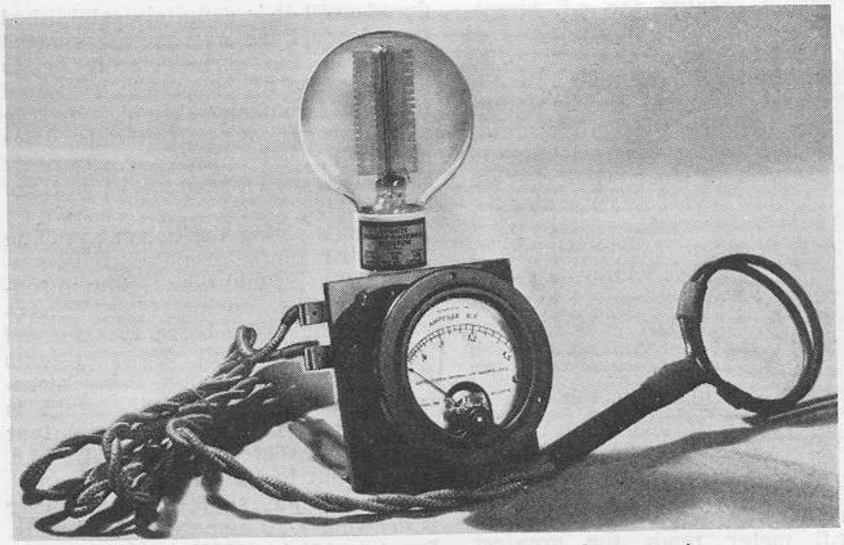


The set-up used to determine the efficiency of a transmitter.

The output of your transmitter can be raised if you will pay some attention to the efficiency of the stages.

Raising Your Transmitter Efficiency

By GORDON E. GRAY, W9CG
Sales Engineer, Ohmite Mfg. Co.
Chicago, Illinois

A TRUE *dummy antenna* is useful, of course, in substitution for the regular antenna to check the transmitter before going on the air. The utility of such a device by no means ends here. While its use solely for this purpose was unanimously recommended as early as the spring of 1935 (see *QST* report on the meeting of the Board of Directors, June 1935) by the Board of Directors of the *ARRL* as a means of more effective employment of amateur frequencies, its adaptability as a tool in better transmitter adjustment far over-shadows its limited substitution of the regular antenna.

Technically a true dummy antenna is a compact high wattage resistor of low inductance. It follows, therefore, that such a device has long been one of the chief instruments missing from the long lists of units available to the amateur, experimenter and manufacturer for use in radio frequency work, particularly in connection with measurement of radio frequency power on transmitters, efficiency of receiving antennas, diathermy equipment and like r.f. generating equipment.

The writer, in making a check among fellow amateurs some of whom had rigs as modern as the state of the art permitted, found in almost every instance that the overall efficiency of the final amplifier as well as the associated radiating equipment was an unknown quantity. Each reckoned that in view of the fact that the "plates of the tubes didn't melt the efficiency must be pretty good—probably between 60 and 80%." They further thought that since they worked fair DX and had a reasonable percentage of answers to calls, most of the power must be getting into the antenna. All admitted, however, that the difference between 60% and 80% efficiency represented about one third more useful power which they might or might not be getting. If they were not, it was costing them something on the electric bill on each and every QSO.

> *While the Dummy Antenna described herein does not of itself radiate, the transmitter under test may do so. All unlicensed persons should familiarize themselves thoroughly with the Federal Communications Commission's Rules and Regulations, so as to avoid violations thereof with the attendant heavy penalties. The Editors.*

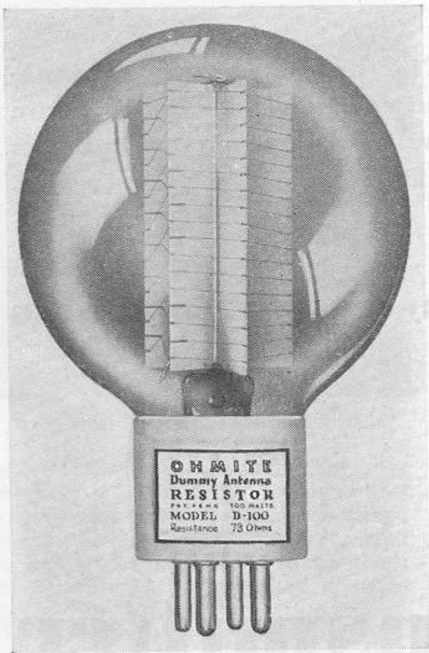
The improvement in efficiency of all stages of the transmitter would represent a definite saving on the amateur's pocket-book. More concrete and tangible evidence is likely to be noticed through saving in equipment. How many of us have purchased a *PDQ150* for the final which the manufacturer assures us can be driven to the moon and back by a single *PDQ15!* However, after hours of fussing and nursing the driver stage, because we have not had an accurate means of checking the performance of *PDQ15* stage while making the various adjustments, we finally make an unnecessary investment in a higher voltage plate transformer, associated rectifier and filter equipment along with a *PDQ50* to get the necessary drive.

Another angle on the possibility of direct savings can probably best be illustrated by a hypothetical case. Suppose a 200 watt transmitter had a final efficiency of 60% (the broadcast station figure). The useful output would be $200 \times .60 = 120$ watts. Improvement in efficiency to 75% would result in a useful output of $200 \times .75 = 150$ watts. How much would additional equipment cost (power supplies, larger tubes, larger tuning condensers, insulators, etc., to say nothing of the steady increased drain on the light bill for each hour of operation) for a larger transmitter at the 60% figure to obtain this 150 watt output? Simple calculation ($150 \times .6 = 250$ watts) shows that enough equipment to make over the transmitter from a 200 watt job to a 250 watt job would be necessary.

This would undoubtedly include additional driving equipment and associated power supply equipment. There is little doubt that by brute force and cramming every watt of the allowable 1000 watt input into the final, we can get enough out even under extremely poor efficiencies to work all the DX we want to. There is less doubt that the cost of equipment and power under such conditions is far out of proportion to the results obtained.

