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INTRODUCTION

In the process of doing Radio Engineering, repair work, and invention, I have discovered many interesting things which amount to "Trade Secrets" in the Field of Radio. Using the information revealed here in this Book, I can assure you that you can not only save money - you can make money if you want to, using my ideas!

I reveal in this Book, as Projects, some mighty interesting things! HOW TO: Build Test Equipment, Standard Broadcast A.M. high and low power TRANSMITTERS you can make, build your own CAPACITORS, Insulators, Antennas, Linear Amplifiers to 1200 watts for Ham use, and many other MANUFACTURING and ENGINEERING SECRETS!

It has taken nearly a lifetime of study, experimentation and work to learn these things - many which I include in this Book for your use and profit.

Please safeguard these ideas and use them in the most ethical manner. Please keep in mind that it is PERFEKTLY LEGAL to use and build the Transmitters and linear amplifiers I show in this Book: in almost any nation except the U.S.A. and that this Book is being read Overseas. In the U.S.A., you will need permission to use linear amplifiers which should be in the form of a Ham Radio License. To become a "Ham" you may write to the AMERICAN RADIO RELAY LEAGUE, 325 MAIN STREET, NEWINGTON, CT. 06111 U.S.A.

You will receive full and detailed instructions, and it is not hard to become a Radio Amateur(Ham).

The large A.M. COMMERCIAL TRANSMITTERS shown here may be built, tested, and sold in the U.S.A. for use Overseas - it is completely legal. For use in the U.S.A. and Canada you will need F.C.C. permission which is difficult to obtain making the use of home-made Commercial Transmitters ILLEGAL here at home unless F.C.C. Rules are complied with! Also, beware of Patent Law Violations if you intend to copy and build these Transmitters for sale to others beside for your own use.

Thanks for looking into the "Trade Secrets of Radio" and for purchasing this Book! THE AUTHOR.
CHAPTER ONE

OLD FASHIONED RADIOS
A CRYSTAL DETECTOR

Diagram showing the construction of a crystal detector.

The adjustment of the "CAT WHISKER" is done experimentally. The Adjusting Arm is moved so that the "Whisker" touches first here and then there on the surface of the GALENA CRYSTAL until a Station is heard. This Receiver is effective only when a very strong signal is present, close by to a Radio Station. A Modern DIODE may be used instead of the Galena Crystal, such as the 1N914 or 2SC0 177.
THE CRYSTAL SET

The old-fashioned CRYSTAL SET was used first as a Radio Receiver. It consisted of the ANTENNA, GROUND, TUNING COIL, TUNING CAPACITOR, CRYSTAL DETECTOR AND HEADPHONES.

If you had good ears and were located close to the Station, your reception was acceptable. The HEADPHONES used in those days were of a VERY HIGH IMPEDANCE, and are not generally found today. There are a few Antiques Radio Dealers who can supply everything needed to build a crystal set, including the Headphones.

THE COIL

The Tuning Coil can be made from a piece of PVC PIPE, with an outside diameter of about 2 inches. A 5-8 inch piece of pipe is recommended, since you may want to experiment with the other Receivers shown later on in the Book. Wind about 60 to 90 turns of Magnet Wire (#28-#30 Gage) on the PVC Pipe Form. The ends of the wire can be terminated with screws and wire lugs for ease in soldering the other wires to it from the Tuning Capacitor, etc.

PARTS VALUES

1. COIL - 60-90 Turns #26 copper wire on a 2"X8" PVC Pipe Form.
2. CAPACITOR - 365 Pf. Variable Capacitor with a 1/4" Dia. Shaft for a knob.
3. CRYSTAL DIODE (ECG 177 or 1N314). Cat Whisker Diodes (hard to find).
4. Head phones - (2000 Ohms Resistance or greater sensitivity)(hard to find)

TRANSISTOR DETECTOR

The Transistor not only acts as a detector, but also provides GAIN. It is Battery Powered, but even this Receiver must be in close proximity to the Station for best results. The Antenna Wire should be a minimum of 25 feet in length.
The use of this Style R.F. Coil adds SELECTIVITY due to the separation of the Primary and Secondary Windings. The coil is wound on a 2 inch diameter (O.D.) piece of PVC Water Pipe. It should be 4-6 inches tall. The wire may be any size from #26 Gage through 18 Gage. Both Windings MUST be wound in the same direction, or CANCELATION of the Signal will occur inside the coil. The Ends of Wire Turns may be terminated with wire lugs for convenience in soldering to the Coil. SEPARATE THE TWO TURNS BY at least 1/8 inch and no more than 1/2 inch. Too much separation between turns will lessen the Coil's Transformer action and may possibly render it useless.

TURNS RATIO

The Turns Ratio should be about 5:1 for Short Wave and the upper Broadcast Band. For frequencies below 1200 KHZ, allow 60-90 turns for the Secondary. The Coil should work as shown for Standard Broadcast Frequencies, however, it may be necessary to experiment with the turns ratio to achieve best results. Many factors may affect the results, such as the type tuning capacitor used across the secondary, frequencies of operation, and close proximity to metal chassis or other objects.

TUNED RADIO FREQUENCY AMPLIFIERS

Use the coil as shown between stages of a TRF Amplifier Section. Each Stage will need it's own Variable Tuning Capacitor.
IMPROVED CRYSTAL RECESSION

OPERATION

The above circuit will give improved Crystal Radio Reception, with increased selectivity and volume. Since there is no amplification, this receiver depends on CLOSE PROXIMITY TO THE SENDING STATION and VERY HIGH IMPEDANCE HEADPHONES (an item hard to find these days).

ADD A TRANSISTOR
This is a very sensitive Receiver, using a single Vacuum Tube. The secret to the Regenerative Receiver's Sensitivity is the Principle of FEEDBACK. A portion of the Signal is fed back through the upper Coil Section, called a "Tickler" Coil. It is very important that all three windings on the coil be wound in the same direction. Otherwise, the process will reverse itself and almost no reception will be possible. The 50K Pot. across the 15 Turn "Tickler" Winding is a simple means of controlling the exact AMOUNT of Feedback. This must be adjusted for best performance, just before Self-Oscillation occurs. Too much Feedback will cause the Receiver to Transmit unwanted frequencies, and will make the Reception bad. 

The Tube is a 6C4, having the advantage of a 6.3 volt Filament, which can be used with many conventional Power Supplies made for Tubes. The RFC prevents Radio Frequency Energy from entering the B+ Power Supply or the Headphones. This Design permits the easy addition of an AUDIO AMPLIFIER. The same PVC Coil form as mentioned earlier, may be used here. Simply add the 15 Turn "Tickler" at the top of the PVC Form, making sure all turns are wound in the same direction. If a Battery operated Set is desired, just substitute a 1.5 Volt Filament Type Tube for the 6C4. Several of these Types are still available through Antique Radio Dealers. Use a 22.5 Volt or higher Battery Voltage for the B+ Supply (according to Tube Specifications). The 100K Resistor may need to be removed and the Headphones placed directly in line with the 22.5 Volt Battery. Do not attempt this at Voltages exceeding 67.5 Volts, as a SERIOUS SHOCK HAZARD exists at the higher Voltage Levels!
A FERRITE ROD ANTENNA

The Ferrite Rod is a rod taken out of an old A.M. Radio. The old wire is cut off using a knife, and new wire is wound on as shown. This Rod must be at least 4 inches in length for best operation.

This Ferrite Rod Antenna will work just as well as some wire antennas, and will scale down your Project. A Standard 365 Pf. Tuning Capacitor may be used across it as a tuning device. (Available at "Ocean State Electronics" Part # CCI8400, 1-800-888-8526).

SCHEMATIC

The ZN414 has within it, FOUR RF AMPLIFIER STAGES, plus a Detector, thus greatly improving the performance of this basic TRF Receiver.
FIG. 3-3. Examples of various types of vacuum tubes, showing their external appearance. (A) and (B), standard glass-envelopes; (C) "IT" glass; (D) and (E), metal-envelopes; (F) 1-pin miniatures; (G) 2-pin miniatures.
CHAPTER TWO
TUBES

The Triode Amplifier

The Design of the Triode Tube Amplifier is straightforward and relatively simple. The formulas also have relevance to Tetrodes and Pentodes, with appropriate variations.

The values of Cc and Rg are chosen to pass the lowest desired frequencies without attenuation. If Cc is too small, low frequencies will be attenuated. If Rg is a very low value, low frequencies may be bypassed to ground. Tube Gain will also suffer, since this resistor along with Rk has this effect.

A MANUFACTURER'S TUBE MANUAL should be consulted for correct parameters. CATHODE SHAS is chosen by the value of Rk. Ck prevents degeneration. Rk X Ck is chosen to be at least 5 Time Constants.

The value of Ck is found by: \( C_k \approx \frac{10^7}{2 \pi f \cdot R_k} \)

(\( f \) = lowest Freq.) \( R_k \) = Cathode Resistor value. Ck is in MICRO Farads (\( \mu F \))

GAIN

Voltage Gain is altered by NEGATIVE FEEDBACK through the Cathode Resistor Value:

\[ G = \frac{\alpha R_k}{(\alpha+1)(R_k+R_p)} \]

\( G \) = GAIN
\( \alpha \) = Amplification Factor (see Tube Manual)
\( R_k \) = Plate Load Resistance
\( R_k \) = Cathode Resistance
\( R_p \) = Plate Resistance (internally) see Tube Manual
STAGE GAIN

In Triodes, the State gain is equal to:

\[
u = \frac{u_{RI}}{R_l + R_p}
\]

\(u\) = Amplification Factor
\(R_l\) = Load Resistance in Ohms
\(R_p\) =Plate Resistance (see Tube Manual)

NEGATIVE FEEDBACK

Negative Feedback is usually caused by the use of a Cathode Resistor.

\[a' = \frac{a}{1 + Ba}\]

\(a'\) = Gain with Feedback
\(a\) = Gain of Stage without Feedback
\(B\) = Amount of Feedback as a Fraction of the Output

NEGATIVE FEEDBACK CHANGES FREQUENCY RESPONSE

Low Frequency is affected as indicated:

\[F_l = \frac{F}{1 + Ba}\]

\(F_l\) = Low Frequency Response
\(F\) = Old Low Frequency Response

HIGH FREQUENCY IS AFFECTED AS FOLLOWS:

\[F_h = F (1 + Ba)\]

\(F_h\) = High Frequency Response with Feedback
\(F\) = Old High Frequency Response
GAIN OF
THE GROUNDED GRID RF AMPLIFIER

\[ G = \frac{R_i (u + 1)}{R_i + r_p} \]

Where:
- \( R_i \) - Load Resistance
- \( r_p \) - Plate Resistance
- \( u \) - Amplification Factor

CATHODE FOLLOWER

\[ GAIN = \frac{u R_k}{r_p + R_k (u + 1)} \]

Where:
- \( u \) - Amplification Factor
- \( r_p \) - Plate Resistance
- \( R_k \) - Cathode Resistor
- \( G \) - Gain
CATHODE FOLLOWER INFORMATION

To calculate the Cathode Resistor Value:

1. Consult the Tube manual for GM (grid to plate)

2. Divide \( \frac{1}{GM} \)

3. ADD this result in PARALLEL to Cathode Resistor for DESIRED INPUT IMPEDANCE

\[
\frac{1}{\text{total}} = \frac{1}{R_1} + \frac{1}{R_2}
\]

NOW, Output IMPED. Value is:

\[
Z_o = \frac{R_k}{1 + (Gm R_k)}
\]

STAGE GAIN

Stage Gain is found by:

\[
\frac{Gm R_k}{1 + Gm R_k}
\]

Gm - Grid to Plate Conductance
Rk - Cathode Resistor

The Cathode follower is useful where a low distortion high quality Signal is desired, into a Low Impedance Load, such as a 50 or 70 Ohm Coaxial cable, or possibly into a Low Impedance Line Transformer.

The TUBE AMPLIFIERS, used in Audio Studios often use this method of Signal to Load Matching.
TRIODE OUTPUT POWER
\[ P_o = \frac{(I_{\text{max}} - I_{\text{min}}) \times (E_{\text{max}} - E_{\text{min}})}{2} \]

Where:  
- \( I_{\text{max}} \) - Max Plate Current  
- \( I_{\text{min}} \) - Min Plate Current  
- \( E_{\text{max}} \) - Max Plate Voltage  
- \( E_{\text{min}} \) - Min Plate Voltage

PERCENT SECOND HARMONIC DISTORTION
\[ \frac{I_{\text{max}} + I_{\text{min}}}{2} = \text{Plate Current without a Grid Signal} \]
\[ \frac{1}{100} \times \left( \frac{I_{\text{max}} - I_{\text{min}}}{I_{\text{max}} - I_{\text{min}}} \right) \]

If Distortion is greater than 5%, LOWER the Plate Load Resistance to correct.

TRIODES IN PUSH FULL AUDIO SERVICE
\[ P_o = \frac{I_{\text{max}} \times E_o}{5} \]
Where:  
- \( P_o \) = Power Output  
- \( E_o \) = Output Voltage

PUSH FULL LOAD RESISTANCE FOR TRIODES:
\[ R_{pp} = 4 \times \frac{(E_o - I \times E_o)}{I_{\text{max}}} \]
\[ R_{pp} = \text{Push Full Load Resistance, PLATE TO PLATE} \]

PENTODES IN CLASS "A" SERVICE
\[ H_1 = \frac{E_{\text{max}} - E_{\text{min}}}{I_{\text{max}} - I_{\text{min}}} \]
\[ P_o = \frac{(I_{\text{max}} - I_{\text{min}} + 1.4I_0 (I_e - I_d))}{32} \]

Where:  
- \( I_x \) = Plate Current with Grid Bias .707 less than normal  
- \( I_y \) = Plate Current with Grid Bias .707 more than normal

2nd Harmonic Distortion = \[ I_{\text{max}} + I_{\text{min}} - 2I_0 \]
\[ I_{\text{max}} - I_{\text{min}} + 1.41(I_x - I_y) \]
\[ \times 100 \]

Where: \( I_0 \) = Plate Plate Current with no Grid Signal

PUSH FULL PENTODES in AB1 and AB2 Service:
\[ P_o = \frac{I_{\text{max}} \times E_o}{5} \]

LOAD RESISTANCE = \[ \frac{1.6 E_o}{I_{\text{max}}} \]

PLATE DISSIPATION = \[ I_{av} \times E_p - P_o \]

Where: \( I_{av} \) = Average Plate Current in Amps, \( E_p \) = Plate Voltage, \( P_o \) = Watts Out
CHAPTER TWO

LOW POWER RADIO
CHAPTER TWO
Low Power Radio

In the Early Days of Radio, the FCC did not exist and many a Radio Station got started by making a home-made radio transmitter of 40 or 50 watts, putting up a wire antenna and doing business. In recent years, I met a man that began in business that very way. After his home-made transmitter burned down his "radio shack," he moved to Oklahoma and opened retail stores selling TV's and Appliances. The "seed money" for his successful businesses all came from his unlicensed Home Brew Radio Station. He never had a license, never dealt with the FCC, and never had anyone tell him he couldn't do it.

We have come quite a ways from "the good old days" when you could do as you pleased. These days, it is almost impossible to get started in low power Broadcasting. The FCC has enacted new Rules and Regulations in order to reduce interference levels in the A.M. Band for the benefit of properly licensed A.M. Broadcast Stations. A.M. Stations which are licensed by the FCC begin at 250 watts power and go up into the 50 KW. Range under certain conditions, if you desire to start a Station of 250 watts or more, you must go through all the legal procedures using a Consulting Engineer to do a Frequency Search, filling with the FCC and paying the necessary fees and waiting for their approval.

EXCEPTIONS TO THE RULES

There are some exceptions to the general rules mentioned above. These include CARRIER CURRENT OPERATIONS, COLLEGE STATIONS, BOARDING HOUSE STATIONS, BEST HOME STATIONS, and Neighborhood Stations. The level of radiation is strictly controlled and limited, but can be enough to provide sufficient coverage. The College Station is a Model for the Best Home, etc. In a College environment, the Students may build their own Radio Transmitter or buy an Approved Type. Various Antennas may be placed about Campus in order to cover all areas; but 100 feet outside the Campus Ownards, the Signal Level must comply to FCC Regulations of 24,000/ft kHz. at 100 feet. At the close of this Book, I also show techniques of Radio Broadcasting for use in Foreign Countries using low power Transmitters and long wire antennas.
The same Signal Strength Limitations also apply to Nursing Homes, Rest Homes, Apartment Housing, etc. In these cases, however, the Radio Station does not use and INTENTIONAL RADIATOR, but the wiring inside the house, apartment, etc. is used as the Antenna. If this is done, the FCC classifies the operation a CARRIER CURRENT STATION. In the cases of a College Station, these are LOW POWER STATIONS, even though they may be Carrier Current. College Stations are not supposed to compete with Licensed Stations, and everything must be "verified" by Records kept in a Public Access File at the Station's Office. Any power may be used, any kind of transmitter and antennas needed to cover the Campus, but just 30 meters (100 feet) outside the Campus Grounds, the Field Strength must be limited to 24,000/F KHz. Harmonics must be measured up to 30 MHz, and corrected if excessive. College Campus Stations are not to exceed 250 Microvolts of RF Feedback into the Power Lines. If CARRIER CURRENT is used, these guidelines do not apply. In any case, the RF Limits set by the FCC are not to be exceeded at 30 Meters outside the Campus Area. Filters may need to be installed to keep the RF down to legal limits where the transmitter connects to the Power Lines, in the cases where small INTENTIONAL RADIATORS ARE USED.

If a College Station uses the in-house wiring as an Antenna, they may feed as much power into the lines as is necessary to do the job, but at 100 feet outside the Campus, the Signal Strength must drop to below 24,000/F KHz. The maximum amount of power normally permitted for CARRIER CURRENT is 50 watts, however COLLEGE STATIONS are allowed almost any power transmitter, any style antennas, etc.—but just outside the Campus, at 30 meters, the signal MUST comply with the Legal limits set by the FCC. "VERIFICATION" can be done by a Certified Broadcast Engineer, or any other qualified person using a "calibrated" Field Strength Meter which is of the type Approved by the FCC.

There is also another application for Low Power Broadcasting inside the AM Band. This is inside Tunnels, Caves, Mines, or Buildings. A special "LEAKY CABLE" can be used, having controlled radiation characteristics. You may feed up to 50 watts RF Power into the System as long as Radiation LIMITS as stated above are not excessive at 30 meters outside the Tunnel, Mine, etc.
"POOR MANS" LEAKY CABLE DEVICE
Original Idea by Ken Van Proyen

Any Length "twisted pair" or "Other" Wire
PL-259
RF Connector

Any Resistor
10-20 Watts
8 - 50 Ohms

Dummy Load

CARRIER CURRENT "LEAKY CABLE"

Any Twisted Pair can be used as a Leaky Cable Device when connected as shown, provided that it is not a "shields" cable. I will cover "SHELDDED" later. Not only will Twisted pair wires work well for any distance of "Leaky Cable" System, but ordinary "ZIP" CORD, LAMP CORD, TELEPHONE LINE STYLE WIRE (1 pair only) and any "balanced" type wire is very good at carrying the RF Carrier along its entire length, be it a few feet or several miles! There is a "catch" to it (as shown above). The Wire Pair must be loaded at its far end by a Resistor of a lower value than 8 ohms and no higher value than 50 ohms (under most situations). I have found that in special cases, up to 300 ohms will load, but generally you lose out by exceeding 50 ohms. The Transmitter is most effective at frequencies below 1 MHZ, but I have seen this method work even at 100 MHZ, under much shorter distances. The "MATCH" to the Cable may not be perfect, but by allowing for the right Resistive Value at the end of the line, this can usually be lowered to a safe level. If too much SWR is present at the "send" end, you may damage your Transmitter. The F.C.C. requires the same Compliance with this as with all other Part 15 Devices. Field Strength is to be measured at 100 feet (30 M) from the Cable and must not exceed 24,000 Divided by (F) Freq. in KILO Hertz. This will provide a figure in MICRO Volts Per Meter as the upper limit for Field Strength.

"SHELDDED" Wire can be used by making the "shields" the outer wire and use the inner Wire for the Center (HOT) wire coming from the Center Contact of the Plug.
HOW TO FIND A FREQUENCY

The single most important thing you need to know is THIN EIGHT FREQUENCY of operation for your Radio Station. In the world of HIGH POWERED STATIONS, this is difficult to ascertain, requiring expensive studies by experts, however this is not the case for your LOW POWER STATION. Since most A.M. low power stations are not expected to reach out over a few miles in any direction, you do not need any expensive frequency searches to determine the correct frequency of operation -IF- you follow these instructions:

Instructions

Obtain a DIGITAL A.M. RADIO. You may either buy or borrow one for your frequency search. Do not use the old fashioned slider dial radios as these may give FALSE READINGS. A digital radio such as the SONY WALKMAN or one of the RADIO SHACK DIGITAL radios will do a good job.

START at the bottom of the Band (about 535 KEZ) and WRITE DOWN ON A PAD EACH QUIET FREQUENCY. Now, SELECT A FREQUENCY THAT IS IN THE CENTER OF TWO OTHER QUIET FREQUENCIES. EXAMPLE: 1230: Quiet, 1240, Quiet, and 1250 Quiet. YOUR BEST CHOICE IS 1240! If you hear a station on the frequency just above or below the frequency you want to use, you will not be able to reach out well with your signal. BLEED OVER MODULATION from that distant station will block your frequency, even when it is on an adjacent channel. For best results, CHOOSE A CENTER FREQUENCY that is quiet on the upper and lower channels, so your station's SIDEBANDS will carry your modulation in a correct manner.

WATCH OUT FOR THESE THINGS

If there is a strong HIGH POWERED STATION NEARBY, where you are doing your frequency search, IT MAY EASILY PRODUCE SEVERAL QUIET SPOTS ON THE RADIO ON SEPARATE BANDS DUE TO HARMONICS and its strong sidebands. Be sure you have a QUIET FREQUENCY where there is LOW "S" on a meter. A distant "weak" station will show you what a low "S" should sound like. If there is total silence, you probably have tuned in a strong Harmonic, free of modulation. Avoid such frequencies as they will not work.
THE COLLEGE STATION

The College Station is presented by the FCC as a "Model" for Low Power Radio. Where possible, these are licensed in the FM Service and usually run at least 100 Watts of power. This is the lowest amount of power which the FCC will usually license, and these frequencies are hard to find, due to "close spacing" between FM Stations.

UNLICENSED RADIO

The College Station may operate legally in an unlicensed manner when Part 15 of the FCC Rules are observed.

TRANSMITTER AND ANTENNA

Any Transmitter (AM or FM) may be used, regardless of its power, and any Antenna scheme is acceptable in order to cover the Campus Area.

LIMITS

The Limits are on RADIATION LEVELS of both fundamental and harmonics. Signal Level must be measured just 30 Meters outside the Campus Area, and must comply with the formula I have previously given. This applies for both AM and FM Broadcasting.

