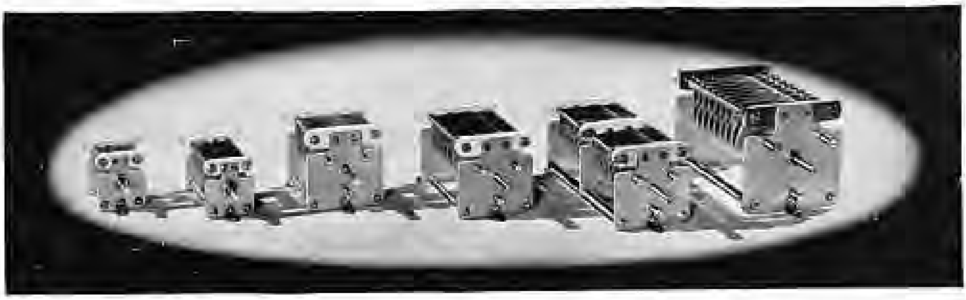
Vol. VII
JAN.-FEB.
1946

XTAL

No 1
Toronto
Ont.



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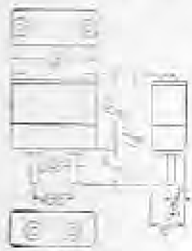

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XTAL

JAN.-FEB. 1946
VOL. VII NO. 1

OFFICIAL PUBLICATION
of
CANADIAN AMATEUR RADIO
Published by
THE CANADIAN AMATEUR RADIO OPERATORS' ASSOCIATION
46 DUNVEGAN ROAD, TORONTO 12, ONTARIO
TEL. MIdway 8235

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US

For this first 1946 issue we think you would be interested in knowing a little more about your Association.

Prior to our first post-war issue, June 1945, a monthly Friday night bull session of service, ex-service, and war industry hams decided it was about time the Association began to function again. As you know, a real fine start was made before September 1939, and like everything else, just as things were coming along . . . bang!! So, after much debate, and many nightmarish meetings, some twenty of the gang offered to do what they could to re-activate the Association, and to get XTAL out again. Many of these were not pre-war members, and the representation was from all of Canada.

So, if and when the work could be done, the stuff collected together, the ads procured, a new and busy printer lined up, etc., XTAL was mailed out to you. In order that it be mailed the boys typed all the address stickers, and on mailing night each time, stuck the labels and stamps on and saw that they got to the P.O. That's why some of the XTALS never reached you . . . the addresses were incorrectly typed. But four issues out of the originally planned five were gotten out. We doubt if any other group interested in any hobby could, or would, give freely so much time.

Assistant secretaries were appointed to try to keep up with sending your membership cards, and answering your swellegant letters. By Christmas it was obvious that something had to be done to give you better service and a finer XTAL. A small canvass was made of our advertisers. Would they feel that an increase in advertising rates was justified? Previous rates being based to cover costs of printing, and postage alone. For an increase in circulation, for the fine example we all set during the war, and for their interest in the amateur market in the future, they said "yes". An advertising rate was thus established that would enable your Association to set up a small office and staff. Don't forget, pre-war, our membership was not large, but with it standing at nearly 1,500 now, and increasing very rapidly the old executive deemed justified in taking steps to keep abreast of the times.

Unfortunately, with office space unavailable in a permanent way, we do not have permanent quarters. But they will be established soon, we are sure. Plans also call for a HQ station, to work on all bands, so that your questions may be answered by means of our mutual hobby. 1946 will see many interesting things for us VEs.

May we mention that advertisers are interested in "paid circulation", whether it is actually paid, or embodied in membership. In order to build XTAL to three or four times its present size, our membership must be enlarged. We have set no goal for membership totals. But, we do expect 99% of the active VEs will become members this year. Every day we run into old-timers: "Gee, I've been meaning to send my dues in," or get letters: "I just didn't get around to shooting in my fees, so am enclosing $2.00, just to make sure I don't forget this time". The annual dues are only $1.00. We know you're with us, so drop a line and your dollar with it. Every one from you . . . and you . . . and you . . . soon makes another 1,000 members.

We hope you will excuse this plea, editorially, but we just realized that the past four issues of XTAL didn't even mention annual dues, except on the application form. Just another thing we overlooked doing things in spare time.

—□—

THEY'RE COMING

Ottawa, Ont., Jan. 16th, 1946. Effective 3 p.m. today, two more frequency bands have been released for amateur use. They are 420-430 mc., and 1215-1295 mc., with peak permissible power for each band, 50 watts. The same bands are released to U.S. amateurs by the F.C.C.

—□—

NETS

Until some of the other bands become available the brasspounders are improvising, and the Lakeshore Net is under way. When the band is otherwise dead traffic is running from Oshawa to Niagara Falls, N.Y., by way of Whitby, Toronto, Hamilton, St. Catharines. This small net wishes some one or two in each town east of Whitby and west of Hamilton would have a listen on 28 mc. Look for 3BAD, 3QU, 3ZE, 3BEI, 3GT, 3AEM, 3CD, 3AKW, 3AUQ, 3AKW, 3QH, W8FMF, and many others from 7 to 10 PM EST.

Antenna Coupling Circuit Design - Part II

By J. C. R. PUNCHARD, VE2KK*

Pi Network Design

The familiar Pi Network has been widely used for many years in amateur and commercial transmitters because of its flexibility, ease of adjustment and smooth control. It provides an excellent method of matching the P.A. stage to the antenna circuit, and is particularly suitable for high power equipment because of its harmonic attenuation characteristics. The Pi circuit is adaptable to both balanced and unbalanced arrangements and it can be used directly between the plate of an amplifier tube and the antenna or transmission line, or it can follow a tapped or inductively coupled tank circuit. Because of its wide usage, it is important to hams to understand how it operates and how to design it for maximum performance. The purpose of this article is to present some simple theoretical considerations, to discuss design limitations and to develop a rapid method of working out practical component values.