A simple and direct means of measuring radio frequency power therefore means to the amateur a simple solution of heretofore tedious adjustments of often unknown value in tuning up the various stages of a transmitter, as well as linking the transmitter itself to the antenna.

(*Turn the page, please*)



Internal view of the Dummy Antenna.

In connection with an r.f. ammeter the vacuum type dummy antenna, becomes this unit which will become fully as indispensable and important an instrument in the ham shack as the voltmeter, the milliammeter, the monitor and oscilloscope have proven to be.

The dummy antenna becomes an r.f. watt indicator when used in series with an r.f. ammeter, and the following determinations serve as a starting point to better transmitter operation. We have to find out how good or how bad our transmitter really is.

(a) Determination of efficiency and output of the crystal or oscillator stage.

(b) Determination of efficiency and output of intermediate and buffer stages.

(c) Determination of efficiency and output of the final amplifier.

A, B and C are in reality the same problem. They are solved by using the dummy load in series with an r.f. ammeter (or r.f. milliammeter in the case of small wattages as in the crystal stage) and a short length of twisted pair or concentric line with a loop used to couple the device to the plate tank of the stage being measured.

If the quality of the twisted pair and link is in doubt, the combination can be coupled directly to the plate tank (Figures 1a and 1b) remembering, of course, that high voltage d.c. is present and should be treated accordingly. (The technique of the operator is a factor and a short coupling means may prove to give less trouble in adjustment. One foot of concentric feeder has been found less critical in adjustment than direct coupling (See Figure C probably because the r.f. ammeter and dummy are more removed from the r.f. field of the tank coil.)

Where the impedance match for the maximum transfer of energy occurs is dependent upon the design of the tank circuit. Since the resistance of the dummy is 73 ohms, (if it were a different value, the theory remains the same) it is necessary to find that point on the tank where the impedance is likewise 73 ohms, or whatever resistance value the dummy might have. A true experimenter will start with the proposition that his antenna match point on the tank *might* be wrong, and seek the proper match to the dummy experimentally.

The optimum coupling for the maximum transfer of energy is determined experimentally by clipping across additional tank turns progressively until the r.f. meter reads the greatest amount of current flowing at tank resonance. For 600 ohm dummies this may amount to several turns.

In the case of a dummy of 73 ohms, optimum coupling for the best transfer of energy will be found very close (generally a turn or less) from center of the coil for each clip in the case of a balanced tank circuit and a turn or less from the r.f. ground end in the case of a single ended circuit.

It should be mentioned here, that the clips, the connecting wires, etc., can add stray capacity and some inductance into the dummy system. With reasonable care in setting up the test circuit, correction for this should not be necessary for the practical determination of the output of the r.f. stage. For a more accurate determination of efficiency, the stray capacity and inductance of the leads can be balanced out by inserting a small exterior inductance and variable condenser in series with the dummy antenna and r.f. ammeter. The values of the inductance and condenser should be such that resonance can be obtained as is noted by a *dip in the grid circuit* meter (high voltage of plate being off) when tuned to such resonance. In this state all stray capacities and inductances are balanced out, and the dummy is the only resistance effective in the circuit.

The stage can now be fired up and tuned to resonance.

CAUTION: The input should be reduced until it is definitely established that leads have not become shorted either in the series circuit or to ground. The r.f. current in a shorted turn can be unbelievably high even in a low power stage and thermocouples can be burned out. After assurance that all is well the normal input can be applied.

By multiplying the current reading of the r.f. ammeter obtained in amperes by itself and then by the impedance of the device ($I^2 \times \text{Ohms} = \text{Watts}$), the watts being transformed into heat is the result. This represents the output of the stage being measured. The efficiency of the stage is represented by the ratio of the output figure just determined to the d.c. watts input to the plate circuit.

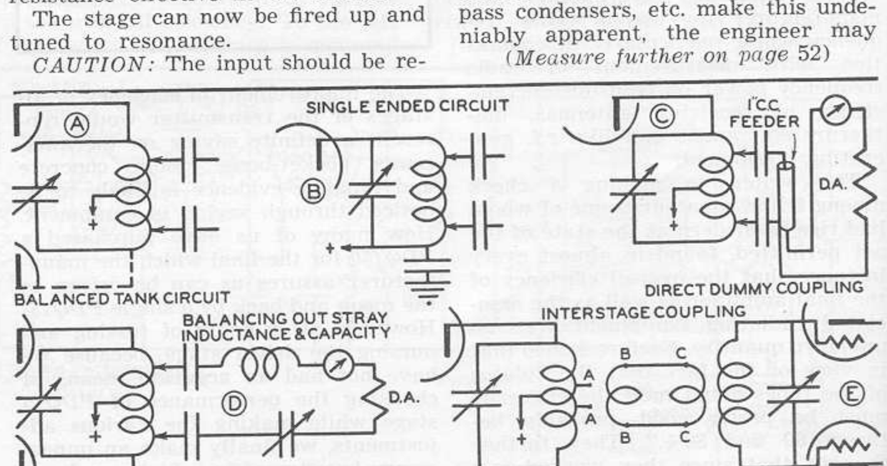
For example, suppose an amplifier is drawing 1/10 ampere at 1000 volts. Input $= (.1) \times (1000) = 100$ watts. Suppose the dummy is 73 ohms and the r.f. ammeter reads 1.02 amps. Output $= (1.02)(1.02)(73) = 76$ watts

$$\text{Efficiency} = \frac{76}{100} \times 100\% = 76\%$$

After finding out exactly what output can be obtained from each stage, all the regular adjustments should be made in bias, etc. to obtain the maximum output as measured by the r.f. ammeter, *always referring back to the input* and *calculating* the *efficiency after* each adjustment. After all, if the plate input goes up faster than the output nothing has been gained in efficiency. If the tube is operating in accordance with manufacturers' recommendations as to bias, drive, plate volts, filament volts, etc., and the efficiency is still low, the next step would be to look for circuit components which are robbing the dummy of the power it should take. Remember that the tube can be operating at maximum efficiency, as evidenced by normal temperatures and cool plate, and actually be delivering to the output or tank circuit most of the power that is in turn being delivered to it.

