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PROCEEDINGS
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Volume 15 SEPTEMBER, 1938 No. 5

"UNBENDING THE GINKS"

A PAPER ON AMATEUR RADIO

By

J. N. Whitaker*

Delivered Before the Radio Club of America, June 2, 1938

Almost every known art or science is practiced by some individuals as a hobby. To this, radio is no exception since probably more individuals are interested in radio than in any other one art, unless it be photography. One might almost say that radio is the direct outgrowth of a hobby, since early experimental work was so largely carried on by individuals whose livelihood was gained wholly outside radio.

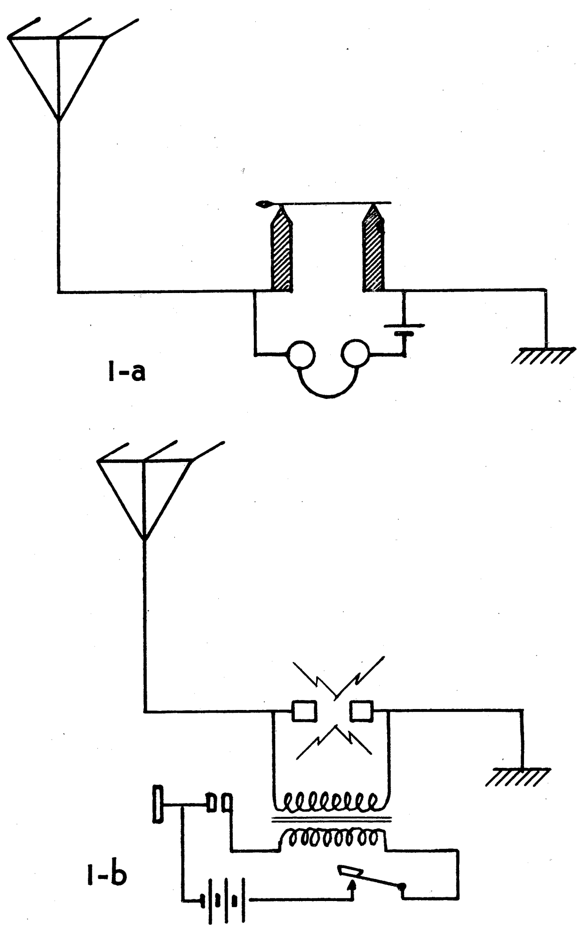

Fig. 1—Simple Carbon Detector and Spark Transmitter.

For many years, the simple spark gap and the crystal detector of Fig. 1 were used in the transmission and reception of radio waves. Many beginners used such a system in which the detector consisted of two pieces of carbon filed to an edge, with a needle resting across the tops of the carbons. A battery and ear-phone, borrowed from the telephone, were connected in series with the carbons and the antenna and ground connected as shown in Fig. 1 (a). The simple transmitter shown in Figure 1 (b) consisted of a spark coil and battery, borrowed from the pump engine, connected to a spark gap, antenna, and ground. Crude as it was, this set-up was capable of operating

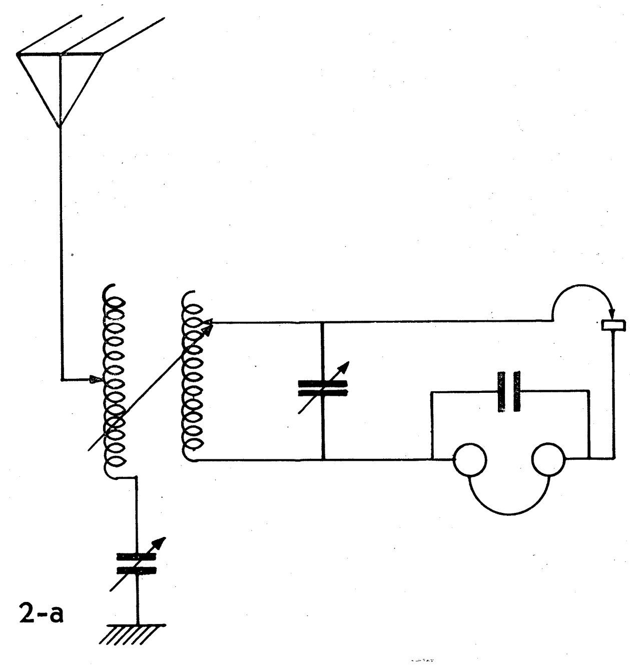

Fig. 2—Crystal Detector, Loose Coupler Receiver and Spark Transmitter.

over distances of up to a mile or so with fair results, and was the germ from which grew the "bug" that was the downfall of what might otherwise have been a good rancher.

As the art developed, numerous forms of crystal detectors and antenna tuning systems were employed for reception.

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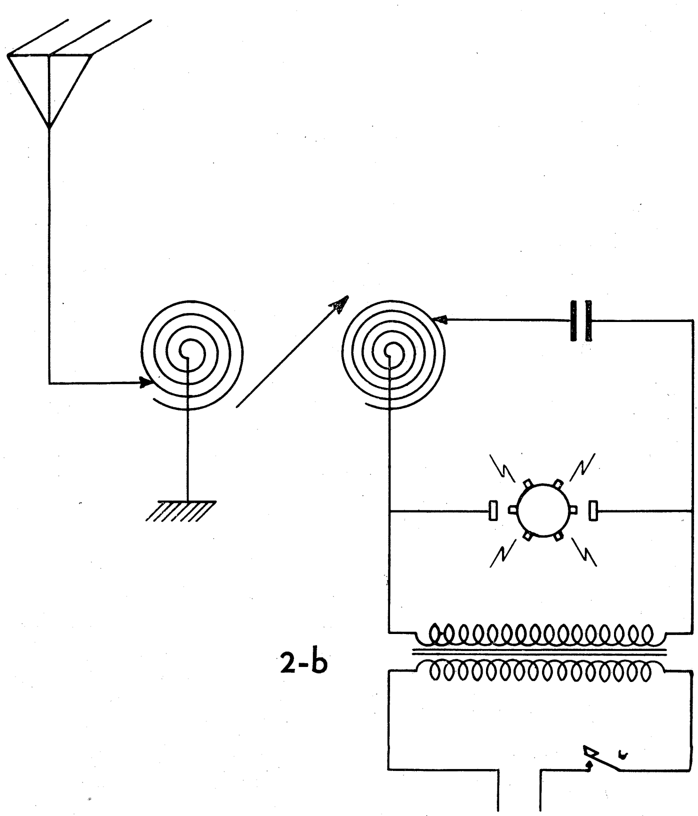


2-b

Elaborate "loose couplers" were made out of cereal boxes, or other cardboard tubing; likewise, oscillation transformers, rotary spark gaps, and real power transformers were used in the transmitter, as in Figure 2a and 2b, and the radio station finally looked something like Figure 3.

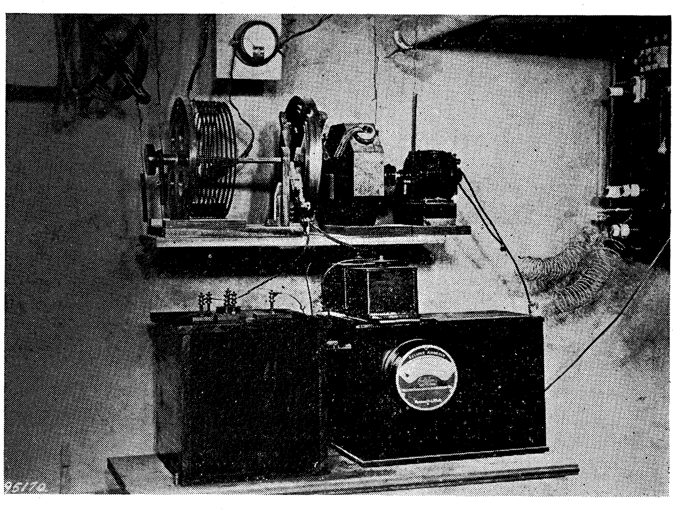


Fig. 3—Photograph of an Old Time Station.

Just as radio was beginning to come into its own, came the world war and the Government ban on amateur radio. Many amateurs immediately offered their services, and their part in the development and operation of the communications systems of the military forces is gallant history.

When the world war was over and the radio ban was lifted, amateurs found the situation greatly changed. The doom of crystal detector was sealed by the availability of vacuum tubes. The old spark transmitter, however, died a much slower death. It was not until the advent of radio broadcasting that the regulations governing the operation of amateur stations were revised, to prohibit spark transmitters. And not until then did they become museum pieces along with crystal detectors.

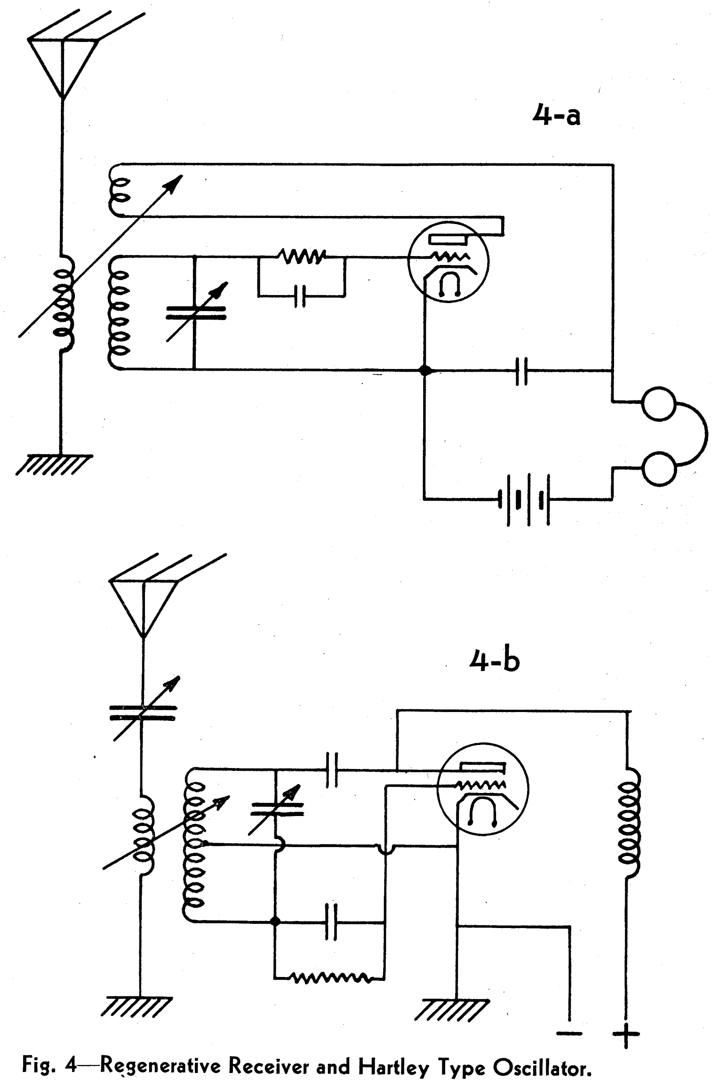


Fig. 4—Regenerative Receiver and Hartley Type Oscillator.