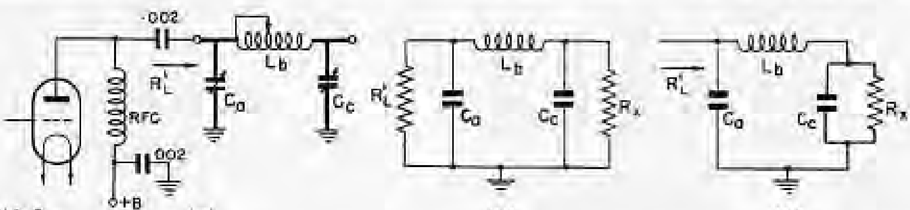


FIG. 6.— (a) (b) (c)

The simplest unbalanced Pi circuit is shown in Fig. 6 (a) arranged to work between the amplifier plate and a resistive load, which is usually a coaxial transmission line. Fig. 6 (b) shows the equivalent circuit from which it is apparent that this arrangement is simply an impedance transformer used to step up the characteristic impedance of the coaxial line, or other load circuit Rx to the proper value Rl' required to load the tube. This circuit can be drawn as in Fig. 1 (c) and at once we recognize the familiar L network, described in Part I of this article,* with an additional condenser Cc connected across the load Rx. Now a condenser in parallel with a resistance has the effect of reducing the effective value of this resistance. If the condenser is variable, we have a convenient control which can be used to control the amount of resistance introduced into the tank circuit, in other words, a load control. Variation of the capacity at Cc will of course affect the tuning of the circuit and readjustment of Ca will be required to establish resonance.

The parallel condenser-resistance combination Fig. 7 (a) can be represented by its equivalent series resistance and capacity Fig. 7 (b) having the following values:

$$R_x' = \frac{R_x X_c^2}{R_x^2 + X_c^2} \qquad (6)$$

$$X_c' = \frac{R_x^2 X_c}{R_x^2 + X_c^2} \qquad (7)$$

Substituting these values in the original tank circuit produces Fig. 7 (c) where resistances Rx' and Rc combine to form Rt and reactances of Lb and Cc' add algebraically. For given values of Rl' and Rx' the values of Ca and L can be obtained directly from Fig. 4 (Part 1). To make the circuit tune, the inductance of coil Lb must be increased until its reactance is equal to the value of reactance found from Fig. 4 plus reactance of Cc at the operating frequency. This solution is carried out by assuming some value of Cc. It is only presented here because it explains in simple terms how matching is obtained.

Many people have tuned in pi networks for years without realizing just what they were doing. From the foregoing discussion it is easy to see why condenser Ca is called the "tuning control" and Cc the "load control". The tuning condenser is used to obtain resonance in the network for any particular setting of the loading condenser. The inductance of L can be any reasonable value below a cer-

*Northern Electric Co., Montreal.

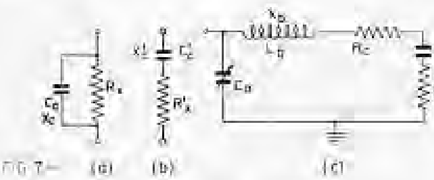


FIG 7— (a) (b) (c)

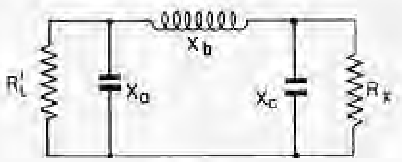


FIG. 8

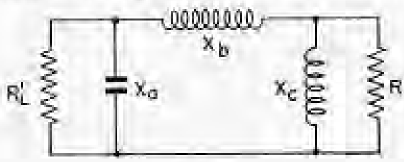


FIG 9

tain maximum. This will result in an unsymmetrical network, where the reactances of Ca, Cc and Lb are all different. It can be shown that a symmetrical pi network, where Xa=Xb=Xc results in the highest efficiency of power transfer. Note:—

$$X_a = \text{reactance of } C_a = \frac{1}{2\pi f C_a}$$

$$X_c = \text{reactance of } C_c = \frac{1}{2\pi f C_c}$$

$$X_b = \text{reactance of } L_b = 2\pi f L_b$$

where f is the operating frequency.

When tuning an undesigned pi network, we normally set inductance Lb at some arbitrary value which we hope is below the maximum value, because otherwise matching cannot be obtained. Cc is then set at about mid-scale value and Ca is tuned for minimum resonance dip in amplifier plate current. (This assumes that fixed bias is applied to grid of amplifier so that a dip actually is obtained when the tank circuit is resonated). If resonance is not obtained, the value of Lb is changed one way or the other until the circuit tunes. Then we look at the value of the loaded amplifier plate current. If it is higher than the manufacturer's rating for given operating conditions, the load impedance presented by the pi circuit is evidently too low. Referring to Part 1, this means that too much resistance is being introduced into the tank circuit. Therefore, Cc must be changed in value to reduce the effective value of the primary load impedance Rx as shown in Fig. 6 (c). From equation 6 we see that the reactance Xc of condenser Cc must be made smaller, which means more capacity. We therefore increase capacity of Cc, retune Ca for resonance dip and recheck amplifier plate current. If it is now too low, plate load impedance is too high, the resistance coupled into the circuit is too small and capacity of Cc must be decreased. This process is repeated until the correct loaded plate current is obtained at resoance dip.

The values of Xa, Xb and Xc can be obtained directly by calculation from the following formulae.

$$X_a = \frac{-R_l' X_b}{R_l' \pm \sqrt{R_x R_l' - X_b^2}} \qquad (8)$$

$$X_c = \frac{-R_x X_b}{R_x \pm \sqrt{R_x R_l' - X_b^2}} \qquad (9)$$

The maximum value that Xb can have is $\sqrt{Rx\ Rl'}$. In other words if Rx = 60 ohms and Rl = 1500 ohms Xb max. = $\sqrt{60 \times 1500}$ = 300 ohms. The inductance required will be Lb = $\frac{300 \times 10^6}{2\pi f}$ microhenries where f is in cycles. If we use this maximum value of Lb, then Xb^2 = RxRl' and the expression under the root sign in equations 8 and 9 is equal to zero. This makes Xa = —Xb and Xc = —Xb which means the three reactances are equal and the network is symmetrical and also the most efficient in transferring power to the antenna.