THE MODEL

The Campus Station is THE MODEL. You may use UNLICENSED Low Power Radio at home, business, or at Church if these same guidelines concerning RADIATION LIMITS are observed. There must be a provision to turn down the power, if requested to do so by the FCC. Logs and appropriate records must be kept at your Low Power Radio Office, in order to VERIFY your compliance with the FCC's Rules, in Part 15. Program Logs should be kept, along with Maintenance and Engineering Logs to show when and how regular Verification is provided. The Logs must be signed by the Person showing Verification that Part 15 of the Rules is being observed.
Note: This is possibly the best choice for the Campus or Camp-Grounds due to control over the Radio Signal.

Only a minimum of power is required for coverage.

* Antennas may be wire, rods or other professional types.

NOTICE: Some CB Antennas act as a "DEAD SHORT" to your Signal. Test with an Ohm Meter first. If there is a LOW RESISTANCE READING at the input connector, DO NOT USE!

Every 50 to 100 feet, a "T" is placed in the RG-8U Coax and a ten foot antenna is set in place to provide enough coverage for the Campus. The resistor load at the very end of the coax is necessary to prevent distortion. Use as many ten foot antennas as is necessary to cover the Campus. [PARTS: "T" - Radio Shack #278-188, Coax - B.S. # 278-1326, Load - Heathkit FHIN-31-A (1-699-253-0670) and end Connectors - Radio Shack # 278-189]. Place antennas out of reach.
TRANSMITTER ON WHEELS

The Micro-Mini Transmitter has been used as an Advertising Tool by plugging into the Vehicles' 12 Volt Battery System and installing a small whip Radio Antenna on the Vehicle. A Sign or Bumper Sticker on the Vehicle may read: "FOR IMPORTANT INFORMATION TUNE YOUR RADIO TO 105.5 MHZ." When those following or alongside tune in, they may hear a Message like this: "Jons Plumbing is having a special on Service Calls this Week only. Call 555-291-5512 for our $29.85 Weekend Service Call - etc." This allows for legal use in areas where there is no other reception on the frequency of use. The Power is .1 watt, just enough to reach out a few hundred feet.

REAL ESTATE
THE "TALKING HOUSE"

Low Power FM Transmitters are also used by Real Estate Offices in the Sale of Homes. A Micro-Mini Transmitter is set up inside the House offered for sale. It operates on 120 VAC or from a small battery pack. Its antenna is no more than 2 or 3 feet of wire laying on the floor or hanging in the window of the House. The Signal Travels outward about 100 - 300 feet. A small Sign in front of the House, tells prospective Buyers to tune in on the Radio for Sales Information. The Details on the House are played non-stop by pre-recorded Message, and whoever tunes in can hear the Sales pitch and any other information offered by the Realtor. Units with up to a 3 minute "Chip" for recording can be purchased. Larger Real Estate Companies know where to purchase these Transmitters - or you can make your own, using "Kits" such as those provided by Ramsey (1-800-446-2291).

CHURCHES

Churches may wish to advertise their Services by Broadcasting the Singing or the Pastor's Sermon to those outside in cars or in the nearby Homes. Just a small .1 Watt FM Transmitter on a clear frequency is all that is needed, along with a small Antenna. Distance of such transmissions is determined mainly by the height of the Antenna. For example, if the Church is located on a hill overlooking Town, a simple rooftop antenna will be very effective, even with a micro-mini transmitter.
There are several Companies offering "KITS" for the Unlicensed Broadcaster. Sold as Educational "Toys," these often have good sound quality and are used in Licensed Stations all over the world, except the USA. Canada and a few European Nations. These Kits are offered mostly in the FM Radio Band, and a few offer Kits for AM Radio. The AM Radio Kits tend to be unstable and without sufficient instructions for proper set up.

**FM KITS**

The FM Kits start at about $20.00 going up to about $1000 or so. Most of these are stable and provide 100 MW. Output, which is 1 watts. This is enough power to cover several blocks when used with a good antenna, which you can make yourself or buy. One Broadcaster, in the Midwest, uses 100 MW, coupled into a 50 ohm coaxial linear cable antenna (home made) and mounted at 100 feet height to cover THE ENTIRE CITY! There is no place within the city within a 6 mile Radius where the signal is not clear! Proper Set Up made this possible. The coaxial cable antenna (collinear) is used by Ham Operators, but is useful for FM Radio when made as shown on the following page. I can not guarantee that the SIGNAL STRENGTH will be legal — you will have to do that. The formula for figuring Unlicensed Legal Limits is 12.6/1KHZ. This figure must not be exceeded and is measured at a distance of 100 feet from the antenna. If the FCC determines that you are running too much power, you will be required to turn it down or turn it off.

A "NO - NO"

Some of the Unlicensed Broadcasters try to run vast amounts of power, which can get them into trouble, but the number one "no - no" is ANTI-GOVERNMENT, ANTI-ESTABLISHMENT HATE BROADCASTING. Differences of opinion, opposing views are permissible, but no profanity, venomous hate mongering is permitted on the air waves.
MORE ABOUT KITS

It is possible to buy a 100 MW Kit, add several stages of RF Amplification, and come out with almost any power at FM, 2 Meter, or other Frequencies. This is often done for use in many Countries in order to obtain an economically priced Radio Transmitter. Some of the Companies that sell Kits are listed below. You may wish to request their Catalogs.

1. RAMSEY - 1-800-446-2295
2. Free Radio Berkeley c/o Steve Dunifer 1442 A. Walnut St, #406, Berkeley, CA 94709 VOICE MAIL - (510) 464-3041 (Request Catalog)
3. ALL Electronics 1-800-826-5432
4. Martin P. Jones 1-800-432-2937
5. DC Electronics 1-800-487-7730
6. Dalbani 1-800-325-2264
7. MCM 1-800-543-4030
8. Parts Express 1-800-538-0531
9. JDR 1-800-538-5000

DC Electronics has a good Kit called "The Stereocaster" which is less than $30.00, has Stereo, and is reliable and stable. It is a good 100 MW Unit, and has been used as the heart of higher power transmitters for Export.

Possibly the best FM Kit is made by Ramsey. The FM 25 is Broadcast Quality for 129.35 in Kit form. These are used in many Nations as the heart of high powered systems by adding several Stages of RF Amplification. They offer a "Super Pro" FM Radio Station which has a built in Limiter, LED Readout, with Mixer Controls, etc. which is perfect for the College Campus Radio Station. See the Information in this Book on College Campus Stations for applications for use of higher power Transmitters which may be LEGAL for use in the USA - (Schools, Camps, Churches, Drive Ins, Hotels, Nursing Homes, Correctional Facilities, etc.).

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The J-Pole Antenna has been a favorite of Hams Radio Operators for many years, because of its high gain and wide Band Width. It also exhibits good performance in all kinds of weather, including thunder storms.

J-Pole Antennas are almost impossible for lighting to destroy, due to the fact that the entire Antenna System operates at "GROUND" Potential!

It exhibits desirable characteristics for use as a MULTIPLE ELEMENT ANTENNA because each element tunes independent of the others, over a WIDE IMPEDANCE range! This is important where phasing, loops, lines and differences in element spacing are required in antenna design. By tuning the individual elements to resonance within the system, low SWR's are possible even when 6 or more J-Poles are used in unison!

J-Pole Antennas can be used in either VERTICAL or HORIZONTAL Polarization, or a combination of both for TRUE CIRCULAR POLARIZATION! I have a 3.4 db gain CIRCULAR J-Pole also available for use where this is required.

J-Poles are relatively EASY TO TUNE UP due to the "Gamera" match which adjusts by simply sliding a clamp along the bottom of the Quarter Wave Length Section, and there is little danger of RF Burns because everything is at "Ground" Potential. When SWR is a little too high, the 5/8 Wavelength Element can easily be "tuned" a little, making "tuning" straight forward and positive!

Each J-Pole is custom made and is designed for long life, low wind load and quick, simple installation.
SPECIFICATIONS:

GAIN: APPROXIMATELY 3.2 db PER UNIT (3 Units for 10 db)

SIZE: FULLY EXTENDED - 8.5 feet high

Approx. 0 inches wide

FREQUENCY RANGE: Any between 28 MHz and 150 MHz.

WIDE BANDWIDTH - suitable for FM Broadcast

MULTIPLE Units produce approx. 3.34 db Gain per unit when spaced 1 wavelength apart.

Provided with UHF Connector (1) and Quality phasing cables for Multielement use.

1/4 Wavelength

"Tunable" Element

5/8 Wavelength

"Tunable" Element

WEIGHT: APPX. 3 lbs. per Unit

Length of Elements in Feet: (5/8 Element) 588

(1/4 Element) 234

Finsx

WIND LOAD: 12 (30/32 lbs. ft²)

Adjust copper strap for proper "tuning" and tighten stainless steel clamp

GAMMA MATCH
TUNING DEVICE
"ADJUST FOR LOW SWR"

"U" Bolts

Mounts Vertical or Horizontal by rotating Bracket "A"

"U" Bolts

BUILT OF HIGH QUALITY STAINLESS "AIRCRAFT" TUBING

DESIGN by
J.R. GUNNINGHAM
1993 - USA
High gain
FM-stereo antenna

This inexpensive F.M. Receive Antenna can be used as an effective TRANSMIT Antenna at powers up to 1kW (intermittent) and 300 Watts Continuous.

Use the Special Balun shown below. AIM THIS HIGHLY DIRECTIONAL ANTENNA IN THE RIGHT DIRECTION and your Transmit power (ERP) will MULTIPLY at least BY TEN!

BROADBAND 88-108 MHZ TRANSMIT BALUN DEVICE

Wire Clips to 300 Ohm Antenna

SO-259 plug connector

3 feet RG 58U
USE 2 FEET FOR 7 M. BAND

Standoff insulator

Ground Lug

Schematic

BALUN COIL FOR MATCHING 72 Ohm or 50 Ohm coax to a 300 Ohm Antenna for Receive or Transmit purposes.

NOTES: RG 8 cable may be used for the Balun if over 300 Watts of power is to be run into the Antenna.

The length of the coil of Coax is 1/2 Wavelength with the Velocity Factor of the line included in the calculation.
FOAM COAX - VF=.8
POLYETHYLENE COAX - VF=.66
EXPECTED DISTANCES
FOR
F.M. RADIO STATIONS
WITH POWERS LESS THAN 1000 WATTS E.R.P.

<table>
<thead>
<tr>
<th>ANTENNA HEIGHT ABOVE AVERAGE TERRAIN</th>
<th>EXPECTED DISTANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 feet</td>
<td>4.5 miles</td>
</tr>
<tr>
<td>20 feet</td>
<td>6.3 miles</td>
</tr>
<tr>
<td>40 feet</td>
<td>9 miles</td>
</tr>
<tr>
<td>50 feet</td>
<td>10 miles</td>
</tr>
<tr>
<td>75 feet</td>
<td>12.2 miles</td>
</tr>
<tr>
<td>100 feet</td>
<td>14 miles</td>
</tr>
<tr>
<td>150 feet</td>
<td>17.3 miles</td>
</tr>
<tr>
<td>200 feet</td>
<td>20 miles</td>
</tr>
<tr>
<td>250 feet</td>
<td>22.3 miles</td>
</tr>
<tr>
<td>370 feet</td>
<td>26.5 miles</td>
</tr>
<tr>
<td>350 feet</td>
<td>26.1 miles</td>
</tr>
<tr>
<td>400 feet</td>
<td>28.3 miles</td>
</tr>
<tr>
<td>450 feet</td>
<td>30 miles</td>
</tr>
</tbody>
</table>

DISTANCES ARE TO HORIZON

NOTE: Larger distances are possible with powers in excess of 1000 watts ERP.
ERP is Effective Radiated Power. ERP INCREASES AS FOLLOWS:
1. By an increase in power delivered to the antenna from the Transmitter.
2. By addition of extra BAYS (radiating elements) to the Antenna System.
3. By an increase in antenna HEIGHT.

FIGURES ARE VALID WHERE THERE ARE NO OBSTRUCTIONS BETWEEN THE ANTENNA AND THE RECEIVER SUCH AS MOUNTAINS, HILLS OR TALL BUILDINGS
USING "RABBIT EARS"
FOR A TRANSMIT ANTENNA
85-150 MHZ

ADJUST FOR "RESONANCE"
OR MAXIMUM RADIATION USING A
FIELD INTENSITY METER AT
A DISTANCE OF 1-3 METERS.

INSTRUCTIONS
Cut "twin Lead" (300 Ohm flat wire) at a distance of 4 inches from the base of
the Antenna. Connect 50 or 72 Ohm coax to this Point using wire clips. "Tune"
the Antenna for MAXIMUM RADIATION. This will be "Resonance" or lowest SWR.
and will match the Antenna to the Transmitter very well. Do not exceed 100
Watts Power for Continuous Operation or 1000 Watts for Transceivers.

CUT and connect RF Cable here
(WIRE CLIPS) from Amplifier or Exciter
CHAPTER FOUR

COIL WINDING

SECRETS
A COIL WINDING OPERATION

EXAMPLES OF SMALL COILS
THE WIRE IN THIS COIL IS 3-1/2 INCH DIAMETER. THE COIL ITSELF IS TEN FEET IN DIAMETER WITH AN EIGHT FOOT DIAMETER CENTER.

Built by Continental Electronics
Dallas, Texas
In the world of coil winding, there are many commercially acceptable means which can be used to make quality coils. The large coils required in broadcast transmitters used for short wave or standard broadcast are extremely expensive. This is because these transmitters are required to operate in a very stable manner for up to 24 hours per day, 365 days per year, and up to 25 years without any major problems except tube replacements and normal maintenance. The coils we will show here are not of that quality, but due to their low cost can be replaced easily after five or six years of normal heavy duty use. They will serve just as well, but for less time under normal circumstances.

In the world of commercial coil winding, machines do all the work of winding - in this book, you will do it yourself. The commercial coils are usually wound using flat wire. This can be purchased the same as round wire, but is harder to obtain and more costly. The flat wire has the advantage of allowing more surface area in each turn, providing for smaller coils in length and diameter. These coils tend to be extremely heavy, which I find much to my disliking. The insulating materials used by commercial winders sell for high prices but last for a long time. The materials used here are cheap in cost but high in quality, but last only 6 or 7 years under normal conditions. After that time, another PVC form can be put inside the same wire and you can keep broadcasting. The plastic PVC material used here has been tested over a ten year period and continues to work in some cases. The problem is that PVC sometimes cracks or becomes brittle after a number of years, but these days a five year life expectancy is not bad for anything we buy, especially considering the low cost of the PVC used here.

Strips of Formica, Teflon, Plexiglas, or plastic may be used instead of PVC for the forms on which coils are made with great results. If used commercial type insulation is available from a motor rebuilding shop, it should be used for greater life. I often hear the concern expressed about heat problems with coils, and most people think that coils get hot and may melt PVC or plastic. This is not valid in most cases, for a properly tuned coil does not get hot, if there is heat buildup, something must be wrong.

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There are various ways in which coils are created. The most common in Broadcast Transmitters is the coil wound on a frame of three strips of insulating material arranged in a triangle. The coil itself is round with a spacing of 1/8 to 1/4 inch between turns. The greater spacing is for higher energy demands, preventing arc-over. In high power installations of over 10,000 watts, coils may take on enormous proportions, amounting to several yards in diameter and as tall as a house! Here we are dealing in powers under 10,000 watts, which can be made in the traditional sizes and shapes. Most coils are now wound inside the frame because this gives more control against movement of the winding. This is very difficult to do by hand and should only be done by a patient, experienced person. For our use, the coil wound on the outside of the frame is best.

Examples of coils are shown so that construction details can be observed. Coil forms are notched in a predetermined way so that windings will stay in place. A saw or file can be used to make the notches. Marks are laid out with a ruler and cut to the desired depth. This is usually at least equal to the radius of the coil wire size. Metal braces hold the coil forms together and are insulated from each other using insulated washers to prevent R.F. currents causing heat build-up, corrosion, and harmonics. If the metal end-braces form a complete circuit, they represent a separate coil in themselves, thus affecting the tuning of the coil and circulating large currents of R.F. within themselves. A triangular end-brace is made of three pieces of metal, each insulated from the other. The three plastic strips which support the coil must be very strong or they will bend out of shape. For most coils, they should be at least 1/4 inch thick and 3/4 inch wide or greater. Simple hand tools will make all the cuts, angles, and holes. When winding the coils, be sure to make them round and not triangular. Once a transmitter which we used in El Salvador had homemade coils, made by an engineer lacking skills, which were triangles. They did not work well, especially since they were wound on forms made of wood! This is about the worse thing you can do. Never make any coils on a wood form and then expect it to remain tense. Wood is famous for absorbing moisture, thus de-tuning the circuit with each change in moisture content. By the way, this is about the most common of all mistakes made by even experienced Amateurs. DON'T USE WOOD for any tuning circuits even if it has 100 coats of varnish, plastic tape or teflon unless you like solving mysteries as to what went wrong with a perfectly good circuit!
Examples of coils

These coils are examples of the kind of craftsmanship found in today's commercial coils. The flat wound inductor is very common for powers up to 5000 watts. Any power above five kilowatts is usually handled with copper or aluminum tubing coils as shown here.

When fabricating tubing coils, it is essential that the coils be made using a tubing forming machine. Your refrigeration repairman will be able to do the coils for you to your specifications, or help you find someone who can. The costs will rise if you do this, but your coil can be "custom made" as you wish and you will still save money.

The coil shown in the "bottom-center" illustration, and the one to its right are both adjustable from the center of the coil. These can also be home-made at a savings if an individual has time to do the extra work and make the inner-springs and contactors from brass rods and spring-stock. A visit to your local machine shop will help you obtain any difficult to find items. The center shafts can be equipped with a knob or "turn counter" for easy adjustment. Antenna phasing units are usually built this way to assure positive accuracy in setting parameters.

All coils should be made heavier than needed for extra life and safety factors. Double the current carrying abilities in every case, and always rate them at 1/2 their actual power handling abilities. Anything less amounts to poor engineering standards.
COIL FORMULA

The Coil Formula is given below. It is used to determine any value of coil you may wish to figure, and is quite accurate for most applications. It is not needed if you wish to build standard coils commonly used in AM Standard Broadcast use; but if you want a fixed coil of a specific value, this will give the number of turns needed and the other necessary information.

COIL FORMULA: \( L = \frac{\pi^2 N^2}{2R+10} \)

\( L \) = inductance in Microhenries
\( R \) = Radius of coil
\( l \) = length of coil in inches
\( N \) = number of turns in coil

Usually, the desired inductance is known and the diameter. Diameter is almost always determined by space limitations, but if various diameters are an option, they may be tried in the formula until a suitable result is obtained. The number of turns may be obtained by winding a few turns on a form and measuring the turns per inch. Then the formula may be tried for an even number of inches, and the inductance per inch figured. This is divided into the desired inductance and the total length of the coil is found. The other factors of the formula may be used in a similar manner to obtain needed estimates on diameter, etc.

In the case of coils with a predetermined number of turns per inch, the formula should be even simpler. Coil forms usually have notches pre-cut into the insulated supports every fraction of an inch. These can be measured to determine turns per inch. Coils wound on solid forms will have grooves if bare wire is to be used, but insulated wire may be used on a smooth form.
THE TUNING COIL

This coil is needed for tuning the antenna to match the transmission line. Two of these are used at each tower and sometimes a third one in series with the tuning capacitor for the purpose of making it adjustable. This same coil is used inside the transmitter in order to match the output with the transmission line. For 1000 watt transmitters, this same coil is just right for the tank coil. You may build them yourself and save about a thousand dollars on this one item alone in the course of building the transmitter and antenna system.

PARTS LIST

1. Three strips of insulating material measuring 1/4 inch thick by 1 inch wide by 13 inches long. These can be made of plastic, fiberglass or other suitable material.

2. Six one inch long brass screws approximately 1/8 inch diameter with nuts and 12 brass washers.

3. 50 feet #10 solid copper wire.

4. Two pieces 1/2 inch wide by 1/16th inch thick copper or aluminum for making a wire clip to adjust the coil.

5. One 1/8 inch by 3/4 inch screw with nut and two washers for wire clip adjuster.

6. One piece of wire braids 13 inches long by 1/4 to 3/8 inches wide. This can be made from stripping the braided shield from a short piece of C.B. Coax or microphone cable.

7. Four 1-1/2 to 2 inch by 3/4 inch ceramic or plastic standoff insulators for the base of the coil. These can be made from PCV Pipe. See the Chapter explaining the uses of PVC.
ANTENNA TUNING COIL

1000 watt A.M. coil
as described in text

1/4 inch copper tubing coil
for 5000 watts use
"Fluted" area is cut out with a small saw. This assures room for inserting R.F. clip after coil is wound.

The insulated wire is bared across the "flute" for insertion of the R.F. clip. (#10 wire shown)
Commercially made coil forms are available (as shown) for those who do not like the "messy look" of coils like the "fluted" type. The fluted style is used by myself quite a lot, but is really hard to make look pretty, but it really does perform beautifully. The coil form shown is designed for bare wire up to #12 in size. It is really handy for building coils for short wave and broadcast purposes. The stiffer wire can be patiently shaped to achieve the results shown in the picture. It can have as many taps at various inductances as you feel you will need. The total inductance of the one shown is 60 uH. This is perfect for A.M. Tuning at powers up to 100 watts continuous. It will handle safely 2000 volts and 1000 watts of R.F. in intermittent service such as required by Ham operators.
A phasor is not a space-age weapon as some might imagine, but a series of coils and capacitors arranged in a special way to make possible a number of antennas tuning feats. With a phasor, it is possible to transform high impedances to low impedances and vice versa. Phasors can divide power between as many as 12 antennas at the same time and control their exact currents in relationship to each other. Phase may be advanced or retarded using the right adjustments so that the entire antenna pattern is tightly under control. Sometimes, as many as six or eight distance Radio Stations must have "protection" from the RF you are generating, so a phasor makes this possible when used in conjunction with the right number and sizes of antennas.

The coils used in phasors of over 10,000 watts are huge and very expensive. These can be made by hand from copper or aluminum tubing, but my readers in the USA must beware of FCC regulations. Everything used in Broadcast work in the USA must meet FCC approval. Consult your local FCC Office for the needed information on these devices, or consult your FCC Rules and Regulations. In most locations where I work, FCC rules do not apply, but similar regulations must be obeyed in these nations as well. In most Foreign Nations, the Regulations are not as strict, but PERFORMANCE is the criterion and the Engineer is held responsible if something does not work as represented to the Government.

The large 10,000 watt coils shown here are the type used in many installations in the USA and throughout the world. The higher quality coils are worth investing in, but for the adventurous type, these large coils can be made with the help of those skilled in making refrigeration coils for commercial uses. The main thing is to use quality materials, no second class tubing that is going to fall apart on you, burn through, and destroy more equipment in the process! Count the costs, and plan every step in advance. Don't leave anything to guess or chance. If you can't do it right, don't do it at all!
ROLLER INDUCTOR

The roller inductor shown uses a grooved form similar to that previously shown, but of bakelite instead of ceramic. This coil assembly MUST be used in extremely dry locations, but not too hot. The heat causes the coil form to deteriorate after a few years. The flutes and holes on the ceramic form are an attempt to deal with moisture problems which keep de-tuning R.F. circuits. When a coil must operate under high voltage or R.F., the slightest leakage can cause a major disaster, or at least a lot of trouble. The more inexperienced operator might make fun of my use of covered wire, but my experience shows that covered wire is MORE RELIABLE and LESS susceptible to moisture due to the new insulating materials used. Lacquered, enameled, or shellacked wire works well, but seems more vulnerable. I have found that these coils of mine made with covered wire do not give tuning problems often encountered with flat wound (bare) inductors.