Then came the self-excited vacuum tube oscillator transmitter and while the frequency generated by the self-excited oscillator was not very stable, it served a very useful purpose since the amateur bands were not congested and unstable emissions could be tolerated.

Some of the more progressive amateurs used electrolytic rectifiers, (popularly known as "soup jars"), together with various types of interrupters to produce a "distinctive note" on their transmitted signals.

The receivers were generally of the simple regenerative detector type, with, in the case of an elaborate receiver, an audio amplifier following the detector and thus were sufficiently broad to make it easy to hold a signal near enough in tune to be copied.

As the public services began to require more and more of the radio frequency spectrum, and that portion allotted to the amateurs was successively reduced, the interference between amateur stations became increasingly serious. This led to the

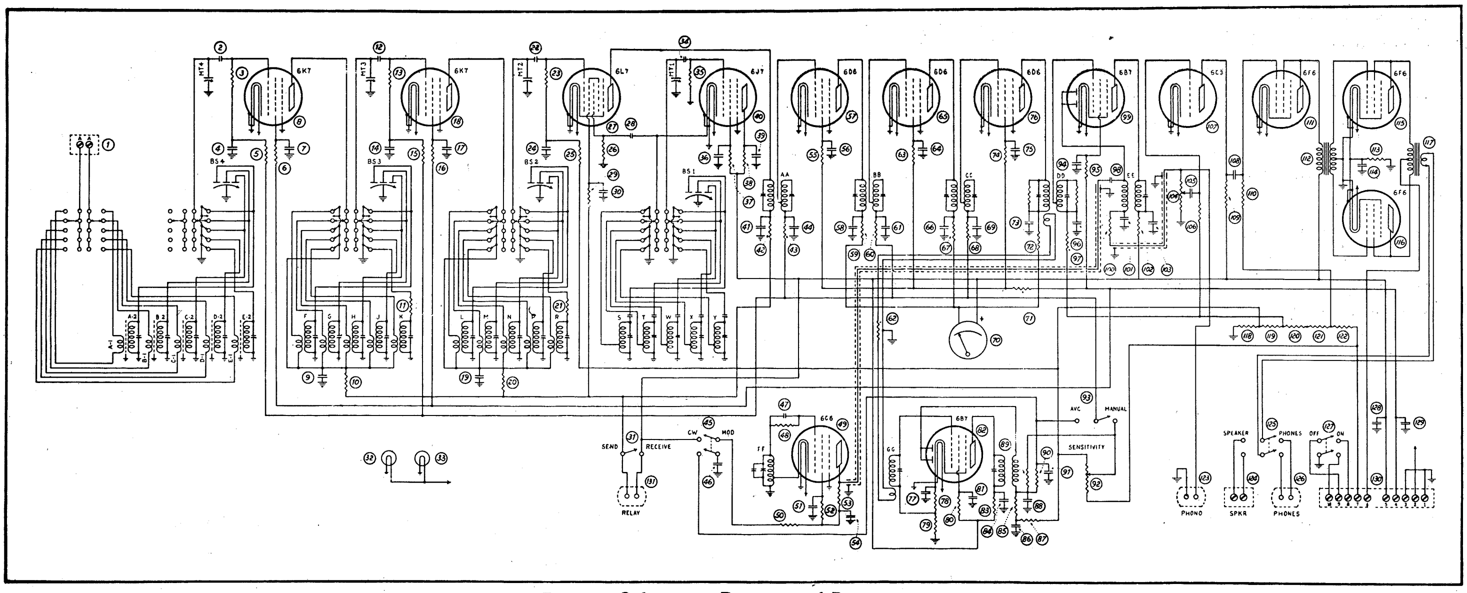


Fig. 6—Schematic Diagram of Receiver

development of more selective receivers, and to the ban on roughly modulated waves. Finally, modulated waves, except for telephony were completely banned. At the same time, radio was becoming more popular as a hobby and more stations were being operated. Thus to obtain pleasure from operating an amateur station, an extremely steady and pure carrier and a very selective and stable receiver were essential.

The master-oscillator-power-amplifier transmitter, and the regenerative detector preceded by one or two stages of tuned radio frequency amplification in the receiver solved the problem temporarily.

The portion of the frequency spectrum allocated to amateur use has been steadily decreased which, along with ever increasing activity makes it practically impossible to operate in any of the amateur bands without the use of a good crystal controlled transmitter and an extremely selective superheterodyne receiver. Thus, we have progressed from the very simple spark gap transmitter and crystal receiver to elaborate quartz crystal controlled transmitters and superheterodyne receivers in the relatively short period of about 25 years.

Frequency Suitability Requirements

The selectivity of the modern receiver requires that the transmitting station maintain a high degree of frequency stability. Otherwise, it is necessary for the receiving operator to continually "follow" the transmitted signal by tuning the receiver. And since Federal and International Law require that the amateur stations operate within certain frequency bands the amateur must use a stable frequency control system not only for successful operation but in order that a "pink QSL slip" is to be avoided.

A few years ago a simple crystal oscillator system was the ultimate in frequency control, and the trend at that time was to build an oscillator which would deliver the maximum power possible without fracturing the crystal. As compared to present day standards, such oscillators were not particularly stable and so the trend is now toward low powered oscillators followed by buffer-amplifiers and power amplifiers. Frequency multiplying systems are also generally used not only in order to obtain higher frequencies but also to minimize feed-back from the power amplifier to the crystal oscillator.

Many of the modern receiving type tubes are especially suitable for crystal oscillator service since the primary requirement is that the tube must deliver a usable power output with a very small power input to the grid. While the regeneration in the tube itself must be sufficient to maintain oscillations of the crystal, it must not be of such a magnitude as to cause internal heating of the crystal. For this purpose some of the more popular tubes are the twin triodes, beam power tubes, and several of the pentode types. Only the more popular circuits will be treated in this paper. The circuits selected are representative and are intended to indicate the modern trend of the art.

The twin triode tube is popular for two reasons,—

(a) One triode section may be used as the crystal oscillator and the other for frequency multiplication.

(b) The mu of each triode is very high, which makes it ideal for both purposes.

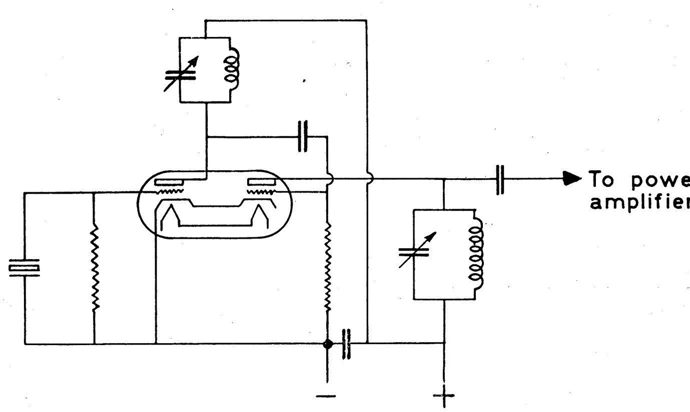


Fig. 7—Schematic Diagram of Twin Triode Oscillator—Frequency Multiplier System.

A typical application of this type of tube is shown in Figure 7. With such a circuit as this, and a plate potential of 200 to 300 volts, sufficient power output may be obtained on the second and third multiple of the crystal frequency to drive a type 6L6 or 807 power amplifier to full output.

The type 6L6 tube will deliver a large power output when operated properly, but care must be exercised in the choice of the plate and screen potentials. Thus, the screen must be maintained at a considerably lower positive potential than the plate or the regeneration within the tube will be sufficient to fracture the crystal. It is also very important that the screen be by-passed to the cathode by a suitable mica condenser, located at the socket terminals since any appreciable lead length at this point may produce parasitic oscillations. With the proper screen and plate potentials 6L6 tube will so operate that the value of r-f crystal current will not exceed 15 milliamperes and will not cause undue frequency error due to heating of the crystal. A typical circuit for so using the 6L6 is shown in Figure 8.

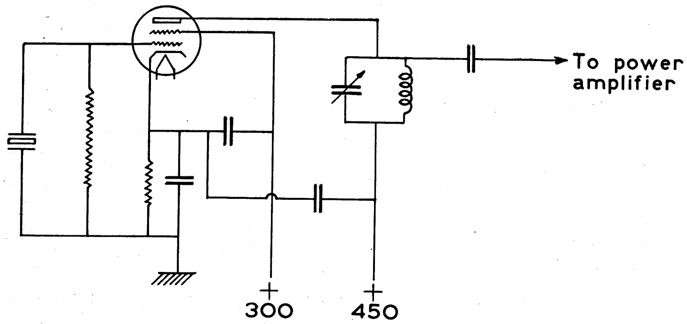


Fig. 8—Pentode Oscillator Schematic Diagram.

Crystal oscillators are generally followed by one or more stages of frequency multiplication. The overloaded amplifier type of frequency multiplier consists, in general, of an unneutralized class "C" amplifier with sufficient r-f power applied to the grid circuit to produce maximum possible distortion. The plate circuit is resonated at the desired harmonic of the input frequency, and provides excitation for the following vacuum tube circuit. Since the efficiency of such a system, is rather low it is commonly necessary to use several stages of frequency multiplication to obtain an output frequency of more than three times the input frequency. A schematic diagram of such a circuit is shown in Figure 9.

