Notes on
Amateur Radio
Transmitter
Design

Compiled by
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PUBLISHED BY JAMES MILLEN, INC., MALDEN, MASS
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INTRODUCTION

This booklet is not offered as a handbook on amateur transmitter design, but as a miscellaneous collection of ideas, suggestions, and handy data that it is hoped will prove helpful to the amateur, whether he be new or old, planning a revision of his station equipment. For a complete and somewhat more academic treatment of the subject, Amateur Transmitter Design, no book is likely to surpass the A.R.R.L. official Radio Amateur's Handbook.

Most of the apparatus described and illustrated herein was originally designed for use at W1HRR. In addition, we are indebted to Herb, Becker, W6QD; Martin Brown, W6ABB; George Grumman, W1DF; and Ed. Roth, W2HYL, and Dana Bacon, W1EZB, for the privilege of including illustrations and descriptions of transmitters built by them for use in their own stations.

In order to secure at least some semblance of order in this presentation of the subject, the contents of the booklet have been divided into sections on Exciters, Final Stages, Complete Transmitters, Modulators, Power Supplies, and Antennas. Naturally, some transmitters are so physically designed that it is rather hard to arbitrarily divide them under such headings. For editorial presentation, consequently, in the chapter on Complete Transmitters will be found some material pertaining theoretically at least to some of the other divisions.

In treating Final Stages, all references to linear amplifiers have been purposely avoided, as their use up to the present in amateur communication work has been quite limited. Primarily, this is because until a little over a year ago, when W. A. Dobretz of the Bell Telephone Laboratories presented his paper on High Efficiency Linear, it was generally considered that their efficiency was limited to about 25 per cent. Sufficient time has not yet elapsed for the amateur fraternity to put into extensive application the...
principles of the Dobson high efficiency linear amplifier. Perhaps another year may see a trend in that direction.

All material on ultra-high frequency equipment has also been purposely avoided, as it is felt that such material is rightfully the subject of another booklet.

In addition to the individuals mentioned above, we are also indebted to the editors of QST for permission to re-use many of the illustrations which appeared originally in QST. We are also indebted to M. L. Mullenman of All-Wave Radio for the illustrations on pages 34 and 56, and to the Radio-Television Supply Co., the Radio Supply Company and the magazine, Radio, all of Los Angeles, for the illustrations of the W6QD and W6ABF transmitters.

April 1, 1938

James Millen

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The EXCITER

In recent years the trend in both amateur and commercial transmitter design practice seems to be toward the treatment of the exciter as a separate unit. During the past year or so much progress has been made in the design details of exciter units with a view toward increasing their reliability, compactness, universal applicability, ease of hand-adjust, and provision for control of frequency adjustment.

The advent of the 52 tube, and the "magnetron," the 858, has made possible a very practical and compact circuit which is the basis of most of the exciters described and illustrated herewith. In using the double-tube type of tube, such as the 858, one of the sections is used as a triode adding harmonic output. Two triodes are often used at the input stages to produce greater output and better efficiency.
In Fig. 11 it is still another example of the use of line-fed tank units to form an efficient and compact exciter. This particular unit is for operation in the 20-meter phone band, using no adjustable air gap type of variable frequency crystal control, in which the crystal is mounted behind the panel and reached from the back by means of a length of flexible tubing, finished with the crystal holder for that purpose.

It was designed by driving the pair of 2C-30 buffer units shown in Fig. 40, on page 40, which were in turn used to drive the twenty meter 4H6s, with final amplifiers at W1HKS, using a pair of W2C2S. The crystal is an 80-meter Holocom at the National CIV variable isolator giving a 97 KC mag in the 20-meter phone band. The unit uses a pair of 8G6 tubes. Simplicity of construction is secured by using a pair of FXT feed tank units mounted on a shallow vertical chassis to which is attached all of the wiring. Control of the crystal frequency is brought out to the front panel by means of the flexible drive shaft furnished as standard equipment with the CIV holder. Where the drive shaft passes through the baffle in the chassis, a shielded gold resistor, grounded, such as used on A.C. coils, is employed to assure smooth tuning.

By using tuning plug-in bases for the pre-tuned tank circuits it is possible to have 10 independent link-adjusting windows on each output tank and to rotate all of the corresponding socket terminals in parallel across the output terminals. In practice it will be found advisable for quick band shifts, to have additional tank coils fitted with the output rods for these bands upon which the exciter is to be operated, immediately at the binding of the link circuit approximately change the timing of the tank and being used in the output stage, so against the tuning of the same tank and after the output coupling is open and the stage is being used as a doubler. Instead, however, the slight additional time required to change the tank will be negligible.

Another similar detail which, while not new in original, is yet seldom seen in similar equipment, is the method of using a tuning plug for matching the d. c. return from one circuit to another, rather than the more general practice of conventional jacks with a plug-and-wound conductor to the return.

Another commercial trick for securing neat wiring is the use of dummy bugs, such as those between the t.l. chokes and the transformers. These handy little gadgets can be obtained from any radio supply house.
FEATURES:
- An effective, dependable circuit
- Variable frequency control
- Detented band shifting
- Uniform application
- Ease of construction
- Relatively low cost of component parts

FIG. 15—FOUR TUNED CIRCUITS WITH TWO DOUBLE-TUNED TUNES ARE USED IN THE EXCITER CIRCUIT. THE TUNING ELEMENTS ARE DRAWN SEPARATELY FOR CLARITY

FIG. 16—THE NATIONAL TYPE CHT CRYS

FIG. 17—FOUR-BOLT VIEW OF THE SPOOL WITH THE PACK AND THE JUXT COVERS OF THE COILS REMOVED TO SHOW THE WINDING

FIG. 18—THE NATIONAL TYPE CHF CRYSTAL HOLDER MAY ALSO BE USED WITH SPACER RINGS AS SHOWN TO PROVIDE AN AIR GAP TYPE OF ARRANGEMENT FOR QUICK AND EASY CHANGING OF CRYSTALS WHICH IS QUITE AN ADVANTAGE TO THE RADIO OPERATOR HAVING A LIMITED NUMBER OF CRYSTALS AT HIS DISPOSAL. WHEN THE NUMBER OF AVAILABLE CRYSTALS AND FUNDINGS IS NOT LIMITED IT IS CONVENIENT TO INCORPORATE SEVERAL IN EACH HOLDER unit AS ALREADY SHOWN IN SEVERAL OF THE EARLIER ILLUSTRATIONS ON THE PRECEDING PAGES.

