourage especially planned programs originating in the United States for broadcast in the other American Republics; and special programs from or about the other Americas for domestic broadcast in the United States. This work is being carried on in several ways.

In addition to direct international short-wave broadcasting, it has been desirable, from time to time, to utilize commercial point-to-point services to the key areas of the Americas, for the purpose of having programs rebroadcast by local radio stations.

To reach all possible radio listeners, in the small towns as well as the large cities, transcription series, produced by Spanish and Portuguese talent in New York and Hollywood, are shipped to the other American Republics to supply stations in outlying areas.

Not only have transcriptions assisted the United States in its war job of disseminating information, as other foreign countries are doing, but transcriptions also are a means of supplying fine radio programs indicative of the aims and culture of the United States to small local radio stations lacking trained talent.

Short-wave, commercial services and transcriptions could not effectively do the entire work necessary from a war standpoint, as certain programs could not be effectively produced in the United States. Therefore, it was necessary to produce radio programs locally in some of the other American nations. As skilled radio talent, producers, and technicians were available in only the largest countries, the Office of Inter-American Affairs sent trained radio representatives to all of the major capitals to work with local radio stations and assist in the training of personnel, both talent and technical, and in producing pro-United States programs of a desirable nature. News and commentary programs were initiated by these representatives, as well as cultural, educational, health, and other types of programs favorable to the aims and work of the United States.

For example, teaching of the English language by radio was carried out in half of the American Republics, with outstanding success. In one country radio English lessons were produced in cooperation with the local government. A United States advertiser, aware of the effectiveness of this program, broadcast radio English lessons in 16 countries. Numerous local radio productions begun by the Office of Inter-American Affairs have become outstanding favorites with local radio audiences and more than 17 programs originated by the Office of Inter-American Affairs have been taken over by United States advertisers.

From a technical, engineering, and program-production standpoint, the Office of Inter-American Affairs has acquainted the peoples of the other Americas with United States radio methods and radio program production standards. A listening audience has been created among the other American peoples that looks with favor on the United States type of radio program.

Radio producers, actors, and technicians brought to the United States from the other Americas for a period of work and study in connection with inter-American short-wave radio productions have returned home eager to apply the United States techniques and methods, in which they had been trained.

Care is taken to check thoroughly the results of broadcasts. Panels of radio listeners have been organized in the other American countries to provide periodic reports on the quality of our short-wave programs. In addition, these broadcasts are regularly monitored. New engineering techniques have greatly improved the control of short-wave broadcasting. Signal intensity monitoring stations which have been installed in various key areas in the other American republics have conclusively proved from their tape recordings that we are putting on a strong signal.

The result of all these coordinated operations of the Office of Inter-American Affairs is that a new and heightened economic opportunity is shaping up "south of the border" for manufacturers of radio receivers, transmitters, component parts, and other radio equipment. A brisk market is in prospect, when home receiving sets become available, that will be supplied either by our own industry or by radio manufacturers of other countries. It was by no means a small market before the war, but its possibilities have expanded broadly since then.

U.S.A. Short-wave stations programming in Portuguese to Brazil

However, common business sense makes it necessary to concede that a merchandising problem exists for manufacturers of radio equipment in supplying the Latin American demand. On the one hand, there is a ready-made audience and an eager market. There is also a buying public that is already familiar to some extent with U. S. radio equipment, particularly radio tubes, of which the United States has been the only sizable foreign supplier since the war began. But, on the other hand, there is a sharp disparity between the economic levels of most of the other American countries and our own. There is a further divergence of economic levels as between any one of these republics and another. The obvious reason why Latin America has only one receiver to about every 33 persons while we have one to about every 2.5 persons is that fewer Latin Americans have been able to afford radio sets at prewar price levels.

Can our manufacturers meet these conditions? Can they supply that thirsting market at price levels low enough to reach the largest number of potential buyers?