The point I would like to make by showing the above inductor is the use of THE SHORTING BAR with the wheel-like contactor. The shorting bar is on top between the two horizontal bars. It is spring loaded so as to bring the brass shorting bar down holding the wheel against the coil. The wheel rotates as the coil is turned and maintains constant electrical contact.
The basic description has been given, and can be seen from studying the pictures of coils. Many high quality coils are custom made on a SOLID form. These are easiest to make and can be wound directly onto PVC PIPE of the right diameter. The inductance of the coil is the most important point, then power handling ability and size. PVC pipe comes in diameters suitable for coil forms, and is one of the best insulators in existence, and it costs very little in comparison to other materials. I have made critical tuning coils, tank coils, and antenna tuners in this manner and none of them have ever malfunctioned. These PVC Pipe Coils all use INSULATED WIRE instead of the usual bare wire. It is wound tightly along the PVC Pipe until the estimated inductance is reached the right number of turns. The insulation is removed through CAREFUL CUTTING WITH A SHARP KNIFE BLADE and then a sliding contactor is made which is capable of a full range of adjustments. If the coil does not need to be adjusted, it can be wound solid, and the ends terminated in brass screws set in the PVC Pipe ends. Connection is made to these screws and brought out to the circuit.

When the PVC Pipe Coil is going to be adjustable, a narrow strip of insulation is removed along the path of the adjuster. If too much insulation is removed you will ruin the coil. The bar for the adjuster is made of 3/16th inch brass welding rod obtainable at any welding supply. Two brass washers of about 3/4 inch diameter are soldered together with a copper or brass washer between them as a spacer. The result is a device that slides freely along the distance of the brass rod, contacting both the rod and the individual turns of wire as desired. A single turn can be contacted at any desired location along the entire distance of the coil. The brass rod assembly is spring loaded and pressures against the wire where the washers are set. The spring material is cut from heavy "shin stock" obtainable from auto parts dealers. This material must be made of brass or other metal which is a good conductor in order to work well. The brass "shin stock" spring material is wrapped around the brass rod and soldered in place after the washers have been put on the rod. I have made many of these, and they perform well at almost no cost. For Standard Broadcast purposes, the close contact between the insulated turns of wire poses no problem whatever. This style can be used to 30 mhz, but works best at lower frequencies.
USE OF THE SHORTING BAR

THE AUTHOR POINTING TO TANK COIL
IN HIS HOME MADE 500 WATT AM TRANSMITTER.

CLOSE-UP OF TANK COIL WITH
SHORTING BAR AND CONTACTOR WHEEL ON TOP OF COIL.
This close-up shows several things about the making of coils. I built this one on a hefty PVC high pressure pipe section. The wire is #12 plastic covered and is sufficient for 500 watts continuous use. The wire is tightly wound on the form and produces 150 UH. inductance for tuning throughout the entire A.M. Band. The transmitter is designed to serve in Third World Countries where availability of units made by high priced manufacturers is limited. The tank coil is adjustable by sliding the wheel to the point on the wire where the inductance is right and leaving it there. The shorting bar itself is 1/4 inch brass welding rod. The wheel is made of two brass washers on a copper tube. The spacing between the two washers is made tight for contactting by placing a third smaller washer between the two outer washers and soldering the whole washer assembly to the copper tube. The copper tube is chosen in size for easy sliding down the brass shorting bar. The close-up shows how the spring pressure is obtained and how the shorting bar is held in place. The pressure comes from the brass "shim stock" (heavy) wrapped around the ends of the shorting bar. This is chosen to give 3/8 to 1/2 inch spring action. As can be seen in the picture, the brass spring is wrapped around the bar at the ends and soldered in place. It is shaped first as shown, and when you know it is tight, then solder it.
The two springs together give about 50 lbs. pressure against the copper wire in the coil. This has to be stiff, otherwise the contact pressure will not hold well enough to prevent arcing or poor contact. The covered wire is bared along the slider's path - nowhere else. The baring of this wire requires patience. I have found the right tool for the job is a moon-shaped woodworking tool of the miniature variety. The sharper the better the job and the safer the user against accidents. When you must put too much pressure on the knife, when it slips, (and it will) something or someone will be hurt! The sharp tool is the safest tool for the job.

Brass screws are used to make the terminations of the wires and slider bar. These are 3/16 inch diameter and however long needed. A good hardware store will have bins full of these. I recommend looking for the older establishments as the new "QUICKIE" Hardware dealers have only what sells fast and in volume. NEVER lower yourself to use aluminum screws for this purpose. They simply are not strong enough to hold the pressure over a period of years. They will stretch in two over a period of time.

The entire PVC Coil Assembly is mounted on two stand-off insulators. The coil operates on the shorting principle with the wasted (active) turns un-shorted. As explained earlier in the Book, when cutting the insulation off the wire, the insulation on top is cut off, but that on the bottom of the wire remains so as to prevent shifting of the wire or shorting of turns. I have used this system for years, and never had a problem if the coil is done carefully.

Some have expressed concern over the insulation causing capacitance effect in the coils. I have not encountered any problems in actual use at powers up to 1000 watts. I am not prepared to say what effect it could have at 10,000 or 50,000 watts. I suppose that at those powers, commercially made coils would be relied on anyway - not to say that insulated wire coils could not be built and used successfully.

Back to the subject of screws. Steel screws work until they rust. Then problems arise which are not easy to resolve. Avoid trouble by using only brass or stainless steel screws in your projects.
This picture shows what happens when the coil is prepared for the shorting bar "slider" by using a pocket knife on the insulation. The coil is still usable, but the job is a little messy. The tuning coil is for a 1000 watt A.M. Transmitter in the driver stage. Two 833-A tubes are driven successfully with this coil. The R.F. Energy developed across this coil is fairly strong, enough to burn a person quite severely if contacted by accident. Once the slider is in place, it is never "slid" anywhere. It is fixed into position and set on the individual turns where it is to be used. This prevents any wear on the winding by the rough sliding of the contactor. The contactor "wheel" does not roll in this case, but serves to make a positive contact on any desired turn. I have used a number of systems, but the contactor "wheel" does a really fine job and is inexpensive to build. As I previously stated, moisture from condensation due to overnight temperature changes does not seem to affect the tuning on coils made using these methods. The only danger real to this coil is the point of contact. It must be firm enough through sufficient spring pressure to assure solid contact. If too weak of "shim" material is used, there will be problems with poor contact. In my transmitter design, the bias supply will prevent any burn-outs due to loss of grid drive, but R.F. drop out will occur and the Station will be off the air until the problem is corrected. In cases where this style of contact is used in the tank coil, the
problem is even more critical and should not be used unless you are sure your 
coil is "up to par." The heaviest wire for the job is a safer way to go, as 
too small of wire diameter will cause difficulty in making a good contact 
with the contactor waleet. While this coil is reliable if made properly, it 
should only be used where change of setting may be necessary from time to 
time. Other coil types will give even less trouble if there is an even more 
positive contact system devised, such as in conventional coils which use "pressure clips."

A good quality pressure clip can be made of two pieces of aluminum sheet 
metal shaped as shown on the following page. The pieces of metal are 
actually 1/16 inch or thicker and are formed by sawing to the right size 
and then drilled for the screw adjuster. The screw puts the right amount of 
pressure for a positive contact. The metal pieces are formed by putting 
enough bend in the two pieces to where the ends separate enough to 
accommodate the width of the coil winding. This makes it easy to slip on, 
then the screw is tightened enough to hold well. Aluminum works well for 
this purpose if it is at least 1/16 inch thick. Copper is a better material 
for this purpose, but it may be a little more costly.

Flat wound wire is easy to obtain if you wish to build a flat wound 
inductor. Most large motor rebuilding shops have several sizes to choose from.
You will have to choose what is best for your purposes and form the coil with 
a jig. The jig should have the size diameter desired and have narrow slots to 
hold the wire as it is formed in a circular motion. This is very hard to do 
without special equipement, but you can make a home-made jig from wood 
with the proper width slots cut in with a saw. Once the coil is released, it 
will spring out into a slightly larger diameter, so these primitive methods 
require experimentation until a form size for each coil diameter is reached.
The larger widths of flat wire will be harder to work with, so if you decide 
to try this, start with the narrow widths and work upwards as your skill 
increases. A very small diameter coil will be virtually impossible to build 
due to the tight bends necessary. Larger diameter coils will be more 
practical to make. Most commercial transmitter builders use flat copper 
strips for making H.F. lines. These can be made of flat copper wire of 3/8 
inch width or better, or of copper braid from coaxial cable.
Two pieces of heavy sheet aluminum shaped as shown and held together with a screw make a good reliable ribbon clip for R.F.
HEAVY COPPER ALSO SERVES WELL.

This home made choke coil uses #12 wire available in any electrical shop.
CHAPTER FIVE

AUDIO TRANSFORMERS

FROM

POWER TRANSFORMERS
Audio transformers are expensive, and sometimes impossible to find. I have made a discovery that could possibly save Technicians and Engineers thousands of dollars. By actual experience, I have found that most cheap power transformers will work perfectly well under even the most critical audio expectations. Due to the new and better materials used in the production of transformers these days, and the automation process, these transformers usually perform very well if the impedance ratio is correct. Any mis-match in impedance can make the best equipment sound like junk. If we first match the impedance requirements in our cheap transformers, we can then do a critical proof of performance test and see if the transformer in question will actually do the job we expect it to do. So then, I am about to show you the easiest way I know to find the IMPEDANCE RATIO.

First of all, IMPEDANCE RATIO ALWAYS REMAINS THE SAME regardless of frequency and power fed through the transformer. The IMPEDANCE RATIO is equal to VOLTAGE RATIO SQUARED.

TO FIND VOLTAGE RATIO, check the transformer with an ohm meter, and find the winding with the highest resistance. We will call this the primary. It may not ACTUALLY be the primary, but for our purposes it will help us obtain our needed information quickly. In series with this winding, put a 10 watt, 5000 ohm resistor and connect the winding to the 120 volt AC power. Now measure the AC Voltage present across the primary. Next, measure the individual voltages across all other windings. This will give the VOLTAGE RATIO. If, for example, the primary voltage measures 100 volts and the secondary measures 10 volts, the voltage ratio is 100 divided by 10, or 10 to 1. The IMPEDANCE RATIO will be this figure SQUARED or 100 to 1. This means that our transformer will reflect 1/100th of whatever impedance is put across the primary, or if reversed, 100 times whatever impedance is fed into the secondary will be reflected into the primary. Thus, if 6 ohms were loaded onto the secondary, 600 ohms would reflect into the primary. By observing the IMPEDANCE RATIO and loading accordingly, it is amazing how well simple power transformers perform at audio frequencies from below to well beyond the range of human hearing. Many 400 Hz power transformers can be tested this way and converted to high class audio work with no problems whatever.
It is amazing to me when I keep coming across Engineers that do not know that a transformer made to match 800 ohms to 30,000 ohms, will also match 60 ohms to 3000 ohms! The IMPEDANCE RATIO is the same. Now, there are some practical limitations to this, mainly the ability of the windings to carry the currents demanded. If there is too much DC resistance in a winding it may not be able to handle the amperage demands, or if the wire size in a winding is too small, it can be easily burnt out! These things should be taken into consideration before attempting to operate the circuit. With this in mind, I can say that many audio transformer demands can be met by obtaining a transformer at the local Electric Shop. Consultants have at times tackled their emergency repairs this way and no one has been the wiser. The down time saved and the results have been worth every cent paid for their work.

TEST SET UP

120 VAC

pri. sec.

Voltage is measured on primary from point "A" to point "B"
Secondary voltage is measured from point "C" to point "D"

IMPEDANCE RATIO is Voltage Ratio SQUARED

Some commonly found power transformers are listed below together with their impedance ratios. These all use 120 volt primaries. The transformers all are available with "center taps" which when used alter the ratios according to the above formulas.

1. 8 volts - 400:1 ratio
2. 10 volts - 144:1 ratio
3. 12 volts - 100:1 ratio
4. 18 volts - 44:1 ratio
5. 24 volts - 25:1 ratio
6. 32 volts - 14:1 ratio
7. 50 volts - 5.76:1 ratio
8. 80 volts - 1.44:1 ratio
9. 120 volts - 1.22 ratio
10. 240 volts - 1.4 ratio

50
In order to perform a simple audio test on the transformer in question, the test equipment shown can be hooked up to the transformer. The transformer is loaded on both primary and secondary with the desired impedance through R-1 and R-2. These are carbon (non-inductive) resistors of 1/2 watt rating such as found in any technician's resistor box. The generator is turned on and adjusted to the lowest desired audio frequency of test, while the output of the transformer is viewed on the scope. The generator is swept through the entire audio spectrum while the waveform is viewed for distortion or non-linearity. A good transformer will remain nearly flat in response from less than 20 Hz. to 20,000 Hz. Of course, the linearity of the audio generator should be tested first. If it is off, this should be noted and subtracted from the transformer performance. If the transformer passes this basic test, it is usually good enough to use in your equipment. If you still are not sure, you can make a full test using a Distortion Analyzer such as the Wav 400 or a Spectrum Analyzer, if this is done, proper resistive pads should be constructed first to achieve a perfect impedance match with the Audio Generator and the Analyzer used. You will find, as I have, that many power transformers work very well at audio frequencies. The object of this is to open the door of possibilities for those not able to find an exact replacement for an audio transformer. A lot of fine equipment has been thrown in the junk pile because someone didn't know the way around a problem. Hopefully, this information will be of use to someone else, as it has been to me.
IMPEDBANCE MEASUREMENT

To measure the impedance of a speaker or other audio device, use the following test rig. The audio oscillator must be capable of providing enough output to hold a steady current through R-1 throughout the test.

\[ Z = \frac{E}{I} \]

R-1 is not used HM-1 is an audio frequency AMP METER. R-1 is used in order to calculate amperage flow through the tested device by dividing the Reading of this meter by the value of "E" (100 ohms). With the current held steady at all frequencies of test (usually 20-20,000 Hz.) the impedance of the device under test may be calculated at each frequency by means of the formula: \[ Z = \frac{E}{I} \]. M-1 gives the "I" and M-2 the "E" in the formula.

It is common to make this test at one frequency only. This may be either 400 Hz. or 1000 Hz. With this test rig, it is possible to easily check the audio impedance of any device.

It is important to use a HIGH IMPEDANCE METER at both of the Meter locations shown or else your meter will load the circuit and give false results.

Be sure to hold the current steady throughout the duration of the tests. Record the voltage (M-2) and frequency each time the test oscillator is changed. A chart or graph may be made showing the impedance of the tested device at each and every audio frequency.

There are various other methods of measuring impedances at audio frequencies, but I believe this is the most straightforward giving acceptable results if done as shown.
CHAPTER SIX

ALL ABOUT

MODULATION
EARLY ATTEMPTS AT A.M. MODULATION

In the early days of radio, methods were sought to "modulate" the carrier wave so that speech could be transmitted rather than simply Morse Code. It was found that by placing a carbon mike (like the one used in telephone transmitters) in the antenna circuit and passing the R.F. through it, the carrier could be modulated. In figures a, b, and c, methods were found to couple the mike to the circuit. This did not produce 100 percent modulation and when large amounts of power were used, the mikes literally went up in smoke! This generated a search for a mike that could handle larger amounts of current. The Lorenz Gas mike (shown in Figure 2) used 25 mikes in parallel all hooked to a single mouthpiece! The Berliner Mike used a fan under it to provide air cooling (figure 3) but was not effective due to blower noise! Some of the later attempts and improvements are shown in the following illustrations.

At last, engineers discovered the vacuum tube amplifier and were able to use crystal, condenser, and moving coil mikes which generated little or no heat. The search for a 20 amp mike finally came to an end!
The above is an example of grid modulation. As you can see, the audio is coupled through an audio transformer into the grid circuit of the RF Amplifier tube. This tube may be the buffer, RF Amplifier, or the final P.A. tube, and the amount of audio drive will increase accordingly. If the audio is coupled into any but the final P.A. tube, the following stages must be linear amps. This creates problems much greater to the quality of audio than the inexperienced builder may realize. Early attempts at linear amps for the A.M. Broadcast frequencies were almost always PUSH-PULL linear. Single-ended linear for these frequencies are difficult to tune and require elaborate control over drive, bias, and all tuning stages. Another problem, but easier to overcome, is the lowering of efficiency when grid modulation is used. Plate modulation (as commonly used) is about twice as efficient as grid modulation in actual practice. When considering the construction of a Radio Transmitter, grid modulation does have distinct advantages. These include: (a) the elimination of expensive high-level audio transformers, heavy power supplies, and other expensive components, and (b) the elimination of at least 20 lbs. in weight in a 500 watt A.M.
Radio Transmitter. To compensate for the lower plate efficiency, a tube with higher power handling abilities should be used in the final stage. I highly recommend a pentode for this purpose because it requires no neutralization, and thereby eliminates potential problems with tuning. I have discovered by actual experiments, that a set of tubes usually run at 1000 watts plate modulated, will efficiently operate at only 500 watts when GRID MODULATED. Attempts at getting more power out of these tubes (such as raising plate voltage or screen voltage) should not be attempted except in the most extreme necessity. My reason for this is that there are tubes made for higher powers which may be substituted which will endure the test of time - and in the long run be cheaper to operate. If a tube is operated close to its maximum ratings, the life of the tube will decrease accordingly. This is just fine if you own a tube factory and like to frequently change out tubes, but for most of us, we would do better to design at least a 100 percent over-capacity into any circuit which is to be operated with round-the-clock regularity. When designing circuits for intermittent use, such as most Ham Transmitters, much smaller components and tubes may be used at the same R.F. Power outputs. These circuits are “un-keyed” regularly enough to allow tubes, transistors and parts time to cool off, but such is not the case with truly Commercial equipment!

In the partial schematic on the preceding page, the R.F. Choke must be present as shown in the grid circuit. This blocks all R.F. from the bias supply or audio circuits, but permits the audio to freely pass into the grid of the vacuum tube. The value of the grid bypass condenser is critical to audio frequency response. This is usually no larger than .001 mfd. By using larger values, the higher frequencies may be "shorted to ground" and bandwidth narrowed if so required.

This basic circuit may be used with triodes with great success, and greater ease in selecting parts values is obtained. In the case of the pentode, the screen voltage must be carefully adjusted and a screen by-pass condenser of the correct value chosen or else the audio quality may suffer. This minor problem is not present with the use of triodes, but neutralization will be found necessary.
The GRID BIAS SUPPLY used in grid-modulated tubes may be a negative voltage from a power supply or simply a resistor of the correct value. The best system is a combination of both. The reason for this is greater stability and much better overall performance. I use a rule-of-thumb for selecting the size of resistor. In simple terms, the resistor is chosen for the value that permits maximum power when used by itself and yet prevents thermal runaway when the bias voltage is removed. The bias voltage supplements the voltage drop across the resistor to obtain the correct bias for the application. In case of a failure of either the resistor or the bias supply, the transmitter will still work.

I have developed the following grid modulation method and prefer it above all others.

![Diagram of grid modulation method](image)

The audio is coupled into the 500 mf. capacitor from the audio amplifier section. The audio power required to modulate a 500 watt transmitter in this manner is less than 10 watts. The critical part is to match the impedance of the amp with the grid input impedance. Most 500 - 1000 watt tubes turn out between 150 - 600 ohms impedance. The value of the bias resistor helps determine the load into which the amplifier will be working. Its value is usually between 1000 to 3000 ohms for most tubes. A bypass capacitor is always required at the bottom-end of the R.F. choke, but is not shown in the illustration. In cases where a transmitter is being built which will handle very high audio frequencies, it may be desirable to place a .1 mf. capacitor across the 500 mf. capacitor to assure better transfer characteristics.
CATHODE MODULATION

In the mid-1950's, it was common to find Hams experimenting with cathode modulation because of its linear characteristics and high-fidelity response. Although I have not directly copied these circuits from anyone else, they are bound to be somewhat similar to those used in the past. The simplest way I know to obtain cathode modulation is to select a tube such as the 6L7, 6146, or one of the TV Horizontal Outputs commonly used in linear amps. In the cathode return lead, the output transformer is placed so that all current passing through the tube must pass through the modulation transformer. This makes it easy to modulate the R.F. passing through the tube, and if a proper impedance match is obtained, perfect audio quality can be obtained - way below and above the human range of hearing! The trick is the impedance match. Often, a transformer can be found of the right value, but alas, the secondary will not handle the high currents! Surplus Dealers often carry several transformers qualified for this kind of service. These are listed at the back of this book.

Due to the difficulty in obtaining a perfect impedance match, and the desire-ability to "get the iron out," I have found this second means of transferring the audio energy very satisfying. A fixed resistor of the correct value is placed in the cathode-to-ground circuit. This resistor matches the impedance of the driving audio amplifier. Using a coupling capacitor of 100 - 300 mfd., the audio is transferred into the cathode circuit. A transformerless Solid State Amplifier section will work fine under these circumstances. I have found the same great results using cathode resistors from 4 ohms (with 4 ohm matching amp) to 1200 ohms. If impedances match, and the amplifier is of proper characteristics, the greatest possible fidelity for the money can be had. I have tested a 50 watt R.F. amplifier modulated in this manner from 1 Hz. to beyond 40,000 Hz. - flat within .5db! The amplifier, of course, must be capable of this performance.

I have built Transmitters using this technique using a variable resistor of 25 watts in the cathode circuit. This could be varied from 2 - 100% and the user furnishes his own amplifier for modulation! The only note, is that the unit will put out more power at low ohms than at high ohms, and will thus require additional audio drive at higher R.F. output levels.
TRANSFORMER CATHODE MODULATION

CONSULT TUBE MANUAL FOR TUBE CHARACTERISTICS BEFORE SELECTING TRANSFORMER

NOT RECOMMENDED AT R.F. LEVELS ABOVE 100 WATTS

AT LEVELS ABOVE 100 WATTS, USE MY MODULATION SCHEME AS SHOWN IN THE FOLLOWING PAGE. Be careful to check for any by-pass capacitors in the circuit that may restrict audio fidelity. The transformer must have sufficient current handling ability to remain cool at all times. The impedance should match quite closely or else modulation will suffer.
I have found that a large power tube may be modulated "cathode modulation" style at the filament return lead where the plate current meter usually connects. The only hard part might be to match the impedance correctly. This can be overcome using the following reasoning: Determine the plate voltage and plate current at which the tube is to be operated and divide current into voltage. Then take the square root of this figure for the impedance value between points "A" and "B". Thus $Z = \sqrt{V/I}$. Most large power tubes may be modulated this way with only a fraction of the power needed at plate modulation levels. A 500 watt A.M. Transmitter requires only a 10 watt amplifier rather than a 250 watt amp section! The frequency response is VERY GOOD. No large reactors are needed to assure low frequency response and the size of the modulation transformer for even a 500 watt unit is small. This particular scheme is my own invention.
The bypass capacitors used at the tube socket have no affect whatever on audio frequency response, but other capacitors must be avoided between point "A" and the center tap of the filament transformer unless they are needed to limit frequency response.