Many practical designs can be evolved by using values of Xb less than the maximum. Normally Xb is made equal to 0.8 $\sqrt{RxRl'}$ or 0.9 $\sqrt{RxRl'}$. This results in larger values of capacity at Cc than at Ca and is the familiar so-called Collin's network. Equations 8 and 9 are then solved using the positive sign in front of the radical. This produces the standard pi network per Fig. 6 (a). If the negative sign is used, Xc becomes positive, i.e. inductive and the network of Fig. 9 results. This is still a pi circuit and is perfectly practical. In some cases it may be more economical to use a coil at Xc than a condenser.

Example—Suppose a 65 ohm coaxial transmission line (properly terminated in 65 ohms at the antenna end) is to be matched to a tube requiring a dynamic load impedance of 1800 ohms. The operating frequency is 14 M.C. What are the circuit values required?

$$X_b = 0.8\sqrt{65 \times 1800} = 274 \text{ ohms}$$

$$\text{also } \sqrt{R_x R_l' - X_b^2} = \sqrt{65 \times 1800 - (274)^2} = 205$$

$$X_a = \frac{-1800 \times 274}{1800 + 205} = -246 \text{ ohms}$$

$$X_c = \frac{-65 \times 274}{65 + 205} = -64.7 \text{ ohms}$$

Circuit values at 14 M.C. are then:—

$$L_b = \frac{274 \times 10^6}{2 \times 3.1416 \times 14 \times 10^6} = 3.1 \text{ microhenries}$$

$$C_a = \frac{10^{12}}{2 \times 3.1416 \times 14 \times 10^6 \times 246} = 46.2 \text{ mmfds.}$$

$$C_c = \frac{10^{12}}{2 \times 3.1416 \times 14 \times 10^6 \times 64.7} = 176 \text{ mmfds.}$$

The use of an A.R.R.L. Lightning Calculator is recommended for rapid determination of the design of R.F. inductances to provide inductance values at least approximating the calculated values. This Calculator is sufficiently accurate that further measurements on coils are not required.

It will be realized from the above calculations that many values of Xa, Xb and Xc will satisfy conditions for matching at one particular frequency. For simplicity however the symmetrical network is the only one which is considered henceforth. For convenience of the designer the values of Xa, Xb and Xc have been plotted in Fig. 10 for various values of Rl and Rx. Do not be discouraged by the number of lines on this diagram because there is nothing difficult about it and its use can be most beneficial. The heavy solid lines running up from left to right show the relation between values of Rl' along the abscissa scale and the reactance of Xa, Xb, Xc for various values of Rx. To provide immediate values of L and C in microhenries and mmfds at various frequencies, reactance-frequency curves have been superimposed on this diagram. The dotted lines running up from left to right are used to give inductance on top scale at frequencies marked when the inductive reactance is known. The dashed lines running down from left to right give capacity on top scale at frequencies marked when the capacitive reactance is known.

All we have to know to use these curves are the resistance of the load Rx, which is usually a 50, 65 or 72 ohm coaxial transmission line or a 600 ohm single wire untuned feeder, and the load resistance Rl' we wish to see looking into the network. If the pi circuit is used for coupling the plate of the amplifier directly, as shown in Fig. 6 (a), Rl' will be the dynamic load impedance required by the tube. The method of estimating this value was given in Part 1 of this article. Once these values are known proceed as follows. Locate value of Rl on the abscissa scale at bottom of Fig. 10. Follow this up the ordinate until it intersects the required load line Rx. If required read the reactance in ohms of Xa=Xb=Xc on right hand ordinate scale. It is not necessary to determine this reactance because from the intersection we can move along horizontally until we intersect the frequency curve required, proceeding straight up the abscissa to the value of microhenries or mmfds on top scale. It is of course necessary to find the value of Ca = Cc in mmfds from the dashed frequency curves, and Lb in microhenries on the dotted frequency curves. These are the values required to give perfect matching between the original resistances. In practice Lb would be a variable coil (preferably a continuously variable roller coil) slightly larger than the value found for Lb at the lowest frequency, and Ca and Cc would be variable condensers having a maximum capacity about 1.5 or 2 times the required capacity.

As an example, suppose we wish to couple a 600 ohm single wire untuned transmission line at 28 M.C. to an amplifier requiring a dynamic load impedance of 2,000 ohms. Then Rl' = 2000 and Rx = 600. Following the 2000 ohm abscissa up until it intersects the 600 ohm Rx curve we read 1090 ohms on right hand scale. Then Xa=Xb=Xc= 1090 ohms. Again following the 1090 ohm line across to intersect the 28 M.C. dashed curve we find Ca=Cc= 5.2 mmfds. Note that this is the total capacity required from plate to ground including stray capacity! The minimum capacity of our variable condenser alone will probably be 20 mmfds. However, we find Lb by following 1090 ohm line across until it intersects the 28 M.C. dotted curve and read Lb = 6.1 microhenries on top scale. We can tell immediately from these figures that we