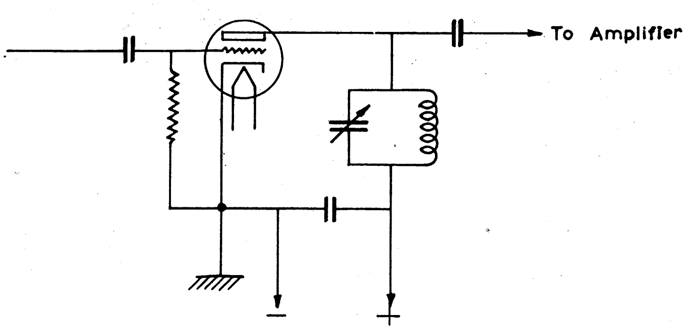


Fig. 9—Distortion Type Frequency Multiplier—Schematic.

While the push-pull frequency doubling system has been known for years, it became popular only on the advent of the twin triode tubes. The efficiency of this type of frequency multiplier is at least equal to the efficeincy of a class "C" amplifier. Two tubes or their equivalent must however, be used each time the frequency is doubled. The twin triode types incorporating the equivalent of two triodes in one envelope, are relatively inexpensive, have high mu grids, and are thus, ideal for frequency doubling applications.

A typical push-pull frequency doubling system is shown schematically in Figure 10. It consists of two triode units with their grids connected in push-pull, and with their plates connected in parallel, a resonant circuit is connected between

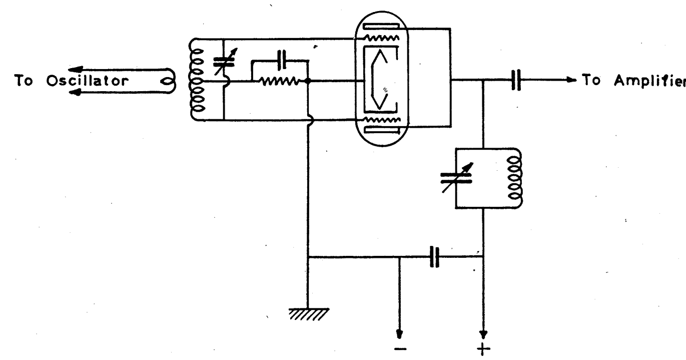


Fig. 10—Push-Pull Frequency Doubling System—Schematic.

the plates and the power supply, and the usual r-f by-pass condensers are provided. While almost any system may be used for providing the grid bias, the most popular is the grid resistor method shown. The bias, in any case, should be sufficient to operate the tube as a class "C" amplifier.

Any and all of the standard vacuum tubes can be made to operate in either of the frequency multiplying systems described above, provided the proper potentials are applied to the various tube elements. Some amateurs prefer the pentode types and others prefer the triodes. Both operate satisfactorily and it thus becomes a matter of individual choice.

The Crystal Controlled Dynatron Frequency Multiplier

Pentode type vacuum tubes have many characteristics which are desirable for oscillator and frequency multiplier applications. In amateur practice receiving type tubes are often used for the oscillator and frequency multiplying stages in transmitters. It is also not unusal in these applications to exceed the ratings established for receiving tube practice. Under these conditions, secondary emission effects may impair the operation of the circuit. One method of overcoming this difficulty is to employ the secondary emission phenomena to yield dynatron action. With this thought in mind, the dynatron frequency multiplier was developed. This system or some modification thereof is now very popular in amateur circles.

Prior to the development of the dynatron frequency multiplier, it was customary to utilize a master oscillator, crystal controlled or otherwise, to generate the primary oscillations. This was usually followed by buffer amplifiers to prevent reaction of the load upon the master oscillator and by frequency multipliers.

The crystal controlled dynatron frequency multiplier fulfills the following operating requirements,—

(a) The primary oscillations of the crystal are accurately maintained, irrespective of load and supply voltage conditions.

(b) Exact multiples of the fundamental crystal frequency are generated.

(c) A useful power output at multiples of the crystal frequency is provided.

Figure 11 illustrates diagramatically the crystal controlled dynatron frequency multiplier system here described. The tube used in this particular instance is a Type 57 or 6C6 pentode, such as is used in receivers. The suppressor and screen grids are connected together and are treated as a single screen grid. The plate and screen potentials are so chosen that the tube has a negative resistance characteristic.

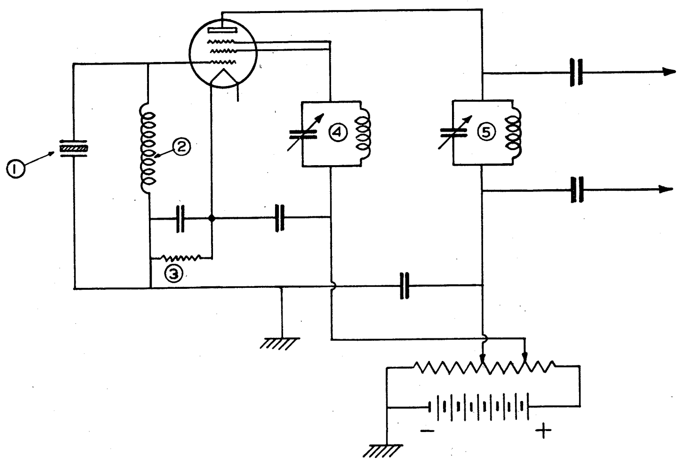


Fig. 11—Dynatron Frequency Multiplier—Schematic.

Referring to Figure 11, a quartz crystal is connected between the control grid and cathode in the conventional manner. A cathode biasing resistor, (3) maintains the proper biasing potential between the grid and the cathode of the tube through the r-f choke, (2). The screen grid is connected through a parallel tuned circuit (4) to a source of potential, as is also the anode, through another parallel tuned circuit (5). As indicated, the screen grid is maintained at a higher positive potential than the anode, the potentials being chosen that the tube has a negative resistance characteristic. Consequently, by the insertion of a resonant system such as (5) in the anode circuit, the device will generate oscillations at a frequency roughly determined by the constants of circuit (5).

Dynatron oscillators are inherently stable, but they are affected to some extent by power supply variations, conditions of load, etc. On the other hand, their frequency is easily controlled or stabilized by the insertion of a small amount of power in the control grid circuit. In the crystal controlled dynatron frequency multiplier, the control or stabilization is accomplished by the insertion of a crystal (1) in the control grid circuit, and a parallel resonant circuit (4) between the screen grid and the power supply. When the parallel resonant circuit (4) is tuned approximately to the fundamental frequency of crystal (1), oscillations are generated in circuit (4) by virtue of the regenerative capacitive feedback coupling between the screen and control grids within the tube.

Oscillations generated by the negative resistance or what is better known as the dynatron characteristic of the tube, will be locked or pulled into step with the crystal control frequency. In this manner oscillations in the resonant circuit (5) will always be built up at some frequency bearing a harmonic, or a sub-harmonic relationship to the crystal frequency.

In practice, the biasing resistor (3) is of such a value that the negative grid bias prevents oscillations in the dynatron portion of the system when the crystal is not oscillating. This is done to preclude the possibility of operating the system on some random frequency should the crystal cease to oscillate. The desirability of such an arrangement is generally appreciated in amateur, as well as commercial circles. It is probably appreciated most by those amateurs who have been so unfortunate as to have received a "pink QSL" from the Federal Communications Commission for off-frequency operation.

Although the tubes of the 57 or 6C6 type are usually considered to be low power receiving tubes, they are capable of delivering an output of over two watts when employed in dynatron frequency multiplier circuits. The screen potential may be on the order of 375 volts and the plate potential on the order of 250 volts, without any danger of injury to the tube. Under these conditions, the r-f current through the crystal is on the order of from 3 to 5 milliamperes, and therefore negligible. While the author has obtained satisfactory results under these conditions, it should be noted that they are considerably in excess of the manufacturer's published ratings and therefore abnormally short tube life may be experienced.

The dynatron frequency multiplier has many uses other than in crystal-oscillator-frequency-multiplier systems. It is being used commercially for frequency multiplication in applications where it is desirable to obtain a relatively high frequency, in synchronism with a lower base frequency. One example of such an application is the carrier tone generator system used in the RCA Communications' photoradio system. In this system, the base frequency (810 cycles) is used to control a dynatron frequency multiplier which generates frequencies of 1620, 2430, and 3240 cycles. These frequencies are selected by means of a tap switch. The resonant frequency of the dynatron plate circuit is altered by adding or subtracting capacity. A schematic diagram of the basic dynatron circuit used in the photoradio application is shown in Figure 12.

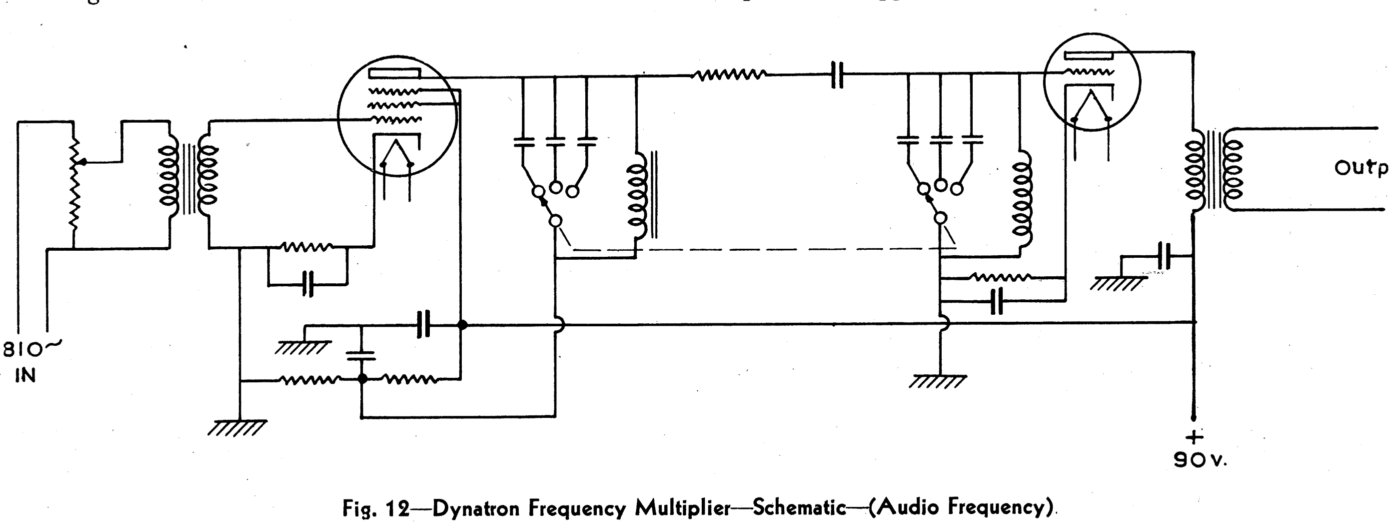


Fig. 12—Dynatron Frequency Multiplier—Schematic—(Audio Frequency).