Going back to my remarks in the chapter dealing with transformers, a close match may be made for an audio transformer using small power transformers. For example, if you have two power tubes operating in parallel to produce 500 watts r.f., and the plate voltage is 2700 volts with 270 ma. of current, we first find the impedance with the above formula. The plate voltage divided by the current equals 10,000. Take the square root and you have 100 ohms for the transformer. Suppose you have an audio amplifier of 4 ohms output which you would like to use for the modulation. A very close match can be made using a 24 volt power transformer made to operate from 120 volts A.C. Let's see what we would have —— The ratio of voltage for this transformer is 5:1 with a 2:1 ratio of 25:1. If the transformer were used in this situation, with the primary between points "A" and "B", and 4 ohms placed on the secondary, the reflected impedance into the primary would be 160 ohms. This is a close enough match, wouldn't you agree? Now, to settle the argument as to whether it will work or not. This particular situation was faced and overcome exactly as described. The 24 volt transformer matched so well that the modulation was within .5 db. from 17 Hz. to 22,000 Hz. A pretty good power transformer, right? All I can say is, "Try it, you'll like it!"

OK. We've faced the impedance problem and won. Now what about the amperage rating of the primary winding? This is critical to proper performance. The transformer primary current rating will be found by math. The primary, in this case, must be capable of handling 200 ma. This translates to 24 watts or a 1 amp. secondary transformer since watts in equals watts out (sort of). To be safe, double this figure and buy a 2 amp. transformer or greater. You will find that most power transformers of this kind have a delightful frequency response if the impedance is reasonably matched! This circuit requires careful adjustment of grid drive in order to obtain desired results. If too much drive is used, modulation quality will suffer.
PLATE MODULATION

Plate modulation is by far the most "fool proof" when speaking in generalities. Once everything is set up (and a major investment made) the equipment will continue to operate in a stable manner for years to come. If a person does not mind the extra weight and expense, plate modulation is the way to go. I personally believe it is a rather great waste of space, money, and work in the long run but it is reliable.

Most plate modulation circuits are similar to this schematic. They utilize a plate reactor capable of handling high currents, high voltage, and have high reactance! This costs money and has tremendous weight! Attempts at reducing the size of this have largely been unsuccessful. Some transmitters use one or more extra secondary windings to modulate other stages (usually screen grids) and this helps some. The basic circuit above will not work at frequencies below 250 Hz. or so without the large reactor. The reactor assures that low frequencies will be present and high frequencies will have a flat frequency response. In even the smallest 10 watt plate modulated transmitters, this reactor is necessary.
The plate reactor in even the smallest transmitter has a lot of wire in it and is usually between 10 henries and 30 henries in value. This kind of coil is difficult to wind and is expensive. I have seen these which weigh several hundred pounds, especially in older model transmitters. With solid state transmitters taking over, the weight is no longer present, just the expense! No wonder there are so many Broadcasters reviving old vintage transmitters!

The rule is that it requires 50% of the R.F. power rating in watts to achieve 100% modulation. This means that if you have a 2000 watt A.M. Radio Transmitter, plate modulated, you will need 1000 watts of audio drive for 100% modulation! These amounts of audio power are an expense due to the heavy modulation transformers needed and the associated components. The power supply must be doubled in capacity which means even more weight and expense. This used to be the way it was done, but there has always been a search for a better way. Just a few of the alternate modulation methods are: Low Level Modulation with linear amplifiers for higher power stages, Ampliphase, Pulse-Duration-modulation, and Polyphase PDModulation. This is just a few of the designs which have been used in order to get away from the old plate modulation problems of cost and weight. The truth is that, while costs have remained high, most of the transmitter makers have gone out of business.

Solid State R.F. Stages have made it possible to modulate at even higher levels with less distortion, but this too is expensive. R.F. Power Combiners make it possible to use R.F. Transistors of the size of a quarter to achieve outputs of more than 5,000 watts! Many of these combiners are used along with even more transistors. The actual cost of building a tube type transmitter remains attractive, and therefore the high power stages remain mostly tubes (not to mention the other rugged features of modern tube types). We are fast approaching the time when (no doubt) all high power stages will be Solid State. With the new materials being made in the Laboratories, heat will soon be a thing of the past in high power transistors. The new Super-conductors will make power handling of R.F. and modulation faster, better, and easier— with powers unheard of in the past!
MODULATION METER
with D.C. Meters

DIODES: ECG 177
C-1: Size determines RF level of pickup - may be a 10-400 pf. tuning Cap.
METER: IMa. D.C.
Meter may be calibrated for modulation percent if so desired.
FREQUENCY: Broadcast through Short Wave
C-1 may be increased in value to increase Meter readings if necessary.

NOTE: The unit must be enclosed in a shielded metal case. The signal
into J-1 is taken off a "T" Connector into the antenna system.

WARNING: NEVER feed the output of the transmitter directly into the
Modulation Meter without a DUMMY LOAD or antenna in
the circuit.

IMPORTANT: FOR POWER LEVELS ABOVE 200 WATTS ONLY
RADIO MODULATION METER

using VU Meters

"Professional Meters Only"

100 percent modulation is "0" VU.

D-1, D-2, D-3, and D-4 = ECG 177 fast switching diodes
R-1 = 25K ohm carbon 1/2 - 2 watt
C-1 = 10 - 500 pf. Average value 50 pf.
C-2 = 1 uf/NP 50 volts

NOTE: D-3 and D-4 may not be needed (these increase sensitivity)

USE WITH POWER LEVELS ABOVE 250 WATTS FOR BEST RESULTS.

INSTRUCTIONS: At J-1, a sample of the output of the Radio Transmitter is fed into the unit through a coaxial cable. R-1 is adjusted to obtain 100 percent modulation at Zero db. on the VU meter using a scope to set the level or another modulation meter.

By changing the value of C-1, the unit will read modulation percentage through the entire A.M., C.B. and Short Wave Bands to 30 MHz.

WARNING: NEVER feed the output of the Transmitter under test directly into the unit without a DUMMY LOAD or Antenna in the circuit. Use a "T" Connector such as the M-358 for this purpose.
PARTS VALUES

C-1 = 30pf  
C-2, C-3 = 100pf  
C-4 = 1uf  
C-5 = .001 uf  
r-4 = 3K  
RFC - 1 = 560uh choke  
C-6 = .001 uf  
C-7, S-1 = .001 uf  

R-1 = 2.5 K set control  
R-2 = 30K internal calibrate  
R-3 = 1.5K  

NOTES:  R-2 should be calibrated for frequency band used. Adjust R-1 for full scale reading. Zero (0) VU is 100% modulation. Reduce values for C-1, C-2 and C-3 to 6 and 12pf respectively for use above 5 MHz.
In cases where a 20 - 50ua meter is not available, or sufficient drive from the transmitter is not available, a simple meter amplifier can be made as shown below:

My Modulation Meters on previous pages will also work with this simple meter amplifier circuit.

A 1-1/2 volt "D" Cell battery will serve well for the meter amplifier if it is not to be left on all the time. If so, use a cheap 5 volt battery eliminator such as used for toys, etc. These are available from your local Radio Shack Dealer for a small price or most Electronic Dealers carry them.

The 123AP transistor is recommended since it is commonly available, but many other "NPN" transistors work as well or even better. Install a transistor socket and experiment for the best results.

I have found that it is not usually necessary to install a gain control on the transistor itself since it responds only according to what you put into it. This is usually adjusted with a gain control in an earlier stage, so you can see there should not be any problems.
THE MODULATION

DOCTOR
There are various ways to enhance the modulation of a radio transmitter. Some of these are include using reverb, boost of mid-frequencies, limiter-compressors, equalizers, and wider frequency response than normal.

Reverb has the effect of adding "liveness" to music and speech. A little reverb can be added to the transmitted sound by adding a reverb unit to the audio chain. Just a slight amount of reverb, which no one would hardly notice, has the effect of making the broadcast signal highly intelligible at nearly double the normal distance from the transmitter. I recommend keeping the reverb level about 30db. below program level if used as suggested above for modulation enhancement. The problems with reverb include the tendency of Operators to use too much reverb and the need for varying reverb time with differing program materials. Speech, for example, requires less reverb time than music performed in a concert hall. If reverb is properly used, at about 30db. below program level, the broadcast signal will appear to have a 9db. increase. This is equivalent to a 30% increase in transmitter power. The cost of an electronic reverb is a small price to pay for the increased coverage, however, I will repeat that too much reverb will drive away the listeners to another station faster than just about anything you can do. Let the modulation-enhancer beware!

Boost of mid-frequencies is one of the safest tricks you can use to enhance the modulation. The frequencies that carry most of the intelligence are boosted while the other frequencies remain as usual. This does as well as reverb, with a lot less risk of running off your listeners. A simple device can be placed in series with the program line to the transmitter, and adjusted to reduce the lower frequencies and pass the higher frequencies with ease. This has the effect of appearing as if the higher frequencies were boosted. A simple circuit using a variable resistor and a capacitor are shown. By varying the value of the capacitor and resistor, a better result can be obtained.

![Mid-frequency booster circuit](image-url)
Even better, for those with the money, an equalizer may be used to enhance the desired frequencies. Many D.J.'s have a personal equalizer which is used only when their voices come on the air. In all other modes, it is "off." Some D.J.'s use equalizers for everything that goes out over the air. Constantly adjusting for the desired results, it gives the D.J. full control over his custom sound. Some work well enough to eliminate "scratchy" sounding records, hums, and other annoying sounds from the program material. When used properly, these are a great asset.

The limiter-compressor is required by law before the input to the transmitter. When set properly, a limiter can appear to bring up the entire program level to a higher dynamic range. This is done by cranking up the audio output level from the control console. The "pots" are run "hotter" delivering fierce, but clean, signals to the limiter. The limiter reduces the output to the legal limits and the broadcast signal has a "tightly controlled" sound. The effect is higher overall modulation levels of all frequencies delivered to the limiter. The compressor basically accomplishes the same thing, but when used in conjunction with the limiter, you have even more control over the sound. Recovery time on a compressor should be set so that "pumping" and "breathing" are eliminated, yet low level signals are brought up to the desired levels and high level signals are "turned down." The basic difference between compressor and limiter is that the limiter just "cuts off" program peaks, but a compressor sort of automatically "turns down the volume." Many audio processors use a combination of all these techniques and cost thousands of dollars. Not all of these units are worth the price they cost, but currently companies like ORBAN, CRL, dbx, Modulation Sciences, and Valley People are building some very fine units.

The modulation may also be "doctored" by removing the frequency limiting devices inside the transmitter. This is desirable in cases where the transmitter is old and does not come up to modern specifications (10KHz for A.M. and 15KHz for F.M.). Beware of exceeding legal limits as you may "walk on" the broadcasters on the adjacent channels. This technique has been used to give certain A.M. Stations that desired "Hi-Fi" sound. The lows on most A.M.'s are usually pretty good, but high frequencies are "cut off" around 7 to 10KHz. I have heard of certain A.M. Stations with frequency responses beyond 15KHz done by removing frequency limiting parts inside the transmitter!
MODULATION MONITOR
500 kHz - 30 mHz
designed by
James R. Cunningham - Sept. 1988

PL-259
20 pf
1mH
12
12
2.5K
*SET*
1.5K
1m/50v.
.001
3K

25K internal calibrate

s volte supply
120 vac 60Hz.

“SET”
SW1

“READ”

ECC121AP

All diodes are 1N914 or equiv.

The “SET” Control mounts on the front panel. With SW1 in “SET” position, adjust front panel meter for full scale. To read modulation percent, switch SW1 to “READ” position and read modulation percentage directly. Unit may be left on permanently. The 5 volt power supply may be a toy battery eliminator for any voltage between 4 and 6 volts having a current rating of at least 10 MA.

This Unit will run any number of remote reading meters of the same type if they are simply wired in series with the primary meter. A terminal strip at the rear of the Unit may be installed for this purpose.
CHAPTER SEVEN

MAKE YOUR OWN

INSULATORS

FROM PVC PIPE
NEVER BUY ANOTHER INSULATOR

The low cost and high insulating qualities of PVC pipe make it an excellent material for making good-strong insulators. In nearly all cases where porcelain insulators are used, these PVC pipe insulators will do the job better. Caution should be exercised against using them in high heat areas, such as close to a large power tube or transformer where heat is normally found. Any place where there is plenty of air and temperatures under 160 degrees F. will cause no problem whatever. Even the hot tropical sunshine seems to cause them no harm.

PVC Pipe comes in all sorts of sizes and thicknesses. The White PVC Pipe is the kind I prefer because I have tested it extensively and it is readily available. There is a high temperature PVC Pipe which I have also tested. It is designed for hot water systems, but must not be confused with the old black plastic pipe which used to come in a roll. That type is worthless for insulators of any size or strength. The gray, hot water PVC is good, but more difficult to locate in some parts of the world, but white PVC is obtainable almost anywhere at the present time and does a good job.

There are accessories for PVC Pipe that come in handy for making custom feed-through insulators, also. I have made 4 inch diameter feed-throughs using accessories made for "toilet plumbing." The design is my own, but they are completely water proof, and serve well to feed RF through the side of a tuning box or Radio Shack (20g) house).

Many diameters of PVC Pipe are a perfect fit, one inside the other. These can be cemented, one inside the other, for extra strength. Phasor coils and capacitors having great weight do well using this system. The bolts inside the PVC insulators should be of brass or copper plated. Avoid anything that will rust - Radio Frequency Energy does strange things to iron, and iron has a way of making harmonics unless it is copper-clad.

I do not think PVC should be substituted for Antenna Base Insulators, as it is not rated for that kind of pressure. If there is any doubt, do it the SAFEST way possible, the accepted way!
NEVER BUY ANOTHER INSULATOR AGAIN

COMPLETED PVC PIPE STANDOFFS
10,000 volts tested!

These pictures show the PVC pipe and cement.

The PVC pipe insulators are used in Radio Transmitters and throughout the RF network. They insulate better than many high cost porcelain insulators. Construction is simple and the cost is only a fraction of store-bought insulators. They are also less susceptible to breakage through strain and hold almost as much weight. Caution should be exercised against heat.
THE PVC PIPE ENDS ARE DRILLED AND FITTED WITH BRASS BOLTS WITH NUTS.

Once the end caps are glued in place, they will be impossible to remove.

THE ACTUAL APPLICATION OF CEMENT TO THE PIECES

The PVC pipe insulators should be cut to the exact size needed and carefully assembled. Once everything is glued together, they should be allowed to set for several hours before use. Maximum strength will come in about 2 days, but within minutes, they will be capable of holding great amounts of pressure. This system of assembly is simple and remains moisture resistant. The bolt holes in the caps should be sealed with a little glue before tightening the nuts. This will make them air-tight and water proof.
Where there's an EMERGENCY, there's a way! These feed-thrus were made from P.V.C. standard toilet fixture plumbing. The pieces all screw together neatly and all threads are sealed with silicone seal to assure water tightness. The large brass bolts passing through the center are designed to carry 5 KW of RF Power to the antenna tower through the side of the Tuning House. The actual cost of both of these units was $10.00 U.S. Money. These were bought at a discount store. Notice that the P.V.C. flanges come with convenient "bolt holes" for attaching to the side of the radio shack. The center hole for the feed-thru bolt had to be drilled. When 10 KW is to be fed through, use 1/2 inch diameter brass bolts or copper tubing. Drilled at the ends for attachment to the feed lines. I tested these units up to 30,000 volts d.c. and detected no leakage. Not only are they water proof, they are also "electric proof."

The measurements are as follows: Flange measuring 6 inches diameter, from base to top of connector, 5-1/2 inches, and the protrusion measures 4 inches in diameter. Needless to say, when there is a need, there is a way! SAVINGS! In excess of $200.00!

When the flange bolts are put into place, a gasket may be made from SILICONE SEAL. These are quite capable of doing the job and resist blows better than porcelain or glass insulators costing much more.
CHAPTER EIGHT

UNDERSTANDING

THIRD WORLD

RADIO PROBLEMS
There are many Complete Radio Studios inside shacks worse than this one throughout the Third World! No one knows the struggles these brave Pioneers in Radio endure to get "on the air!" This Studio worked for years using a child's toy phonograph and ceramic cartridge for the D.J. The "Cart Machine" consisted of a battery operated cassette recorder with A.C. Adaptor! Sometimes, there were two of those things, when one was not in the shop for repairs.

The home-made transmitter at right operated at about 400 actual watts, though it was intended for 1000 watts. The coils were made using wood strips which soaked up moisture and de-tuned it daily! This was done because the man who built it did not know about PVC Pipe Coils. The transformers in this thing were from the local Light Company, rewound by hand! The frame is from the local hardware store. This was the noisiest AM Transmitter I have ever heard and never used a front door or blower.
THE ANTENNA TUNER

The big black arrow points to the steel box used to house the 1000 watt antenna tuner in El Salvador. The box was constructed by a local Engineer using scrap metal. To save money, it was made too small, thus generating tuning problems. To further complicate matters, no coax or acceptable transmission lines were used from the Radio Shack to the antenna. The small black arrow (lower left) points to the 1/4 inch diameter wire used as a transmission line. Needless to say, this was impossible to tune, and was not even supported by insulators. It hung from 10 ft. high poles touching the wood from place to place. The bare copper wire was brought close to the ground in an attempt to lower the impedance.

The rocky soil around the tower was also a poor place to put ground radials (only 40 of them). The worse thing was the location of the Station - on top of a mountain - ten miles out from San Salvador City. No wonder the signal could not be heard in the City! This was the condition of the Station when I first arrived on the scene. A little Engineering advice, and the Station was relocated in the lowlands (Sonoma), a better ground system installed, and the Tower fed by RG8/U. Needless to say, for the first time the Station generated both listeners and income! The story goes on... At later dates, we replaced the home-made console, installed a limiter, line amps, phone lines, equalizers, and a first rate Station developed Broadcasting the Gospel throughout the Region.
INSIDE THE RED BOX

When the Radio Station in El Salvador was re-located to Sonsonate, the same "RED BOX" was used again for the antenna tuner. I have included here the actual photo showing the poor condition of this attempt at tuning. The base of the .062 condenser was badly corroded, the coil itself was made of small copper wire, the center tap going to the condenser was poorly wrapped in place (without even a clip) and the twisted wires shown went to the tower through a 3/8 inch diameter ceramic tube. Needless to say, there was room for improvement!

Out of five Radio Stations I visited in El Salvador, only one had a transmitter that was operating at over 1/10th of its rated power and all had problems with insufficient ground radials. To show the extent of this, the workers at a 10,000 watt Station (showing a power output of 400 watts!) were instructed to the poor condition of the ground system, proudly stated that they had a full 30 feet in every direction! My calculator showed a need for 200 feet radials! No wonder FA tubes and tuning condensers keep blowing out! After an interview with the owner, explaining the extent of the problems, he still did not want to make the needed repairs (Date:April, 1987). I guess 400 watts and 8 miles of coverage was enough, he complained of financial problems and the inability to obtain "parts." With his operation in such a mess, no wonder he has "financial problems!" To date, he still has done nothing to correct the engineering problems at the Station.

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HOME MADE TRANSMITTER

The first radio transmitter used by a certain Radio Station in Central America actually produced 400 watts when tuned up, but changed daily due to wood coil forms which absorbed moisture. Pictured is the same transmitter with the replacement coil and tuning condenser now in use (ten years later)! As you can see, the coil form is made of good material now, but the coil itself leaves something to be desired. With the sloppy arrangement of parts and poor quality workmanship, no wonder this 1000 watt transmitter has never been able to deliver the goods! The coil shown is the driver tuning coil delivering the power to the grids of the two 833A tubes. Feast your eyes on this wonder of modern engineering! I personally know the Owner and the exorbitant fees paid to the builder of this electronic marvel. These conditions exist in many nations due to the extremely high costs of obtaining good equipment. Even donated equipment may be impossible to get into a country with high tariffs, import fees, and shipping costs. I know cases where new equipment in the USA is cheaper than taxes and imports on a used transmitter in a poor country. What I am showing here is the result of unqualified individuals operating under trying circumstances to build an affordable Radio Station.
Believe it or not, in one Central American nation, the majority of towers look like this one! Looking straight up toward the top, you can see the various bends in the structure. This particular tower is 190 feet tall and could hardly stay up if any more structure were added. This is a new tower, not something so old it is about to fall down. The beat that they could do is shown here. I personally know the man who climbed this tower to paint it a day after I took this photo. I did not see him at all. If you look closely, on the left hand side of this tower is a set of wires running all the way to the top. This is their attempt to give it more directional ability without much expense. The ground radials to the left side of the tower are completely missing due to the fact that the land where the Station is built is too small for a good antenna system, and the main area of coverage is to the right of the tower. So then, all the radials were placed to the right and the tower set over in the very corner of the land. One sided radials, plus the wires running up the tower on the left side of the photo are the directional array. It would be OK (maybe) if it worked, but it really performs poorly unless the ground has been soaked with 40 inches of annual rainfall which comes in July, August and September. The rest of the year, the signal goes up instead of out. By the way, the wires going up the left hand side of the tower are grounded and are supposed to reflect the signal toward the right side of the tower. This is one trick I
never came across before, nor have I read about it. If anyone reading this has
used similar gimmicks, let me hear from you.

Whether the attempt at increasing the directional ability of this tower
worked or not, one thing is certain, the Consultant got paid for his work. I
know of cases in Foreign Nations where Engineers modified transmitters, added
unnecessary parts, removed components, and otherwise degraded the equipment,
all just to get the money!

I am currently involved in a situation where the Engineer could not get the
transmitter to stay on the air with a full plate voltage, so instead of finding
the problem and fixing it, he rewound the plate transformer to a lower voltage
and cut the output power from 1000 watts to 100 watts! Now, no one can fix
it without a new plate transformer. After checking the transmitter, I found
that the reason it will not operate with the correct plate voltage is that a grid
bias resistor has been replaced with one of the wrong value, allowing too much
plate current. By the way, the plate current meter is burnt out as well. I
isolated the problems, but was unable to fix it due to the liability of the
"Consultant" who must work it out with the Station Owner. The Engineer
responsible for this mess operates as a Consultant in five Countries, but hardly
knows his stuff. Truth is sometimes stranger than fiction.

There are a number of problems unique to Central American nations. One
of these is the volcanic ash which makes up the soil in various places. This
ash behaves more like glass than soil, and is an excellent insulator. Conventional A.M. Antenna methods leave something to be desired in many of
these places. In these areas, every trick in the Book has been tried, plus some
in books to come!

One of the best antennas in Central America I saw was years ago atop
several downtown store buildings. The Engineer had his own style "long wire
antenna" strung up along with some vertical elements which covered hundreds
of square miles and performed better than most towers now in use! The man
who invented it used the "cut and try method" until he got it right! To this
day, vertical and horizontal wires work when all else fails.
CHAPTER NINE

WIRE ANTENNAS

FOR

STANDARD BROADCAST
PARALLEL TRANSMISSION LINES

It may be necessary to use parallel transmission lines with some of the antenna ideas given in this book. Parallel lines have the advantage of transferring a greater percentage of the signal over a greater distance and the added advantage of being "balanced." These lines are ideal for the "do-it-yourselfer" and can be made from wire or tubing with insulators every so often to maintain the correct spacing between wires.