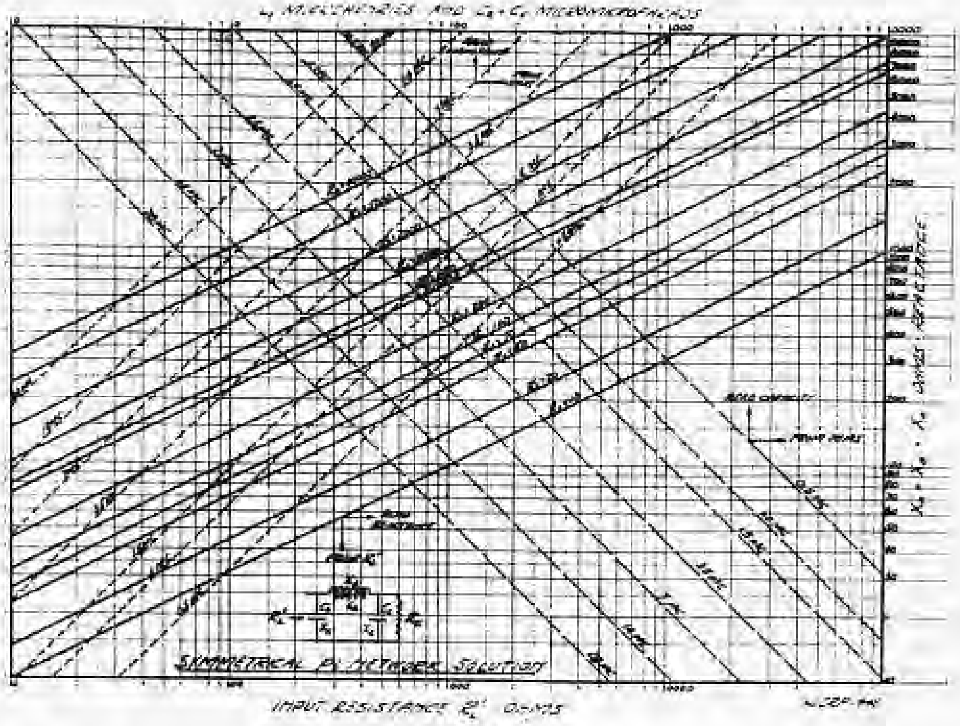


FIG. 10

will be in trouble trying to obtain a match at this frequency, because the stray capacity in the circuit will always be greater than the 5.2 mmfds matching capacity required. This particular example was chosen to emphasize the necessity of reducing stray capacity to a minimum at frequencies above 14 M.C., because the capacity values required for matching are of the same order as the strays.

In the above example, we have the choice of abandoning this circuit entirely on this band, changing to a 50 ohm coaxial feed to the antenna, or reducing the load impedance Rl required. From Fig. 10 it is apparent that even if we go to Rx = 50 ohms, Ca and Cc will only be 17 mmfds. By paralleling two tubes of similar type in the final amplifier, we could reduce Rl' to 1000 ohms in the above case. From Fig. 10 we see that for Rl' = 1000 ohms and Rx = 50 ohms, Ca = Cc = 24.5 mmfds and Xb = 1.3 microhenries. In this case, the strays could be allowed to replace Ca and Cc and we could probably tune the circuit without using additional condensers, and the pi would simply be a variable 2" dia. coil having 6 turns spaced 3 turns per inch. This is not a practical arrangement and our advice is to not use a directly coupled pi circuit above 14 M.C. particularly if we wish to use pentode amplifier tubes, with their attendant high Rl.

There is one trick used in commercial equipment which is worth describing. Suppose in the above example we find we require 5.2 mmfds for matching. The stray capacity from plate to ground is estimated or measured to be 30 mmfd. If other coils are connected in parallel with Ca and Cc and their inductance is adjusted to anti-resonate a capacity of about 50 mmfds at the operating frequency in the 28 M.C. band, then Ca and Cc can be made 50-30 + 5.2 = 25.2 mmfds. In other words, the shunt coil absorbs the 30 mmfd stray capacity and 20 mmfds of the condenser and allows another 5.2 mmfds to be added to provide the matching capacity required. The circuit will appear as shown in Fig. 11.

The anti-resonant circuit consisting of the 0.65 micohenry coil, 30 mmfd stray and 20 mmfd added capacity will present a very high impedance to the circuit if

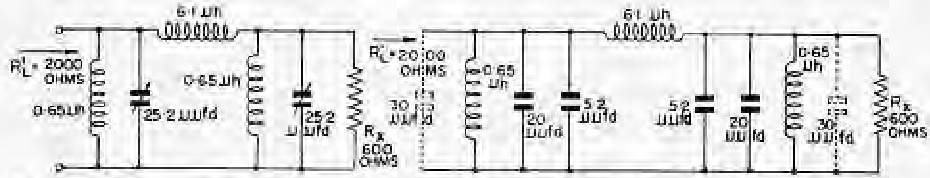


FIG. 11.— (a) (b)

the Q of the coil is reasonably good. The losses will therefore be low and the effect of shunting the circuit with a coil will be negligible. By this method it is possible to obtain matching capacities as low as 1 mmfd.

The above discussion is included to show how a circuit of this nature can be designed exactly on paper if the frequency is below 15 M.C. Above this frequency cut and try methods are usually more effective, provided they are guided by an essential understanding of the relative component values actually required to provide matching. From Fig. 10 it can be seen that to obtain reasonable values of capacity at 28 M.C., the network should be worked between the lowest possible impedances. To match a 50 ohm line at 28 M.C., Rl' should be about 200 ohms in order to make Ca = Cc = 55 mmfds, which is a reasonable value. This can be accomplished by tapping the circuit across a small section of a standard tank circuit as shown in Fig. 12 (a), or connecting it directly in series with the tank circuit per Fig. 12 (b). We then have smooth control on the amount of resistance to be coupled into the tank circuit. The advantage of the pi circuit over the L network is its flexibility mentioned above and his ability as a low pass filter to attenuate harmonic voltages.

microhenries from Fig. 10. The two variable condensers could have a maximum capacity of 100 mmfds and the coil could have 8 turns spaced over 1 inch and a 2" dia. The value of L and C can now be found from Fig. 4, Part 1, using 200 ohms for Rt, the introduced resistance, between c and d, and estimating Rl, the dynamic load resistance required by the tube between e and f. (Note—When the tank circuit is designed for an introduced or coupled resistance of 200 ohms or thereabouts, it is not necessary to take the R.F. resistance of the coil Rc into account and Rt may equal Rx because Rc is usually only a few ohms for high Q coils). The tuning procedure for circuit Fig. 12 (a) is as follows:

1. With the pi circuit disconnected from the tank and with reduced amplifier plate voltage, resonate main tank condenser C for minimum dip on plate current meter. If L and C have been found from Fig. 4 no trouble should be had obtaining resonance. Incidentally, the value of minimum dip current should be very low if the coil has a reasonably high Q, because the impedance across the unloaded tank should be very high.