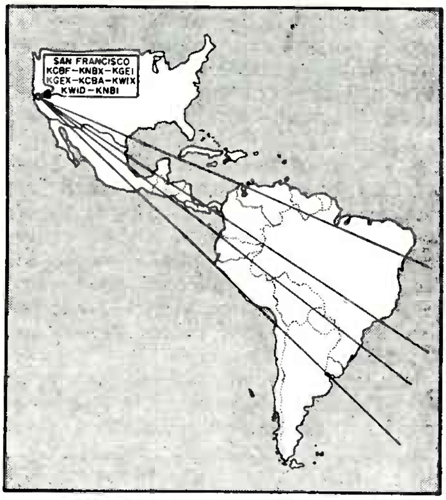
One answer is that, even before the war, we partially met the demand. We supplied this market by export and by radio equipment production in South America. In 1941 United States exports of radio equipment of all types to the other Americas totaled $12,789,000. By principal classifications these exports were as follows: radio receiving sets, $7,724,000; radio receiving tubes, $1,191,000; component parts, $2,390,000; loud speakers, $214,000; accessories, $243,000; and transmitting tubes and equipment, $1,027,000.

Considering the difference in economic conditions and therefore in the cost of materials and labor between the United States and other competing countries, can we design equipment at price levels that will compete favorably with equipment offered by competing manufacturers? That is a question to be answered by our own radio manufacturing industry only after surveying the possibilities of meeting Latin American requirements with equipment of sufficient simplicity to hold down production costs. The only alternative perhaps is the establishment of large-scale and widely distributed radio equipment factories in Latin America.

A notion of the extent of the sales possibilities of household receiving sets can be gained by considering these facts: approximately 60,000,000 radio receivers serve 135,000,000 people in the United States as compared with only 4,200,000 sets serving 130,000,000 population of the other American Republics.

But that tells only part of the story. There are also differences in listening habits, transmission conditions and other factors that modify the picture.

Networks are not so highly developed in the other American republics as in the United States. There are only half a dozen networks that are of major development. The largest of them is one headed by Station XEW in Mexico, which has a companion-competing network. Both networks are operated by Emilio Azcarraga. Brazil has the Byington and Chateubriand networks, and Cuba the CMQ and Cadena Azul chains. In Argentina, the three major networks of consequence are those headed, respectively, by Radio Belgrano, Radio El Mundo and Radio Splendid in the capital, Buenos Aires. None of these networks has the number of either wholly-owned or affiliated stations that the leading United States networks comprise.



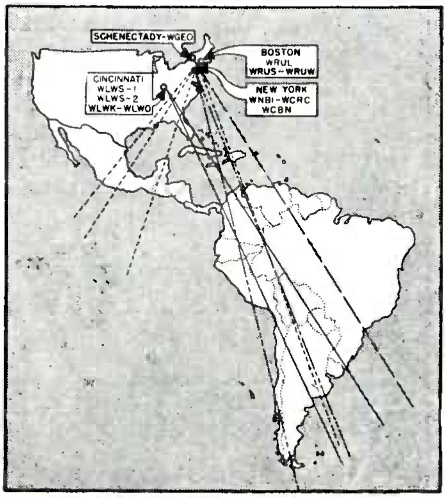
U.S.A. short-wave stations programming in English to Central and South America.

An important consideration is that a substantial proportion of Latin American transmitters broadcast their programs simultaneously on both long- and short-wave on two or more frequencies. In fact, probably about one-half of the Latin American transmitters are short-wave. This procedure is necessary because of local topographic conditions, which determine whether a broadcast from a given point can be received on long-wave or on short-wave. The use of high frequencies by these transmitters is not intended, as with our own, for international broadcast but is designed for reception within the country.

What we in the United States know as the "broadcast band" is actually only a part of the broadcast band for the home receivers in the other American Republics. In the United States a short-wave band on the receiver dial usually is just an added gadget; in Latin America it is used by fully half of the listeners. This factor has been of great value to the Office of Inter-American Affairs in its direct international short-wave broadcasting. It is of special significance to the plans of the United States radio manufacturing industry in supplying the Latin American market. In Peru, for example, approximately 85 percent of the home receiving sets have short-wave bands.

Another difference in Latin America is the existence of many low-power commercial broadcasting transmitters — some running less than 100 watts — which are what we would term makeshift installations, even if often ingeniously makeshift. In general, standardization is not highly developed as yet. This is true not only of equipment but also of broadcast time advertising rates.