The chart given above simplifies the calculating of impedances for open-wire lines. These are usually used with the two wires side by side in a horizontal plane, but it is sometimes advantageous to mount one wire above the other in a vertical fashion. However, it is done, it is important to maintain uniform spacing between the wires throughout their entire length.
In the early days of AM Radio Broadcasting, nearly all antennas were wire antennas. Until the 1950's it was common to see two AM Towers with a group of wires suspended between them. It was discovered that the long wire antenna did better for DX transmission due to its angle of radiation. In order to have a good ground wave, it was found necessary to have a good ground radial system of at least 120 quarter wave-length radials in every direction. Later, it was decided that DX was not the object of most AMer's anyway, and the wires were removed from between the towers and the tower(s) became the radiating element. Until now, this is the accepted AM Antenna System. In order to achieve directional ability, more towers are added to the System and phased according to the need. Many small stations are omnidirectional, and require only one tower. This is the simplest of all AM Antennas commonly in use. Usually this is a single quarter wave-length tower with its ground radial system as mentioned above.

In some areas of the world, this does not work very well due to several factors. The chief of these being the poor ground conductivity. Added to this is the fact that in many places, there is no such thing as several acres of land all together where a complete antenna system can be put up. Due to this, the majority of antennas in some nations are sub-standard. In parts of El Salvador, the soil conductivity is poor and the land parcels small with many towers having 50 feet or less of ground system. In effect, the "ground screen" is all that is present - no radials. If a person wished to re-locate to where there is more room for radials, it would not be possible, therefore you must make do with what you have. I have included in this chapter some attempts to deal with this problem, some with a degree of success. Keeping in mind that the signal goes straight up under "normal" circumstances, you can see why these attempts may be a definite improvement over a "tower." I have found that where there are few or no ground radials, a few wires hooked to the neighbor's barbed wire fence is a great asset. The entire fence acts as a "counterpoise" (sort of). Anything is better than nothing! If the fence goes around the entire lot, you have a more balanced ground effect.
HORIZONTAL VS. VERTICAL

It is common to hear concern expressed over looking AM coverage due to polarization of the signal when a wire antenna is used. True, when the wave leaves the long wire antenna it has a horizontal polarization, but as it travels along it rotates more than one would think. I have taken field strength readings of AM Stations in various places in the USA, and have never found a Station that did not have a strong horizontally polarized signal in spite of the vertical antenna system used. This is especially true at a distance over 5 miles. I am not attempting to explain this. I only accept it as a fact due to my experience. I have actually made AM Signal tests using long wire horizontal antennas, and have always found just as good a reading in the vertical plane as in the horizontal. At these low frequencies, there is little to be gained with a vertical tower except height. This is an important factor, and coupled with the idea that wires are a nuisance, the tower has its advantages. Polarization is not a problem at AM Frequencies. Going higher into the Short Wave Band, the differences are greater, but not a problem, especially when DX transmission is desired.

No matter what type antenna is used, at frequencies under 3 MHz, a good ground radial system is needed. There is no way around it. In places where a full ground radial system is used, yet the earth has poor conductivity, the antenna will still not work well. Both ground conductivity and a good radial system is needed even when a long wire antenna is used. At the higher frequencies, no expensive radials are needed, only a well designed antenna – and there are many to choose from.

It is my personal opinion that all Broadcasting for Public use should be put in the higher frequency ranges where expensive antenna systems are not needed, and the AM Band converted to Government, TV Re-broadcast, and Utilities Control. However, right now we are faced with the AM Band as is, and must deal with its problems as best we can.

The following antenna ideas have been used to try to improve AM coverage and some listed here are still in the experimental stages and are my own adaptations.
PARASITIC DIRECTORS LOWER RADIATION ANGLE

Below is a diagram of a tower (in center) with three parasitic directors arranged in a circle around the tower. Each director is 4% shorter than the 1/4 wave-length tower and is isolated from all else with insulators. The directors are horizontal wires on 30-50 ft. high poles in an attempt to lower the radiation angle. For towers with a poor ground system, these aid in the attempt. The directors attract the signal in all directions about the tower, bringing some of the high angle radiation down toward themselves, and thus, a lower radiation angle. If the tower is 1/2 wave-length, the directors can be made 1/2 wave-length, less 4%, and a larger spacing between them and the tower can be used. A, B, and C are large poles used to support the wires on insulators. Smaller poles are used between them to give more strength to the wires and a more circular shape. This same scheme works well when done in a triangle rather than a circle, but with fewer poles, there is less rigidity to the wire system. Another variation of this is to arrange the wires as shown, with the center of each parasitic brought down to within ten feet of the earth. The signal in each director is forced into an even lower angle.

A, B, and C are 50' poles

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A full-wave director (less 9%) may be built around the perimeter of the
tower. The ground screen is in the center with the radials (if any) going out
from there. The arrangement causes a low angle field to develop within the
proximity of the tower.

The full wave director has both ends of the wire tied apart and is fully
insulated from the ground system and the rest of the antenna.

There are other ways of lowering the antenna radiation angle such as
top loading. Using guy wires for top loading helps a little, but I prefer
other means. Top loading, along with other means of lowering the radiation
angle is the best way to go. As you know, the best form of top loading is a
1/2 wave-length tower instead of a 1/4 wave-length tower. If this is not
possible, the "capacitive hat" needed may be built from connecting the upper
segments of guy wire directly to the tower where insulators are now present.
Jumpers should be placed across the top insulators to accomplish this.

There are aircraft metal rods which are used for antenna sections on some
"beam" antennas for Ham frequencies. Six or eight of these can be attached
to the top of the antenna reaching out 20 feet or so in all directions. This
works about as well as the guy wire method. Sometimes it is possible to
construct a platform-like "top hat" if the tower is strong enough at top to
hold the weight. Both height and width contribute to the effect. Sometimes
wires are run out in a horizontal direction all around the top and insulated at
their ends where they are held out. Plastic rope serves well to hold them out
away from the tower. The top loading and parasitic director together will
increase the effect of lowering the radiation angle.

When there is no possible way to increase the ground radial system, these
and other "tricks" must be resorted to. Increasing transmitter power when
the antenna system is bad has several negative effects. One of those is to
create harmonics which are a hazard to navigation as well as to other
Broadcasters. The best harmonic filter is a good antenna system. Traps and
better antenna tuning will be needed if much power is run into a sub-standard
antenna. Traps may also be needed inside the transmitter.
A tuner suitable for 5000 watts of RF is not easy to build, but if you really think you need one, this is it. The values of C-1, C-2, and C-3 are dependent on frequency, and antenna. These capacitors should be capable of handling large RF currents, whatever your power and antenna demands. The coils are not easy to build, but not all that hard either. L-1 is wound large enough to handle the power and L-2 is larger still. L-1 is wound inside L-2! Many years ago, it was common to find these. If you know where you can buy one, you had better do so now, for they are harder to find than a needle in a haystack. The outer coil should be about 14 inches in diameter and with slightly more inductance than the inner primary. Any taps on the inner coil are set by putting your hand inside and moving a coil clip. The outer coil can be adjusted using coil clips also. It is presumed that this assembly will be used in a permanent installation, and is much larger than those used for Ham radio. This is designed to handle up to 5KW continuously into a center fed system. It will feed a balanced line or a center fed antenna direct, according to how the coil taps are set and what value of capacitors are used. C-1 is really simple. It is frequency dependent and can be selected from the values listed for the "T" tuner. The amperage rating of this capacitor is far more important than any voltage ratings, and the tap on L-1 can be adjusted as usual for maximum efficiency and best modulation characteristics from the antenna used. C-2 and C-3 are set for equal currents with RF Meters set in each side of the line. They are not shown in the diagram as it may not be necessary to leave them in after everything is set up. If you are using a 72 ohm dipole antenna, C-2 and C-3 are not needed. These capacitors are needed only when there is reactance.
If the value of the reactance in the line or antenna is known, C-2 and C-3 are easy to determine in value. Simply consult the reactance chart and line up the frequency with the value of reactance to find the value of capacitor. The amperage rating of the capacitors will be found by the formula \text{I}^2\text{R}.

Since the power is known and the antenna resistance is known, dividing power by \text{R} gives \text{I}. Taking the square root of this gives the answer. My recommendation is to select capacitors which have a heavier rating than needed. This way, you will not be spending more money and time for repairs later. If it is possible to use a standard line tuner with your installation, do so, for you will incur more expense and maintenance with this type tuner. If the tuner is really needed, you can make it yourself if you want to. The coils are possible to build using good quality #10 wire and quality insulating materials. Number ten wire will serve for 5000 watts easily if proper tuning is accomplished. Any larger wire size will make it really hard for you to work, if not impossible. The SPACING between the inner and outer coils should be about 1 inch with a clip INSIDE for the center coil. Once the coil assembly is made, it should be mounted inside your tuner box with the capacitors. Leave enough room for C-2 and C-3 even if you don’t need them now. Later, down the road, you may find the need for them.

The inductance values for L-1 and L-2 are no problem. A standard line tuner for Broadcast Frequencies uses 50 to 60 microhenry coils. A few of the older "boxen" used 120 microhenry coils. By consulting the reactance chart, you will get an idea of what inductance range you may need. Build your coil with enough turns to accomplish whatever task you may wish to accomplish with it and you will not have to go back and change it later.

The coil winding formula is really accurate, and will help you zero in on the exact number of turns and the size you need. With a single 100 ohm coil (under "secondary illustration") you will see a cheaper way to build a tuner for a dipole antenna. L-1 can be tuned to resonance throughout the AM Band by selecting the right value for C-1. The center tap for L-1 is set according to frequency and the two other taps are adjusted for equal currents into each leg of the antenna being fed using Meters for the purpose. This is less elaborate and less stable, but serves the purpose. Values of parts are chosen as outlined above. Antennas or lines with reactance will need series capacitors as shown in the first illustration.
5000 WATT BALANCED LINE TUNER

fig. A

outer coil construction - and view

The outer coil is 14 inches in diameter and the inner coil is 12 inches in diameter. Two different methods are used for holding the coils together as shown in figures "A" and "B." Figure "A" shows a masonite, plywood or fiber ring on the ends of the outer coil. The rods a, b, and c are rectangular measuring approximately 1 X 2 X 18 inches long. The rods a, b, and c of figure "B" are the same length but are 1 X 1 1/2 inches.

The wire is number 10 gauge, but if you think you can do it, larger wire may be used. The inner coil easily slides within the outer coil and fastens to the Masonite ring by metal strips marked 1, 2, and 3. These are held with screws. In figure "B" there are three metal braces between a, b, and c which hold the three rods in place. These metal strips do not touch each other, but are drilled so that fiber washers isolate them. The tiny dots on the very ends of the rods are drilled and tapped for the screws that will hold the assembly inside the outer coil by way of the fiber ring and the metal brackets.

This is all shown in figure "C" and hopefully you will test the size and shape of the assembly before you wind the wire. The inner coil should be made first and after everything fits, do the outer. The air gap must be at least 3/4 inch and in order to achieve this, the outer rods must not be notched too deeply. This procedure is described elsewhere. The inner coil may be notched as deeply as desired so as to achieve the desired separation between windings. But I recommend adjusting O, R and S to a smaller size instead.

Wire clips may be made as shown in the coil Chapter, and shaped to the round shape of #10 wire by placing 1/2 of the clip assembly over a #10 steel nail and hammering it into shape.
The finished assembly looks like figure "C" and will handle 5000 watts R.F. easily under nearly all conditions. Only in cases where very low antenna line resistances are encountered would the wire need to be made heavier, and that because of the higher asperages.

The ends of the windings are terminated in 1/4 inch brass bolts and braided or strap-type jumpers are made with a wire-clip at the ends. The coil may be used to run balanced to balanced, unbalanced to balanced, or balanced to unbalanced. Enough jumpers should be made and the proper hook-up used for the application. The inner coil is clipped from the inside by placing the hand inside and moving the clip(s) to the right position.

DETAILED SPECS.

The actual size of the outer winding is 14 inches in diameter by 15 inches in length. There is a total of 30 turns in this 15 inch length, making one each half-inch. The full inductance of the outer coil is 207 uh. or 6.9 uh. per turn. The inner coil has the same length, the same number of turns, but a 12 inch diameter. The total inductance of the inner coil is 159 uh. or 5.3 uh. per turn. If this is too much inductance for your frequency of operation, increase the spacing between turns and use the coil formula to figure the two inductances. You will need 205 feet of #10 solid wire to build this coil. Do not splice.
This Antenna uses the principle of co-phased verticals to produce a broadside, bi-directional pattern, providing 7-10 db gain over a dipole at the same height. It is effective for low angle signals and makes an excellent DX Antenna for 3.5 and 7 MHz. The Vertical Elements are the actual Radiating components, while the horizontal Elements act as phasing lines and contribute very little to the radiation pattern. The L/G Ratio should be fairly low. The Network is first tuned for resonance at the fundamental, then the Tap is adjusted for the best match. "L" is determined by the Frequency of Operation. Reflector/Directors may be used also.
NOTES:
1. Center and End Poles are 225/FmHz in Feet (height)
2. Spacing between Poles is 673/FmHz in Feet (Length of upper wire sections)
3. End Radials are 1/4 to 1/2 Wave Length
4. All other Radials are spaced ONE EACH 3 FEET and 1/4 Wave Length long
5. CENTER COUPLER STRAP IS A MINIMUM OF 2 inches wide
6. Upper Wire Elements are #8 Gage Solid Copper Wire or larger
7. All Radials are #10 Gage Wire of larger (preferably copper straps of 2 inches width or wider)

USE GROUND STAKES AT THE ENDS OF MAIN RADIALS
The long wire antenna system can be easily made to perform in a single direction. There are just a few simple rules to obey and you will have the results you need.

**ALL POLES ARE THE SAME HEIGHT**

Wire "B" will pull the signal toward itself or reflect the signal away from itself depending on its length. As Reflector it pushes the signal away from itself. As Director, it pulls the signal toward itself.

Rule for Director: make this wire 4 percent SHORTER than the antenna wire.
Rule for Reflector: make this wire 5 percent LONGER than the antenna wire.

Making the Antenna directional will increase the Antenna Gain. This acts as if you have multiplied the transmitter power, but your signal will mostly be in one direction only. Use of both reflector and director acts as if you have increased transmitter power 8 times! Use of 1 added element, 3 times the power!
The wire antenna above can be made 1/4 to 1/2 wave length with amazing results. When cramped for space, or if the tower won’t put out a decent signal, this may improve the coverage. The poles can be spaced apart as needed for the frequency, and the heavy copper wire spaced from top to bottom between insulators. I have used this method as close as 18 feet from the earth with wonderful results! Many poles or few can be used to hold up the wire. With two poles as shown here, the results are easy to predict. Spacing between wires should be between 3 to 5 feet or cancellation will occur.

This antenna “wonder” requires a good ground system, the same as all AM Antennas for proper results. Even a 1/10 wave length Antenna will function very well when used with a quality ground, at AM Frequencies.

I have discovered, that where there is only room for a ground screen (this is often less than 15 X 15 feet) a person can erect a steel wire fence all around the property, and weld the ground system into the fence wire several times, then add ground stakes at equidistant intervals, thus obtaining a satisfactory coverage with the Signal.
As shown in the above diagram, the antenna is supported on poles arranged in a circular fashion. The total circumference is a full wave-length. The ends of the wire antenna are brought directly down into the antenna tuner. The tuner can be either balanced or unbalanced with acceptable results. The ground system is not as critical as with a smaller wave-length antenna and better radiation patterns are obtained with this antenna than with smaller antennas. The poles are about 30 - 35 feet high, but I have experimented with similar antennas successfully with only 20 ft. poles. Since the antenna is low to the ground, the impedance will not be very high and should not be hard to match.

The radiation pattern is OMNI as with a single tower. The horizontal pattern is not a problem at Standard AM Broadcast frequencies. If a more vertical pattern is desired, a single center pole can be erected with the center of the antenna tied to the top and the ends brought down to ground level to two small poles in a TRIANGLE SHAPE, and center-fed (example B).
NOTES:

This Antenna installation is on a roof top in Port Au Prince, Haiti. It operates with a power of 1000 Watts on a daily basis. Under Emergency situations, a 50 Watt Transmitter is switched in, operating from a Battery Inverter. The entire System is the Design of J.R. Cunningham and was installed to correct Transmitter burn outs of a 50 year duration due to insufficient Antenna for correct "Loading."

Many Engineers tried to correct the Burn Out problems to no avail since there was no room to place the needed 385 Feet Tower or Wire Antenna. The Antenna below was more than sufficient and continues working to date without high SWR or other problems.

Coverage is excellent due to the good ground conductivity of the area and the good efficiency of the entire System. Listeners report daily from a 50 Mile Distance.

SIX GROUND STAKES are used as shown (8 feet deep into the soil) and tied into the City Water Pipes (Fort Au Prince is still using steel pipes instead of plastic!) All Ground Radials are tied together and fan out across the flat concrete roof top as shown in the Drawing. The Wires are all number Ten Gage or larger.

610 KHz ROOF TOP ANTENNA
RADIO 4VJS
Joseph Simone, Owner

A, B, and C are 15 foot high Poles. The BOLD LINES INDICATE the Wire Antenna which makes Two Turns on insulators, a total of 385 Feet of wire. The Distance from (A) to (B) is 75 Feet. From (B) to (C) is 65 Feet. From (C) to (A) is 45 Feet.
The Total height of the Wire Antenna above Earth Ground is no more than 35 Feet, yet the "Ground Wave" from the System is quite acceptable. This is due in part to the Four Guy Wires holding up "Pole A" which have been insulated on the ends and connected directly to the vertical Lead Wire going up from the Tuning Unit. This gives a little better "Radiation Characteristic" and allows for a better signal strength from the Wire Antenna System. Port Au Prince is close to Sea Level and has quite a lot of Salt Water lying beneath the soil, providing for an excellent "Ground Wave." Without good soil conductivity, this Antenna would be far less effective.

The Author Standing By Pole "A"
On The Roof Top

To my right side is the Antenna Tuning Unit. After the Antenna was completed, this Unit tuned up quickly and easily, the Antenna Resistance approximating its Theoretical Value, somewhere between 35 and 50 Ohms. Separation between Turns in the Antenna Wire was kept at 1 Meter (just over 3 feet). Any closer spacing between the Turns would have reduced efficiency and raised "Reactance" greatly.
THE IMPORTANCE OF GROUNDING FOR AM RADIO

In the case of AM Radio, the "antenna" consists of two parts: (1) the tower or antenna wire element suspended on poles and insulators and (2) the earth itself.

In order to make the earth act as the second half of an AM antenna, you must have a number of ground wires going in all directions. It has been found by actual experience that in very dry areas, 120 wires at least 1/4 wavelength long are needed or the signal will not leave the tower or wire for its desired receiving points.

GROUND conductivity describes the ability of the earth to act as the other half of your antenna. In rare cases, where there is much surface water, or water less than 20 feet below the surface, there is no need for many GROUND RADIALS (as the ground wires are called). The earth itself carries the signal out in what is called a GROUND WAVE. This ground wave is very helpful in order to reduce "fading" and weak signals. The ground wave can reach out about 100 miles, and in some cases 150 miles from the transmitter site.

It is IMPORTANT TO SET UP A "GROUND WAVE" from an AM Station. One cannot depend completely upon one or two ground wires, even when the earth is full of ground water because such a few number of wires may develop problems, or for some reason fail to operate correctly, so a LARGE NUMBER OF GROUND RADIALS IS RECOMMENDED for AM Stations - AS MANY AS POSSIBLE - UP TO 120 QUARTER WAVELENGTH RADIALS going out to all points of the compass.

ONE OF THE ANTENNAS WE USE IN OUR LOW POWER AM INSTALLATIONS IS THE "DDBB" TYPE used by GALCOM and developed by James B. Cunningham especially for this purpose. This Antenna uses only 1 GROUND RADIAL under NORMAL CONDITIONS, BUT IN SOME CASES IT MAY REQUIRE MANY, MANY MORE RADIALS - especially where the earth is DRY, RANDY OR ROCKY!! If you have a question about the effectiveness of the SIGNAL, contact us for consultations before investing in a system or acquiring the station LICENSE.

SHORT WAVE RADIO

The importance of GROUNDING decreases for short wave, especially at frequencies above 3-5 MHZ. Short wave at these lower frequencies also needs good grounding, but it is not nearly as critical as the AM frequencies below 11 MHZ. Many AM Broadcasters chose a LOWER FREQUENCY under the belief that it will reach out farther, ONLY TO SUFFER FAILURE BECAUSE THEY CAN NOT AFFORD TREMENDOUS EXPENSES ASSOCIATED WITH BUILDING AN AM ANTENNA SYSTEM BELOW 1 MHZ. If you select a frequency BELOW 1 MHZ, BEWARE! YOUR SIGNAL WILL NOT DO WELL UNLESS YOU SPEND OVER A THOUSAND DOLLARS FOR A SIMPLE SYSTEM AND MANY THOUSANDS OF DOLLARS FOR THE BEST.
AM RADIO

In order for AM Radio Transmissions to be effective, the Antenna must be located in a place where there is good GROUND CONDUCTIVITY.

WHAT IS GROUND CONDUCTIVITY?

GROUND CONDUCTIVITY is dependent upon how much water is directly below the soil or on top of the soil. THIS WATER ACTUALLY BECOMES THE BOTTOM HALF OF YOUR ANTENNA SYSTEM, AND IS RESPONSIBLE FOR CARRYING THE SIGNAL TO YOUR LISTENERS. Without PLENTY OF WATER OR GOOD GROUND CONDUCTIVITY, THE AM SIGNAL WILL NOT REACH YOUR LISTENERS!

THE GROUND WAVE

The GROUND WAVE is what good AM RADIO RECEPTION DEPENDS ON! The Sky Wave is needed for SHORT WAVE (above 3 MHz to about 30 MHz) but can not be depended upon for good AM Reception, because of FADING and SKIP.

A GOOD GROUND WAVE will be present where there is GOOD GROUND CONDUCTIVITY! Where GROUND CONDUCTIVITY IS EXCELLENT, A 50 WATT AM SIGNAL OFTEN REACHES OUT 50 MILES OR BETTER!

Where POOR GROUND CONDUCTIVITY IS PRESENT, THE SAME 50 WATT SIGNAL WILL CARRY ONLY ABOUT 2 MILES FROM THE ANTENNA!

BIG TOWER - LITTLE TOWER

Where there is poor GROUND CONDUCTIVITY, a really BIG TOWER will not provide a good signal, but where there is GOOD GROUND CONDUCTIVITY, even a simple sky loop WIRE ANTENNA will provide a tremendous coverage area!

DO NOT PUT YOUR AM TOWER HERE!

NEVER put the AM Tower on a hill top. That is the very WORSE PLACE IT CAN BE, BECAUSE IT IS THE FARTHEST AWAY FROM THE WATER TABLE! AM TOWERS BELONG IN THE VALLEY FOR BEST OPERATION!

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POOR GROUND CONDUCTIVITY?

Where there is an existing AM Tower placed on a hill, or where there is no other place of land available for a Tower Site, there is a way to achieve basic coverage with your AM Signal.