Leaky insulation, high circulating current losses, and so on, may mean that the *load* may not get even an appreciable percentage of this power. Unless warm or hot inductances, bypass condensers, etc. make this undeniably apparent, the engineer may

(*Measure further on page 52*)



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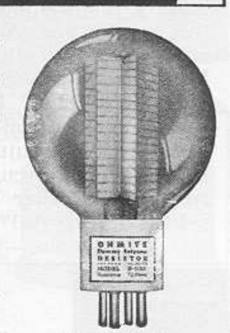

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Visual D-Meter

(*Continued from page 14*)

mitter. In the 5 meter position the trimmer condenser only is used to cover the band. Set the selector switch to the off position which will disconnect the padders and tune the trimmer to a 10 meter signal. Advance the regeneration control to the point where the tube breaks into oscillation.

Tune for a whistle which will give a reading on the output meter and then readjust the trimmer for maximum indication on the meter. Now any variation in the signal will change this beat note or whistle and will likewise change the reading on the output meter. Remove phones.

The above procedure is followed for the other bands and the initial adjustments are made by adding additional capacity from the selector switch and its associated padding condensers. A shorting type switch must be used so that as the switch is rotated, the condensers will add to each other in capacity.

A total of five positions cover the 5-10-20-40-80 meter bands with the capacities shown on the schematic diagram. Each variable padder has a capacity range of from 10 to 70 mmfd. The 40 and 80 meter bands are tuned with a higher capacity than would be reached with the padders alone so additional capacity is furnished by the fixed mica condensers as shown. The high C. greatly adds to the stability of the monitor.

In actual use with a low power oscillator it was founa that a short piece of wire about one foot in length offered sufficient pickup to the monitor even though located some 10 feet away. Do not use too much pickup as to do so will block the monitor signal.

The extreme sensitivity of the meter makes it important that the case be grounded to reduce body-capacity effects. A vernier dial in place of the knob shown will further add to the operating ease and precision adjustment.

In conclusion it is well to repeat that the monitor reads changes in frequency in cycles and is therefore fast reading if this condition takes place. A frequency change of but a fraction of one kilocycle will cause the needle on the output meter to drop to zero if care is taken in properly setting the regeneration and trimmer controls.

The users of this instrument will be amazed at the drift in their transmitters, but it can safely be said that if the monitored signal stays on the meter in any position above 0 reading, that no change will be recorded at the receiving position. [Grand Island Station is the exception, hi, Ed.] The meter should not be relied on for *exact* edge-of-the-band transmissions.

—30—

NEXT MONTH!
"A SPECIAL RECEIVER"

Transmitter Efficiency

(*Continued from page 16*)

overlook these possible sources of inefficiencies unless they practically jump right out at him. The writer remembers only too well a metal clad plate blocking condenser mounted on a metal chassis without benefit of stand-off insulators. Without a means of measuring the output, the writer rested snug in the satisfaction of a job well done because the tube apparently was doing its stuff, until a pool of compound dripping to the stage below indicated that about half the tube output was melting compound instead of going up the feeders.

Visible proof of losses may not always be so apparent. There is no doubt that the difference in the plate current reading between the loaded and unloaded conditions gives a fair indication of the presence of losses, however, several factors (tube characteristics, bias behavior) involved make it practically impossible to estimate the probable efficiency. It is not intended in this article to more than border on the many possible sources of inefficiencies in r.f. circuits. Practically all amateurs have handbooks and other sources of information on the subject treated with far more thoroughness than could be employed in an article of this type.

I have endeavored to show, however, that a simple means of measurement of power will enable the amateur to see some tangible proof of his efforts to improve his transmitter antenna and stages. As a matter of fact, even if the final amplifier had proved to be 80% efficient in the first place, there is a great deal of personal satisfaction in knowing what the actual figure is. Then, too, 90% efficiency is still worth trying for and not at all unattainable.

Because the dummy load can be used as an accurate indicator of r.f. power, additional uses other than the determination of efficiency alone become apparent, for example:

(d) Determination of the optimum setting of all coupling devices for maximum transfer at the nominal impedance (impedance matching) between stages.

This is solved as follows. Regardless of what the efficiency of the stage being measured is, there will be one setting of the coupling device (link or otherwise) which will give the maximum reading of the r.f. ammeter representing the best impedance match between the stage and the load. Any other load having the same impedance as the dummy will also be matched perfectly with this setting. (The chances are that the grid and plate circuits of the stages being coupled may have widely different impedances both between themselves and the coupling method. Reference here is made to the actual link circuit itself which is generally used and which has been found guilty of losses even in short lengths of 6" or so.)

Consider Figure 1d as a typical case. Generally the output of the driver can be measured at point BB although if the coupling coil itself is suspected of losses the output can be measured at point AA as described in previous paragraphs and at point BB after the optimum setting for maximum energy transfer is made. A decrease in indicated power at point BB with the same plate input would mean losses in the coupling system itself. *The plate input would, of course, be referred to again as it may have been reduced through wrong adjustment of the coupling coil and less power at point BB may be due to this reduced plate input rather than losses. The comparison between plate input and power output must always be made before any conclusions can be made as to losses occurring.* Repeating the power measurement at point CC will allow calculation of losses occurring in the line from point BB to point CC, again *referring to the plate input* before definite conclusions are made. The same procedure can be followed for further information in

(e) Determination of the efficiency of the transmission line between the final amplifier and antenna.