With the dynatron frequency multiplier, it is possible to obtain perfect control of output frequencies up to and including the thirty second multiple or sub-multiple of the controlling frequency.

The physical construction of the tube determines it efficiency as a dynatron oscillator, and, therefore, the working range in the radio frequency spectrum. Employing the 57 type tube, the upper limit appears to be approximately 10 megacycles. With other tubes, particularly the pentode types, designed for ultra high frequency operation, satisfactory controlled dynatron oscillations have been produced at considerably higher frequencies. Special dynatron tubes have been designed with characteristics permitting operation at 160 megacycles. The power output at any frequency appears to be governed by the circuits employed and the ability of the tube to produce dynatron oscillations rather than the ratio of the output frequency to the controlling frequency. In other words, the output will be of the same order of power whether or not a controlling frequency is applied.

Amateur Trends

The general trend among the amateurs seems to be toward radio-phone operation and away from the old style telegraph operation. While many old time operators are loath to admit this the majority of the newly licensed stations operate telegraph systems only for a sufficient length of time to qualify themselves for an unlimited radiophone license. Both types of communication have their advantages. For instance, it is possible to communicate with extremely weak distant stations by means of telegraph when a voice modulation on the same signal would be unintelligible. On the other hand, most telegraph contacts are of the "how's my signal—see you later" variety. There is little or no personal touch in a keyed signal such as there is in a voice signal, and, consequently, little incentive to prolong a contact.

In the earlier days of amateur radiophone operation, most stations were equipped to operate both phone and "C. W." telegraph. The "C. W." telegraph systems were used for calling a station, and the radiophone was used after the contact had been established. At the present time few radiophone stations are equipped with telegraph control. This is a normal evolution, as it is natural for human beings to express themselves with their voices rather than with their hands.

Most modern amateur stations are capable of being operated on several frequencies within any chosen amateur band. This is accomplished by the provision of several crystals in the oscillator system. The desired crystal is selected by means of a tap switch. The difference in frequency between crystals is not sufficient to necessitate retuning of the transmitter, and, as a result, the operator needs only to snap the switch to a new position to change the transmitter frequency. This is often very helpful in cases of extreme interference.

Figure 13 is a schematic diagram of the exciter unit used by the author. This exciter is equipped with six crystals and a selector switch. The frequencies of the crystals are such that the fourth multiple of their fundamental frequency falls within the limits of the 14 megacycle amateur radiophone band. The circuit used incorporates both the crystal controlled dynatron frequency multiplier and the push-pull frequency doubling system, together with a power amplifier and the necessary plate, filament and bias power supply systems.

In an emergency, this unit may be removed from the rack and used as a low powered portable transmitter. The power

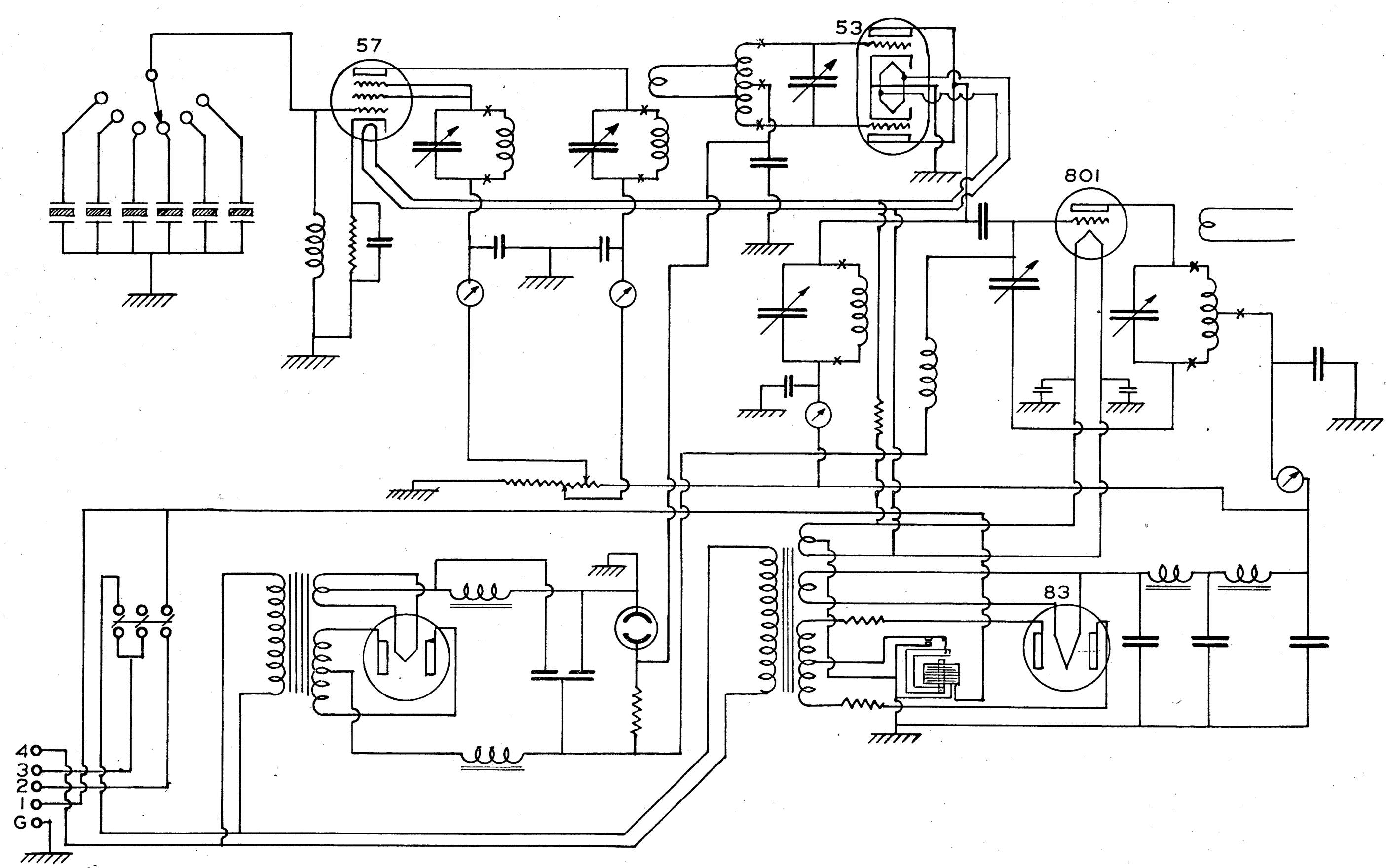


Fig. 13—W2BFB Exciter Unit.

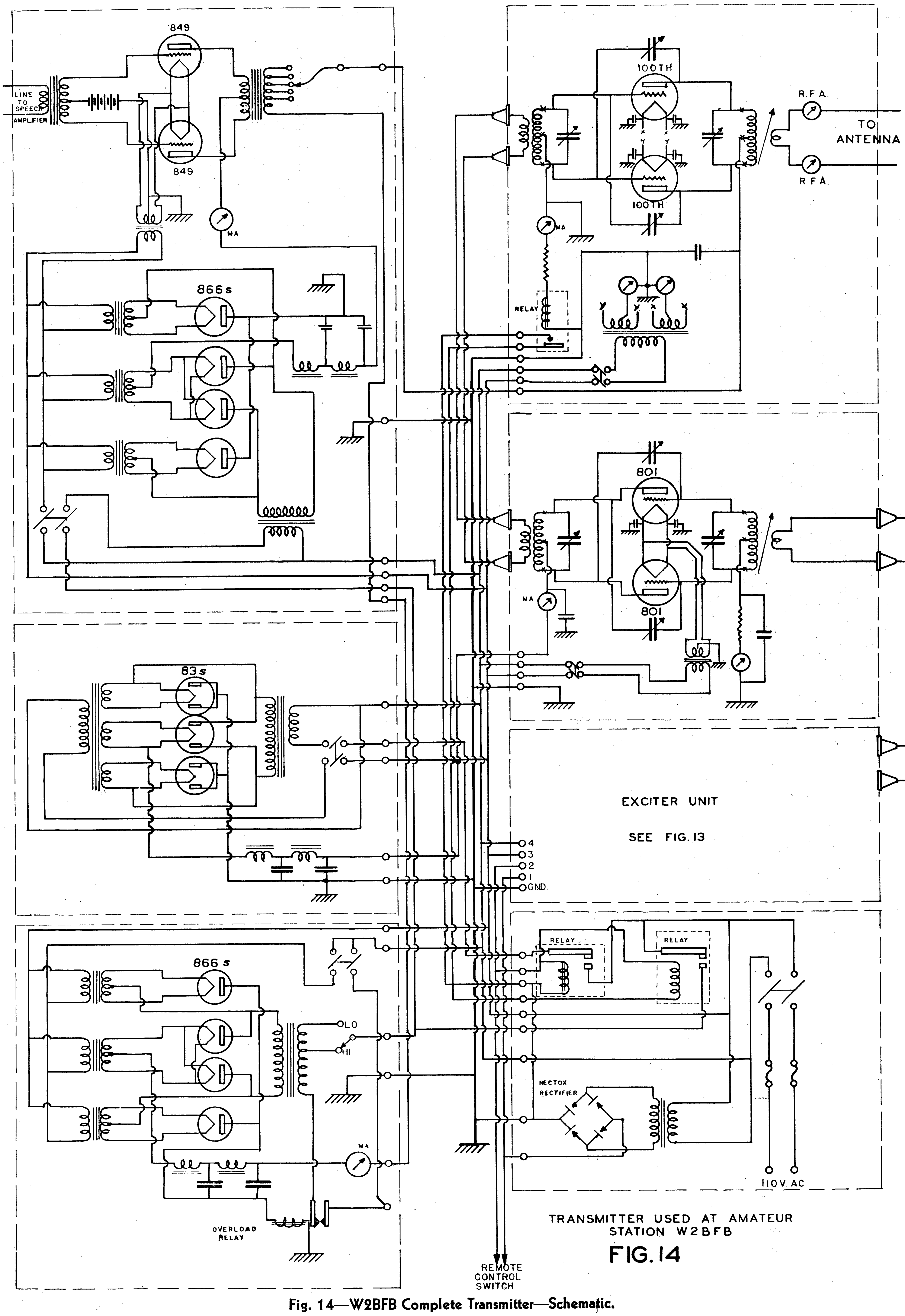


Fig. 14—W2BFB Complete Transmitter—Schematic.

requirements are not beyond the capabilities of a small rotary converter, which may be operated from an automobile storage battery.