The FIRST THING NECESSARY IS TO DO SOMETHING TO IMPROVE THE GROUND WAVE! The single MOST IMPORTANT THING IS TO PUT A LOT OF LONG COPPER WIRES OR STRAPS going out from the Tower in all directions. They must be at least 1/4 wave length, or they will simply be a waste of money! At AM Frequencies, 5 - 10 Meter Radials are a waste of both money and time. UNLESS YOU HAVE EXCELLENT GROUND CONDUCTIVITY IN THE FIRST PLACE, IN SUCH CASES, THE WATER BENEATH THE SURFACE OF THE EARTH SERVES AS THE GROUND SYSTEM.

Where GROUND CONDUCTIVITY IS POOR, A MINIMUM OF 50 Radials is needed; but 120 Radials of 1/4 Wave Length is the International Standard! With this amount of wire about the Tower (or wire antenna’s base) you will be able to set up a ground wave that is acceptable for most areas, even if there is not much underground water!

For Power Levels below 1000 watts, #14 gage through #10 gage wires are the best choice, but at HIGH AM POWER LEVELS, 30 COPPER (or Aluminum) STRAPS of 1/4 wavelength (about 4–6 inches wide) will dramatically IMPROVE your Signal!

AFTER you have placed A MINIMUM OF 50 GROUND RADIALS OF 1/4 WAVELENGTH OR BETTER, just below the surface of the earth, you may now wish to improve the coverage even more by going from a short 1/4 Wavelength Tower to a TALL 1/2 or 5/8 Wavelength Tower! The added HEIGHT adds to the STRENGTH OF THE GROUND WAVE! The Tower itself can not radiate a desirable signal without the improved GROUND SYSTEM! Millions of dollars of WASTED MONEY have been spent on HIGHER AND LARGER TOWERS, without any IMPROVEMENT IN THE AREA OF SIGNAL COVERAGE, because WITHOUT A GOOD GROUND SYSTEM, AM RADIO IS IMPOSSIBLE!!
HOW GREAT A DISTANCE CAN I EXPECT?

The following figures are based on REAL LIFE EXPERIENCE and ACTUAL CASES.

RULES OF BROADCAST ANTENNAS: When you multiply transmitter power
FOUR TIMES, you reach out only DOUBLE THE DISTANCE.

1. 250 Watt A.M. Radio Broadcast Station with a good Antenna System will reach
   30 miles in every (all) directions. With a poor Antenna - 13 miles.

2. A 500 Watt Station with a good Antenna System will reach 43 miles in
   all directions. The same Transmitter with a poor Antenna - 18 miles.

3. A 1000 Watt Radio Station with a good Antenna System will reach 60 miles
   in all directions. With a poor Antenna - 25 miles.

4. A 5000 Watt Radio Station with a good Antenna System will reach in all
   directions 130 miles. With a poor Antenna System - 58 miles.

SQUARE MILES COVERED

in the above four examples you have the distance in all directions. The real
Area covered is shown here through the use of the Formula: A=πr².

1. 30 miles in all directions equals 2826 square miles.
2. 43 miles in all directions equals 5906 square miles.
3. 60 miles in all directions equals 11,304 square miles.
4. 130 mile in all directions equals 53,066 square miles!

* Many large Cities have over 5000 people per square mile. A single 250
  Watt Radio Station could cover a City of over 1-1/2 Million People!

* Statements by Radio Engineer James E. Cunningham Box 8, Stonewall, Ok
  71571 United States of America
## Antenna Resistance/Reactance Chart

<table>
<thead>
<tr>
<th>Antenna Height* in Electrical Degrees</th>
<th>Self-Supporting Type</th>
<th>Guyed-Mast Type</th>
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<tbody>
<tr>
<td></td>
<td>R</td>
<td>jX</td>
</tr>
<tr>
<td>G</td>
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<td>+j25</td>
</tr>
<tr>
<td>200</td>
<td>23</td>
<td>+j50</td>
</tr>
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</table>

*Courtesy J.R. Cunningham*
Radiation Resistance will be higher in cases where low frequency Antennas are erected over earth of only average conductivity. Figures above are valid for antennas having a perfectly conducting Ground Plane, such as high frequency Antennas, where a Ground Plane can be constructed all of Metal. For A.M. Radio use, the chart gives only a RELATIVE INDICATION, and Readings may be as much as DOUBLE the Resistances shown above.

Courtesy J.R. Cunningham
FOLDED UNIPOLE TUNING

THERE ARE BASICALLY TWO METHODS OF TUNING UNIPOLES:

1. Tune for 50 ohms resistance with positive Reactance

2. Tune for ZERO REACTANCE with a higher input resistance in the range of 110 - 155 Ohms.

METHOD NUMBER ONE:
A. The tuning skirt is shorted to the Tower at 1/20th wavelength from its bottom. If the Tower is a 1/4 wavelength Tower, this would amount to 1/5th its height. This will give an Antenna Resistance of 50 ohms with between 200 and 350 ohms + Reactance (inductive) at the Feedpoint.

B. Tune out the + Reactance with a variable or fixed capacitor. Its value will be between 350 and 2500 PicoFarads, depending on the frequency of operation within the Broadcast Band.

METHOD NUMBER TWO
A. Adjust the shorting bar or ring UPWARD to a point where ZERO REACTANCE shows on an impedance Bridge at the Feedpoint. The Antenna RESISTANCE will fall somewhere between 110 - 125 ohms. This Resistance is matched to the 50 Ohm Feedline with a Standard AM ANTENNA TUNER.

B. Antenna height should be above 75 Degrees (.1 Wavelength) for best results if this Method is used. Shorter Towers may work better with Method Number One.

BEST METHOD OF ALL
A. USE THE ANTENNA TUNER INSTEAD OF THE CAPACITOR FOR PERFECT TUNING. With the Antenna Tuner, you will not only tune the antenna to resonance, but you will be able to eliminate HARMONICS that other Methods may fail to remove.
CHAPTER TEN

MAKE YOUR OWN

MICA TRANSMIT CAPACITORS

USING EASILY OBTAINABLE

MATERIALS
HOME-MADE TRANSMIT CAPACITORS

FVC PIPE

THE FVC PIPE FORM IS 3-1/2 INCH DIAMETER by 4 INCHES TALL
END PLATES are 1/4 inch thick aluminum held in place with angle brackets as shown

ALL SCREWS ARE NICKEL PLATED BRASS AND ARE COUNTER-SUNK
The material shown for insulator was obtained from a motor rebuilding shop and is .030 mica sheet with a dielectric constant of 4 and an electrical factor of 1000 volts per mil inch. The plates are made of sheet aluminum at .005 inch thickness obtained from a printing shop. This is old printing plate material. Most newspaper shops sell these from 20 to 50 cents per sheet. One sheet is large enough to do several capacitors.

INSTRUCTIONS

To make a standard .001 mfd, 10KV capacitor, 12 insulators are cut measuring 2-1/2 by 2-1/2 inches. Eleven (11) plates are cut measuring 2 by 3 inches. The ends of the plates are bent at the 1 inch mark and the plates are alternately assembled as shown. To hold them in place, a little bee wax is placed on each plate and insulator. They are kept centered on the insulators and all the even numbered plates are brought out to one side and the odd numbered plates are brought out to the other side. Then, small hardwood clamps are made of two pieces of wood which are drilled for 4 brass screws. These are used to hold the plates together, and are put in place with
only enough pressure to hold them firmly together. The plates are tested with an ohm meter to make sure there are no shorts at this point. The wood clamps and entire plate assembly must be sealed so that it will fit into the PVC case. The aluminum plates will be trimmed where they come together so that all plates are even on the ends when the brass pressure-end-plate is in place. This brass end-plate is made from 1/8" thick brass plate material and is made with three screw holes. The two small holes secure the aluminum plates using small screws. This makes the ends rigid enough to easily assemble in the final stages. The tapped center hole will accept the center screw after everything is put together and assures electrical contact with the inside aluminum plates. Copy the ASSEMBLY ILLUSTRATION and pre-assemble everything before this next step to make sure plate ends are pre-formed for easy assembly before the sealing process begins.

An electric hot plate is needed and canning wax from the local grocery store is melted down in a metal pan. The plate assembly (with wood clamp in place, but not tight) is immersed in the melted wax and simmered until no bubbles are seen coming out from the assembly. This takes about 20 minutes, and the wax must not reach boiling temperature. WARNING! Hot wax is dangerous and burns like gasoline. Avoid any open flame or sparks during this step and keep a fire extinguisher near by in case of accident. After the plates have been simmered until no more bubbles rise from the assembly, USING HEAVY GLOVES, tighten up the wood clamp screws until they are firm. The extra wax will be forced out from between the plates. Do not attempt to remove any wax from the end plates or from between insulators. This is needed to assure best results. Allow the plate assembly to cool enough to handle and then assemble everything except the top end plate. Pour the entire thing full of melted wax and assemble the top end plate. This amounts to putting in three screws. Hopefully you have planned ahead to where everything fits right. Allow it to cool for several hours and then you can test it as follows:

**TEST**

1. You will need a low current, high voltage supply. I use a Color TV Set!
2. You will need a meter capable of measuring 25KV or better. I use a Fomosa Electronics 2800-A such as used in the TV Shop.

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CAPACITOR TIPS

1. Make all aluminum plates at least 1/2 inch smaller than the mica insulators so that there will be 1/4 inch mica overhang on three sides.

2. Scrape away all burrs from the edges of aluminum plates.

3. Angle brackets can be made from angle aluminum and drilled and custom tapped to match your screws. These hold exterior END CAPS in place.

4. In case of doubt about possible leakage, test your capacitor interior as shown under "TEST SET UP" before you put it in the case.

5. Screws passing through the wood clamp must be at least 1/4 inch away from the plates.

---

ASSEMBLY ILLUSTRATION
3. The entire unit is set up as is the diagram. The capacitor initially does not come in contact with high voltage, but is tested as shown for leakage. When it is obvious that there is no appreciable leakage, then the unit may be labeled and put into service at 1/2 the test voltage. Capacitors will last a long time if this rule of thumb is observed. If you attempt to operate the capacitor at 20,000 volts, I recommend that you make it unable size using thicker mica material and a larger case. Actual tests show that this is necessary. The capacitor here is rated at 10KV, even though it passed a 27KV static test, so as to assure long life.

**TEST SET UP**

![Diagram](Image)

**TEST before and after filling case with wax!**

After the high voltage test probe is in place for about 5 seconds, if the test meter does not drop down to near zero, you have an arc inside the capacitor. The amount of movement of the needle on the test meter should be low. A slight movement is normal, but if the meter reads any voltage to speak of, you have too much leakage and the unit must be taken apart and done over. You can see why it is important to do it right the first time. I will repeat, the most important step is to get all the air gaps out from between the plates when you are simmering the plates in hot wax. If bubbles keep coming to the surface, then the capacitor must be kept in the hot wax until there are no more bubbles rising from the plates. At that point, it is ready.

**NOTE**

Use of CORNER SCREWS on plates makes assembly easy. Use only small screws.
THE FINISHED CAPACITOR

Silicone Seal is used around inner edge to prevent hot wax from leaking out during Sealing.

END VIEW
CHAPTER ELEVEN

ANTENNA MEASUREMENTS

WITH

INEXPENSIVE EQUIPMENT
The following is a method of measuring your antenna resistance, and this includes for Standard AM Broadcast, which is as accurate as the famous OIB-1 Bridge with the Rotomatic Generator. I have compared these tests with the OIB-1 and found them within 1% on all occasions. The secret is to follow the instructions exactly as I have outlined them. I don't know if anyone else has used this procedure as I thought it up myself as a means of measuring antenna resistance which doesn't require any special and expensive equipment.

The resistor is an ordinary variable resistor such as used for volume controls in old radios. The wattage is about 2 watt. The variable capacitor is also the "receive" type capable of handling only a few watts. It's value should be about 500 - 1000 pf. as needed to achieve resonance with the choke coil. The value of the choke coil is not critical either, but should be about 68 - 120 uh. in value, and must be of the non-ferrite variety. It should be of the miniature type, and may be hand-made if need be. The R.F. Generator should be capable of causing the SWR Meter to deflect full scale when hooked up directly. This would be somewhere between 1 and 2 watts and must be accurate. A frequency counter can be used to check the exactness of the signal generator. Everything can be hooked up to the antenna system and the variable condenser set for resonance. This will show up as maximum reading on the SWR Meter, which is loosely coupled. This is done by using a short clip lead from the SWR Meter wrapped around the lead between the coil and capacitor two turns or so. The SWR Meter is set down on an insulated place and must not be hand held or otherwise grounded. Enough RF will be picked up from the 2 turns of clip lead to activate the Meter. If necessary, a piece of wood, paper or plastic can be set under the Meter to prevent grounding to the antenna ground system. The level control on the Meter should be set for a mid-scale reading at resonance. Resonance will be noted as a peak reading between two lower readings as the capacitor is adjusted.

At this point, do not disturb the Generator Level, Meter Adjustment, Capacitor or Coil. Carefully remove the Generator ground clip from the antenna ground and connect it to the variable resistor. Remove the Capacitor clip from the antenna and connect it to the other side of the variable
resistor. Adjust the variable resistor for the exact same reading on the SWR Meter as before. Be careful to move nothing from it’s place other than the two clips mentioned so as to assure accuracy in the measurements. Now, with an accurate ohm meter, measure the resistance of the variable resistor setting. This is the antenna resistance at the frequency of test. A complete “proof” can be run for antenna resistance at various frequencies. This test is very reliable if precautions are taken against moving test components and wires during the test, and the SWR Meter is not grounded or touched after the resonance reading is taken. A good high quality variable resistor should be used for the greatest accuracy, but even low cost units give a high degree of accuracy if an accurate ohm meter is used to check the values. I devised the use of the cheap C.H. SWR Meter as an indicator because the old way of using an RF Amp meter is costly and trouble prone due to the higher Drive required for the tests. Ordinary Shop Test Equipment can be used for these tests, and as I said, if done correctly, they are as accurate in measurement as the expensive Professional Bridge used for the purpose. The object of this information is not to take away from Professional Equipment Manufacturers, but to make these tests available to those who CAN NOT afford this equipment and have no other recourse. See “HELPFUL HINTS” notes.

\[
\begin{align*}
G & = \text{Gen. Gnd.} \\
R-1 & = 250 \text{ ohms} \\
C-1 & = 500 - 1000 \text{ pf} \\
L-1 & = 6c - 120uH \text{ as needed}
\end{align*}
\]
It follows, that if it is possible to do resistance tests using inexpensive equipment, maybe the reactance values can be done too. It is true that we can do the reactance tests easily, but it is not as easy to obtain accuracy. A reactance test is really easy to mess up, but here it is.

The same generator, coil, capacitor and SWR meter can be used for these measurements. The trouble is, reactance cannot be directly read on an inexpensive meter. Meters that read reactance costs plenty and often do not read accurately without consulting graphs or charts for correction factors. The best we can do here is to figure the value of capacitance and calculate the reactance using math. I hope you have your Scientific Calculator handy or are good at figures. You could also use the reactance/resonance Chart supplied in this book. But it will not have the degree of accuracy you desire for doing an Antenna Proof.

1. With the test set up as shown, first resonate with the antenna in Position Number One. Then find resonance in position Number Two. Note if you must increase or decrease the capacitance for resonance in Position Number Two. An increase in capacitance shows that the antenna is capacitive. A decrease in capacitance shows that the antenna is inductive.

2. After noting this, you may figure the actual value of the reactance. This is done by measuring the values of your capacitor with a capacitor tester, first in Position Number One, then in Number Two. Using Math, figure the reactance of your capacitor in both positions and subtract the smaller value from the larger. The remainder will be the actual value of your antenna reactance at the test frequency. Each frequency will yield another set of figures which may be plotted on your Proof Chart.

Many factors affect the accuracy of these readings. Make sure you eliminate all stray capacitances and work under controlled conditions.
A switch may be used to make the changes between positions one and two. It should be a ceramic switch with large contacts for a positive connection. An SWR Meter could conceivably be built into a test rig with provision for connecting to the pick-up point. Coils of various values could be made switchable or clips for the purpose could be built into the test rig. A variety of coils could be kept in a drawer and the capacitor could be specially made similar to a substitution box. I recommend keeping it really simple and to avoid all stray inductance or capacitance.

At A.M. Frequencies, I have used a capacitor substitute box and checked it's results against the OIB-1 Bridge and have obtained accurate results. I doubt if this would be reliable with most capacitor boxes or at higher frequencies. My capacitor box is an Eico Model 1180 and is very reliable since only high class components are used in its construction. I would prefer using a vacuum capacitor in the tests, with a good capacitor tester, such as the Leader LCB-740 or the Sencore LC75 digital meter. If the capacitance values are accurate, you can figure the reactance values accurately. The capacitive reactance formula is \( \frac{1}{2\pi fC} \). For a more professional bridge you can build yourself, refer to my "HELPFUL HINTS" Chapter.
ADJUSTING THE ANTENNA

To adjust the antenna tuner, a person needs only a cheap SWR Meter as used in the preceding examples of antenna measurements. This is coupled to the tower at feed point "X" in the same relative manner as before - that is, a loose coupling with the case of the SWR Meter ungrounded. Using a low transmitter output, adjust the settings of L-1 and L-2 for maximum reading on the meter. This corresponds to maximum antenna amperage. Now, with modulation, adjust the setting of L-1 (only) but not L-2 for about 25% forward modulations on the meter. This will allow proper fidelity of the broadcast signal. The antenna amperage will read slightly less, but actual performance will be peak.

Most of the Radio Stations I have visited in Foreign Nations do not have RF Amp Meters in the Antenna System, furthermore, the Engineers do not own one, and have to pay someone with an Amp Meter to do these adjustments. Then, the Consultant takes his Meter with him when he leaves! The Engineers at the Stations have no way except the normal transmitter readings and the sound of the signal on the radio to tell if the antenna is adjusted or not. You see, there are times when the local Engineer wants to have at least a rough idea of how his antenna is doing, and (you might as well forget it) the Boss is not going to buy an RF Meter so you can check it! Why should he, when no one else has one either! So, the best way to do it is my way with a cheap C.B. Meter loosely coupled to the tower feed. With this meter, the Engineer at least can tell if he has forward modulation and if the tower is fed the same as before (by comparing previous readings). Such a cheap Meter will cost the Engineer about $50 in most cases, whereas an RF Meter (used) capable of 5 amps will cost him nearly $300 and all the other Stations will want to borrow it! RF Meters also burn out easily, as most of us know. There is little to lose if an SWR Meter is used for checking the basics, and much to gain. These tricks can be used here at home for the Ham on the 160 meter band or even higher frequencies if an antenna tuner is used. I have found that a high power SWR Meter made for in-line use can be put in the line of a Standard Broadcast Antenna, and the above adjustments easily (and correctly) made with no difficulty. Make sure your meter is capable of taking the power from your transmitter before you try this. Otherwise, loosely couple it with an insulated wire clip lead.
In most simple antenna installations, the "T" Network is used for its simplicity, "Z" matching ability, and harmonic reduction. The R.F. Amp Meter should be inserted at point "X" and the tuner adjusted for maximum amperage. Coil L-1 is adjusted along with L-2 to match the coax impedance. This can be done without an R.F. Bridge by adjusting both coils for maximum R.F. Amps into the antenna first and then with 100% modulation adjust L-1 for no more than 25% forward meter deflection on modulation peaks. This assures that best tuning has been accomplished. A small radio can be tuned to the frequency and listened to while doing the adjustments. The radio will confirm that no distortion is present from improper adjustment of L-1. If too much modulation swing is present, L-1 is past the point of matching the line impedance and must be adjusted in the direction of less meter swing. At 100% modulation, the meter will move 22.5% forward from its reading at no modulation. At 25% swing, the modern Standard of 125% modulation will be within reach. If an R.F. Meter is not available, construct the power meter below inside a metal box for doing the above adjustments.
This device may be placed between the Antenna tuner and the Antenna itself, at the point where the lead-in wire attaches to the tuner. When maximum 5F Current is found, the lamp will be at its maximum glow. After the Antenna is tuned, the lamp may be removed, or left permanently in the circuit.

**PARTS**

The sensor wire consists of 5-15 turns of #18 - #10 coated wire, depending on how much current is to be drawn into the antenna system. This is coiled into 1/4 inch to 3/4 inch diameter coil. Across it is placed a small lamp such as the R5084 dome lamp, the type used in automobiles. This is shown mounted in a fuse block sold at auto departments in stores. This is isolated from grounds and shorts. The device consumes almost no power and may be left in the circuit after tuning is accomplished. The actual resistance of the total assembly is about .2 ohms and works well for frequencies up to 3 MHz. At frequencies higher that this, the number of turns should be reduced to 2-7 turns, depending on the frequency of operation (30 MHz upper limit for the device).
CHAPTER TWELVE

BUILDING

YOUR OWN

RADIO TRANSMITTER
The secret to transmitter building is the determination to do it. This Transmitter shows in my first and incorporates several of my own inventions. I call it the "CUNNINGHAM 500" which fully adjusts from 10 watts to full power with a single control. This control may be permanently set if so desired. This "power raise - lower function" is done through the use of a special Biasing circuit controlled by a rheostat or Variac.

The Modulation is accomplished through another special circuit which operates on the filament return lead. The performance is well beyond legal limits and therefore a frequency roll-off capacitor is included in the Schematic. The transmitter requires complete knowledge of R.F. Tuning Procedures in order to set it up, but once set, it is very stable.

The Schematic (in Basic Form) is given in the following pages and is simple enough to build and use. I have used the modulating scheme successfully in a number of applications and enjoy it because it puts away about $2000 from the cost of a new transmitter, totally eliminating big modulation tubes and components and making the Transmitter very LIGHT WEIGHT!
One of the main reasons more transmitters are not built is the FCC Type Acceptance Rules. With all the effort and expenses involved to get Approval, it may not be worth it for just a single unit. Unless you are going into the Transmitter building business, maybe you should not even try for type Acceptance. Some engineers have gone through with it and enjoyed every moment and according to them, it has been worth the effort.

Included in this book are some schematics of transmitters I have built. One is for plate modulation at 500 or 1000 watts, the others use either grid or cathode modulation. These modulation schemes give excellent frequency response – beyond the range of human hearing – and for this reason frequency cutoff circuits are employed.

The following radio transmitter (model 20) is possible to build into the Short Wave Bands very successfully. The 6DG6 tube should be replaced with a 6BG6 or 8LB6 for these higher frequencies. By raising the plate voltage, an 807, 614A, 4CX230B, or higher class tube may be used. The cathode modulation serves well if proper R.F. Bypassing is used in the appropriate places.
The model 20 is a Standard Broadcast Radio Transmitter available from 530-2000 KHz. This 20 Watt Radio Transmitter is useful as a Standby or for Missionary Broadcast as a first transmitter. It is adjustable to any power from 2 watts to 20 watts into a 50 ohm load, using a single control. A separate audio amplifier of 10 watts power is needed for modulation, and must have a 600 ohm output. Any audio amplifier of 10 watts will do if a separate 100 ohm matching transformer is used. A modulation limiter should be used ahead of the transmitter to prevent overmodulation.