After the final stage is adjusted for maximum output (say e.g. on a 73 ohm dummy load) suppose we substitute a 73 ohm concentric line and place the dummy at the far end which would normally attach to the antenna. Without readjustment of the transmitter the r.f. current at the transmitter should be approximately the same as with the dummy. Likewise, the plate current and plate voltage. On a poorly regulated plate supply, in the event of a plate current change, plate voltage will also change.

If there are any appreciable line losses the current will be progressively less out to the end of the line where the dummy is attached. The current measured at this point is the current in the dummy and the power is calculated as before. The difference between this figure and the previous figure determined at the transmitter would be the approximate line losses, providing mismatches have not occurred which may alter the efficiency of the amplifier itself due to several reasons. This loss figure then may not be strictly true since the line losses are in part due to insulation resistance which in effect shunts the dummy and lowers the nominal resistance of the whole system.

If the plate current or voltage changes appreciably, this is due to mismatches and/or appreciable distributed capacity entering into the system. Any change in plate current or voltage means that the efficiency of the final amplifier will alter and the figure for line losses may also include a change in amplifier efficiency as well. As a matter of fact, if the match was poor in the determination of the amplifier efficiency and should happen to be improved upon when the line was brought in to the system, an increase in overall efficiency might be the result. The above possibilities would also apply to previous measurements made on the link coupled stages described in the previous paragraph under (d).

[Next month the author concludes this interesting subject with a complete explanation of different dummy antennas and their application towards improving the radiation efficiency of an antenna. This applies to receiving as well as transmitting antennas. Ed.]

325-Watt Transmitter

(Continued from page 31)

into a line of 500 ohms, which is cable-connected to the 2A3 input circuit in the modulator section of the transmitter. The volume indicator on the front of the preamplifier provides a convenient means of checking the level of modulation with a gain control readily available for close, quick adjustment. Examination of the schematics will show how the various units are interconnected.

The pictures show clearly the placement of components and the schematic diagrams how they are connected.

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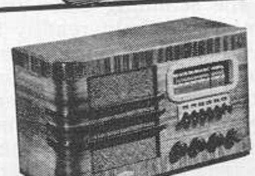

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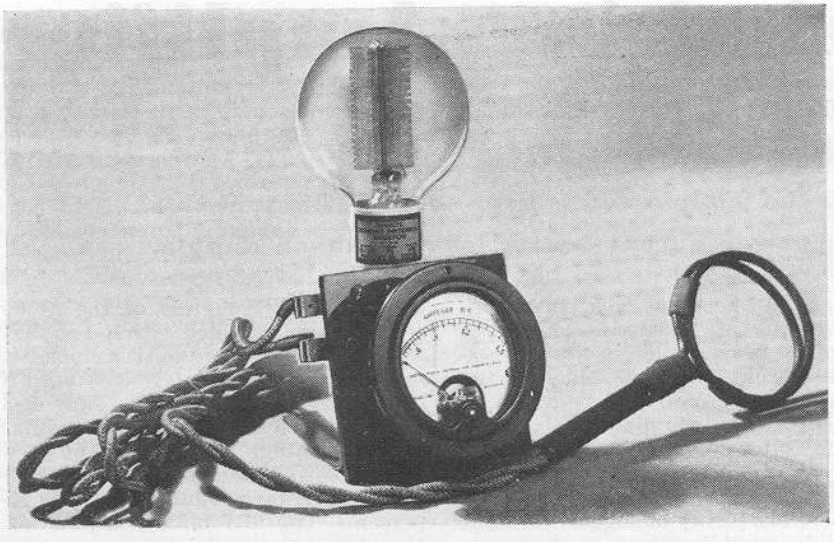


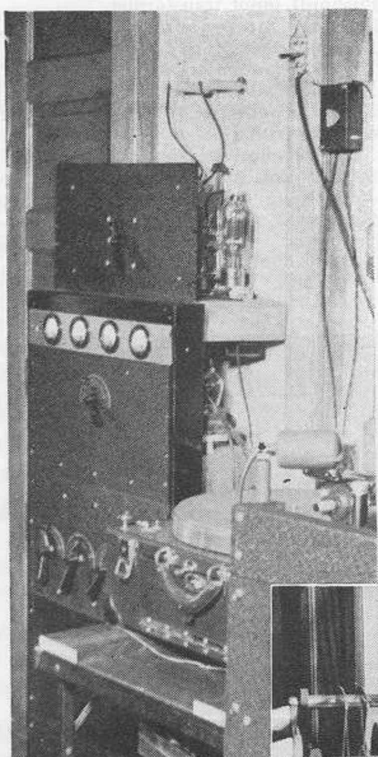
The matching instrument: an r.f. meter and a dummy antenna.

An excellent way to raise the output of your rig without a change in input, is to improve the match with the antenna.

By GORDON E. GRAY, W9CG
Sales Engineer, Ohmite Mfg. Co.
Chicago, Illinois

Upping Your Rig's Output

IN last month's article it was demonstrated that a Dummy Antenna in connection with an r.f. ammeter offered a practical means for the measurement of radio frequency power. With a simple and practical means of measuring r.f. power, not only can the plate circuit efficiency of the various stages of a transmitter be determined, as previously outlined but also additional data about the complete installation, from crystal stage to antenna which more or less have been assumed in the past, can be determined within practical limits.



The use of the described theories were tested by the author at W9UAQ with gratifying results.

For example, consider the ½ wave doublet which has theoretically a 73 ohm impedance at the center. The presence of trees and other objects in the vicinity may alter this value appreciably. Obviously the greatest and most efficient transfer of power would be obtained using a transmission line with the same surge impedance as the point of feed in the actual antenna under consideration with all of the factors of nearby objects accounted for. There is no question that some amateurs have locations which make it virtually impossible to string up an antenna in say more than two or three ways. One of these possibilities may be better than the other two and an actual rough determination of the impedance of the radiating system in each of the cases will help determine which of the systems to use as far as transfer of power is concerned.