One might question the purpose of licensing some of these installations at all. But the issue loses validity when we consider the natural and sensible desire of the governments of the other American republics to foster the growth of radio even if, at first, it is necessary in some cases to sacrifice quality to quantity to set up broadcasting stations. Already Brazil, Cuba, Mexico and Argentina have developed extensive plans for international broadcasting. With growth will come improvement in equipment. Later will come gradual tightening of licensing standards.



U.S.A. short-wave stations programming in Spanish to all Spanish-speaking countries of the other Americas.

Sending radio technicians to our neighbors may or may not be continued as a government function after the war. But, if it isn't, it would be shortsighted on the part of United States radio interests—both manufacturing and broadcasting—not to maintain such operation on their own account.

Much has happened during the war in the inter-American radio field. Describing the international short-wave broadcasting situation as it existed in the other American republics during their visit there in 1941, a United States Congressional subcommittee reported to Congress as follows:

"In the field of radio it would appear that we have been considerably remiss in keeping up with the pace set by other countries in acquainting citizens of Latin America with our national plans, procedures, purposes, culture, background, and related facts. In a large metropolitan city of one country visited by the committee, the Free French and the Japanese have more time on the air per week than we do. The Germans broadcast on the radio in the same city an average of 2½ hours per day. We broadcast one-half hour per week. . . . The radio is an extremely effective medium for reaching the people and we must avail of it on a much larger scale as an approach to better understanding!"

The tremendous advance in United States radio programming, since this statement was made, is indicated by our current consumption of more than 280 program-hours of inter-American radio time per week.

Looking to the future, it has been recognized by the United States Government that the free exchange of information internationally is one of the essentials to the maintenance of friendship and understanding between the United States and other peace-loving nations. One of the highest officials of the State Department has pointed out that modern communications have added a new and vitally important factor to international relations that formerly were largely confined to relations between governments through diplomatic representatives.

"Today," he stated, "it would not be too much to say that the foreign relations of a modern state are conducted quite as much through the instruments of public international communication as through diplomatic representatives and missions . . . If the closer communications with each other of the peoples of the world are to result in mutual understanding, they must provide the full exchange of information and knowledge upon which understanding rests.

"The necessity of seeing that the full exchange is made—that the whole story of a people's character, its arts, its sciences, its national characteristics, is truly told— is a necessity which no modern government can, or would wish to, evade. This does not mean that the job is a job government should attempt to do itself. Clearly, no government can accomplish that tremendous labor, and no democratic government should try to undertake it. All the various instruments of communication—press, radio, motion picture, book publishing, works of art—must and will play their part. . . . Government's responsibility is not to do the job itself—not to supplant the existing instruments of international communication. Government's responsibility is to see to it that the job gets done and to help in every way it can to do it."

Books must follow sciences, and not sciences books.

FRANCIS BACON

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 (May 1945)

COMMUNICATIONS' ROLE IN ELECTRIC UTILITY SYSTEMS.......................*S. J. Combs*

CORRELATION OF FIELD AND CIRCUIT THEORY.......................*L. L. Libby and N. Marchand*

FREQUENCY CONVERSION CIRCUIT DEVELOPMENT (PART II).......................*Harry Stockman*

BRITAIN'S POSTWAR TELEVISION PLANS.......................*Alan Hunter*

FREQUENCY OF CAPACITANCE TUNED LINES AND RESONANT LINE OSCILLATORS.......................*Hugh A. Brown*

GERMAN AND JAPANESE COMMUNICATIONS EQUIPMENT

RESISTIVE ATTENUATORS, PADS AND NETWORKS (PART IV).......................*Paul B. Wright*

DENVER AND RIO GRANDE WESTERN 118-MC F-M SYSTEM.......................*A. B. Cavendish*

CQ (June 1945)

A MOBILE TRANSMITTER-RECEIVER

You can build this exceptionally well-designed unit, it features a non-radiating super-regenerator.......................*Howard A. Bowman,* W6QIR

COMMERCIAL OPERATING IN SIX MONTHS

How the Hoffman Island Maritime Service Radio Training System functions.......................*W. Warner,* W2NJO