The Model 20 may be obtained as a rack-mounted unit or built into a case with a blower upon special request. Each unit is preset to frequency at the factory and adjusted to the rated output into a standard 50 ohm dummy load. If another load resistance is desired, please specify upon ordering. Audio frequency response of the highest quality should be expected from your Model 20, as the circuit used is capable of response beyond the legal limits. This Transmitter is designed for use by the Missionary Radio broadcaster where expensive equipment is not available, and may be shipped by Air Mail to any part of the world due to its light weight - usually under 30 lbs. Tapes used are readily available in most nations, and the unit is easily serviceable. The unit plugs into 120 Volt, 60 cycle A.C. and requires no special wiring. Specify if rack-mount or case style is desired upon ordering. Higher powered units are also available from CUNNINGHAM at comparable savings.
Building these Models, has its problems. The Model 20 is different in that it does not use a tuned circuit (coil and capacitor) at the grid of the 6V6 tube. If the layout is followed as given in the Plans, this can be built with good success. If a tuned circuit were included here, it would ease the construction pressures, but add to unnecessary expense. The output from this tube has no tuning either, at the grid of the 8SQ3 tube. With the special biasing circuit, none is needed, and it is actually less critical than the preceding tube.

The CATHODE MODULATION scheme is my own invention and is capable of incredible response. In all of my tests, if impedances match, response is flat from about 4Hz. to beyond 40,000 Hz. C-8 coupling capacitor may be made as large as 50uf, without any problems with audio quality. This capacitor isolates the amplifier circuitry from the transmitter, yet allows the audio to be coupled. The C-15 capacitor limits the frequency response to around 9,700 Hz. This may be varied for desired results. An audio level of +30 dbm. will produce 100% modulation. It is possible to over-modulate beyond 250% if a limiter is not used ahead of the transmitter.

L-5, L-6 and L-7 are wound on a single PVC Pipe of a 2 inch O.D. Bell wire is used on the Model 20, and is tapped at the right places for the frequency used. Once set to a frequency, there are no adjustments needed except occasional touch-up of the bias level to compensate for tube aging, etc. At frequencies beyond 2MHz, the 8SQ3 tube is changed out with 6BG9 or others capable of these demands, otherwise a grid resonator is used at pin 3.

Note that the same transformer winding is used for both plate voltages and biasing supply. This scheme works without a problem and is extremely dependable.

An RF Monitor Pickup Coil is built inside the PVC Pipe. Actually, this is a small RF Choke (non ferrite type) which is selected in value for the best results at the frequency used. This will feed a modulation monitor or scope very well.
AM BROADCAST TRANSMITTER

1000 WATTS

PLATE MODULATED
The following transmitter is a full 1000 watt AM Broadcast unit and is made using tubes commonly available in foreign nations. The 6DQ5 tubes are used instead of 857's or similar types because of superior performance and availability. The 6DQ6 audio tubes are used because of cost effectiveness and high voltage handling ability with superior audio quality. The entire transmitter uses the same space as normally expected from a similar 1000 watt unit. This transmitter serves well if care is exercised in building, especially in the RF Section. The coils should be constructed as outlined in this book, for least cost and acceptable performance.

The construction of L-4 is important to the overall performance of the RF Section. Should wrong coil winding methods be used, the RF Drive will be insufficient and it may be impossible to obtain full power output. Simplicity in best in making this coil. Use a 1 inch (outside diameter) piece of PVC pipe for the form and wind on enough turns of enameled #26 gauge wire to achieve resonance with C-4 set midway. The number of turns will be according to your frequency and the inductance value may be obtained from the resonance charts in this book. If you do not have an inductance checker, you can estimate (accurately) the number of turns using the coil winding chart found elsewhere in the book. L-5 is equally important and must be wound on a 1-1/2 inch form or larger. It should be made about 280uh in value and MUST be adjustable. With this value of inductance, it will be possible to tune the grids of the 813A tubes to any Standard Broadcast frequency. This is in case the transmitter is ever used at another frequency. This type coil is shown Figure RFD-2.

The TANK COIL should also be made with sufficient inductance to adjust to any Standard Broadcast frequency. This will give your transmitter added value in case someone uses it at another frequency someday. The "L" Network Coils, L-7 and L-8, should also be made with this in mind. The condensers for plate loading and the "L" Network will have to be selected according to frequency. The following chart will be useful in this section. The right C to L ratio is necessary for best performance, as this not only affects power, but audio quality as well.
### Parts List

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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<tbody>
<tr>
<td>C1</td>
<td>10 µF AIR</td>
<td>R1</td>
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<tr>
<td>235</td>
<td>0.01 - 3 kV</td>
<td>2</td>
</tr>
<tr>
<td>4.8</td>
<td>1000 µF</td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>0.01 - 5 kV</td>
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<tr>
<td>7</td>
<td>0.01 - 10 kV</td>
<td>6</td>
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<td>10</td>
<td>20-300 pf variable</td>
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</tr>
<tr>
<td>11</td>
<td>10 kV mica</td>
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<td>0.01 - 10 kV</td>
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<tr>
<td>3</td>
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</tr>
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</tr>
<tr>
<td>46</td>
<td>100</td>
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</tr>
<tr>
<td>14</td>
<td>6.7</td>
<td>3 - 6 turn, #14 wire</td>
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<tr>
<td>20</td>
<td>58</td>
<td>SET TO FREQUENCY</td>
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</tbody>
</table>

### Radio Freq. Section

- Copy: James R. Cunningham
TUNING CAPACITOR VALUES FOR STANDARD BROADCAST

COIL VALUES
L-3, TANK COIL - 120 uH recommended. L-7, L-8 are 40 to 80 uH and built to handle 1000 watts. Number ten wire or larger recommended for this.

* C-10 Vac. variable (10 KV) 300pf. serves to fine tune C-11

<table>
<thead>
<tr>
<th>TUNING CAPACITOR CHART</th>
<th>C-11 (10 KV)</th>
<th>C-12</th>
<th>C-13</th>
</tr>
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<tbody>
<tr>
<td>frequency</td>
<td>capacitance</td>
<td>frequency</td>
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<tr>
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<td>.0015</td>
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<td>.006</td>
</tr>
<tr>
<td>540 - 600</td>
<td>.002</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* values given for C-11 are the totals of C-10 and C-11 combined after final adjustment has been made. Actual values will vary only slightly.
Power dividers are an essential part of the world of radio due to the fact that they make possible the division of power between two or more sources or two or more loads.

Coils and capacitors are usually used to accomplish this purpose and the design and use of simple power dividers is not beyond the reach of those lacking a Degree in electronics. All you will really need is a few parts and the ability to put them together. Your Source of R.F. should be less than 100 watts, but it is possible to experiment safely with powers up to 500 watts. Make sure that nothing is moved, adjusted or touched until the power is completely "OFF." Just hook up the coils and components in question when the power is off; provide some method of measuring the currents in each branch of the circuit (R.F. Meters) and make adjustments until you have correct readings (1) at the transmitter and (2) in each branch of the circuit.

YOU CAN USE THE CIRCUITS GIVEN ON THE FOLLOWING PAGES AS BASIC DESIGN PATTERNS TO FOLLOW.

You do not need to know a bunch of equations in order to have successful and practical results in the REAL WORLD. You can build a power divider for your Radio Station's PSRA, etc., very easily without knowing even basic algebra by simply copying the schematic on the next page. The capacitor is usually about .002 mfd. at 10KV, and load number 1 can be your dummy load with load number 2 representing your antenna system. If you need to burn up less than 800 watts of power, instead of buying an expensive dummy load, you can just use LIGHT BULBS! Buy those big ones which come in 150 to 300 watt sizes at your local Supply house and mount them in porcelain sockets (the kind they used to use in the chicken coops)! Give adequate ventilation for the bulbs and provide a knife type antenna switch so your power divider can be switched in and out of the circuit as it is needed. This switch will be BEFORE the jack going to the divider and AFTER the transmitter.
POWER Divider for Unequal Currents

The above circuit has been tested under actual operating conditions. Capacitor C-1 is selected according to frequency and divided by four when used with L-2. L-2 makes possible the use of a smaller capacitor and when positioned above the capacitor as shown, makes possible the use of a capacitor of less voltage rating.

Capacitor C-1, coil L-2 combination is adjusted to remove reactance from the transmission line coming from the transmitter. L-1 is adjusted for correct currents into the two loads. Load #2 will always be the smaller of the two currents. Resistance is set by positioning the taps on L-1 correctly. Reactance is tuned out with L-2. L-2 is not necessary if a capacitor is selected of the correct value for removing the reactance from the line.

When using this circuit, the two loads must be pre-adjusted correctly to represent the proper load (usually 50 ohms - zero reactance). The taps on L-1 can then be adjusted easily for correct currents into the respective lines.
Schematic for RF Power Divider

Instructions:

1. The above Schematic is used for dividing power from a Radio Transmitter into two separate Loads. Any proper load such as a dummy on one side and antenna on the other, two dummy loads, or two antennas will work equally well. The line going into PI-1 is usually 50 ohm coax, but can be of any value.

2. "Test" is for an SWR Meter or In Line Operating Impedance Bridge. The coils are set according to the desired currents in Loads 1 and 2. L-3 is adjusted for minimum SWR and correct resistive Load into the Source (Transmitter).

3. L-3 is selected in size to be approximately 1/2 the value of L-1 & L-2. L-3 is adjusted for lowest reactance and settings of L-1 and L-2 are adjusted for correct current ratios and correct line resistance on the RF Bridge. L-3 should generally be about 30 - 60uh. in value.

4. It should be noted that all these adjustments inter-react, but the primary purpose of C-1 with L-3 is to remove reactance from the line going to the RF Source.

5. The value of C-1 is according to frequency. This may be selected from the Capacitor Chart elsewhere in this Book. This value is divided by four when used with L-3 or used at full value when a vacuum variable is used.
OPERATION: Both transmitters are adjusted individually for a 50 ohm load. Then, they are hooked to the Power Combiner, which is adjusted for minimum current in M-1 reject circuit. The ANTENNA CURRENT is adjusted for MAXIMUM into the 50 ohm coax and into the Antenna itself according to normal tuning procedures. If one of the transmitters fails in power output, the network adjusts automatically to maintain a proper load balance by allowing a portion of the output to go into the 50 ohm dummy load resistor. Thus, a perfect 50 ohm match is always maintained between both transmitters and the antenna system. When M-1 is adjusted to near ZERO, and each transmitter supplies its rated power output into the Antenna, the unit is correctly adjusted. Condenser C-1 is according to frequency C-2 is found experimentally according to frequency charts and correct performance.
This Radio Transmitter was designed to operate continuously without rest up to 14 hours per day, non-stop. The unit may be modified for Keying as per Two Way usage by installing a Keying Circuit made for that purpose. This Radio Transmitter may be used as a low power unit, or as an EXCITER to drive linear up to 2000 watts legal limit (Ham) or 50,000 watts COMMERCIAL.

The Transmitter is very stable and actually operates over a range from just above audio into the 50 Mhz. Region and beyond. In order to use for lower Broadcast Frequencies, the Tank Coil should be replaced with one of a larger inductance, usually a minimum of 80 uh. The Loading Capacitor may also be increased in value by installing a second capacitor as shown by the dotted lines on the Schematic (see following Page). A larger value variable Loading Capacitor will make tuning possible down into the 3 - 4 Mhz. Range without the need to change the 16 Turn Tank Coil. The Tank Coil is made adjustable for Frequencies into the Ham Bands, and the Tap must be adjusted as needed.

The AUDIO RESPONSE IS ALMOST UNBELIEVABLE, being limited only by the Response Characteristics of the driving amplifier (User Supplied). I have tested this Transmitter from 5 Hz. through 40,000 Hz. flat within .5 dB!! The Bypass Capacitor on the Cathode of the 6L6G limits audio frequency response and should be in the range of .1 Mfd. to prevent exceeding F.C.C. Limitations!!

This Schematic calls for the Power Meter as shown, which will track accurately once it is calibrated. Wattage can be written in on the meter face, and power read directly. If the value of Antenna Load changes, then the meter must be re-calibrated. The Transmitter will tune through a wide range of load impedances, but the 50 ohm coax load called for is now a Standard (N-9),

CATHODE MODULATION is nothing new, but the manner in which I have designed this unit is my own, and I am happy to report on its stability and dependability.
HI-FI Broad-band EXCITER/TRANSMITTER

Audio Driver 500Wt
8-600 ohms 5W to 25W, adjust for input 2W

606 BUFFER

RELATIVE POWER

POWER: UP TO 20 WATTS R.F.
RF FREQUENCY RANGE: 1.5 - 30 Mhz
AUDIO RESPONSE: 15-20 KHz (actual)
or to limits of AudioAmp. Driver

CRYSTAL: ICM #4522101 as by CUNNINGHAM 75° C.
DESIGNED BY James H. Cunningham
1983
LOADING CAPACITOR (in dotted lines)
is according to frequency and is NOT
USED IN MOST APPLICATIONS.
CHAPTER THIRTEEN

HELPFUL HINTS
In a lot of older equipment using high voltage power supplies, mercury vapor rectifier tubes are common. Many home made radio projects use these tubes because they are easier to install than solid state rectifiers and many surplus dealers offer these tubes for practically nothing. This makes the use of these tubes rather widespread despite problems associated with internal arcing due to insufficient warm up time, etc. Mercury vapor rectifier tubes have rather large current carrying abilities and high voltage capabilities, a very desirable characteristic when designing high voltage power supplies.

Mercury vapor tubes may not last long under some circumstances, but shown here is a way to use older tubes right down to the final end, instead of throwing them away when they first start arcing inside. By the addition of the choke coil shown in the transformer center tap circuit, tubes will go on operating after you would normally have to discard them! Used tubes can be used instead of new ones meaning that you can get them from other Radio Stations or Engineers that do not know this secret (usually FOR FREE!). The choke does not even have to be made for high voltage if its value is less than 2hy. - just put it in series with the center tap to ground, and it absorbs the reactive shock normally appearing across the tube plates, thus extending tube life! Current carrying ability of the tubes is in no way degraded, IT IS ACTUALLY IMPROVED! The addition of this choke coil is highly recommended in transmitter power supplies where rectifier life is unsatisfactory or new tubes are not available (such as in underdeveloped areas of the world).
BIPOLAR SUPPLY USING ANY FULL WAVE
RECTIFIER SYSTEM

THIS SYSTEM SHOULD BE USED WITH LOW CURRENT DEVICES

The 9 Volt Transformer provides a full 12 Volt Supply when rectified and filtered, due to the fact that the DC Voltage is found by multiplying 9 Volts times 1.414. This is the rectified Voltage, without a load.

The two 50 Ohm resistors provide for A VOLTAGE DIVIDER, which divides the 12 Volts into two parts, providing for a Plus and a Minus 6 Volt Supply. This Power Supply is perfect for Op Amps and small Mixer Circuits using Signal Transistors, etc.

I use this Power Supply for a Microphone Preamplifier, which uses two 741 Op Amps, each using a Plus/Minus Voltage Supply.

As can be seen in the Schematic above, there will always be a load on the Power Supply due to the total resistance of the two 50 Ohm Resistors, totalling 100 ohms. Without any further Circuitry added, there will be a current drain in the Voltage Divider of 120 MA. This calculates to just under 1 Watt Dissipation for each resistor. The Power Rating of the resistors should be about 1-2 Watts, each resistor, depending upon the Total Load. Due to complexities resulting from large Loads, do not use this circuit where large amounts of current are required, such as in Power Amps, etc. as it tends to waste Power, as well as requiring very expensive resistors and transformers for such uses.
AUDI0 HINTS

In many radio installations, R.F. can be a problem when it enters the audio lines to the transmitter. The circuit shown below will reject R.F. and all frequencies below 50Hz. or above 15,000Hz. The audio level leaving the circuit will be reduced to 50% of the audio entering the device.

![](image1)

Audio Response: 50 - 15,000 Hz.

![](image2)

Audio Response: 15 - 25,000 Hz.

In figure 2 is shown another R.F. rejection circuit which is easy to make. This device rejects all R.F. but passes all audio frequencies entering the network. The resistors used in these networks are 1/2 watt resistors. Capacitors may be 50 volt rating or greater. I recommend at least 400 volt capacitors in all circuits where possible. Experience shows that these usually last longer and are just as inexpensive to purchase as the lower voltage units. In cases where space is a problem, the smaller capacitors should naturally be used.

The above circuits are normally used in the lines driving the transmitter, but if necessary, may be used in any other location where R.F. is a problem.

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In many Studios and installations throughout the world, inexpensive equipment is used with surprising results instead of the high priced equipment supplied by Dealers. One of the most expensive devices used in Radio Work is the Audio Console. A "cheap" Console will cost over $4000.00 and the prices soar to over a half-million dollars for "custom-made" units!

For someone just starting out in the Business, you do not have to have all the fancy "dooh-dads" and "gizmos" in order to have a perfect audio quality production. In the world of audio equipment, you do not always get what you pay for. With a simple audio mixer costing $29.00, you can get the same frequency response as with higher priced units. The difference is in the fancy case, the NAME, and the extra features. Most features are only a convenience and not a requirement.

The problem with using semi-professional equipment for Broadcast or Studio work is the interface. The impedances must match or even the best equipment will sound like junk. Balanced lines are usually used on Professional equipment while unbalanced lines are used with home-style equipment.

First of all, you should find a way to match the impedances because most professional Consoles will accept "unbalanced" lines by simply grounding one of the inputs. Shown below is the easiest way I know to match these impedances when using unbalanced lines.

![Diagram](image)

The resistors shown are 1/2 watt carbon-film type available anywhere. R-1 is to match the load of the device providing the signal and R-2 is to match the input of the Console, Recorder, Amplifier, or other signal using device. When these impedances are matched, there is seldom a problem with distortion. If hum shows up in the lines, there are several easy to use methods which I will show in order to eliminate it.
In the example just shown, R-1 is always the value of the output impedance of the device supplying the Audio Signal. This could be, for example, a cassette tape player with an 8 ohm "ear phone jack." The input of the resistive pad is connected to this jack. R-1 is 8 ohms in order to match the output circuit of the cassette player. Now, if the signal is to be fed into an audio Console with an input impedance of 20,000 ohms, R-2 will be made 20,000 ohms and the volume of the cassette player adjusted about 1/4 to 1/2 volume to provide a usable signal level for the Board. The same applies when matching high to low impedances. When both loads are properly matched and volume levels are set, there should be no distortion unless from R.F. or hum pickup. This is about the easiest way I know to match lines. The same applies to low level lines. The resistors themselves seldom pick up any hum or noise. If there is any doubt, build the resistive pad into a metal can and provide a separate ground for the case than the one used for the low side of the unbalanced line.

**Balanced lines** can be matched using similar techniques—only 3 resistors are needed instead of the usual two.

![Balanced Circuit Diagram](https://via.placeholder.com/150)

In the above example, R-1 has a value equal to the incoming line and R-2, R-3 each have 1/2 the value of the outgoing line. Balanced lines from 4 ohms to 30,000 ohms may be matched this way. At higher impedances, hum pickup may become problematic. To overcome this tendency, the balanced "line transformer" is the least expensive way to go. Telephone "repeat coils" may also be used to assure that there are no stray hums on audio lines.
The audio line transformer is the best way to eliminate "ground loops" or hum from audio signals at low cost. Line matching transformers are almost always provided with "center taps" on primary and secondary windings. These aid in both impedance matching and hum elimination.

The method of hook-up shown above is most often used to stop stray hums found on incoming lines. The center tap on the incoming line side is properly grounded which balances out the stray hum fields giving top-notch performance at the least possible cost. These transformers tend to be expensive, but much cheaper than the Commercial "Hum Loop Eliminators" which cost from several hundred to thousands of dollars. As a general rule, only ground shielded cable on the "Board" end of the line.

In using balanced audio lines, the most common error is to attempt to ground both ends of the shield. This must never be done, especially where the transmitter is located in the same building as the studio. The "twisted pair" wires which are usually used have a shielded braid which may be grounded at whichever end works best. For error-safe installations, never buy or use shielded pair which does not have a plastic jacket over the shield. Most R.F. and hum pickup problems which can not be solved are due to its common use. When every single audio line in the studio or station maintains its own isolation and integrity, "ground loops" are easy to isolate and eliminate. In some cases it may be necessary to re-wire the entire facility with modern jacketed cables in order to cure the D.I.'s headache. When using bare cables, they will have to be braided together their entire length and soldered at times to the Station Ground System, plus the frequent use of isolation transformers or other devices. To assure easy installations, I recommend the use of fully jacketed cables in every case, except perhaps inside equipment cases where other techniques are normally used.
When an isolation transformer is needed at the input to a piece of equipment, the primary center tap often must be grounded only to the shield and not to the equipment ground in order to break the ground loop. There is no hard-fast rule except: "Whatever works best, do it!"

I have found that in most installations there is no worry about hum pick up if everything is done uniformly. The balanced inputs to Professional Boards usually adapt well to unbalanced lines without hum pickup if there is sufficient incoming audio drive. In cases where the Board must bring up the volume level significantly, it may be wise to install a pre-amp before the Board. If this is not done, no transformer in the world will solve your problems with hum, noise, distortion and even interference from nearby radio and TV Stations.

In cases where a slight sacrifice in audio quality is not feared, it is possible to permit a slight mix-match in impedances in order to interface equipment. I have found it impossible to find certain transformers which perfectly match some equipment. There have been times when I have had to use "build-out resistors" on standard transformers in order to make a reasonable match. As an example, if you had a transformer matching 150 ohms to 600 ohms, but you needed and could not find a 600 to 600 ohm transformer, you could use resistors on the 150 ohm winding to increase the impedance. The result would be a reasonable match with some loss in audio levels. A pre-amplifier may be needed to bring the audio up to the desired level.

Referring to the Chapter on transformers, I have stated that in emergency situations it is possible to use even power transformers for audio use if impedances are made to match. Much care must be exercised in doing this and everything must be pre-tested for ratio and frequency response before putting it to use. On the other hand, using the build-out resistors method above, better results may be had by using audio transformers of just about any kind. For example, an output transformer (with center taps) may be adapted to line isolation or impedance matching use and made to match nearly any impedance using the resistor method. So long as audio levels are kept sufficiently above noise levels, this works really well, and I see no reason to prohibit its use when needed. Many audio problems can be prevented simply by raising audio levels dramatically before the signal enters the lines. Levels can easily be brought down later at the destination using resistive pads, etc.
Shown here is the popular "Y" Pad. It is used to take two outputs from a single incoming line. It can also be reversed so as to mix two signals into a single line. The "Y" Pad is simple to build. All the resistors have the same value - the characteristic impedance value of the line. If the line is 600 ohms, all resistors are 600 ohms. If the line is an 8 ohm speaker line, all resistors are 8 ohms in value, with (of course) sufficient wattage size to handle the power demands. This is an impedance device and therefore should not be depended upon for power usage as its primary FUNCTION. This pad has only a 6db. loss, which is very small considering its versatility.

There are many other pads which may be constructed using resistors, and for those, I recommend consulting a Broadcast Engineering Handbook such as provided by the N.A.R.