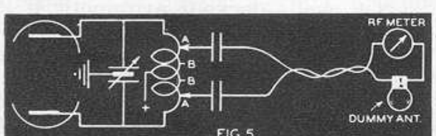
Other considerations, such as directional effects, may also alter the choice. *Considerable* mismatch between the transmission line and antenna can be tolerated without too serious an effect on the transfer of power or the overall efficiency between final amplifier input and antenna. How much mismatch can be tolerated in a given arrangement will depend upon a number of variable factors and without a means of *watching* what actually happens to the power while the matching procedure is being followed, extremely bad yet not apparent mal-adjustment of the system can be the result.

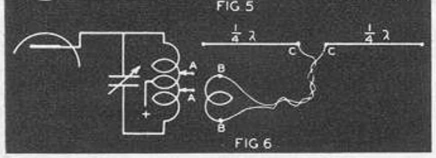
There is a tendency to overcouple, especially on 'phone transmitters, in order to bring up the plate loading to twice the audio output capability of the modulators at the required load impedance. An extremely poor antenna system might be incapable of loading the final to the correct figures yet overcoupling as far as the plate milliammeter reading is concerned will make it appear that the final is loading properly and the antenna is taking the load. Further, an r.f. ammeter in the feeders will mean little since strong standing waves in the feeder which would accompany overcoupling (overcoupling is in reality a mismatch) might also give the false impression that high feeder current represents the maximum transfer of energy to the radiator. Actually a current loop might shift to the exact location of the r.f. meter, in which case there would be a high reading.

Under the conditions just described it would be better to couple loosely and be satisfied with a lower plate input and readjust the audio input and matching transformer to the new plate impedance. It can be demonstrated that more r.f. power may be actually delivered to the antenna with the loose coupling and reduced plate input as follows:

A 73 ohm transmission line terminated with a 73 ohm dummy antenna is adjusted for maximum transfer of energy to the dummy with the match on the final tank at AA (in Figure 5) employing the same procedure as in the previous article on amplifier output measurements. Substituting a 600 ohm dummy antenna will cause the plate input to reduce and the power being transformed into heat in the 600 ohm dummy antenna will be less than that which was transferred to the 73 ohm dummy antenna. By clipping farther away from the points AA on the tank, points BB on the tank can be reached which will bring the plate loading up to the original figures. The power delivered to the 600 ohm dummy antenna will have dropped practically to nothing and most of the plate input can be charged up to a now inefficient amplifier and also high losses in the transmission line. This is no longer serving this purpose, but acting as an extremely poor radiator. As a matter of fact the transmission line does of itself not have its rated nominal surge impedance unless *terminated by an impedance* equal to its rated nominal surge impedance. By virtue of this fact, standing waves will exist when the line is terminated otherwise.

It is true that a point somewhere between AA and BB can be found where power delivered to the 600 ohm dummy antenna will be greater than delivered to it when the clips are at AA, the correct points for the 73 ohm match. The power will be nowhere equal to that delivered to the 73 ohm dummy antenna but it will be greater than that delivered at the point BB where the plate loading appeared to be correct even though at this intermediate point the plate input will be down considerably. Under these conditions the former 73 ohm, either twisted pair or concentric line, probably becomes part of the load since it will be serving as a poor radiator and any power absorbed by the dummy exists by virtue of the dummy being a part of the poor radiating system. It might be well to state at this point that in addition to the 600 ohm termination to the 73 ohm line (which in this case was a flexible concentric cable), the writer tried two 73 ohm units in series for 146 ohms as a termination and also two 73 ohm units in parallel for a 36.5 ohm termination. Both the latter cases represented a 2 to 1 mismatch, yet the power delivered to the load after readjustment of the coupling for maximum transfer of energy was better than 90% of the amount delivered to the correct 73 ohm termination. Strangely enough, the overall efficiency from plate input to





load remained practically the same and the slight reduction in power delivered was accompanied by a similar reduction in plate input. Here again any attempt to overcouple and bring up the plate current to the previous value noted for the 73 ohm termination was accompanied by a noticeable decrease in power. It cannot be stressed too strongly that overcoupling results in a reduction in power output and an increase in input. This obviously causes the overall efficiency to decrease rapidly since, as stated before, percent efficiency equals

$$\frac{\text{output}}{\text{input}} \times 100$$

With the above facts at hand, one should be able to make some practical measurements on a given installation. Realizing that antenna types are as numerous as tubes, a book of procedure as large as a service manual would be necessary to cover all cases. It is hoped that the following actual determinations on a typical amateur array will suffice to illustrate the "point of attack" which would be similar in all types in gaining better antenna and feeder efficiency.

(f) Determination of the efficiency and impedence within limits of the antenna system itself.

Figure (6) illustrates a typical means of coupling a final amplifier to a ½ wave doublet antenna. As previously described, the r.f. power delivered at AA, BB and CC can be determined. In a particular case measured by the writer, the plate input was 140 mils at 1080 volts or (1080 x .140) 151 watts. The power measured at AA was 91.5 watts as evidenced by a current 1.12 amperes in the 73 ohm dummy load.

$$I^2R = (1.12)\ (1.12)\ (73) = 91.5$$

The efficiency of the final was $\frac{91.5}{151} =$ 60.5%.

The power at BB was the same but at CC for the same plate input the current was 0.96 in the dummy indicating (0.96) (0.96) (73) = 67 watts being available for delivery to the antenna.

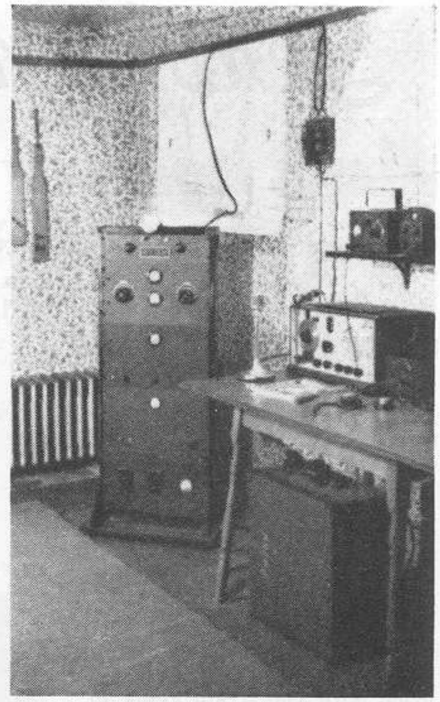
Note the *overall* efficiency was $\frac{67}{151} =$ 44.5% and the obvious loss in power in the transmission line was 91.5 − 67 = 24.5 watts.