2. Set Ca = Cc at approximately midscale value which should give 50 to 75 mmfds including strays.

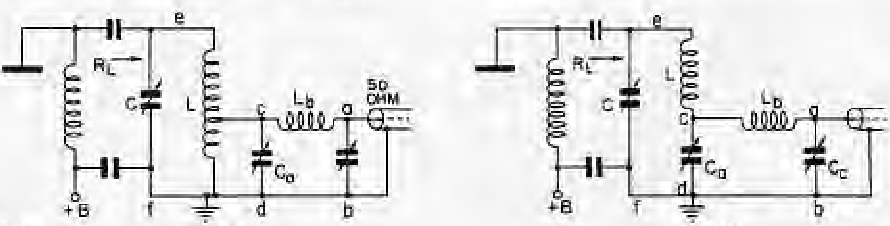


FIG 12.— (a) (b)

At 28 M.C., Lb may be obtained from Fig. 10 and designed by means of the Lightning Calculator. It need not be adjustable, unless it is larger than actually required.

For Rx = 50 ohms and Rl' = 200 ohms Ca = Cc = 55 mmfds and Lb = 0.6

3. Turn off power and connect tap on main tank about 2 turns from ground end. Since the impedance from c to d is purely resistive when pi network is properly adjusted, the tap point on the coil can be roughly estimated by the formula:

$$N_{c\text{-}d} = N_{e\text{-}f} \sqrt{\frac{Rl'}{Rl}}$$

where Nc-d = number of turns c to d.
Ne-f = number of turns on coil L.
Rl' = impedance c to d (200 ohms in above example).
Rl = dynamic load impedance of tube.

This is simply based on the fact that in a transformer the impedance ratio varies directly as the square of the turns ratio.

4. Turn on power and without touching setting of tank condenser, adjust Ca for minimum dip plate current. If the minimum value is less than the normal rated load current for the tube, increase the coupled resistance by increasing the capacity at Cc and retune Ca for minimum. This lowers the impedance across a to b, raises the impedance across c-d, thus coupling in more resistance to the tank circuit and lowering the impedance e to f. The coupling can of course be increased by moving the tap farther up the tank coil, but it is preferable to keep it as close to ground end as possible to reduce the effective reactance which may be introduced into the tank circuit. If pure resistance only is coupled into the tank, the setting of the tank condenser C will not change appreciably during the load adjustment procedure.

5. If minimum dip current is too high, reduce loading by decreasing the capacity Cc and retune Ca for minimum.

6. Check tuning of condenser C for minimum dip. Its setting should be very close to the original value. If its setting has changed appreciably, the pi network is coupling in reactance and either its adjustment, or its component values are in error.

mized by decreasing the value of Rl' to 50 ohms instead of 200 ohms. Fig. 10 shows that Ca = Cc = 112 mmfds and Lb = 0.3 microhenries approximately (not on curve) at 28 M.C.

If the strays are minimized, this circuit will also match the 600 ohm single wire feeder with which we struggled previously at 28 M.C. We can choose Rl' = 20 ohms arbitrarily, then if Rx = 600, Ca = Cc = 50 mmfds and Lb' = 0.65 microhenries approximately. From Fig. 4 we find L and C as before, by estimating Rt as 20 + 2 = 22 ohms and the tube load Rl.

The pi circuit can also be coupled to the tank inductively per Fig. 13.

This circuit is harder to handle because high values of mutual inductance are required between tank and coupling coils for normal pi circuit component values. Unless the input capacity Ca is made very large, the input impedance of the pi will normally be at least several hundred ohms, which requires high values of mutual. Inductive coupling will be discussed in Part III of this article.

The pi can be adapted for balanced push-pull operation per Fig. 14 (a) and (b). For given input and load impedances, the component values are obtained as before from Fig. 10. Lb is then halved and half put in each side of the circuit. Fig. 14 (b) is the preferable circuit because the grounded split stator condensers tend to balance charging voltages which may build up on the transmission line. In this case, the capacity of each section is made twice the value obtained from Fig. 10, so that the effective capacity across the pi is same as the value used for an unbalanced pi circuit. The complete solution of the push-pull

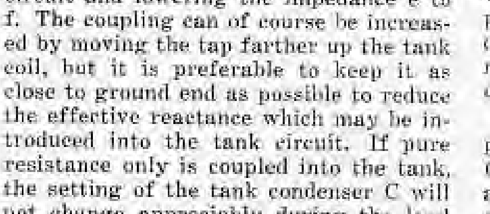


FIG.-13

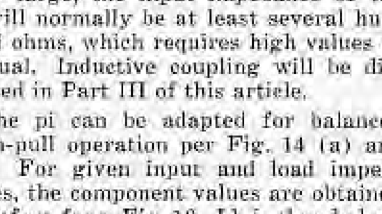


FIG. 15

The same tuning procedure is followed for circuit of Fig. 12 (b) except that the condenser Ca is short circuited during step 1 above.

The problem of strays can be mini-

circuit is too involved for discussion here and will be reserved for a future article.

Condenser Voltages

It is of considerable importance to know what voltages to expect across the pi circuit condensers. These voltages depend on the impedance at the particular point and the power being transmitted through the network. By Ohm's Law, and neglecting losses,

$$E_1 = \sqrt{R_l' W_0} \qquad (12)$$
$$E_2 = \sqrt{R_x W_0} \qquad (13)$$
$$E_3 = \sqrt{R_t W_0} \qquad (14)$$

where E_1 = RMS volts across Ca at carrie.
E_2 = RMS volts across Cc at carrier.
W_0 = RMS Carrier Power output in watts.
E_3 = RMS volts across C at carrier.