A more compact and less expensive arrangement is the new type multiple holder in which four holders with selector switch have been combined into a single unit. While provided with a plug-in base for mounting in a standard five-pin tube socket, the unit may also be single hole panel mounted. In many ways this latter is the most preferable arrangement in that the selector switch is easily accessible. When so mounted, connections are made directly to the ends of the plug grime.

In the photograph below will be seen the thermal bar mounted which all of the crystals must be mounted on as well as the low-capacity switch which makes the selection of any one crystal completely independent of the others.
**Variable Frequency CRYSTALS**

One of the characteristics of a properly finished cut crystal is its ability to oscillate with uniform output as the air gap of the holder is varied through a reasonable range. By taking advantage of this property, it has been possible to develop the type holder illustrated in Fig. 28. As Fig. 2 shows average performance curves. In the commercial model, the air gap is varied by means of a special shaped cam, resulting in practically a straight line frequency tuning curve. The outstanding advantage of a "variable frequency" crystal-controlled oscillator of this type with which some frequency shifts can be readily made without the danger of going outside of the band limit. Not only is this valuable in avoiding heterodyne, but also in tailing a station with which a definite audible beat has not been previously made.

The Bolivar crystals furnished with the National vari-gap holders are normally geared for a fundamental frequency in the 2000-4000 band. At the frequency range of 0.01% the range of any one unit at the fundamental frequency is approximately 8 kHz. In the 28-Mc. band, a range of approximately 8 kHz. In actual operation this range is wide enough to permit evasion of intermediate frequencies, and still not wide enough to cause confusion.

The important fact is that such a crystal is unresponsive to the mounting direction. It is important that a correctly ground high-drift type crystal of proper design be used with the mounting described. Many crystals have been found to oscillate with an air gap of more than three times the crystal thickness, while many others have good stability in any of the cut-crystal types but have failed to oscillate in the vari-gap mounting.

**FINAL STAGES**

Even just what classification being the "buffer" stage or stages in general, rather than a wide point. In some cases the buffer is physically.

The buffer is tuned at the frequency at which, at least, built right into the same, as in the case of the WRED unit on page 10. Then again, it has no detectable effect on the output as long as the tuned circuit of the buffer is operating in its resonant condition. Having already been partially treated in some of the sections just described and about to be treated more fully in connection with the complete transistor description in the transmission on page 41 when the buffer makes a second or parallel panel of stage.

We are on the grounds of saying that the impedance of the plate circuit should be high, since this permits the tube to operate at highest efficiency.

The impedance equals 100 kΩ approximately. Therefore, for any given output efficiency (Q), we may conclude that the impedance (increases as f increases), and that the tank circuit having the lowest capacity has the highest efficiency.

The above statements apply particularly to unbalanced circuits. When the circuit is loaded, another consideration comes into the picture, namely, storage capacity or flexibility of the circuit, if you prefer. To make this clear, suppose a single triode, Class C, is driving a loaded parallel resonant circuit. Once the cycle cycle, the tube will supply a short pulse of power to the circuit, and the energy in the inductance and capacitance of the circuit, however, will supply power steadily to the load, throughout the entire cycle. Obviously, the storage capacity must be large compared to the peak input per cycle, or poor wave-form and maximum operation will result. As the tube bias is decreased, the driving impulses will become of longer duration and low frequency. At this point, the grid bias is decreased to Class B condition. Another feature is that the input power will be amplified over its entire half cycle and the 200% may be safely doubled as compared to Class C. Going one step further, push pull Class A is 50% power over the entire cycle, and the 200% may be increased to perhaps twice that of Class C value.

Other things being equal, the lower output is proportional to the plate current. Therefore, if the plate current is doubled, the energy storage should be doubled, which means that the 200% should be 1.5 as high. (Double capacity, one half induc
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Thus, the double plate voltage also requires double the energy storage, but since doubling the plate voltage doubles the oscillatory voltage, the storage capacity is automatically increased four times. Therefore doubling plate voltage permits using an "elastic" frequency at high (Double inductance, one half capacity.)

It is a simple matter to determine the frequency, the following principles, combining these, as a formula which is based upon past experience:

\[ E = x \times \text{Tune} \times \text{Gangueul Capacity} \times \text{Cycles} \]

But now let us get back again to this business of a Coupling.

Then, of course, and the tank condenser.

The chart above is a convenient means of determining the correct coil form and number of turns of view to use with the calculated capacity. There are two groups of curves, one for the 1000 and 2000 MC coils and the other for the 3000 and 4000 MC coils. The X12-5 is 155, the X12-6 is 156, and the X12-7 is 157. The curves are for use with the transformer. The transformer is a 155 type. The X12-5 is for the 1000 MC coils and the X12-6 is for the 2000 MC coils. The X12-7 is for the 3000 and 4000 MC coils. The chart is designed to be used only on one band, the type of coil form will be determined by the individual requirements, and will be determined by the individual requirements. The chart is designed to be used only on one band, the type of coil form will be determined by the individual requirements. The chart is designed to be used only on one band, the type of coil form will be determined by the individual requirements.