The exciter unit is followed by a medium powered push-pull amplifier, which, in turn, is followed by a 1 KW, class "C" modulated push-pull final amplifier. The complete transmitter is shown schematically in Figure 14 while Figure 26 shows a photograph of this transmitter.

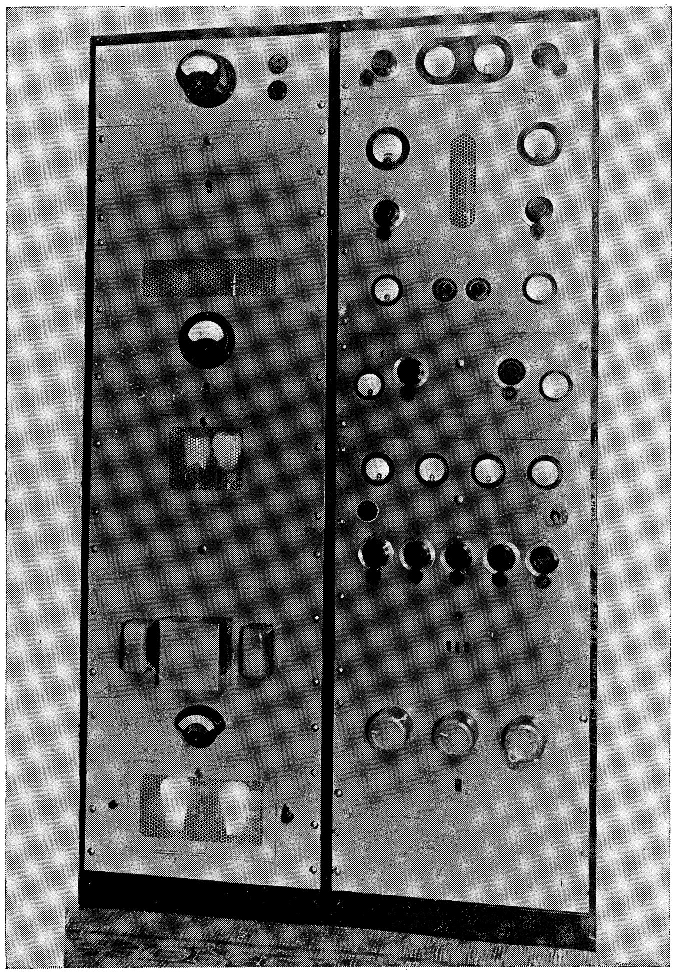


Fig. 26—Photograph of W2BFB Transmitter.

The speech amplifier is of the usual high gain type with push-pull 6L6 output tubes. The input impedance of the amplifier is ½ megohm and is intended to operate from a condenser-velocity type microphone. The output impedance is 500 ohms, and operates into a line running to the modulator.

The modulator is equipped with 849 type tubes. The grid bias on the modulator is adjusted for class "AB" operation. Smaller tubes could be used for this purpose if they were operated as class "B" amplifiers, but there would be more audio frequency distortion present. For this reason, the author prefers the larger tubes operating as described above.

Modern Receiving Trends

The congested condition of the amateur bands places very rigid requirements on the receivers, as well as on the transmitters. High sensitivity, extreme selectivity, and ease of adjustment are absolute essentials. The only receivers which meet these requirements are the superheterodyne type. With this type of receiver, at least two stages of r-f amplification are needed to provide the required image rejection. Most modern receivers have sufficient sensitivity to receive any signal which is above the atmospheric noise level.

Devices have been developed to eliminate the effect of high noise peaks. One such device is described in the February, 1936 issue of "QST". Similar devices are incorporated in some commercially built amateur receivers.

The only real serious problem remaining is that of obtaining the proper selectivity. The selectivity of modern receivers is usually governed by the band-pass characteristics of the intermediate frequency amplifiers. It is highly desirable that this band width be controlled by the operator in order that he may adjust the receiver for a maximum band width when receiving strong signals from stations operating on a comparatively clear channel, or for minimum band width when receiving weak signals, or signals which are subject to severe interference. The most convenient and effective method of obtaining band width control is to provide a variable coupling in the intermediate frequency transformers. With such an arrangement, it is possible to obtain a band width which is continuously variable between 1500 and 15,000 cycles.

There are times, however, when a band width of 1500 cycles is too great. For these extreme cases, the receiver manufacturers have provided a quartz crystal filter. A typical crystal filter is shown schematically in Figure 15. With a crystal

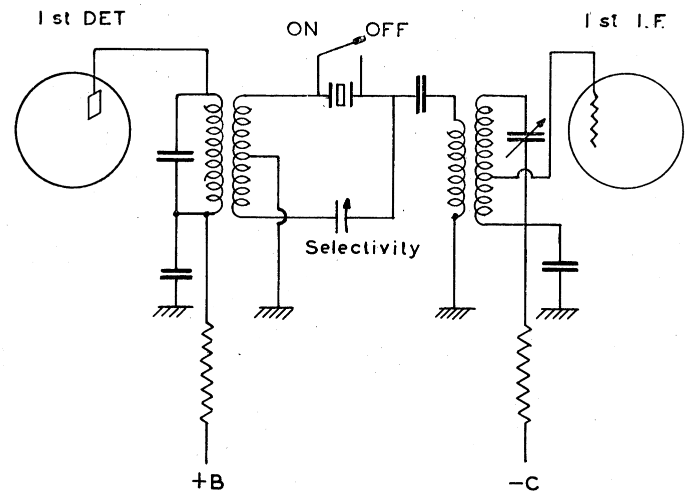


Fig. 15—Crystal Filter—Schematic.

filter it is possible to narrow the band-pass of the receiver to approximately 200 cycles, if necessary. Such a narrow band width is completely destructive of the fidelity of speech transmission but it will often provide a means for successfully completing a contact that would otherwise be lost in the interference of other stations. Another advantage of extreme receiver selectivity results from the fact that the background noise is directly proportional to the band width of the receiver. For this reason, a signal which is normally below the noise level may often be made intelligible if an extremely selective adjustment of the receiver can be obtained. The use of properly balanced receiving antenna and transmission line systems are very effective in increasing the signal to noise ratio. Many receiver manufacturers are providing a balanced input system for the antenna couplers. Some of the receivers are also equipped with electrostatic shields between the antenna coupling coils and the first r-f amplifier grid input circuit. This arrangement reduces the electrostatic unbalance of the input coupling circuit and thereby reduces local noise pick-up.

Monitoring Systems

All amateur radiophone stations should be equipped with a monitoring system capable of indicating the percentage of modulation of the transmitter. While a means for indicating overmodulation is required by law, no conscientious amateur will stop at that point. He will equip his station with means for detection of any improper operation of his transmitter. The most satisfactory instrument for this purpose is the cathode ray oscilloscope. A few years ago such an instrument was beyond the means of the average amateur. At the present time, however, there are very good cathode ray tubes available at prices within reach of all, and, as a result, few stations are without such equipment.

There are many simple overmodulation indicating systems in general use. The most popular arrangement is indicated schematically in Figure 16. This arrangement is very simple

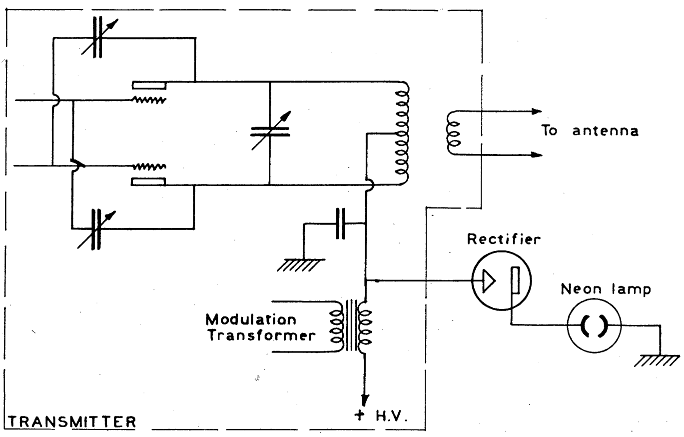


Fig. 16—Overmodulation Indicator.

and is practically fool-proof. It consists of a small high voltage rectifier tube, such as is commonly used in a cathode ray tube power supply, connected to the modulated r-f amplifier, as shown in the diagram. A neon lamp flashes when the plate voltage to the power amplifier becomes negative due to overmodulation. This arrangement complies with the law and is a very effective overmodulation warning. The neon lamp will flash a red warning on any overmodulation peak, regardless of the duration of the peak. The lamp may be mounted in any convenient place and is usually mounted in front of the operator.

A very effective monitoring system may be incorporated in a superheterodyne receiver. A schematic diagram of such a system appears in Figure 17. A photograph of the receiver incorporating this monitoring system is shown as Figure 27. This arrangement has been in use at the author's station for several years and has proven entirely satisfactory for monitoring local, as well as distant stations. Any station that can be received reasonably well can be monitored perfectly.

A standard cathode ray oscilloscope is equipped with a tuned circuit, resonated at the intermediate frequency of the receiver. A link coupling is arranged to transfer a small amount of r-f power from the second detector input circuit to the resonant circuit in the oscilloscope. When a signal is tuned in, the r-f envelope will appear on the face of the oscilloscope tube and may be studied by the operator. The pattern obtained in this manner is the same as that obtained by coupling the oscilloscope direct to the antenna of the transmitter. If it is desired to obtain a triangular modulation pattern with this

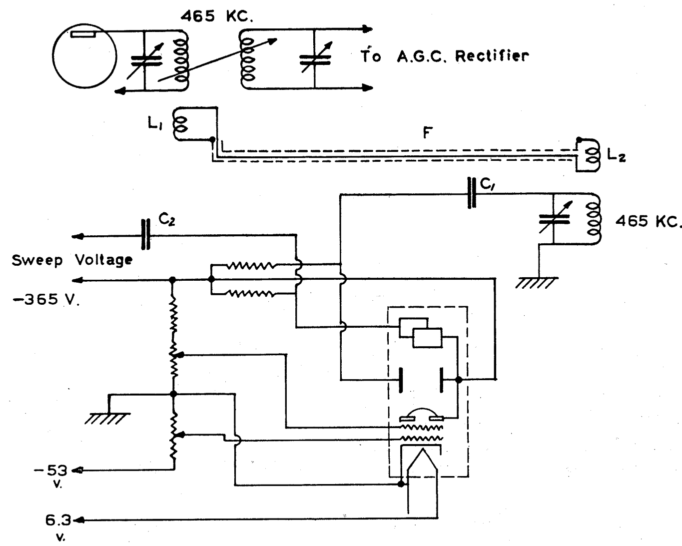


Fig. 17—Modulation Indicating Monitor.

arrangement, the linear sweep circuit may be replaced with a suitable connection to the receiver's audio frequency amplifier system.