Substitution of the antenna for the dummy made absolutely no visible change in plate input or adjustment of the transmitter indicating that all impedance matches were substantially correct.

A ½ wave antenna has a 73 ohm theoretical impedance at the center, and the presence of trees or other objects in the vicinity may lower this value appreciably. (To all intents and purposes the antenna impedance at the center is equal to the radiation resistance.)

An approximate calculation of the impedance of the antenna system just illustrated can be made, however, several assumptions which may not be entirely correct have to be made and the technique of the experimenter has to be taken into consideration.

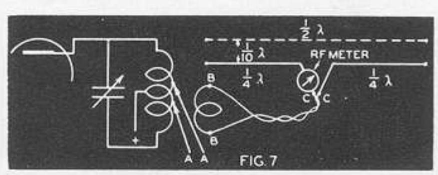
The following illustration (Fig. 7) will serve to indicate what is meant and no doubt will re-open an avenue of



W9TKD, where some tests were made.

experimentation which will eventually solve many of our antenna problems which of late have been of major interest to most amateurs.

As illustrated before, power measurements at AA, BB and CC can be made to determine exactly what amount of r.f. power can be delivered to the antenna at point CC regardless of the overall efficiency of the transmission line, etc. The transmission line can have considerable losses without effecting *this experiment* just as long as we know what they are and what power is delivered at CC. In the particular experiment made by the writer, substitution of the antenna for the 73 ohm dummy at CC made absolutely no changes in plate input, transmitter adjustment or coupling arrangement and it reasonably could be assumed that the antenna was taking all the power previously delivered to



the dummy. Insertion of the r.f. ammeter, as shown, revealed exactly the same r.f. current that flowed in the dummy indicating that the antenna radiation resistance and hence impedance was to all intents and purposes 73 ohms. (This is one of the assumptions which may be incorrect. Theoretically the ammeter would have to be in the exact center of the antenna at the current antinode or loop. It is felt that the ammeter was sufficiently close to this point to be within the errors in reading the ammeter.) The actual figure was 0.96 amperes indicating

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Transmitter Efficiency

(*Continued from page* 17)

67 watts being delivered to the antenna.

The results being so close to theory the writer then was curious to see the effect of something in the field of the antenna. Accordingly another half wave antenna was placed approximately 1/10 wave away. No attempt was made to tune it either as a reflector or director since we were only interested in the effect on the antenna impedance. The antenna ammeter reading immediately rose to 1.2 amperes. The plate input was down to 138 watts, no doubt due in part to the mismatch between the new system, the 73 ohm line, and the final. This reduced plate input would undoubtedly result in a slightly different efficiency for the final as well as a different amount of line loss, however, in view of previous experiments on 2 to 1 mismatches the overall efficiency (amplifier, coupling and line) was assumed to be the same as before and the delivered watts calculated to be $(138 \times .445 = 61.5)$ 61.5 watts.

Actually with a well regulated plate supply the plate efficiency for various plate currents could be measured and a curve made between input amperes and percent efficiency for more accurate determinations. The new impedance was therefore roughly,

$$Z = \frac{61.5}{(1.2)\ (1.2)} = 42.6 \text{ ohms.}$$

Due to the lack of time (and a low impedance line) the determination of a more correct figure of impedance was not made since curiosity in regard to the effects of nearby objects was satisfied. A reasonably accurate determination could have been made by substituting a 30 to 40 ohm line for the 73 ohm line using two 73 ohm dummy resistors in parallel for 36.5 ohms and repeating the measurements as in the case of the single half wave determination.

While it may be argued that the ordinary tungsten filament lamp has fairly low inductance at radio frequencies, and consequently might be used in the measurements just described, it is also true that the d.c. resistance reduces to less than one-half at "black out" which corresponds to zero light and about 12 volts across a standard 115 volt lamp. At this point also there is still about 2.5% of the nominal wattage of the lamp flowing through the lamp. Absolutely cold, with no current flowing, the d.c. resistance is about 1/12 of the hot resistance. Assuming that the inductance and skin effect are negligible, the d.c. resistance corresponds to the r.f. impedance.

To the amateur attempting to use an ordinary lamp as a dummy antenna (strictly speaking lamps can never be a *true* dummy antenna as will be shown later) this means that in addition to the lamp or bank of lamps he must have some means of knowing the brilliancy of the lamps compared to the normal brilliancy before he can make an intelligent assumption as to the actual wattage being consumed by the bank. In addition he must have pre-calibrated the lamp bank on d.c. using a wattmeter to obtain a reference curve of the relationship between the brilliancy and the watts input, and he must also have at hand the characteristics of the lamps. Figure 8, showing the resistance and, therefore, the impedance at the various percentages of brilliancy.

Incidentally, the curves in Figure 8 apply only to 110 volt tungsten lamps above 40 watts and are *average* characteristics. 110 volt lamps below 40 watts will not follow these curves nor will lamps at other voltages such as 32 volt, 6 volt, etc. Additional curves for these other sizes and voltages would be needed if low wattages and impedances are required.

In the latter case he would, of course, use an r.f. ammeter in series with the bank of lamps. To obtain the watts consumed he would then multiply the current obtained by itself and then multiply by the resistance of the lamp (obtained from the characteristic curves) at the determined brilliancy (I^2R = Watts).