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Having arrived at the design of the output tank circuit, the next question is the mounting. Few indeed are the variable condensers designed with the 100-kilocycle range in mind, but simplifying the problem is the transmitter construction, using limited high frequencies. Just recently, a complete line of variable condensers for tank circuits has been developed by National for use with their line of transmitting induction coils and transmitting condensers so that these two units which have been designed to work together electrically may also be easily used together mechanically. An ideal application of one of these combination coil-condenser units is shown in the illustration on page 55. In addition to its use in filtering tank circuits, they may also be used in combination as shown at the center top of the illustration, to form a composite frequency-typical coil-network.

In the accompanying illustration, it will be noted that the smaller UR-13 induction coil forms is almost identical as the larger size. The surface of this coil form is quite rough, and if it is found, it would be a very useful wire, but it was found generally more convenient to have an unremodeled surface so that each with different pitch of winding can be readily constructed.风速为的空气旋转使包络线更均匀，但它可能会使整个系统变得复杂。整个系统应该设计为松散和灵活，以便于安装和拆卸。一个良好的设计是，将空气包络线安装在可拆卸的框架上，这样就可以在发射机中方便地安装和拆卸。}

Some Complete TRANSMITTERS

Fortunately it is desirable to build a complete transmitter as a single unit, rather than as an assembly of many individual units, even though this may result in extra cost. An illustration of how such a unit could be built is shown in the small picture of Fig. 23. In this picture, the three main components of the transmitter are shown as separate units, but they are connected by wires. The picture shows the connections between the various units, and the wiring diagram explains how the units are connected to the main power supply and to the external power source. The transmitter is designed to operate over a wide range of frequencies, from 100 to 1000 kilocycles, and it is capable of transmitting power ratings of up to 1000 watts.

The transmitter consists of the following main units:

1. The power supply, which converts the alternating current from the main power line to direct current suitable for the transmitter.
2. The oscillator, which generates the carrier wave at the desired frequency.
3. The modulator, which modulates the carrier wave with the audio signal.
4. The amplifier, which amplifies the modulated signal before it is sent out through the antenna.
5. The antenna, which radiates the transmitted signal into the atmosphere.
Following the thought originated in connection with the W5JD transmitter of the preceding pages, we have in diagram form a design for a transmitter which may be built from the junkyard, eliminating the need for a frequency crystal holder, but also the frequent changing of transformers to a single compact vacuum-tube blower unit. Meter rectifier is secured by providing jacks and plugs for switching the blower between different plate and grid circuits. The blower uses two 3A5 tubes in the "cathode" circuit arrangement, to which we have previously referred. Using a 3A5 as a cathode, the output from the last section of the second 3A5 is ample to drive the 5K2 tube high-frequency tube used as a buffer. This tube, in turn, can fully drive a pair of 6L6s, even with 600-ohm input.

This particular transmitter has been operating a good deal on the "phone" band and found to be particularly well adapted to such high-frequency operation. In this design, as in the case of the previous one, great care has been exerted to assure stability of mechanical assembly and operation.

The means of mounting the filament transformer directly on the chassis of a transmitter of this type has been found to be extremely worth while in eliminating large leads carrying heavy alternating currents.
Transmitter Design

Feeling that it really takes no more time to do a good mechanical job at the first place than the more usual rough-and-ready one, it is the particular (intact herein) to illustrate and explain upon the mechanical rather than the electrical design features of a moderate-power 5-140 final amplifier correctly designed for use with a compound exciter unit (see pages 12 and 14) to form a trapezoidal one-half kilowatt plug-in transmitter. Considerable number of photographic illustrations and drawn parts to circuit components and description. Particularly interesting should be the views taken prior to wiring and panel mounting.

Briefly, the transmitter is built around the ovoid steel chassis of W-frame, under which is mounted the filament transformer and the IR28 sockets, and to the sides of which are attached the aluminum brackets carrying the relatively lightweight 5-140 components, such as the two variable condensers, the neutralizing condenser, input tank coil, and the buffer tube socket. This chassis unit is illustrated in Fig. 105, 153, and 156, without wiring and without mounting of the front panel, in order to illustrate the simplicity and neatness of the type of construction.

Perhaps at this time it may be well to point out some of the conventional details that contribute much to the neat final appearance of the complete unit. Again, precision in this connection are, of necessity, of the utmost importance. Although condensers actually, it takes very little, if any, more labor for any part of the construction to form-up the type of brackets shown from sheet aluminum in an ordinary way, than it does to bend up strip stock in the more usual manner. The round holes in the two rear brackets add much to the appearance and little to the labor, as holes of this size are very easily cut in aluminum, with an ordinary tempering tool or fly-saw. By mounting the filament transformer in the manner shown, not only is its relatively heavy weight supported by the strongest part of the chassis, but extremely short lead ends result. Coupling between the exciter and this amplifier is by means of a low-impedance link with a pin-based plug-in type, mounted adjacent to the buffer tube as the amplifier chassis.
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Transmitter Design

The main transmitter is one at W1EX in a 1W, 20-meter phone unit, with a pair of W2-25A in the final, modulated with a pair of B3A175s in Class A8-B. The first amplifier, illustrated hereon, is driven by the lower-tuned KR-26 transistor, described on page 22. When used, the suppressor bias of this smaller transistor is charged, of course, from negative to positive and the suppressor-modulating circuit is used to modulate the plate current of the KR-26. The grid current of the KR-26 and the grid roll of the 25A45 parallel final stage. The 26A18 was selected for its ability to provide the 25A45 in this type of application. As for the modulating control it features a little air in, and the showing several view.