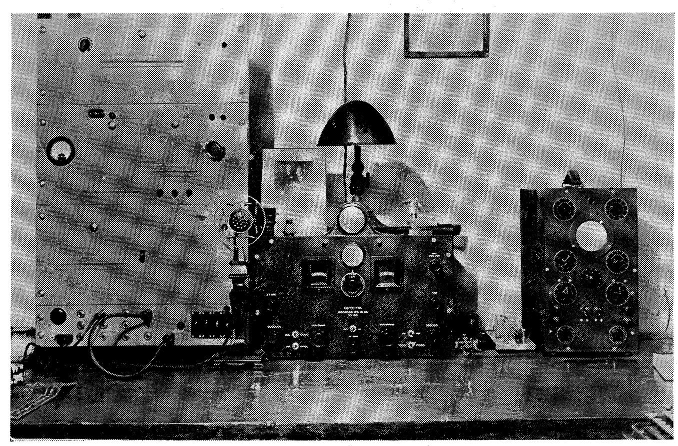


Fig. 27—Photograph of W2BFB Receiver and Monitor System.

Antenna Systems

The problem of antennas for amateur use is never quite the same in any two locations. The type of antenna used is generally more dependent upon the space available and the friendliness of the neighbors than on any other factor. The amateurs realize more and more that an efficient antenna system is the most economical method of "increasing power". The trend is therefore, to increase the efficiency of the radiating system rather than to build the transmitter up to the "1 KW" class. Various types of directive antennas are becoming increasingly popular, both for transmission and reception. The same antenna is generally used for both transmission and reception. The most desirable arrangement is a directive array which may be rotated through 360 degrees. An antenna of this type is commonly known as a "rotary beam" antenna. It generally consists of a half wave self-supporting rod with either a reflector or director, mounted on a rotatable member. The entire assembly is mounted on a suitable mast or pole and rotated by means of a reversible motor controlled from the operating position. A potentiometer is mounted on the rotatable structure and is

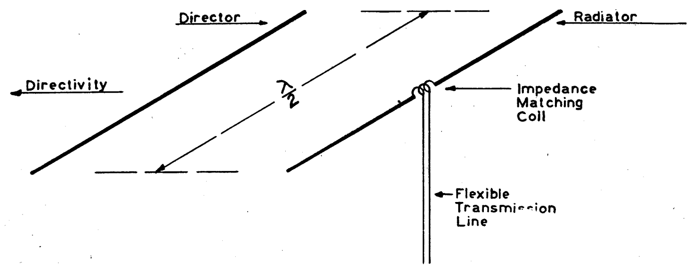


Fig. 18—Rotating Beam Antenna.

connected to a meter and battery located at the operating position. The meter is calibrated in points of the compass in order that the operator may easily determine the direction in which his signals are being radiated. A schematic diagram of an antenna of this type appears in Figure 18. A photograph of this antenna arrangement is shown as Figure 25.

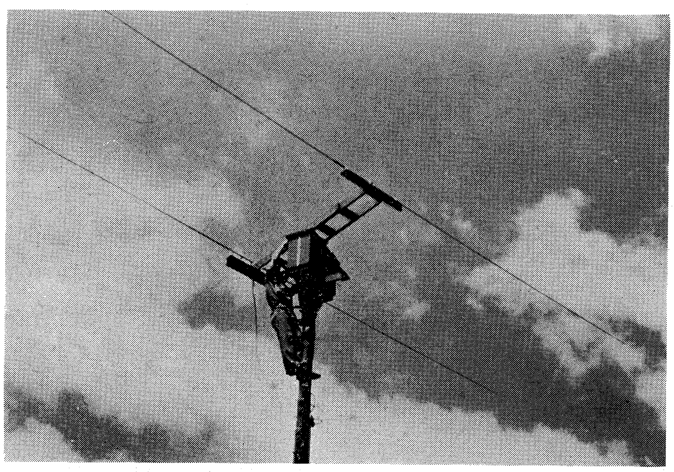


Fig. 25—Photograph of Rotating Beam Antenna.

A commercially built antenna which has been popular for some time is known as the "Johnson Q" antenna. It consists of a standard half wave doublet broken in the center, with the transmission line coupled to the radiators through an impedance matching system consisting of two parallel aluminum tubes. This type of antenna is illustrated in Figure 19.

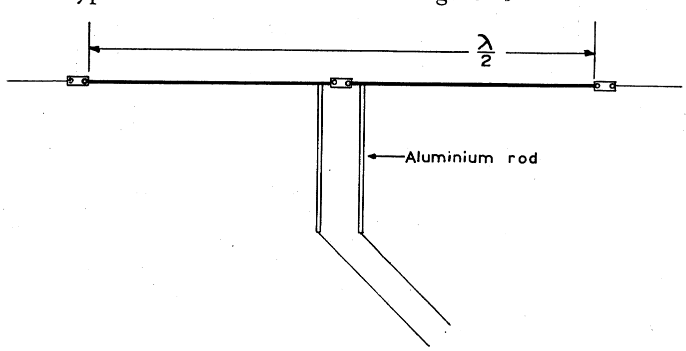


Fig. 19—Illustration of Johnson "Q" Antenna.

There are several types of fixed directional antennas in general use. The diamond antenna is one of the most popular where space permits the erection of such an array. This type of antenna is shown in Figure 20.

An adaptation of the Adcock direction finder antenna is also very popular. This adaptation is known as the "8JK beam" antenna, primarily because amateur station W8JK was

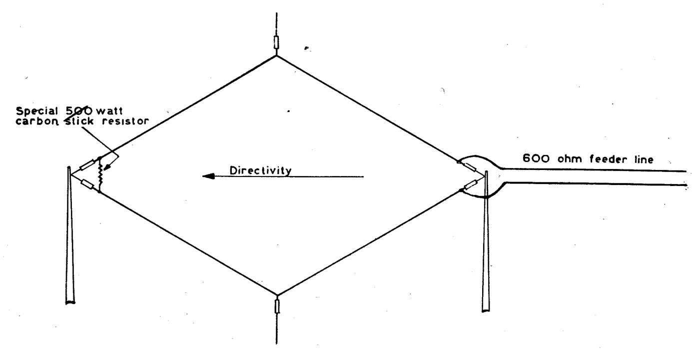


Fig. 20—Diamond Antenna.

the first to give this system general publicity for amateur uses. A schematic diagram of this antenna is shown in Figure 21.

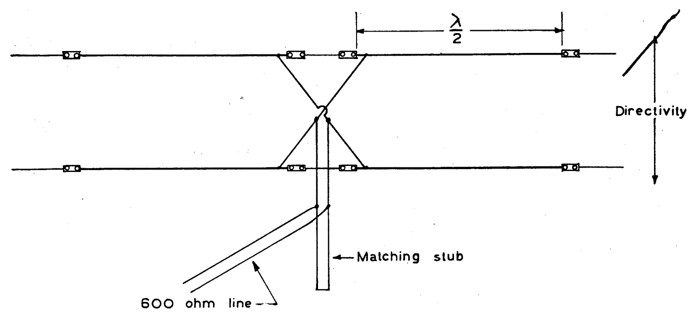


Fig. 21—"8JK Beam" Antenna.

The directional antenna used by the author is known as the "extended dipole" antenna. This antenna was developed by the RCA Communications' transmitter engineers. It consists of a flat top, approximately 1.2 wavelengths long, with the feeder line connected in the center of the flat top. The feeder system is resonant, although a non-resonant line would be preferable if the length of the feeder system was over 100 feet. The antenna points North and South, and radiates best to the East and West. The radiation pattern is shown in Figure 22.

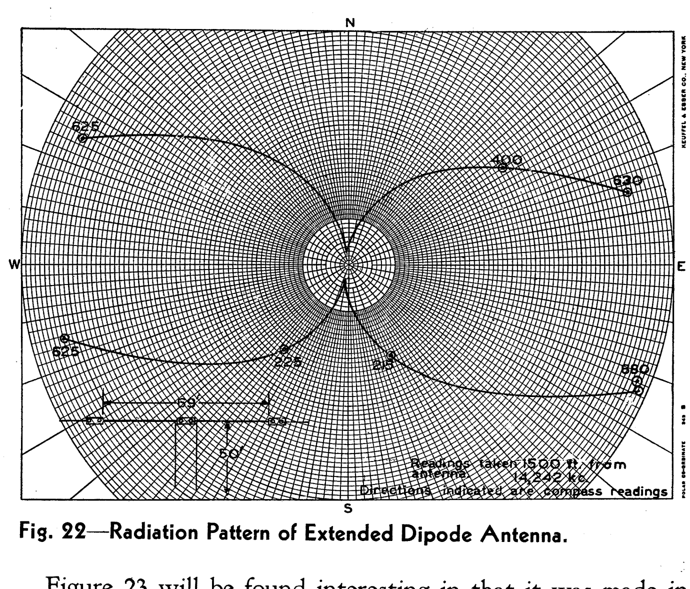


Fig. 22—Radiation Pattern of Extended Dipode Antenna.

Figure 23 will be found interesting in that it was made in an effort to check the measured radiation pattern shown of Figure 22. To make this chart, each station contacted over a considerable period was spotted on the map and a line drawn between that point and the location of the antenna being checked. The interesting feature is that the practical coverage of the antenna thus shown corresponds almost exactly to that indicated by radiation pattern of Figure 22.