From the foregoing information Rl' and Rx are known. The approximate power output is known from the tube ratings and operating voltages. E_1 and E_2 can then be calculated from equations 12 and 13. The peak value of these voltages will be 1.414 times the RMS values. For C.W. the variable condenser used should have a peak rating not less than twice the peak value computed above. For phone, the RMS voltage at 100% modulation will be twice the RMS carrier value. The peak voltage will therefore be 2 x 1.414 x RMS voltage. Using a safety factor of 2, the minimum voltage rating of the condensers should be 4 x 1.414 x RMS carrier voltage.

Obviously, for any given power, the cost of the condensers can be reduced by designing the circuit for low impedance operation where possible. Use of 50 or 70 ohm coaxial transmission lines instead of 600 ohm feeders will help considerably in reducing the voltage rating required. By using the circuit of Fig. 12 (b) the input impedance of the pi can be designed to a low value, which requires larger capacity at Ca. The cost of this increased capacity must be balanced against the cost of higher voltage rating.

Condenser Currents

Since hams usually use variable condensers in pi circuits, the current rating is of secondary importance. However, at the lower frequencies it is often necessary to use fixed mica padding condensers. In high power equipment, the current rating is of prime importance. Currents are calculated as follows:

RMS Carrier Current through

$$Ca = Ia = \frac{E_1}{Xa} \text{ amps.}$$

RMS Carrier Current through

$$Cc = Ic = \frac{E_2}{Xc} \text{ amps.}$$

RMS Carrier Current through

$$C = I = \frac{E_3}{X} \text{ amps.}$$

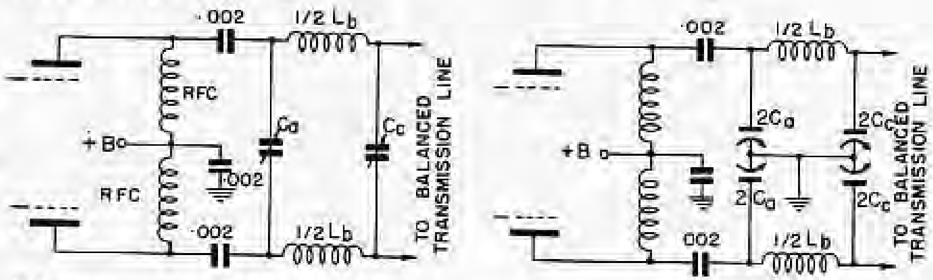


FIG. 14.— (a) (b)

Summarizing, we can write the following table for minimum voltage rating of condensers in pi circuits, using safety factor 2:1.

Condenser	CW	Phone
C	$V_r = 2.82 \sqrt{R_t W_0}$	$V_r = 5.56 \sqrt{R_t W_0}$
Ca	$V_r = 2.82 \sqrt{R_l' W_0}$	$V_r = 5.56 \sqrt{R_l' W_0}$
Cc	$V_r = 2.82 \sqrt{R_x W_0}$	$V_r = 5.56 \sqrt{R_x W_0}$

It is easy to see from the above formulae why large condensers are required for phone operation, especially when the power and the impedances are both high.

Peak current values are as follows:

Condenser	CW	Phone 100% Mod.
C_a	$I_a = \dfrac{1.414\ E_1}{X_a}$	$I_a' = \dfrac{2.828\ E_1}{X_a}$
C_c	$I_c = \dfrac{1.414\ E_2}{X_c}$	$I_c' = \dfrac{2.828\ E_2}{X_c}$
C	$I = \dfrac{1.414\ E_3}{X}$	$I' = \dfrac{2.828\ E_3}{X}$

Safety factors of 2:1 should be used on the manufacturer's ratings, which vary with frequency since condensers are rated on a K.V.A. basis.

(Continued on page 38)

A Multi- Band Ham Antenna

By R. L. ADAMS, VE3AMR*

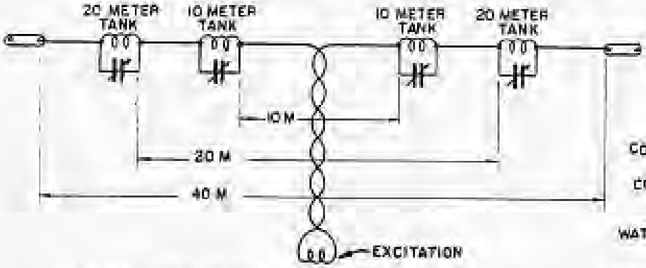


FIG 1 — MULTI - BAND ANTENNA SYSTEM

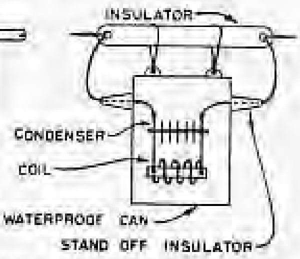


FIG 2 - DETAILS OF TANK

There have been several alternative methods of tuning an antenna for operation on several bands. The method described by the author, while not actually constructed, would appear from theoretical considerations, to have a high efficiency and proved a simple means of operating a single antenna on three or more ham bands.

A basic antenna is a center-fed balanced doublet antenna. The half-wave dipole in the center section in Fig. 1, is cut to resonate at 10 meters. Connected to the ends of this section are parallel tuned circuits resonant at 10 meters. A section of antenna conductor is added to each of the 10 meter tuned circuits, such that the additional lengths form a dipole resonant at 20 meters. Connected to the ends of this dipole are tuned circuits resonant at 20 meters. Again, sections of antenna are added to the 20 meter resonant circuits, such that the total length of the dipole formed is resonant at 40 meters. As many pairs of tuned circuits may be added to the antenna as there are frequencies to be radiated.