The 2500 volt front panels carry all of the "scaled print" structure. The RF and the grid collector panels are separate units. The supporting framework of the RF section is made of 5" inch angle angles. The "sprints" for the 25A45 are laminated FR-5, flat space frames. National Grid Cover frames and other insulating panels have been made for the Type TML condenser, but are sold separately. The insulating transformers are bonded close to the fluorescent content of the tube to provide a cold as a possible for the heavy AC fluorescent heating current.累累, copper tubing is used for fluorescent and the and grid pins on the terminals. The 25A45 and grid pin are "plated" on as a metal to add in Series in the 16 and 23-meter CI pens in addition to 24.
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A slightly different style of construction than that used in any of the other transmitters shown in this booklet is that of Figs. 10 and 20, designed and built by W0Y1C. All of the units are overwound on stabilised mica coil packs in the same conventional manner, but, instead of being designed on a laminated core, are wound on a light gauge steel bobbin with banded rear door. Such coils are now being claimed by many of the large parts dealers and are finding considerable favor among those amateurs, especially those having limited workrooms, where the condition of the wiring of any transmitter must be protected.

The complete transmitter, including carrier, buffer, final stage, modulator, and power supply, is housed in a one-back cabinet. The top panel carries the antenna tuning system comprising an inductance link coupled to the final plate tank coil, the tuning condenser, and the thermal-couple ammeter.

Reference to the rear view shows that the usual step-down construction has been avoided. There are two important reasons for this change. One is that the assembly results in the elimination of long filament leads. No distortion list in this transmitter is longer than three inches. The filament for the BR-30's are supplied by two individual filament transformers located directly above their sockets. The second important result of avoiding step-down construction is to provide a "shorten effect" for the whole transmitter so that the heat generated by the tube rails toward the top of the case and flows in cool air through the heat sink down near the floor. A distinct departure from usual construction is the invention of the modulator tube, which has the effect of putting the tube inside the high potential of the grid, along with a material shortening of the leads.

FIG. 30 - REAR VIEW OF THE TRANSITTER
FIG. 31—THE 802 IN AN EXPERIMENTAL SET UP

The extremely low R.F. driving power, the small amount of high-frequency power, and the freedom from modulation difficulties, has made the 802 a favorite such used final stage tube in moderate-power phase transmitters. While the initial cost of the tube itself is slightly higher than that of a group of equivalent tubes, the saving in assembled equipment practically counterbalances these differences.

When suppressor rectifier, loaded, the maximum suppressor current is limited by the 25 per cent of the D.C. power applied to the plate circuit. As at the receiving end of the suppressor (i.e., at the grid circuit), the tube is operated at the plate circuit anode voltage. As the suppressor voltage is increased, the suppressor current is reduced until, at the plate circuit, the suppressor current is equal to the plate circuit current. This condition is only arrived at when the input and output circuits are sufficiently balanced. An excellent example is the 802; this tube is efficiently used in the suppressor circuit and is designed for maximum output. In the case of the 802, the suppressor current is limited to a maximum of 100 watts, of low, deep, clear quality. Of course, for use at 802, the suppressor is required, but the efficiency of the suppressor is very low. In the case of the 802, there are no legal limitations, but they have the definite advantage over tubes of low R.F. driving power and is preferable in the elimination of extra-thermal conditions and unwanted circuits.

R.F. tubes may be divided into three general groups: those of the 300-

FIG. 32—THE NEW R.F. TRANSFORMER IN AN EXPERIMENTAL SET UP

A proper layout and size of the R.F. transformer is necessary for best results. The transformer should be designed to give the proper voltage and current for the 802. The transformer should be made of high-grade materials and should be capable of handling the higher power levels. The transformer should be designed to provide a good match between the high-frequency and low-frequency circuits.

The 802, when used in a suppressor circuit, is capable of handling a carrier of 60 watts or more, and when used with positive suppressor bias by e.g. pur-
In addition to the many other advantages of the R.F. regenerative circuit, this type of receiver has a number of other advantages. The most important of these is the absence of any fixed tuning condenser or any fixed tuning inductance, and this makes it possible to use the receiver as a regenerative detector for any of the amateur bands. The only tuning condenser required is that which is used to resonate the circuit of the receiver. The receiver is then tuned by adjusting the tuning condenser until the desired band is obtained. This method of tuning is very convenient and is especially useful for mobile receivers where it is necessary to change the band from time to time.

FIG. 16 - TRANSMITTER CENTER FOR A THREE-BAND TRANSMITTER USING AMATEUR BANDS AND 300 WATTS ON PHONE

A circuit diagram of the transmitter is shown in Fig. 16. The transmitter is a two-stage regenerative type, with the first stage being a regenerative detector and the second stage being a regenerative amplifier. The regenerative detector is used to detect the signal and the regenerative amplifier is used to amplify the signal. The regenerative detector is operated by a voltage-controlled oscillator, and the regenerative amplifier is operated by a voltage-controlled amplifier. The voltage-controlled oscillator and the voltage-controlled amplifier are both controlled by the tuning condenser, and this makes it possible to change the band from time to time.

Another application of the R.F. regenerative circuit is as a regenerative detector for any of the amateur bands. The receiver is then tuned by adjusting the tuning condenser until the desired band is obtained. This method of tuning is very convenient and is especially useful for mobile receivers where it is necessary to change the band from time to time.

FIG. 17 - CIRCUIT DIAGRAM OF THE TWO-STAGE REGenerative TRANSMITTER

The circuit diagram of the transmitter is shown in Fig. 17. The transmitter is a two-stage regenerative type, with the first stage being a regenerative detector and the second stage being a regenerative amplifier. The regenerative detector is used to detect the signal and the regenerative amplifier is used to amplify the signal. The regenerative detector is operated by a voltage-controlled oscillator, and the regenerative amplifier is operated by a voltage-controlled amplifier. The voltage-controlled oscillator and the voltage-controlled amplifier are both controlled by the tuning condenser, and this makes it possible to change the band from time to time.
To what extent, electric meters or instruments present only one problem, that of balancing the budget. Toward the solution of this problem we can often offer help, but unfortunately, we do not think much of the suggestions below may be helpful or making the most of available meters.