While this method gives a fair idea of the output of a transmitter it still has the objection that the impedance match necessary for maximum transfer of the impedance resulting at full brilliancy may be a bad mismatch at the new impedance resulting at the lower brilliancy. Also during modulation in "phone" transmitters, a lamp bank dummy actually represents a changing impedance due to the fact that the watts input is increasing as much as 50% (100% modulation). The adjustments obtained on the transmitter, therefore, are of little value as the antenna represents entirely different load conditions. Keying checks for thumps, etc., on c.w. or code cannot be definitely made either since the filaments of the lamps will cool off between dots and dashes lowering the impedance. E.G. the initial thump at the start of the dot or dash will undoubtedly appear different to the lower impedance of the cooling lamp bank than it would to either the antenna or *true* dummy load.

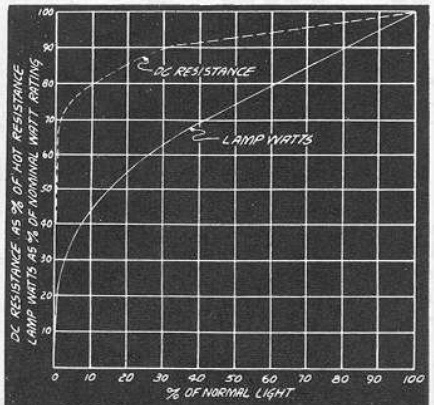

Fig 8 TUNGSTEN LAMP CHARACTERISTIC CURVES (110 VOLT - 40 WATTS AND ABOVE)

While it is admitted that a readjustment of the coupling or matching scheme can be made to obtain the maximum transfer for measurement of the overall efficiency of the amplifier or oscillator being measured, this latter objection on radio telephone and keying checks on c.w. cannot be overcome and further, the actual efficiency of the *coupling scheme itself which is to be used eventually to couple to the antenna or transmission line* cannot be determined. Even this latter objection would be overcome to some extent by the use of the proper size lamp or lamps for the expected wattage to give the desired impedance corresponding to the amateur's choice on his particular coupling or transmission line scheme.

Inspection of the hot resistance of the standard lamps available, Figure 9, will show immediately that unless the amateur is lucky, a mathematical genius, or has plenty of valuable operating time to spend in working out the necessary combination of series, parallel and series-parallel combinations to use which will result in the impedance of his choice and the wattage he hopes to get out of his transmitter, the use of a lamp bank dummy load will neither reveal any reliable or useful information, nor be more than a minor help in the transmitter adjustment.

Watts	Volts	Amps.	Hot Ohms	Approx. Cold Ohms
7	110	0.063	1750	146
15	110	0.136	810	675
25	110	0.227	485	40
40	110	0.364	303	25
60	110	0.545	202	17
75	110	0.682	161	13.5
100	110	0.910	121	10.0
150	110	1.360	110	9.2

For example, in making a laboratory test using the *true* dummy antenna on a 14 megacycle transmitter of the 125 watt input variety and a 72 ohm coupling system, it was found that by making a few minor adjustments in grid bias and driving power the efficiency was improved from approximately 33% to 75%!! No change was made in the coupling scheme during the

(*Continued on page* 48)

QUESTIONS and ANSWERS

J. S. C., Davenport, Ia.: What is the wobbly signal that I hear on the very short waves which sounds like very much distorted speech?

Probably transatlantic telephone. These transmissions are both put through a frequency inverter and are frequency modulated to insure privacy. There is not any easy way to decipher them.

U. P. W., Tallahassee, Fla.: How do submarines receive radio signals?

They are received on a regular antenna similar to that used on all ships. The one exception is that that used on a submarine is heavily insulated against contact with the water, while those used on ships are usually bare copper wire.

I. T. Y., Baxley, Ga.: I have devised a means of sending signals through the air for a short distance which uses only two coils placed in magnetic relation to each other. There is not any radio frequency current nor carrier. Do I need a license?

No.

K. I. V., Waycross, Ga.: Is the high voltage in my receiver of fatal power?

Ordinarily not, but it is advisable to stay away from it. Persons with bad hearts may be so startled with the surprise of the shock as to seriously injure themselves when inadvertently stepping away from the set.

T. P. L., Brownsville, Tex.: I have an ordinary broadcast receiver, but want to hear the foreign shortwave broadcasts. How can I do this?

You may build up, or purchase any one of several shortwave "converters" which may be placed ahead of your receiver to bring in ultra high frequency waves. They are not as satisfactory as a regular receiver designed for that use, however.

C. A. S., Munsey, Ind.: How can I find the grounded side of an a.c. lighting line.

Answer: There is an inexpensive special neon indicating device on the market which can be connected between a grounded object and each one of the a.c. terminals in turn to show the circuit grounded side of the line. An experimenter can easily rig up a device of this type using a small neon bulb or a 10 watt lamp, socket and connecting wires.

O. R., Chicago, Ill.: I hear a steady beat note in my receiver at the very top of the dial mixed in with the last broadcast station. What is this?

Answer: Your set is probably out of alignment, and you are picking up one of the various airline or marine beacons. Take your set to a serviceman and have it re-aligned.

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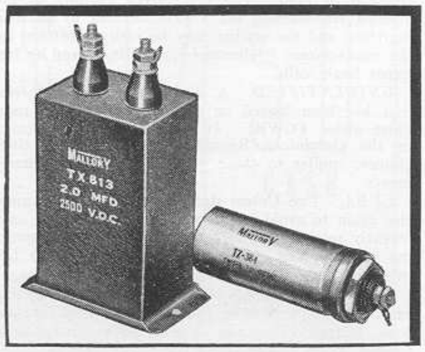

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Journal" will shortly be operating on 9.67 meg. (a frequency now occupied by W3XAL) . . . that JDY of Darien, Kwangtung, is heard on 9.92 meg. from 5 to 6 a.m. daily . . . that VUD3 of Delhi, India, is now on the air from 6:30 to 8:30 p.m., instead of from 5:30 to 7:30 p.m., and that news in English is released at 7:30 p.m., instead of at 7:10 p.m. (VUD3 is now using a directional antenna beamed on North America, and is being received with excellent volume during the first hour of its transmission) . . . that the country of Albania has just completed construction of a short-wave transmitter and is sending experimental broadcasts to America on 15.765 meg. . . . that PSH of Rio de Janeiro is now on 10.22 meg. daily from 3 to 4 p.m. . . . that a new Colombian station, using the call HJ4DAU is working on 8.65 meg. during the early evening hours . . . that the new Saturday transmissions from PHI, Huizen, Holland, on 11.73 meg. from 4:15 to 4:45 p.m. have weakened considerably in volume and are often inaudible . . . that the station on 6.11 meg. near 6:30 a.m. is not VPB of Ceylon (as reported by many), but is definitely located in Siam, and uses the same announcer employed by HS8PJ on 9.50 meg. every Thursday from 5 to 7 a.m. VPB is evidently still on the air, but has not been heard locally for some time.