To 10 meter excitation the tuned circuits at the ends of the 10 meter dipole appear as high impedances, so that sections of antenna beyond the resonant tuned circuits do not affect the operation of the 10 meter dipole. Also, changes in the resonant impedance of the tuned circuit due to atmospheric conditions do not materially affect the 10 meter dipole, since the impedance of the tank circuit is many times that of the end of the antenna. When 20 meter excitation is fed to this antenna the 10 meter tank circuits appear as inducive reactances in the 20 meter dipole, and the physical length of the 20 meter dipole may be shortened slightly. The loss in radiation due to the reduction in antenna length is slight. The wire lengths between the several tuned circuits in the antenna are adjusted for maximum current, or power in the antenna by the usual means of cutting the antenna.

The tuned circuits may be tuned to resonance to within a few percent, by means of a Q meter, or by an absorbtion method. These tuned circuits in the antenna, have a high R.F. voltage across them, and condensers having the same spacing as the one used in the final amplifier will be necessary. The tuned circuits must be protected against atmospheric conditions, it is suggested that the circuits be contained in waterproof containers and supported in the manner shown in Fig. 2. Vacuum type condensers may be used to advantage in this circuit arrangement, the tuning adjustment being made by adjusting the inductance of the coil.

A particular application of this antenna would be its use in a directional array; to transmit, for example, in the 5, 10 and 20 meter bands. The director and reflector elements would have tuned circuits inserted in them in a similar manner to the driven section, making a compact three or four band directive array. The system described eliminates the difficulty of a complicated antenna tuning system which must be switched when the transmitter frequency is changed.

*Jr. Research Engineer, National Research Council, Ottawa.

QSLs? See announcement elsewhere.

Report From The Nation

HAPPY NEW YEAR GANG! Just give us back 80, 40, and 20, and we'll call it Utopian. Things are still looking up . . . the RI just called to say that we are now authorized to use the 420-430 and 1215-1295 mc. bands. Now that we've almost reached the penthouse we'll settle for an express car to the basement . . . if you know what we mean (and we think you do)! By the way . . . DON'T FORGET . . . that 'CQ XTAL' contest . . on page 28 . Try and think to mention it to the gang in case they haven't heard becuz . . . it's WORLD-WIDE . . . and speaking of the gang, SALUD, to OM John Willis 1OQ who having recently returned from a sojourn of over 4 years Overseas at which time he toured Sicily, Italy, France, Belgium, and Germany. Musta been a swell trip becuz he sez he didn't get a scratch. He ended up hobnobbing with H.M. the King in person, who slipped him the B.E.M. FB John our hats are off and our elbows bent . . . 3LZ is chief op at CP Air stn. in Sioux Lookout dictating letters to his wife . . . the brute . . . wants to get on and asked brother 3XQ in Belleville and sends 73 to the Ottawa gang . . . howdy Joe. Usual swell note from Dave Scholes in Victoria to say that there were 40 guys at their last meeting. The visiting hams included 3GU, ex-3AUU now 5XX, 4KP, ex-5OI, 5PB, and 4BH. VSWC is setting great example . . . real up-and-at 'em radio club . . . have their own clubhouse with plans afoot to renovate interior, transmitter, furniture and plumbing (?) . . . they're doing it with VICTORY BONDS bought by the club assets during the war . . . we REPEAT, a SPLENDID example . . . Yessir, 1LB, just back from O/S was O.C. No. 1 Can. Div. Support Sigs through Holland and Germany and is now at Camp Sussex, N.S. . . . FB card from 3AGC in Chatham . . . a lovely thing to see again . . . is a QSL card. 3MQ been digging into captured enemy wireless equipment to see what makes it tick . . . from Peterborough comes a nice note letting us in on a real Ripley . . . it's from Streyan Leith Sr., who tells us that his son Streyan Jr. got his ham ticket when he was only 13! . . . and at 18 he was asked by the Gov't to help with communications on the Alaska Highway! . . . 3AXT is on 56 meggies . . . 3NI in St. Thomas reports for the local gang and sez that 3AUI is all set to go after 4 years O/S . . . that 3HQ is back from opping in the RCNVR . . . that 3ATJ is QSYing to Toronto, and 3ATZ, APL, AMJ, are pushing dust from rigs in prep for big doings . . . 3BAA was in Navy for 6 and served aboard the 'Prince Henry,' 'Quatsino' and the 'Kohanee' . . . 3LS in Galt was RCAF lad for 5 years as Wireless Mechanic . . . John Bolt, former 3AIF is now in Nanaimo with Reemies . . . RCEME to you . . . ex-4XY is on land line in Lyton, B.C. . . . looks forward to getting on ptble. way up thar in them mountains.

3AVR reports from Port Weller that 3FT up and got himself a wife 'way out in Fort George, B.C. . . . Felicitations OM . . . 5AAR is still a long way from home in Centralia Flying Training School, RCAF, teaching radio range to Link pupils . . . Picture of a man looking for himself . . . page 4PA! . . . still no word from 3TM, or 3CP, 3RO, or 3WA . . . what's the matter with the Banana Belt? . . . and . . . the BLAA network! had a good visit with 3DU t'other nite he's looking hard for a missing bi-push aided and abetted, of course, by the ole man of the mountain 3AJE, and powerhouse 3HI the motor magnate . . . wanta buy a Chevvie! 3ALX and 3AAO are helping Dave Gerry sell ham parts while 3AOO listens hard for 3WX on 28 MC . . . up in Timmins AFV tells us that 3UF is getting set and 3BB is looking hard for a missing 40 metre band, 3ARR is stymied with 60 cycle junk . . . 3VZ wants his name stuck on the list of VE ops . . . 2PF will be on 28 come this issue. 3BU pens nice letter and wants XTAL to leap and bound . . . introduces Messrs. G. S. McElhinney and A. H. Bush as new associate members . . . welcome fellows. 1EW reports from St. John, N.B., and looks forward to pounding brass upon exit from Army as Lieutenant . . . 1EC lost rcvr and freq meter in fire at Halifax, is now in Grand Pre and rebldg. . . . Mrs. F. J. Muskett of 2986 West 37th, Vancouver, B.C., is otherwise known as VE5TH. She sends 73 and sez her son 5DO is opping for