We shall start with two. It is not hard to see the reason for this because of the moderately poor quality of the meters. In our assembly of the present magnet in D.C. Vianos, and Beckford A.C. instruments, making the repair in a read. The error is larger than one might expect. Before writing this paper, we tested a number of instruments of different makes in a standard and steel relay tachometer panel. With the meter in the worst position, the error was from 10% to 15% low, depending upon make, in the position where they are normally used, the error is only 2.5%.

Unfortunately, about one-half so much. This is why it is so necessary to remove a meter from an ad and repair means, change scale, and so forth. This is not an operation that we recommend, as the meter is very apt to be "sticky." Unfortunately, the principal reason for this "stickiness" is almost ir-removable. In most cases, the meter is marked at 30% of its full scale against the moving system. It is very difficult to read against this as magnetic particles are attracted to the air gap and non-magnetic dust is attracted to the scale and coil by the electro-magnetic change which is often present. If you must take your meters apart, do it in a place where the air is only, and lay a clean sheet of paper over the table before that you are working. To remove the meter from its case we will be given.

To use a single meter for all measurements, we may use the meter with a plug or a meter leads. The single instrument is usually a milliamperemeter of high enough current to carry the maximum current appearing in the transformer, probably 200 mA, or 500 mA if the meter is used for many purposes. For instance, a low range of 500 mA is highly desirable as an indicator of grid current when operating or checking excitation. A multi-range instrument would be used, but.

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In this section, the author discusses the use of meters in amateur radio applications. The text explains the importance of balancing the budget when selecting and using meters. The author provides a detailed explanation of how to troubleshoot and repair meters, emphasizing the need to remove the meters from their cases carefully to avoid damaging them.

### Transmitter Design

The section on transmitter design covers the selection and calibration of meters and also mentions the use of meters in the context of transmitter design. The text suggests that meters are essential tools in the design and troubleshooting of radio transmitters.

### Power Amplifier Coil Data

A table is provided with data on coil specifications for different power amplifiers. The table includes columns for frequency, inductance, and other parameters relevant to power amplifier coil design.

### Power Amplifier Input Transformer

Another section discusses the construction and design of input transformers for power amplifiers. The text explains the importance of selecting the right type of transformer and provides guidelines for designing input transformers.

### Photograph of the Push-Pull Final Stage

A photograph is shown of an actual push-pull final stage, which is a common configuration in power amplifiers. The photograph is labeled "Push-pull Power Amplifier Input Transformer."
Transmitter Design

There are obvious advantages in having a choice of transmitting frequencies quickly available in each amateur band. Many stations would like to use a transmitter on another band if the labor of hand-switching was not too great. Then again, a slight change in frequency during a QSO will often take care of undesirable interference difficulties.

Such universal transmitters have been built, of course, but the inherent simplicity of each band set beyond the facilities of most amateurs. In an attempt to make a successful compromise between convenience and economy, the transmitter described here was recently built.

The most important component is simplifying the transmitters as far as possible for the 20 and 40 meter bands. This type is being used for QSO's, but it has not been reported. Two bands, 40 and 80, are available, set in sections marked more useful than four bands in a transmitter which requires laborious handling of plug-in cards and moving in local frequency changes. For example, a phone may move quite easily with just the 20- and 15-meter bands, which between them will take care of varying conditions of signals, etc. Similarly, each will have in most instances one set either the 20- and 80- or the 40- and 40-meter bands.

With this concern made, the transmitter design took shape rapidly. The system used calls for the switching of multiple pre-rated tank circuits right through from the load stage to the crystal oscillator. Such a method of band-switching minimizes troubles due to variation on contact resistance by the close movements of operators' fingers. It also increases the reliability of the set to any operator.

The layout, however, is not yet as perfect as one would desire. The receiver stage is still in the preliminary stage of the overall height.
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There is a further refinement of the buffer circuit which we believe is quite unique. This is the excitation control, $R_x$, which varies the excitation voltage from zero to about -30 volts. At zero volts the buffer $R_{0}$ is doing its best, while at the other extreme the full negative bias is sufficient to cause almost complete cut-off. The control is exceptionally smooth at all positions, and is very satisfactory in every way. The negative voltage is obtained from the voltage drop across the bias resistor $R_x$. These resistors are connected in parallel, and need not be a single resistor. The reason for the arrangement is to permit the balancing of the two $R_{0}$s, and make it possible to use a resistive-type potentiometer for the control.

A double-tube type of construction is used in the final stage in order to shield the input and output circuits of the plate circuits when mounted vertically, as recommended by the tube manufacturers. This shielding also provides a very handy shield on which to mount the signal-tuning condensers, grid and plate-damping switches. Similar equipment for the grid circuit is mounted on the lower shelf. The grid coils are standard National R-66 receiving coil forms with the pins knocked out of the base and then mounted back to back. The grid and plate-plates are geared together with ordinary half-and-half couplers, as in the case of this transmitter, from outside and ends to be found in most amateur transmitters. The condenser-couplings and the inductance coils are from surplus receiving tuners. The matching and phase plates are taken from an old double-tube double-tube reflex tube, the left one being dropped out, and the frame and braces are bent up from a piece of brass strip.

The circuit in general is quite similar to that recommended by the tube manufacturers. Care should be used, however, in routing the high-voltage plate supply lead to see that it is as short and as far from $R_x$ as possible. The condenser and feedback R-F chokes shown in the illustration and diagram are located so that they may be inserted in the circuit if it is not desired to maintain the circuit in the form of the plate plate. Likewise, an R-F by-pass condenser should be connected across the plate-plate plate and the bypass condenser across the plate-plate plate. The screen voltage is obtained from the drop across the condenser and is mounted on the back edge of the upper deck. The upper grid and plate plate plate plate plate voltages are obtained from D-batteries.
Transmitter Design

Such a range permits economy in the design of the amplifier for many reasons. Speech microphones have higher output than high-fidelity ones, and usually are less expensive too. The same is true of audio transformers, in general.