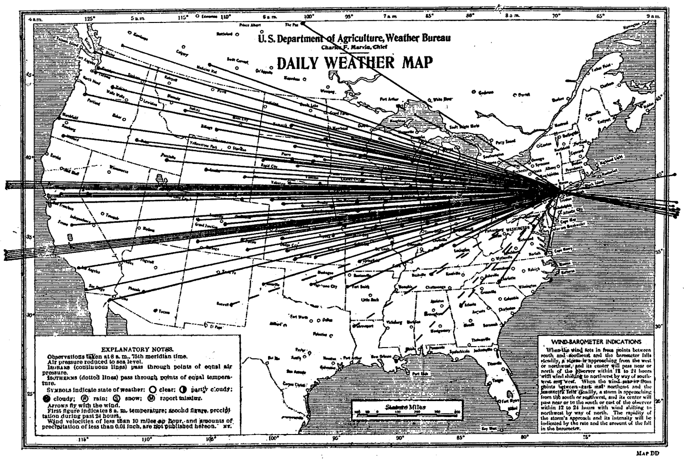


Fig. 23—Map used to check Figure 22 in practice.

As previously mentioned, it is common practice to use one antenna for both transmission and reception. For this purpose, an automatic transfer relay is used to transfer the antenna from the transmitter to the receiver or vice versa. This transfer relay is generally connected in parallel with the transmitter starting relay in such a way as to automatically transfer the antenna to the transmitter when the transmitter is turned on, and to the receiver when the transmitter is turned off.

The transmission line impedance is usually on the order of 600 ohms, and the receiver input impedance on the order of 75 ohms. It therefore becomes necessary to provide a means for matching the 600 ohm transmission line to the 75 ohm receiver input in order to realize the full advantage of the antenna. The general practice is to make use of a tuned transformer which is tapped at 600 and 75 ohms. The tuned transformer is resonated at approximately the center of the frequency range to be covered. A schematic diagram illustrating the change-over relay and the receiver impedance matching system is shown in Figure 24.

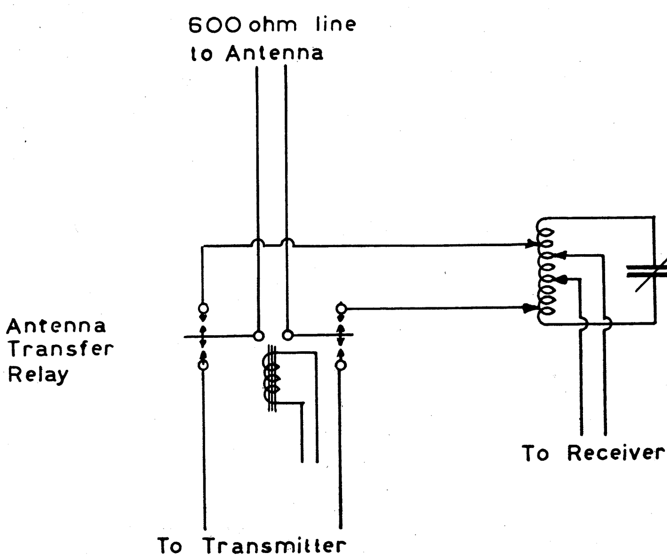


Fig. 24—Transfer Relay and Impedance Matching Network.

Interference Problems

The amateur is continually confronted with the problem of interfering with the reception of broadcast programs. This is particularly annoying in densely populated areas where it is all but impossible to locate the transmitting antenna at any considerable distance from the broadcast receiving antenna. Usually a simple wave trap in the antenna of the broadcast receiver will eliminate all traces of the amateur station signals, but it never seems to eliminate the various other noises that are attributed to the amateur, especially those that occur in those periods when his station is not in operation.

Many freak conditions are encountered in interference problems. For instance, one amateur received a telephone call from an irate neighbor in the wee small hours of the morning and was requested—none too gently—to stop causing the light in his bedroom to "blink". This very disturbing phenomena was finally eliminated by placing a fixed condenser across the neighbor's lamp socket. Another rather disturbing case of interference was discovered by one of the Westchester amateurs. His neighbor, having a very elaborate radio-phonograph combination, was entertaining a number of guests one afternoon with phonograph music. To his understandable surprise, a strangely familiar voice was heard—"calling C-Q" whenever he touched the phonograph pick-up arm. Proper grounding and the installation of a suitable antenna on the broadcast receiver solved this problem.

A most startling incident occurred in New Rochelle. In the middle of the preparation of a Sunday dinner, a gas range suddenly began to call "C-Q". The cook probably thought that the roast had suddenly come to life, or that the steer's ghost had come to haunt her. This particular case was caused by resonance in the gas pipe between the earth and the stove, and by the accident of the location of the transmitting antenna with respect to the stove. A little careful bonding and grounding eliminated the "voice from the oven".

As a general rule, the neighbors are very tolerant, and are willing to permit the amateur to use what means he sees fit in eliminating the interference. Also, a good modern broadcast receiver is seldom, if ever, bothered by interference from an amateur station. Unfortunately, this is not true in the case of some of the receivers of the all-wave-super-so-and-so type. Neither, however, is it true of the better receivers, if the amateur station is not properly operated.

Any conscientious amateur will do everything possible to obtain and maintain the proper operation of his equipment. The overmodulated radiophone transmitter will often cause interference in near-by broadcast receivers which will be as objectionable as the clicks caused by radio telegraph transmitters. Many individuals, as well as clubs, throughout the world are working together in an effort to combat this evil, and a great deal of progress is being made along these lines. The monitoring system which utilizes the cathode ray tube in conjunction with a receiver, as described earlier in this paper, is the most reliable equipment for use in detecting overmodulation difficulties of remote stations. The author has been able to assist many stations in eliminating their difficulties by the use of this system. Requests are continually being received for checks and test schedules with stations as far distant as Australia and South Africa.

Interesting Amateur Activities

Amateurs in all parts of the world have some very interesting contacts with each other. It is common practice for several amateurs, each in a different part of the world, to get together on pre-arranged schedules and hold a "round table" chat. These contacts are not only very interesting but they create no inconsiderable amount of international good will. A few of these contacts will be described below.

A local station was covering the band looking for a little excitement. A station in Greece was coming through with a fairly good signal, as was a Cuban station, and the MacGregor Arctic Expedition. The station in Greece was contacted, and asked if he would stand by while the other two stations were contacted. In short order, the station in Cuba and Arctic Expedition were contacted, and the party was on. Each station was able to hear the others quite well, and the exchange of friendly greetings followed by comments and "tall stories" continued for some time. By mutual agreement, each station "takes the air" for a given length of time. At the end of the allotted time, the next station in line comes on and the operator adds his comments, and, perhaps, a "tall story" or two.

On one occasion, the author enjoyed the thrill of working a three way contact with a station in Australia and a station in South Africa. Each station was able to hear the other two stations, and the contact was maintained for nearly half an hour. At that time the conditions had changed and the station in South Africa was no longer audible.

While contacts such as these are not unusual, the most common are over much shorter distances. In fact, some of the most enjoyable "round tables" are between stations within a radius of approximately 20 miles. The value of such contacts in time of emergency is clearly indicated by the splendid work done by amateur stations during floods and other catastrophies. By contacting stations regularly, the amateur station owners know what time of day certain stations are likely to be "on the air", and their geographical location. With this information available, they know immediately who to look for at different times of the day should an emergency arise.

The amateurs of Westchester County hold regular "round tables" at least once each week. There is very little technical discussion included, as a general rule. The time is devoted almost entirely to enjoying the contacts as much as possible. The method of creating fun during these "sessions" will be described in greater detail later.

The introduction of all wave receivers has made it possible for many broadcast listeners to enjoy some of the "round tables" between the amateurs. This is proven by the large number of listener's cards received by the more active amateur stations. In some instances, groups of listeners have requested amateurs to lecture on their hobby in order that the listeners may become better acquainted with what transpires "behind the scenes". Such a lecture was given by one of the Westchester amateurs a short time ago, and the response was so great that two additional lectures have been arranged in neighboring communities.

The lecture in Pelham was accompanied by a practical demonstration of amateur radio. A portable transmitter was installed in the lecture room, along with two receivers. The transmitter was operated in the 56 megacycle band, rebroadcast on the 28 megacycle band by a near-by station, and again rebroadcast on the 14 megacycle band. The regular Westchester group of amateurs were all standing by ready for the word to go ahead. When the lecture was over, each station in turn contacted the portable station in the lecture room through the chain hook-up described above, and many of the persons in the audience were given the opportunity of talking "over the air". A station in Cuba was also contacted during the above proceedings, and the operator obliged by telling something of the operation of a sugar mill.

The "Westchester EarBenders"

The "Westchester Earbenders" are a group of amateurs who meet "on the air" each Sunday and Wednesday night throughout the Winter season. The purpose of the organization is to promote good fellowship, assist each other in solving knotty technical problems, and to obtain all possible enjoyment from amateur radio. The organization was given its name by one of the listeners. The meetings "over the air" are generally discontinued in the Summer, when the 14 megacycle amateur band remains "open" at night. This is done to prevent interference with distant stations. In the Winter months, distant stations are not usually heard after nightfall, and there is little danger of causing general interference during the sessions.

A number of unique expressions and terms have been coined by the "Earbenders". In order that the reader may understand the meaning of these expressions, a list appears below, followed by a word of explanation.

"Earbending"—Getting together for a good time via amateur radio.

"Pants Pressing"—When the intended victim immediately becomes suspicious that something unusual is going on, but is not quite sure, it is said that the trickster is "pressing a pair of pants" for him.

"Pants Stitching"—Working out some scheme to play a trick on some of the other members.

"Putting on the Pants"—When a station is completely taken in by one of the tricks, he is said to have had the "pants" or "britches" put on him. (The terms "pants" and "britches" are used interchangeably.

"Ear-muff"—A listener who does not have an amateur station but who listens in on the "Earbenders" regularly. This name was originated in retaliation for the name "Earbenders".

"On the Air"—When a station is in operation, it is said to be "on the air".

"Session"—A gathering of the "Earbenders" "on the air".

"Non Air Conditioned Transmitter"—A transmitter that cannot be heard over any great distance.

When an operator becomes completely bewildered, he is said to have "become befuddled and developed feedback". (This also originated with one of the listeners).

The official emblem of the Westchester "Earbenders" is a small pair of green "pants". No one can be a member of the organization unless he can easily be heard by all of the present members; is capable of "having the pants put on him" without becoming resentful, and has had the "pants put on him" in good shape.