Daytime Europeans

For the first time in many months, European stations are now being received on the Pacific Coast with good volume throughout the morning and early afternoon.

Peculiarly enough, the best English station at noon is GSB (9.51 meg.) and at 2 p.m. is GSC (9.58 meg.). GSI, and GSG are all fair at 10 a.m., but fade out by 11:30. GSD, however, often holds up all afternoon until the end of transmission 5.

In sharp contrast to the conditions a few months ago, the 25- and 31-meter bands are now best for daylight European reception, while 19- and 16-meter bands are useful only between 7 and 10 a.m. It is expected, however, that the lower wavebands will improve considerably during the next 60 days.

Treasure Island

Before long, the new short-wave station on Treasure Island, San Francisco Bay, will be broadcasting regular programs directed to the Far East. It is expected that transmissions will commence with the opening of the World's Fair in February.

The station will operate from 9 p.m. to 3 a.m., so as not to conflict with broadcasts from W2XAD and W2XAF, and will use the same frequencies of 15.33 and 9.53 meg. which are now in use by these Schenectady transmitters.

Visitors to Treasure Island during the Fair will be given the opportunity of inspecting both studios and transmitting equipment of this modern short-wave broadcaster.

—30—

10M Transmitter

(*Continued from page* 36)

voltage on the 210 and halves the bias. Plug the key into jack No. 1 and key in the cathode. Turn off the speech amplifier for c. w. work.

It will be noted that filament switches have been inserted for every stage, which will be found of advantage when testing out any one portion of the set.

Coil data is shown for 10 meter operation. This is for 40 meter crystal and 20 meter doubling. Double again in the buffer stage and amplify in the final. In winding any coils remember that a turn or two may have to be added or subtracted from those given due to circumstances.

—30—

Vibrator Tester

(*Continued from page* 20)

meter to fluctuate and the reading is low. By comparing different vibrators it is easy to set up standards of good, fair, and bad vibrators.

[*The fundamental vibrator tester circuit is reproduced by express permission of P. R. Mallory & Co., Inc., Indianapolis, Ind., U. S. A.*—Ed.]

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Transmitter Efficiency

(*Continued from page* 44)

tests after the initial adjustment for maximum transfer was made upon firing up the amplifier. Further, no additional adjustment was found necessary after the 75% efficiency figure was attained showing that because of the constant impedance characteristics of the dummy antenna the coupling system could be once adjusted and forgotten eliminating one of the questionable factors in the subsequent adjustment of the amplifier for improved efficiency.

Referring to Figure 8 let us see just what difficulties would be encountered when using lamps for the same experiment. Note that for 72 ohms it is impossible to choose a combination of lamps so that 40 to 50 watts of lamps would be used with 72 ohms or thereabouts, as the impedance or resistance. We, of course, would not be aware that the efficiency was going to be as poor as 33%. We would probably choose a 100 watt lamp and hope for an 80% efficiency which would result in normal brilliancy of the 100 watt lamp providing our impedance match is approximately correct. At the actual original efficiency of 33% the output was approximately ($125 \times .33 = 40$) forty watts. Characteristic curves (Figure 8) will show that forty watts into a 100 watt lamp results in a brilliancy of 8% of the normal and a resistance of 78% of the hot resistance or ($.78 \times 121 = 94.5$) 94.5 ohms. While this value is not sufficiently different from the 73 ohms desired, and while, as a matter of fact, tests show that impedance mismatches as great as this on the *true* dummy load can be tolerated, it will be noted that as the efficiency of the amplifier is increased by the various adjustments, the mismatch gets worse instead of better and would in some instances necessitate a readjustment of the coupling device for maximum transfer of energy.

If we had been contemplating the use of a 500 ohm system, we would probably have chosen two 60 watt lamps in series for the expected 100 watt output and resultant impedance of 384 ohms (from the characteristic curve for 83% of 120 watts or 100 watts each lamp has 95% of the hot resistance or 192 ohms each) which represents a mismatch in the other direction from the desired value. At the initial 40 watt output, which actually resulted, 304 ohms (from the characteristic curves for 33% watts each lamp has 75% of the hot resistance or 152 ohms each) would be the impedance of the bank under this reduced wattage. Four 25 watt lamps in series-parallel would have been a better choice but there you have it; with a box full of various sized lamps, probably including those from the xyl's favorite floor lamp, a photo electric system, a wattmeter, a slide rule, an excellent education in algebra, a good foundation in Ohm's Law, two sets of curves, a sure-fire coupling system for variable impedances, along with plenty of time and mental gymnastics, and we can conclude that lamps make fair dummy loads. For accurate, reliable results with a minimum of time and manipulation it would seem that a constant impedance dummy load and an r.f. ammeter constitute the answer to the amateur's prayers for an r.f. wattage indicator.

—30—

Phonograph Records Make Good Insulators

Convenient, high insulating mounting panels for 5 meter rigs and other experimental layouts can be easily made from old phonograph records. Two records glued together make a very serviceable and rigid panel. Records faced on one side only can be glued to give a smooth front panel. These improvised panels should be at a temperature of 70 degrees or more for easier drilling and workability.