Also, the loss with the lower frequency components is smaller than with the higher frequencies, resulting in a greater output. However, the loss in the higher frequencies of the broadcast band would be serious.

The filter provides a passband of about 800 cycles per second. This is a desirable range for speech, as the human voice is transmitted in this band.

The filter is a simple high-pass filter with a cutoff frequency of about 1500 cycles per second. It provides the necessary attenuation for the higher frequencies of the broadcast band.

The output of the filter is applied to the speaker through a step-up transformer. The transformer is designed to provide the necessary impedance transformation.

The circuit diagram of the speech amplifier and economy class modulator is shown in Figure 60. The power supply for the filter and the transformer is derived from the output of the amplifier.

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Transmitter Design

As we have remarked, a ten-watt amplifier does very nicely for grid or suppressor modulation, but it does not go very far with plate modulation. Where larger amounts of power are required we use the rig illustrated in Figure 78 and shown in diagram Figure 79. This unit employs a pair of plates in Class B and has a rated output of approximately 100 watts. As will be seen, the output transformer is designed to supply a 500-ohm line, so that this unit operates very slowly using the speech amplifier for the normal program source. It requires a little more power than 2A5’s are rated to produce in Class B (half-watt more), but the slight additional power is easily obtained either by increasing the ratings by a small amount, or by eliminating tube bias entirely. The output transformer employs a matching network of the universal type, being provided so that any output impedance likely to be encountered can be readily obtained. The proper tap is very easy to determine. When modulating a Class B stage, the grid bias is reduced to an extent, the greater part of the latter coming from the modulator output, will be neutralized by the plate voltage divided by the plate load resistance, the correct load resistance for the modulator being obtained by looking it up in a table of tube characteristics. The ratio of these two resistances is equal to the square of the turn ratio of the transformer when the match is correct. To determine whether it is driving or step-down, the simplest rule is that the driving having the highest voltage also has the highest impedance.

The 838 and 836 are used in this amplifier at W1RHX that is quite interesting, though it is doubtful whether any amateur would follow it very closely. It employs a pair of 835 tubes, which are capable of developing about 2.4 KW Class B. Though we never operate them Class B, it is interesting to note that only 6 watts of signal driving power are required, which is well within the capabilities of our speech amplifier. In actual practice they are never called on to deliver more than 300 watts, and so they are rated at 300 watts Class A. It is evident that the most conservative of all the operation gives ample output. The reason for choosing such extensively large tubes requires some explanation. One reason is that W1RHX is located in the country, and power is supplied by a gas engine generator. Although the voltage regulation of our present generating system is much better than that of our earlier engines, our experience has made us disinclined to run a high-powered Class B stage with line-voltage power supplies. Our present system is a gas engine generator with a fixed field excitation unit, which makes it possible to keep the line regulation to 1% or less. There are a battery from the previous Class-B days of W1RHX, which if you wanted power you had to use big bottles to get it.
POWER SUPPLIES

Because all power supplies tend to be pretty much standardized, without allowing much variety for new and novel ideas, they are apt to be treated as a necessary evil. They deserve more attention than they usually get, for they are an important part of the transmitter as well as one of the most important.

FIG. 32

A combination unit, developed for use in conjunction with the buffer-driver section on page 44, is shown inclusive of all the tubes in a single package. This unit is furnished with transformers for use in an external power amplifier. Two 56's in push-pull may be operated either in Class B, or in Class A when it is desired to have a plate of 560 V for Class B stages. However, when the amplifier stages are driven into clipping, the sensitivity of the power amplifier unit is reduced, and the output voltage is further reduced, thereby increasing the distortion of the output. The input leads to the 56's may be shielded and may, in some cases, require filtering to overcome B.F. pick-up.

Very often rectifiers can be used instead of chokes for filtering out bias. Chokes are normally used in power supplies because they present a very high impedance to the desired D.C. If a rectifier, however, is used with a filter on AC, it will have essentially the same effect as a choke. It will also have a large D.C. voltage drop. In some cases such a drop is quite permissible. For instance, if the radio amplifier stages only need about 200 volts it is not necessary to have a large DC voltage drop.

This way for RF filtering, particularly in receivers.

Conductors for primary purposes, preferably either of the oil-imregnated-paper type or the electrolytic type. For voltages of about 400 or higher, it has been our experience that oil-imregnated units are by far the most satisfactory. It is possible to operate electrolytic condensers in series for use on high voltages, and our original 4000-volt power supply at WIREX used a large bank of electrolytics in this way. They gave quite a bit of trouble. Every now and then one conductor in a group would blow, probably because of the difference in leakage resistance of the different units, which caused the voltage to divide unevenly. As soon as one unit blew, the others would go also, of course. It is characteristic of electrolytic capacitors for this thing to happen. A test is made to determine if there is a fault in a capacitor for a short period of time, and the voltage drop that would have occurred if the capacitors were not connected, and possibly the condenser troubles may be attributed to this in part. On the other hand, we have never had any trouble at all with the oil-imregnated-paper condensers we have used, and we think to have the over a period of years. They have been less expensive than cheaper units. They certainly can hold it.

Properly placed, fuses are a good idea in the power supply. Even small rectifier tubes will handle enough power for short periods to blow a fuse in the
Notes on Amateur Radio

teasy to cause a delay of 15 seconds or more before the 27 draws plate current. A delay is used in the plate circuit to turn on the plate voltage of the high-voltage rectifiers. One virtue of this design is that it compensates for line voltage fluctuation. If for any reason the rectifiers heat unusually slowly, the voltage on the secondary of the 117-volt AC transformer will not fall. When final amplifier with grid input power is low, the heater voltage will fall, but the heater filaments do not fall. When final amplifier with grid input power is low, the heater voltage will vary, but not fall. When final amplifier with grid input power is low, the heater voltage will vary, but not fall.