All members of the "Earbenders" are located within an area of approximately 25 miles, with the exception of CO6OM in Cuba. This station is equipped with a special diamond antenna directed on New York, and can be heard under almost any normal conditions.

Some of the stunts used in "putting the britches", or "pants", on the other fellows are interesting. The following are some typical examples.

A short time ago when antennas were the principal topic of conversation and interest, a perfect "pair of britches" was "fitted" on most of the group. The station where the "stitching" originated had very recently erected a new antenna. All were deeply interested in the results, so the time was ripe for the trick. The proceedings were as follows:

(a) Two antennas were ostensibly used; one of which was fed in the normal manner, and the other fed through a "delay system". All other stations were requested to listen and report on the results as noticed at their respective stations. A phonograph with two pick-ups was used for the test. Each pick-up was carefully placed in the same record groove, but on opposite sides of the record, and their respective outputs appropriately mixed in the speech amplifier. The effect was perfect, and all stations except one reported that they were receiving a delayed signal, or an echo effect. All reports were very serious, and no one realized what was going on except the station who reported the signal as perfect. (That particular station knew what was going on, and his report was intended to indicate to the others that the test really had some technical significance.)

(b) The second part of the test was made in the same manner, except that the "second antenna" was to be rotated slowly. All were asked to report on the signal, indicating whether or nor the signal was "properly phased" at any position of the rotatable antenna. For this test, one pick-up was "faded" in and out. The reports were still very serious, and some stations even reported a much stronger signal when the "phasing" was correct.

(c) This test was intended to give the whole thing away. Both pick-ups were used as in the first test. An off center hole was bored in the record and the test carried out. Some of the "Earbenders" became suspicious that there was a little "pants pressing" going on, but could not be quite sure, and asked for another test.

(d) The last test was made by using a single pick-up, but the phonograph motor was reversed, and the record played from the center out. At the conclusion of this test, some one realized that all tests had been carried out with the use of a phonograph record, and that all voice transmissions were normal, and that they had been fitted with a good "pair of britches", but they were at a loss to explain how the results had been accomplished. After a little good natured argument, and after several impossible explanations had been made, the whole series of tests were explained, much to the merriment of all.

A trick that was used several times with good success was the "synchronous operation" of "two stations". This trick generally consisted of two operators talking over one station. The effect of occasional phase shift was produced by using some means for distorting first one voice and then the other.

Once, several operators were visiting a station and decided that they could do a little "pants pressing" by producing a heterodyne with a whistle. The station came on the air and called one of the "Earbenders". As soon as the contact was made and the conversation started, one visitor blew the whistle while the other started calling the station. When it was "turned over" to the victim, the response was immediate—the victim thought he had heard a bona-fide heterodyne and that there was another station trying to break in.

The initiation of CO6OM (a Cuban station) into the "Earbenders" was the hardest problem of all. The operator had been listening in for so long that he was very cautious about what he reported on any "stunt". He finally was "fitted with a pair of pants" in good style, and is now a bona-fide member of the organization. All the usual tricks were tried with no success. Finally, one of the members increased power, and CO6OM noticed the increased signal strength. He was immediately informed that the increased signal was due to a very unique antenna array that was being used. Being intensely interested in new antennas, he was thrown completely off guard, and the "stitching" began.

He was told to draw out the antenna as it was described to him. The description was given in such a way that when he was all through, he had a word rather than a sketch of an antenna. The word was "P A N T S", and CO6OM was an "Earbender".

Several times each year, the "Earbenders" have a party. At these parties almost anything is liable to happen. Some of the tricks played on the host are worth mentioning. For instance, a buzzer is connected to the antenna and the host is chided about his noisy receiver. One member of the "Earbenders" discovered a Universal motor packed in a box in his cellar, running merrily along, with the brushes sharpened to an edge so that a ring of sparks completely encircled the commutator. The effect was as complete as the buzzer connected to the antenna. (He was blamed for spoiling the broadcast reception in the entire neighborhood also.) During one party, the local police called to find out the meaning of a red lantern which was suspended from the antenna. Another "Earbender" found a huge pair of "pants" suspended high in the air, on a rope between a tree and his chimney.

With the exception of the author, none of the "Earbenders" are interested in radio except as a hobby. The membership includes bankers, ministers, music arrangers, dentists, business executives, sugar mill operators, etc. Most all members are also interested in both motion and still amateur photography. At the parties, the entertainment usually includes some photographic exhibitions, as well as the friendly nonsense. All are real "good fellows" and are always ready to lend a helping hand to any member or neighbor. Few of this group ever met before they become acquainted "over the air".

The foregoing description of the activities of the "Westchester Earbenders" is an indication of how amateur radio is truly a means for "Unbending the Ginks".

THE FINCH SYSTEM OF HOME FACSIMILE

AS DESCRIBED TO THE CLUB

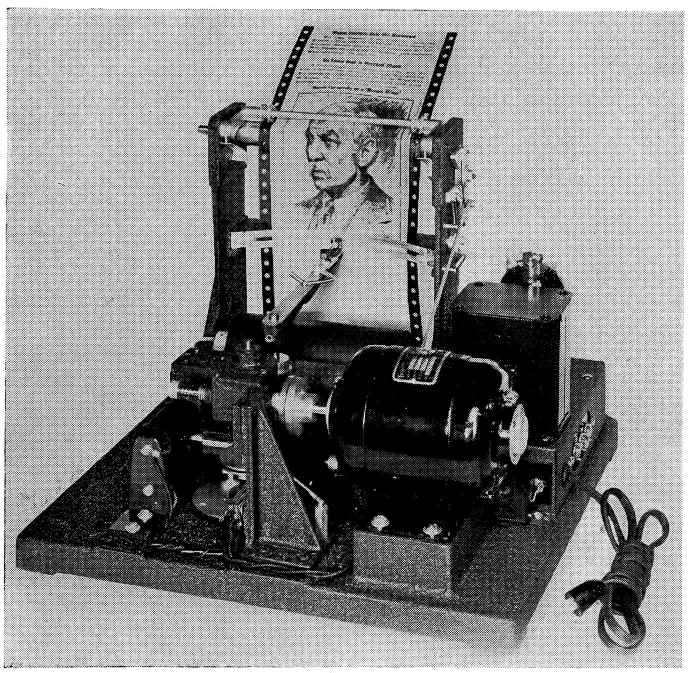
BY

R. H. MARRIOTT, April 14, 1938

Radio facsimile transmission as a communications medium is not new. It has been used commercially for years in sending news pictures and other copy across the Atlantic. Not until recently, however, have systems suitable as adjuncts to radio broadcast service been developed and these are being adopted only because certain basic problems have now been solved satisfactorily. Amongst these is the problem of synchronization, by which facsimile transmitting and receiving machines are maintained in step with each other and the problem presented by the need for simple and reliable automatic methods and equipment by which the radio facsimile newspaper may be printed in the home.

Synchronization

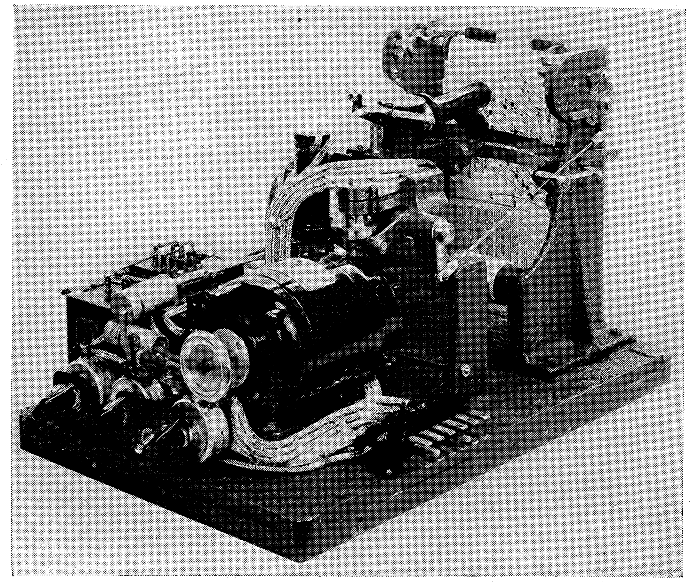
In the Finch radio facsimile system synchronization is effected by two simple means. One is the motor that drives the home recording machine in such a manner that it holds its speed at a substantially constant value. The other is a sensitive electromagnetic clutch operated by what is termed the



"selective synchronizing pulse"—a low frequency tone modulation of the radio signal of extremely short duration which not only starts and stops the recording machine at exactly the right time but also keeps the receiving machine in exact step with the transmitter throughout the printing period.

Scaning Unit

The facsimile transmitter employs a scanning machine which comprises the "copy head"—which holds and advances the copy—and the "scanning head." The latter consists of a small



electric bulb, a lens system and photocell. The light from the bulb is focused, as a small spot, on the surface of the paper carrying the copy and the reflected light is picked up by the light-sensitive photocell. The scanning head is moved from side to side through a small angle by an electric motor so that the spot of light traces a series of parallel paths across the copy. The copy is moved upwards through a distance equal to the diameter of the light spot at the end of each scanning stroke. In this manner, the entire surface of the copy is scanned horizontally one hundred times for each vertical inch of copy. The variations in light reflected on the photocell effect a change in current flowing through it and thus control the amplitude of the tone available for modulation purposes to the radio transmitter in the same manner as in sound broadcasting.

Recording Unit

The recording machine is in many ways similar to the scanning instrument. A "copy head" holds the electrosensitive recording paper which is fed as a continuous strip, two newspaper columns in width, from a roll carried in the lower part of the machine. A small synchronous motor moves the recording stylus back and forth across the paper in step with the scanning head of the transmitter. The recording stylus, .010 inches in diameter, marks the paper throughout one half of each excursion in accordance with the intensity of the audio tone signal. At the end of each excursion the stylus comes to rest until a low-tone signal impulse sent out by the transmitter starts the next excursion through the action of the magnetic clutch. In this manner the recorded copy is built up line by line to duplicate the original copy.

The home recording machine requires about 300 watts for its operation and may be connected without auxiliary amplifying equipment to the output circuit of any broadcast receiver having a power output of four watts or more.

The broadcasting station from which facsimile signals are sent is tuned in as when regular sound programs are to be received. The facsimile recorder is switched on and the volume control of the receiver is turned to the point where copy has the desired contrast. There are no adjustments on the recorder other than the initial adjustment of framing and of stylus pressure.