SPECIAL NOTE:

When feeding one piece of equipment into another, be sure to consult the schematics of each and determine if one transformer is feeding another transformer. If so, you absolutely must use a resistor pad between the two devices! If you fail to do so, you will have mysterious distortion, frequency attenuations and boosts for no apparent reason. Don't try to correct the problem with an equalizer. Nothing is wrong with the equipment - the problem is due to feeding one transformer into another. The pad is the solution!
The telephone unit is used for putting audio from the phone lines directly "On The Air" in a radio station or Recording Studio. The audio from the announce mike is coupled into the unit and makes a proper "mix" coming from the audio console. The 1 K. Pot. is a ten turn Pot. for achieving a good balance between the Announce Mike and the audio coming in from the phone lines. Both caller and Announcer will be heard "On The Air" and over the phone lines at the same time. The Radio Transmitter is connected to "Console Out" or a tape recorder may be used here if desired. In most cases, resistive pads should be used at the three inputs to this unit for correct loading.
ANTENNA INSTRUMENTS

For accurately measuring the resistance and reactance of antenna circuits, the operating impedance bridge (QIB) is a most useful device. These are used in most broadcast engineering done commercially instead of the old substitution methods. For ham operators and radio engineers on a budget, I recommend the QIB illustrated in the 1987 issue of the AERL HANDBOOK. In Chapter 25, pages 39 - 41, all the necessary information is given for a Bridge usable from 2MHz, to 50MHz. With a little adjustment, it will perform well at standard broadcast frequencies. The savings over a similar commercially made bridge amounts to at least 1600 dollars.

If a less expensive instrument is desired, a noise bridge can be built which will accurately do the same things. As with all antenna measurements, extreme care must be exercised to follow instructions exactly - and even then, the possibility of error is great. Nothing can take the place of experience with a given piece of Test Equipment. Once all the mysteries are understood, all the pluses and minuses figured out, only then can reliable antenna measurements be consistently made.

NOISE BRIDGE SCHEMATIC

ZENER DIODE = 3.6V, 1/2 watt ECG 5000A
TRANSISTORS = ECG 188 UHF/VHF/VIDEO
T - 1 = broadband xfrmr. - B trifilar transformer #26 enam. wire on 3/8 inch diameter Ambicon FT-37-43 toroidal core or eqq.
A - B = test points for digital meter for (R) accuracy.
Before using the Noise Bridge, it must be calibrated. The "%" Dial can be read from the test points "A" and "B", with a digital meter, but should be calibrated anyway with numbers appearing on the Dial plate. This is done by using carbon resistors across the "TEST" point and noting the exact resistances on the Dial. The REACTANCE Dial will be set at "ZERO" and will correspond to midway in the range of the capacitor.

REACTANCE will be calibrated using a non-inductive resistor mentioned above across the "TEST" points. This is done without any wires or long leads - with a resistor with short leads inserted in the test connector.

The REACTANCE Dial will be calibrated with MINUS values in PILOFARADS to the left (counterclockwise) and PLUS values in PILOFARADS in a clockwise direction. ZERO will be in the center between these ranges with the capacitor plates midway.

TO USE THE UNIT it is turned on and placed in the antenna circuit directly without coaxial cables in the line, and the receiver is set to the frequency of test and volume turned up. There will be a loud noise heard in the speaker and the "S" Meter will read high. The bridge is adjusted for a null by moving "%" and "X" Dials back and forth until the least amount of signal is received on the Receiver. This is the "null." RESISTANCE is read directly from the dial, or if accuracy is required, with the digital meter.

REACTANCE VALUES are read from THE CHART, with Charted Figures DIVIDED BY THE FREQUENCY OF TEST. This will give fairly accurate values. It should be kept in mind that the Bridge may be used to accurately adjust an antenna system without reading the values at all. Simply use it to adjust for ZERO REACTANCE at the frequency. This would be done by inserting it at the desired location, with all coaxial lines and tuning devices in place. The Antenna Tuning Devices are adjusted for ZERO REACTANCE and pure resistance. Once this is done, the antenna is "tuned" and will work properly.
REACTANCE CHART

1 MHZ.

-2000
-1600
-1200
-800
-400
Xc

DIAL 70 50 30 10 10 30 50 70 DIAL
60 40 20 0 20 40 60

XL

400
800
1200
Xc

(+)

DIVIDE BY FREQUENCY IN MHZ.

J.R. CUNNINGHAM

For use with Noise Bridge.
RACK PANEL I.D. CHART

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16 1/16" (408mm)
43 7/16" (1103mm)
27 3/8" (695mm)
3" (76mm)

Courtesy J.R. Cunningham
CHAPTER FOURTEEN

HAM LINEAR AMP FOR 10 METER BAND TO 60 METERS

WARNING! F.C.C. forbids use of this instrument on C.B. bands.
The basic layout can be determined from the above illustration. The Tank Coil is placed directly between the two tuning capacitors. If the frequency is changed or if the exact value of tuning capacitors are not obtainable, smaller tuning capacitors may be used with fixed 4KV disk capacitors bridged across them to bring the over-all values up to par. The tuning capacitors will still tune, but simply have less range. In the above left side you see the 4KV disk capacitor riding atop the antenna loading capacitor since the original frequency was lowered. Rather than changing the entire tuning assembly in order to tune the new frequency, the modifications were made on both variable capacitors the same way. A NEW COIL was made with extra turns, and as you may be able to see, four turns were shorted out by soldering a solid jumper across the unwanted turns. The remaining turns are active for the frequency used. For lower frequencies, more of the Tank Coil is used, and the jumper is changed according to the frequencies used. The above can be accomplished by installing a ceramic switch and using coil taps as is customary.
NOTE: Use terminal strips where needed. The 1/4 inch hole at back is for tuning the trimmer cap.
WARNING: F.C.C. forbids use of this equipment on C.B. Frequencies
THE LINEAR AMP SHOWN may be built on a chassis measuring 11 X 7 X 2 inches deep. The tubes are 6L66/6J66 horizontal output tubes as used in older model Color TV Sets. These are available at less than wholesale costs at the ELMIRA Factory-direct location I show at the back of this Book. The High Voltage Transformer is special and may be obtained at one of the addresses also listed. The Peter Dahl factory will special wind any transformer to your own specifications for a price. Call for a quotation.

The line from the input connector to the relay must be made of 50 ohm coax as well as the line from the relay to the cathodes of the tubes. The line going back to the relay from the tuner and the line going out to the antenna connector also should be coax. This will prevent feedback and other problems. Ground both ends of all coax jumpers used.

The diode used for "key" function is ECG 177, but may be any other capable of turning on the relay at the proper frequency of operation.

The High Voltage Bridge Rectifier is made from ECG 125-A's bypassed as shown on the following page. If really high voltages like 1000 - 3000 volts are used, for safety use the schematic assembly shown. The six units together will take the place of $30 each diodes which are normally used in these applications. The ECG 125 type will sell for about 15 - 20 cents each and when used as shown will serve perfectly well in the biggest transmitters in existence. The savings is actually THOUSANDS OF DOLLARS in a single transmitter high voltage assembly - the kind used commercially by A.N. - F.M. Radio Stations. I am sharing this secret with the world in hopes that someone will benefit in the manufacturing of better - cheaper equipment for home-use or Commercial applications.

The coil is hand-made from #12 gauge solid bare wire. The spacing is 1/16th inch between turns. The tuning capacitors can be bought at FAIR RADIO SALES, MESHNA, M.P. JONES or DAVILYN. Your local supplier may be of help as well.

The three filter capacitors are put in series to handle the high voltage. If weight is no problem, a special capacitor may be utilized.

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Instead of the usual 8 amp. 600 volt units put together in series, the ECG 125-A type axial lead rectifier may be substituted if six of the units are put together as shown and by-passed with a 100,000 ohm resistor (2 watt). This makes up one unit. For 1000 volts, two or more of these are put together for each leg of the bridge rectifier. To be perfectly clear, each leg will consist of two of the above in series. For power supplies for large transmitters, use one unit for each 200 to 300 volts. These are wired in series and each unit bypassed with the 2 watt 100,000 ohm resistor. Up to 24 of these can be run in series (per leg of the bridge). The maximum amperage these can continuously run is 3 amps. More Diodes should be paralleled if more amperage is needed. These will cheaply replace diodes costing up to $40.00 each for less than $1.00 per unit.

For the Linear Amp on the preceding page, in some cases, one or two of these in parallel will do, but if the radio is keyed too long, they will get hot. I am speaking of one or two ECG 125's alone, not as shown above.

An added advantage with these six in parallel as shown is there is no need for expensive heat sinks in the construction. Hundreds of these diodes can be purchased at less cost than one heat sink assembly! I have accidentally "dead-shorted" rectifier assemblies made for 1000 watt A.M. Transmitters using this method, and have never blown a diode! The breaker kicks and the diodes remain cool. The wire lugs are used for ease in assembling units on terminal boards.
1200 WATT
CATHODE DRIVEN LINEAR
USING HORIZONTAL OUTPUT TUBES

WARNING: ILLEGAL FOR Citizen Band Radio use.
The Linear Amp shown here is a do-it-yourself project and requires a little skill and care. This equipment is usable for Ham Radio frequencies and is legal for C.B. use in Countries other than the U.S.A. and Canada. This unit takes the use of Horizontal Output tubes to the practical limits. There have been linearers made using more tubes, but they are not practical since there are angle tubes available which handle larger powers and are more cost effective.

The eight tubes shown above currently cost (total) $65.00 at Elmlar. This is a true wholesale price. For powers into the 2KW range, a person should buy surplus tubes from Dealers listed in this Book.

The power transformer is capable of over 1 amp intermittent at 1400 volts. A transformer like this is almost impossible to find in a small size. One readily available transformer is the power transformers found in MICRO-WAVE OVENS. Often, repair shops have used transformers which may be bought for $5 to $10.00 which are in perfect shape. These usually are capable of all the demands this Project can place upon it and should be rugged enough to never burn out. One such transformer is the TRIAD-UTRAD 6340 - HS65 - 7070. Due to the high current demands of this 1200 watt Linear, your RELAY will need to be capable of switching 10 AMPs(1) of 120 VAC. This is done by using a separate relay for the power transformer only and switching in 12 volt coil through the small relay used for the rest of the Linear.

The R.F. POWER put out by this Linear Amp is almost 5 amps. This can be switched through R.S. Relay #275-216. Two of these may be used. One for the regular switching and the other for the Power Transformer Primary switching. The unit used for the Primary should have all the contacts paralleled so as to assure extra long life.

Enough spacing must be left between tubes to allow air for cooling. A Muffin Fan should be built into the unit on the side of the case or above the tubes to assure adequate air flow. Use R.S. #273-241 or equivalent.

The chassis must be grounded to the Power Company ground through the use of a three-pronged safety plug. This helps assure the user a long life! The CHASSIS is home-made. Any sheet metal shop can do the work.

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The basic layout is shown as seen below the chassis and above. This is to illustrate the plate wiring and cathode wiring. If these are kept neat as shown, the unit will not have parasitics. Layout and parts placement and spacing otherwise is NOT CRITICAL.
NOTE: For simplicity, only one 20LF6 is shown in the diagram. All are in parallel except for the filaments which are in series and fed with 120 VAC. Use \(0.01\) uf - 50 v. Disc capacitors between pins 1 and 12 of all tubes, and from 389 of all tubes to chassis ground.
1200 WATT LINEAR NOTES

TUBES: Drivers - 6L6G with filaments in series supplied by 12.6 V transformer
       Finals - 2SA56 eight with filaments in series supplied by 120 VAC

DRIVER R.F. CHOKE - 150 ohm (1/2" diameter x 2-1/2" tall - #20 ga. wire)
FINAL PLATE CHOKE - 150 ohm - same as above (Insulated Wire for all Chokes)

TUNING CAPACITORS - PLATE LOAD CAP. 150 pf (.02 air gap)
Antenna load cap. - 1000 pf receive type
DRIVER LOADING CAP - (30 - 50 pf 400V.)

COIL DIMENSIONS - DRIVER LOAD COIL = 6T #12 ga. wire 4/8" I.D. (bare Wire)
spacing between turns 1/16 - 1/8 inch
PLATE TANK COIL = 4 - 6T #10 bare wire 3/8" I.D.
2" long with 1/2" spacing between turns

COUPLING - ALL COUPLING BETWEEN STAGES is 50 ohm coax as follows:
1. FROM INPUT TO RELAY (Ground to Chassis-Coax Braid Ends)
2. FROM RELAY TO DRIVER
3. FROM DRIVER TUNER TO CATHODES OF FINALS
4. FROM FINAL TUNER TO RELAY
5. FROM RELAY TO ANTENNA CONNECTOR

BIASING DIODES: STUD TYPE 5amp 90 volt type. on heat sink. DIODES ARE IN SERIES - ONE STUD IS GROUNDED, THE OTHER USES INSULATOR WITH HEAT SINK COMPOUND. DRILL HOLES ACCORDINGLY. USE 1/16 to 1/8" sheet alnum. for sink.

RESISTORS: CONTROL GRID of DRIVERS ARE TIED TOGETHER with 100 ohm 2 - 3 watt resistor to ground. Make leads short.
CONTROL GRIDS of ALL FINALS ARE TIED TOGETHER and have 100 ohm 2 - 3 watt resistor to ground. Non-Inductive resistors.

CAPACITORS: PLATE CAPACITORS FROM DRIVER AND FINALS ARE 2.5KV
CATHODE CHOKE: 27uh choke for 6 finals must be heavy duty.

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The rectifier panels consist of three (3) ECG 128 diodes in series for each leg of the Bridge. Each individual diode is bypassed with a 1 - 2 watt resistor having a value of 186,000 ohms. This provides surge protection for the diodes.

The TRANSFORMER is preferably 1200 - 1400 volts rated at 1 amp. Many 1/2 amp transformers will work in intermittent service such as used here. The transformer will draw considerable current and the house circuit breaker should be of 30 amp capacity with #10 wire to the Linear.

Each FILTER CAPACITOR is RATED AT 100 mfd. at 450 volts or greater. THESE MUST ALL BE THE SAME AND CLOSELY MATCHED IN CONDITION. The total resulting value is 50 mfd. This is sufficient filtering at this high of voltage. For those operating on a budget, try just one bank of capacitors resulting in 25 mfd. If too much hum is present, add the second bank.
When "Normally Open" Sw 1 is depressed, 120 VAC entering "Relay Coil" causes contacts 1 and 2 to "make." This provides for a "hold" circuit allowing the "Control Relay" to remain "ON." when Sw 2 (normally closed) is depressed, it breaks the relay "hold" circuit causing the Control Relay to turn "OFF."

CONTACTS 3, 4, and 5 are used to provide "control voltages" to other relays in the transmitter or for stop functions. This relay can be chosen so that more contacts are available than what are shown.

It is customary to use no more than 120 VAC for these control functions. If 120 VAC is not present in the Supply Source, then a Step Down transformer is placed inside the Transmitter for this purpose. Other Relay voltages may also be used as a "Control" such as 24 volts, 12 volts, or 6 volts.
**B+ DELAY CIRCUIT**

**3-6 SECONDS**

When 120 VAC comes on to operate the B+ circuitry, the relay permits a delay before contacts close for normal operating conditions. While contacts are "OPEN" the B+ resistor is in the circuit, allowing a limited current to pass through the secondary of the B+ Transformer, thus protecting the B+ circuitry (not shown) from too powerful of surges. When the delay is past, the relay capacitor charges allowing for a full voltage to appear across the relay coil, thus closing the relay and allowing a full B+ voltage to be developed from the transformer. The 1A fuse allows for additional protection against surge currents or "shorts."

OPERATION

RELAY COIL
RS 275-214 (600 Ohm coil)
or Eqv.
CHAPTER FIFTEEN

EQUIPMENT SOURCES IN THE U.S.A. AND CANADA
ANTENNA EQUIPMENT - PHASORS - COILS - NEW R.F. CAPACITORS

1. KINTRONICS
P.O. BOX 345 Tel. (615) 878-3141
Bristol, Tn. 37621-0845

2. COSMIN Electronics
P.O. BOX 222
Pipersville PA 18947 215-847-2944

3. J S BETTS Co. ALSO HAS LARGE PARTS INVENTORY FOR HAMS, etc.
P.O. BOX 426
FAIRBURN GA 30213 404-964-3764

4. EAGLE HILL ELECTRONICS (specializing in surge protectors)
41 Linden Av
Rutledge PA 19070 215-544-9879

5. ANDREW CORP. Highest quality antennas and accessories
10500 W 153rd Street
ORLAND PARK IL. 60462 312-349-3300

AUDIO EQPT. AND PROFESSIONAL BROADCAST STUDIO ITEMS

1. L.T. SOUND (Production Room Eqpt.) very good
P.O. Box 338
Stone Mountain GA 30088 404-493-1258

2. LAUDERDALE ELECTRONIC LABS. (Broadcast Eqpt.)
16 SW 13th Street
Ft. Lauderdale, Fl. 33315 305-784-7755
3. BSW
7012 29th Street West
TACOMA WA 98406 1-800-626-8434

4. ALLIED BROADCAST EQPT.
Suite 309 Chaddick Center 1201 E 15th Street
Plano TX 75074 317-935-5193

5. BRADLEY BROADCAST SALES
15555 L Frederick Rd
Rockville MD 20855 301-762-9222

6. BROADCAST ELECTRONICS
4100 N. 24th Street
Quincy IL 62301 217-224-9400

7. PROFESSIONAL AUDIO SUPPLY
5700 E Loop 820 South
Ft Worth TX 76119-7650 (817)683-7474

8. LONG'S ELECTRONICS (AUDIO VISUAL NEEDS)
2700 Crestwood Blvd
Birmingham AL 35210 1-800-639-3410

CAPACITORS

1. JENNINGS CAPACITORS (including vacuum type)
SURCOM ASSOCIATES
305 Wisconsin Av
Oceanside CA 92054 619-722-6162

2. PLASTIC CAPS, INC.
2423 N Pulaski Rd
Chicago IL 60639 312-488-2229

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PARTS AND TEST EQUIPMENT

1. MOUSER ELECTRONICS
   2401 Hwy 287 North
   Mansfield TX 76063 817-463-4422

2. FORDHAM RADIO
   855 Coaklin St
   Farmingdale NY 11735 516-752-9950

3. INTERNATIONAL CRYSTAL (crystals only) HIGHLY RECOMMENDED
   10 N. Leon
   Oklahoma City OK 73102 405-236-3741

4. CRYSTEK (crystals only)
   1000 crystal Dr.
   Ft Myers FL 33906-6135 813-836-2100

5. BRD ELECTRONICS (watt meters and dummy loads)
   802 "B" Old Hickory Blvd
   Lancaster PA 17601 717-908-0667

6. CONSOLIDATED ELECTRONICS (small parts & Test Eqpt.)
   705 Watervliet Ave
   Dayton OH 45420 513-252-5662

7. NCM ELECTRONICS (similar to above) reasonably priced
   656 E Congress Park
   Centerville OH 45459-4072 513-434-0031
1. FAIR RADIO SALES (true Gov't. Surplus) reliable-dependable (many parts)
1016 E. Eureka Street
Lima OH 45802 419-223-2166 or 227-6573

2. DAVILYN CORP. (another good source for Hams, etc.)
13401 Saticoy St
N Hollywood CA 91605-3475 (818-787-3394)

3. H and R CORP. (robotics parts, microwave and test eqpt.)
401 E Eric Av
Philadelphia PA 19134 215-426-1708

4. OCEAN STATE ELECTRONICS (excellent Source)
P O BOX 1458
WISTERLY, RI 02891 (1-800-865-8626)

5. MARLIN P JONES AND ASSOCIATES (priced right)
P O BOX 12685
LAKE PARK FL 33403-0865 (305-840-8230)

6. ALL ELECTRONICS CORP.
895 S Vermont Av
LOS ANGELES CA 90006 213-380-8000

7. BAYTRONICS (used military radios for Ham use)
P O Box 591
SANDUSKY OH 44870 (write for catalog)

8. ELECTRONIC RESEARCH LABS. (high class new and used test gear)
ATLANTIC and FERRY AV
CAMDEN NJ 08104 609-541-4200
1. PETER DAHL CO.
5869 WAYCROSS
EL PASO TX 79924 915-751-2300

2. SEE SURPLUS AND PARTS DEALERS (large transformers will be under SURPLUS)

TRANSMITTERS

1. HARRIS CORP. (BROADCAST TRANSMITTERS)
P O BOX 4290
QUINCY IL 62305 1-217-222-6200
24 hour toll free for parts for HARRIS-GATES EQPT. 800-422-2210

2. FACTORY DIRECT SALES - AM, FM and TV TRANSMITTERS AND ANTENNAS
c/o Jimmie Joint, 17194 Preston Rd, Suite 122-297, Dallas, TX 75249
1-800-278-3328

3. OMNITRONIX - AM SOLID STATE TRANSMITTERS
1374 Cinnamon Drive
Pt. Washington, PA 18074 215-866-2400 or 800-2323

4. CONTINENTAL (specialists in high power transmitters for short wave)
P O BOX 270879 (Office: 4212 S Buckner Blvd.)
DALLAS TX 75227 214-301-7161

5. BAYLY ENG. (FM Broadcast)
167 Hunt St
Ajax Ontario Canada L1S1P6 416-883-8200
1. NEW SENSOR CORP. (SOVTEK RUSSIAN TUBES)
30 Cooper Square, New York City, NY 10003
(212) 529-0466 or 1-800-633-5477 (FAX 212-529-0490)

2. CORNELL (small tubes cheap)
4215 University
San Diego CA 92105

3. ANTIQUE RADIO SUPPLY (serious Suppliers of tubes and parts)
6221 S. MAPLE AVE.
TEMPE, AZ 85283 (902) 830-6411 or 1-800-709-8789

4. PLASTICS TECHNOLOGY, INC.
SOLID STATE RECTIFIERS for Transmitters
205-833-8277

5. Aero Electronics (power tubes for Xmtrs.)
2129 Venice Blvd.
Los Angeles CA 90066 213-737-7070

6. EIMAC-VARIAN (High quality)
301 Industrial Way
San Carlos CA 94070 415-592-1221
also 1676 S Pioneer Blvd.
Salt Lake City UT 84104

7. ECONCO (rebidders)
1318 Commerce Av
Woodland Ca 95695 916-692-7553

8. Richardson CECEO
2115 Av "X"
Brooklyn NY 11235 718-646-6300
9. RF PARTS (tubes, transistors, etc.)
435 South Pacific Street
SAN MARCOS, CA 92069
1-800-737-2767 or 819-744-9700

10. Freeland Products (rebuilder)
Rt 7, Box 828
COVINGTON, LA 70433 504-893-1243

11. Surplus Sales of Nebraska
1315 Jones St.
Omaha, Nebraska 68102
1-402-346-4750

IMPORTANT NOTE

These are only a few of the Suppliers, but these I have dealt with and have found them reliable. It is important to note that Companies come and go, usually merging with other Corporations, and by the time you get this Book, all of the above may not be in business. Hopefully you will find enough information here to be helpful, making whatever Project you chose to do fully possible.
CHAPTER SIXTEEN

SCHEMATIC

SYMBOLS
<table>
<thead>
<tr>
<th>Device</th>
<th>Symbol</th>
<th>Device</th>
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<tr>
<td>A-c source</td>
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<td>Crystal, piezoelectric</td>
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<td>Antenna, general</td>
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<tr>
<td>loop</td>
<td><img src="image" alt="loop" /></td>
<td>chassis act at Z —</td>
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<td>or counterpoise</td>
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<td>or counterpoise</td>
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<td><img src="image" alt="Bell" /></td>
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