FIG. 27. THE NATION al STANDARD STUDY CHART FOR THE PA FORM OF THE TELEGRAPHY APPLIANCE.

With many-power rectifiers such as the 500, filament should be allowed for running temperature consistent with the operating temperature and with the operating temperature of the transformer. The rectifier tube has about 90-volt drop, and this should be added to the rectifier to allow for the plate voltage when the transformer is started. A 100-volt drop is a normal range, but for higher voltages, it is not advisable to exceed 120 volts.

The turn indicator is in Figure 28 to indicate the primary of the transformer to turn on the plate voltage of the high-voltage rectifiers. One virtue of this design is that it compensates for line voltage fluctuation. If for any reason the rectifiers heat unusually slowly, the voltage on the secondary of the 117-volt AC transformer will not fall. When final amplifier with grid input power is low, the heater voltage will fall, but the heater filaments do not fall. When final amplifier with grid input power is low, the heater voltage will vary, but not fall. When final amplifier with grid input power is low, the heater voltage will vary, but not fall.
ANTENNAE

The chapter will be well started if we admit right at the beginning that it is not intended to be a treatise on the subject. Such treatise will be found in any one of a number of standard books, such as the A.R.R.L. Handbook. This chapter is merely a collection of notes on our experiences.

For general purpose work on 20 and 40 meters we have had very good work with the vertical dipole with QAR center feed. This system has a lot to recommend it, as the highest frequencies at least. It is easy to adjust, and unlike tested ones is easy to install without the need for a favorable low angle. The system works particularly well for the folks who live in the city, space is at a premium, for room is always found for a vertical wire and it can be placed so that the QAR feeders come directly in the second story window.

We have made a QAR, on the ground

The insulator was specially made to the dimensions shown in Figure 82. As you read from the drawing, they are not intended to be absolutely right, but they are made from oval parts, and they are simply draped over the insulator rod to the position desired and then they are inserted with a wrap of tape. The insulators and bracing shown are designed to match 70 ohms to 56 ohms, or in other words, they will match a center-fed half-wave antenna to a feeder using No. 12 [12 AWG] wire and ferrite spacers (such as National A-03 spacers).

The convenience and tightness of the coaxial line can be achieved if marked that an extra quantity of the insulators have been made. These are obtainable from National Company for the time being, but we had a good deal of

The vertical dipole described was quite effective, but the next step was a dipole, adding a half-wave reflector to get directional effect. One of our more immediate developments along this line is shown in Figure 84 and Figure 85. Two reflectors and two radiators are used in this array, all suspended from four hanger posts which fan out like the ribs of an umbrella. The whole is supported on the top of the mast shown in Figure 84, and is capable of being rotated at will.

This array works very well and we are very pleased. Unfortunately, such an array not only looks like an umbrella frame, but in a strong wind it acts like one also. However, many of the outlying stations and some of the inland stations have found it a great help in the long run. Some of them are even better than the four paling structures at WHERS. Follows who
have hired Manu to demonstrate the directional qualities of his new rotary waveguide. We should perhaps point out that the fullness of the antenna is the mechanical weakness of the array, and it's put in the tower which supports it. This antenna was put up by local residents in our design, and is quite stable and sound. This happens to be a ham radio antenna, and it's likely that the aluminum tubing is filled with a suitable insulating material. This antenna was put up by local residents in our design, and is quite stable and sound. This happens to be a ham radio antenna, and it's likely that the aluminum tubing is filled with a suitable insulating material.

Transmitter Design

As we have mentioned above, we are in pursuit of constructing a super Y (four wavelengths) at WIRHRX. There seems to be a definite trend in the direction of VHF and UHF antennas for high-frequency work. They were in demand at first because they radiate horizontally, unlike vertical antennas which have shown a tendency to be noisy at the higher frequencies. Apparently this is true only because most high-frequency receiving antennas have been vertical and therefore unamplified for the suppression of such signals. When proper receiving antennas are used, the amplifier does not produce as much noise as it would if a transmitting antenna were used.

![Diagram of a super Y antenna](image)

The super Y antenna is a good example of how the power gain can be obtained, and interested in these types has been growing. As the V and UHF bands, the tower seems to be the more popular. Both take up a lot of room, and there is a significant sense of cleared and level ground available. As a result, the antenna needs to be strong enough to handle big and down, through trees and between obstacles. Under such inexact circumstances, the V antenna works out better, as it seems to be less affected by the terrain. It is also, in general, easier to build. The principal advantage of the Diamond, or rhombic, antenna is that it can be made entirely of wire, by passing the far-end with a jumper. We personally have found that matching the resonance is the antenna to its maximum capacity, and actually leaves it is not in view, to work over the system in question for the antenna, using it as a reference. The most common type of antenna used in this type, and is very similar to the antenna used in the United States Navy. The matching transformer type may depend, of course, on individual circumstances.

![Diagram of a rhombic antenna](image)

With minor differences, it is possible to use some sort of horizontal antenna for reception. As has been pointed out many times, a directional antenna offers advantages in reception that are at least equal to the benefits of reception, for it not only increases the strength of the signal but also reduces background noise. As the design of the antenna is the same for both transmission and reception, the same array can be used, and usually, it is used for both purposes. This switch of one tool is a necessity of course. It is a good idea to have the switch interspersed with the power supply of the transmitter and receiver, so that these two can be shut down simultaneously when the switch is thrown.

![Diagram of a transmitter and receiver setup](image)
The accompanying illustrations make rather succinctly tell the story of our ladder mast, originally designed and perfected to support one end of a V-halyard system. The lower shown on the preceding page served as the support for the apex of the V, and a convenient wire supported the remaining end.

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Some Recent Notes

The first step in the erection of the mast is the construction of a suitable base. The holes for the base should be at least three feet deep and three feet apart, preferably larger at the top of his poles, then proceed to spike in place by overlapping piece of 2 by 4 to give the required additional support. Just about that time, he was suddenly faced with the problem of how to fasten the several pieces of wood end from under the 2 by 4. We have heard that someone recently did this with a knife!