WIRED WIRELESS TRANSMITTER

You can get "on the air" via the power lines for the duration.......................*J. D. Potter,* W3IKM

AN EMISSION-TYPE TUBE CHECKER

This tester is easy to build and belongs in every ham shack.......................*Richard E. Nebel,* W2DBQ-WLNB

A VOLTAGE-REGULATED POWER SUPPLY

A dependable source of power for experimental work.......................*Athan Cosmas*

RADIO AMATEUR'S WORKSHEET, No. 1—NOTES ON RECTIFICATION

ELECTRONICS (June 1945)

ELECTRONIC WELDING OF GLASS

Localized heating without destructive surface-boiling is accomplished with the aid of high-frequency guns.......... *E. M. Guyer*

U-H-F IMPEDANCE MEASUREMENTS

Using special probes, impedance measurements can be made with low-power laboratory equipment......*N. Marchand and R. Chapman*

A PRETUNED TURNSTILE ANTENNA

Description of a unit that can be adjusted before being erected.......... *George H. Brown and J. Epstein*

MOVING-COIL PICKUP DESIGN

Description of dynamic pickup whose resonance peaks are beyond the usual audio range.......... *Theodore Lindenberg, Jr.*

ELECTRONIC SALES ENGINEERING

Young men, with technical as well as sales training, are the key to the industrial market.......... *S. S. Egert*

PREDIMENSIONING QUARTZ CRYSTAL PLATES

New mass-production method keeps temperature-cycling rejects below 2 percent.......... *B. P. Haines, C. D. O'Neal and S. A. Robinson*

AUDIO MIXER DESIGN

Various types of high and low-impedance mixer circuits for audio amplifiers.......... Richard W. Crane

INDUSTRIAL RADIOGRAPHY

Practical instructions for inspecting welds, castings, and finished products with x-rays or radium.......... *Wayne T. Sproull*

THE BETATRON

Comprehensive survey of induction electron accelerators, with basic design equations.......... *Theodore J. Wang*

ARTIFICIAL DELAY-LINE DESIGN

Chart simplifies design of artificial line for signal delay.......... *J. B. Trevor, Jr.*

AIR TERMINAL SOUND SYSTEM

West Coast system features speech compression and flexibility by using multiple amplifiers.......... *William W. Brockway and Don C. Brockway*

MEASURING R-F POWER WITH THREE AMMETERS

Chart speeds conversion of r-f ammeter readings into r-f resistance, reactance and power of load.......... *J. L. Hollis*

COMPUTING MUTUAL INDUCTANCES

Chart simplifies computation of M for coaxial circular coils to a simple multiplication.......... *Michael J. DiToro*

ELECTRICAL COMMUNICATION (Volume 22, 1945, Number 3)

RADAR

DEVELOPMENT OF AIRCRAFT INSTRUMENT LANDING SYSTEMS.......H. H. Buttner and A. G. Kandoian

SPECIAL ASPECTS OF HIGH FREQUENCY FLEXIBLE BALANCED CABLES.......N. Marchand

SPECIAL TRANSMISSION PROBLEMS — IN SOLID DIELECTRIC HIGH FREQUENCY CABLE.......A. G. Kandoian

UNITED AIR LINES' REPERFORATOR SWITCHING SYSTEM....R. E. Hanford

ELECTRON TRAJECTORIES IN A PLANE DIODE — A GENERAL RESULT.......Léon Brillouin

SCHOTTKY'S THEORIES OF DRY SOLID RECTIFIERS.......J. Joffe

DEVELOPMENTS IN CARRIER TELEGRAPH TRANSMISSION IN AUSTRALIA.......R. E. Page and J. L. Skerrett

RECENT TELECOMMUNICATION DEVELOPMENTS

ELECTRONIC INDUSTRIES (June 1945)