But surprisingly, the ladder mast can readily be carried with out any runners on which we hesitate to engage a definite opinion. Maximum local wind velocity will, of course, have much to do with the matter. In our case, the original ungalvanized mast was limited to thirty feet, plus a few shots at a time to make it suitable for use also as the support for a half-wave vertical. In the spring, with the addition of three guys, however, it might easily be extended a great deal further. Of course if we want to work on the more narrow part of the attic by which means of our friendly feet to have been giving up for quite a few years now, we might suggest such greater length.

FIG. 30, 31 TO 38

The bottom section is ready to be nailed into the mast. The top section, which is shown at right, should be nailed into the mast with a few nails to hold it in place. If any old wire runs, or any other matter is placed, it is a wise plan to secure it with a few pieces of wire to hold it firmly in place.

In more settled areas of the country it is difficult to obtain the electrician's corner at a price that will permit you to build the mast. On a high mast you will have to do a little or a lot of rigging to get it all up. The best way is to have the mast in place for the entire support. A plumb bob dropped through the truss is the best practice to determine when the mast is properly lined up. When the bob is properly lined up and rigidly fastened, then proceed to add two ladders at a time, as you climb uprightly the assembly. Always advance the supports to the point of the plumb bob as you ascend until added, and carefully adjust its alignment. Never, never use a ladder or any other means of supporting the mast while the ladder is in use. When you have all the ladders properly lined up and rigidly fastened, then proceed to add the assembly. Always advance the supports to the point of the plumb bob as you ascend until added, and carefully adjust its alignment. Never, never use a ladder or any other means of supporting the mast while the ladder is in use.

Transmitter Design

In the case of the broadcast antenna, the 200-foot mast is used simply as a support for the lower end of the antenna, and is fastened to the mast at an angle of about 30 degrees. The mast is then raised up and rigidly fastened, then proceed to add the assembly. Always advance the supports to the point of the plumb bob as you ascend until added, and carefully adjust its alignment. Never, never use a ladder or any other means of supporting the mast while the ladder is in use. When you have all the ladders properly lined up and rigidly fastened, then proceed to add the assembly. Always advance the supports to the point of the plumb bob as you ascend until added, and carefully adjust its alignment. Never, never use a ladder or any other means of supporting the mast while the ladder is in use.
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we use one of the few VHF-band-pass double
pole-double throw Nos. 521-525.
The ends of the feeders are attached to the
socket just under the cap with two antennas
inserted as shown in Fig. 20. This construction
takes away any strain from the feed-in-
leads and thus prevents insulating failure as
easily due to the opening of the joint between
the lead-in and the building wall insulator.
Before fastening lead-ins to plate, gaskets
should be made of balsa or fly paper seamed
with roofing cement. Also at this point,
it might be well to remember that the different
tension in wire across some of the shorter lead-in
wires on the market and those offered by the
manufacturers is not the same, and it is
important not only in a difference
in grade of material from which it is
fabricated, but also in the
handing. A lead-in that is not
rather distorting to look over a bow, some
weeks after all installa-
tions to discover that
the supposedly
strain free wire is, after all,
only nickel-plated steel.
A 100 per cent
porcelain insulator is
all right, quite
able to withstand
a local thunderstorm
and should be grounded
whenever in use.

about Condenser Insulation: High grade ceramic
insulators (such as the best quality of Insulators) are properly
regarded as second only to fixed quartz for high frequency
insulation. Quartz is so very expensive that it is out of the
question for most users. Fortunately it makes but little
difference, because the best ceramics give results almost equally good. When properly
used "when possibly used" it a big phrase however, and covers a multitude
of things. As far as the user is concerned, the main thing is to keep the insulator clean.
Dust (and particularly the dusty stuff of industrial districts) causes a marked reduc-
tion in the breakdown voltage as well as an increase in losses. The best
cure is to incline the rig in a dust-free, but where this is not practical
more regularly cleaned.

Transmitter Design

Miscellany:

about Pick-up Coils: Pick-up coils for antenna or link coupling are often
constructed by winding ordinary rubber-covered wire around
the outside of the coil. Although convenient, this method has
some serious objections. It is infinitely not safe, since the low break-
down strength of the rubber often allows lethal voltages to
appear in unexpected places. Further, losses at high frequencies
are unusually great. A better scheme is to wind the pick-up
coil of heavy wire, and mount it inside the coil form. To do
this, wind the pick-up coil with a diameter slightly greater than
the inside of the form. Then, holding one end of the coil in
each hand, twirl it as if you were winding up a spring. As you twist the turns of wire
will grow smaller in diameter. When small enough insert the pick-up coil in place, and
release the ends. As it unwinds it will expand again until it fits
snugly in the form. The ends of the coil are brought out to ter-
minals on the coil form. The result is a neat, efficient, and well-
installed job.

on soldering coil, pruning: Many plug-in coil forms have
bulbous terminals similar to tube prongs. We are sometimes asked
how to solder wires to these terminals without leaving lumps on the sides of the prongs.
Answer: Dip the prong in a small pool of solder, and withdraw it slowly. This is
the only practical method. It is handy to have a small cup drilled in the lip of your
soldering iron for this purpose. It should be about 1/4" diameter and 1/4" deep.
Though less convenient, the same results can be secured by melting a lump of solder
in an iron spoon.

on Lead-through Bushings: Occasionally also we are asked why we do
not make a small lead-through bushing. We do. A G-S 8-Stand-off, mounted through
the panel, leaves nothing to be desired either for efficiency or neatness.
In the section to follow will be found several National Company Engineering Bulletins describing in detail such essentials of the amateur station as receivers and oscilloscopes. Also for the convenience of the transmitter constructor, is included a copy of the latest National Company catalog of component parts.