MERCURY ARC HEATING FREQUENCY CONVERTER.......S. R. Durand

SHF POWER MEASURING.......H. Gregory Shea

HIGH FREQUENCY POLICE EQUIPMENT

FREQUENCY ALLOCATIONS

SELECTING COAX CABLE.......Dr. Victor J. Andrew

VHF NETWORK FOR TELEVISION RELAY

MULTI-CHANNEL ARMY COMMUNICATIONS SET

RADIO RELAY NETWORK PLANS FOR THE FUTURE

DU MONT'S PROJECTION TELE

MODERN DEVELOPMENT LABORATORY TECHNIC

MARINE VOICE-CODE SET

DESIGNING FILTERS FOR SPECIFIC JOBS—II.......Arthur H. Halloran

HIGH FREQUENCY AVIATION IGNITION SYSTEM

SHORTAGES IN RECEIVER TUBES?.......J. Albert Stobbe

POWDERED IRON CORES.......C. T. Martowicz

TUBES ON THE JOB

FM AND TELEVISION (May 1945)

FINAL FREQUENCY ALLOCATIONS
Released May 17, 1945

MIAMI HAS FIRST 118-MC. POLICE SYSTEM.......Lieut. Ben Demby

CIRCULAR ANTENNAS FOR FM BROADCASTING.......M. W. Scheldorf

MEMORANDUM ON SPORADIC E INTERFERENCE.......Major Edwin H. Armstrong

152- TO 156-MC. MOBILE UNITS.......G. A. Leap

BETTER WAYS TO MEET LISTENERS' NEEDS.......Milton B. Sleeper

FM BROADCAST & COMMUNICATIONS HANDBOOK.......René T. Hemmes

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

QST (June 1945)

RADIO (May 1945)

RECEIVER DESIGN FOR THE NEW FM BAND
A timely discussion of the problems involved, and how to overcome them, when designing receivers for the higher-frequency band .... *A. C. Matthews*

AN ADVANCED CRYSTAL PICKUP DESIGN
Describing a new design which has reduced mass and inertia, and provides remarkably clean reproduction from records heretofore considered poor recordings .... *Roy Dolly*

A NEW TRIPLE DETECTION COMMUNICATIONS RECEIVER
Dana Griffin's new design has outstanding advantages in high-speed code reception. This article describes fully the methods by which these improved results are achieved

FINAL TESTING OF BROADCAST TRANSMITTERS
Describing the technique of testing high-power transmitters prior to putting them on the air .... *Harold E. Ennes*

RADIO DESIGN WORKSHEET: NO. 36—AUDIO AMPLIFIER PLATE-CIRCUIT EFFICIENCY; CAPACITOR POWER FACTOR

PRODUCTION TESTING
Some pointers on the design of mass production test equipment .... *Robert G. Herzog*

RADIO CRAFT (June 1945)

AIR RADIO MECHANIC .... *Raymond Lewis*
TELEVISION AND THE AMATEUR .... *Laurence Schwab, Jr.*
NO SELECTIVITY IN THIS RADIO .... *I. Queen*
"PHOTOPULSE" .... *E. Lloyd Thomas*
FM U.H.F. CONVERTER FOR PRE-WAR RADIOS
CATHODE-RAY PHOTO TESTS
HANDIE AND WALKIE COMBAT PORTABLES
TUNING ON THE U.H.F. .... *I. Queen*
CATHODE FOLLOWERS .... *O. E. Carlson*
DISC-SEAL TUBES .... *John Kearney*
BROADCAST EQUIPMENT, PART IX .... *Don C. Hoefler*
AN ELECTRONIC "OMNICHECKER," PART I .... *Robert E. Altomare*
IT'S THE DESIGN! .... *Louis Hagen*
CONDENSERS .... *Jack King*
RE-ACTIVATOR SAVES TUBES .... *Myron G. Albin*
NON-PRIORITY CODE RECORDER .... *Bob Melvin*
32-VOLT RECEIVER FOR SMALL PLANTS .... *B. W. Embree*
FIXED-BIAS VOLTAGE SUPPLY .... *F. C. Davis*
CARRY-AROUND RECEIVER .... *Edwin Bohr*
CYLINDERS FOR BETTER SOUND .... *Nathaniel Rhita*

RADIO NEWS (June 1945)

RADIO NEWS - Radio Electronic Engineering Edition (June 1945)

SERVICE (May 1945)

TELEVISION (June 1945)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