Prov. Police in Port Alice, B.C. . . . Fred Hale 3BG from Kapuskasing still talking about dandy hamfest in Toronto . . . no wonder . . . lucky stiff, he won an 807 and an 813 . . . there oughta be a law! . . . Alf Ackerman 'way out in OSOYOOS . . . yessir it's a town . . . in British Columbia . . . is 5LC . . . is in the radio business . . . and is helping 4 young chaps get started in the ham game . . . that's the spirit Alf OM . . . 4AEO discharged from the Navy is back on again . . . 3AYR is now in Rainy River with CNR . . . Welcome letter from Rev. Geo. L. Landry in Louisdale, N.S., 1PP . . . he is anxious to get back at it again too . . . 4ALS of Baring, Sask., needs a 12 volt to 500 volt, 250 mill dynamotor to get going . . . any help gang? . . . 3PE of Stratford bawls us out for not giving him advance gen on last Hamfest in Toronto . . . sorry EC OM . . . at last we have found how to stand on our heads and pat our tummies at the same time and in future will be able to get these announcements out on time. 2JT is back with us again . . . he was in Java for 2 years and thanks Radio Handbooks for salvation . . . he was a prisoner of War! . . . 1HB is back after 5½ years as WO in RCAF . . . We're looking forward to more news from the Clinton Amateur Radio Club at RCAF Radar and Comms. School after nice note from 4MX . . . Sparkie Maclean writes from Overseas in the occupational zone where they have 80 metres to play with . . . he sez it's full of Dutch and French hams . . . here's the rub . . . he actually sez phooey to 80 and wants 28!! . . . well, we don't blame him becuz who wouldn't want a band upon which one could depend to talk to buddies at home in Canada . . . he would like to hear from some of the old gang and may be reached at H.Q., R.C.E. M.E., 3 Cdn. Inf. Div., C.A.O.F., as Lieut. John Maclean, VE1JV . . . don't forget the guys in that occupational force fellers . . . they have a pretty dull time and welcome as many letters as you can pen their way. 4AHD in Lethbridge thinks XTAL is swell . . . so do we Bernie . . . and are trying hard to keep it that way . . . 4ABW wants more 4's to tell XTAL what's up . . . heck, he sez . . . the 3's are taking up all the space . . . he's a Stalwart Sask. fella! 2IF has new rig all cranked up in Noranda . . . Jim Scace . . . formerly of Brantford we think, 3DR, bemoans steel window sashes and sez there oughta be a law in Toronto . . . good to hear from the Old Timers . . . mebbe we oughta start a 25 year club . . . any ideas fellas . . . how about the OT of 25 or more years at the noble art dropping us a special line . . . c'mon! . . . Larry Dias writes a newsy letter from Pt. Edward . . . has been QRL for 3 years in various parts of the country on Radio, Ascid, Radar and Gyro . . . his call, 1IT. Russ Buckley is new Associate member from Toronto . . . 5ACW with right pert note to say he and 5IO are in a huddle on a shiny rig . . . The Lakehead gang in Fort William have been getting under way with some lively meetings and are doing some FB long range planning . . . had 30 members at their last but only 6 VE OPs! Mebbe 3AZJ, 3ANP, 3HU, 3AZK, 3AMN need some reinforcements. C'mon gang par is 100% . . . fie! . . . 3FS at RMC is looking at a key again after a 5 year leer at the Gerries . . . 1ED is back after a hitch as WOG in RCAF and wants an XTAL sent to brother 1JV in Dland . . . 3ATF in London corrects us on filter fact formulae . . . 1KS in Sackville . . . we got lost in a covered bridge near there once . . . is all het up over a Communications Department in VEOPs . . . with Relay Stns., Tfc., 'neverything . . . hitch your britches Ron we're comin' at ya . . . BUT SOON! . . . and you'll be plenty busy when we crack with it, OK? . . . 3ER now in Whitehorse YT is ready to go on 28 with Skyrider and all . . . AND of all things, and after all these years it takes lil old XTAL to bring Bill Butchart out of hiding! . . . and whatta swell letter we got from Bill . . . he and his 4LQ sure put a whale of a signal into this part of the country . . . with only 45 WATTS input! . . . 4TX is badly in need of coaxial cable to get going . . . 2RW/1KV has been all over this dizzy old globe the past three yars with ATC . . . 3ACS QSYed to Black Donald Mines . . . 5QA likes Q-Meter and Filter Fact articles and tosses orchids to us on XTAL's appeal . . . for which we shyly blush and thank that Penticton gentleman . . . Away up in Dawson Creek, B.C., Stan Carnell writes us as Secretary of The Dawson Creek Amateur Radio Club . . . real live outfit even though only two of them have ham tickets, 5PR and 5JQ . . . DCARC is Peace River's first ham club . . . let's give 'em a big hand fellas . . . Jim Musselman 4ANM, now in VE3 country would like to hear from any old mates on 110 (City of Toronto) Sqdn., RCAF, and can be reached at Box 242, Dundalk, Ontario . . . he has a brand new Radio and Electrical business and is busier than the proverbial cat . . . nice rehabbing Jim . . . ex-3WJ is still in Montreal . . . how about a note, George? . . . 3QK smells a discharge from RCOC in London . . . 3IR is back in harness after a spell with CBC overseas services . . . 3WX would like good down to earth dope on Pentodes . . . where's Brock Morgan? . . . 3HZ, Al Cahill got himself decorated with an M.B.E. by Gen. Crerar . . . FB . . . Bob Murray got an O.B.E. . . . FB . . . 3ABL just got his ticket from the Navy and is rebuilding . . . Bill Martin of Kitchener just out of RCAF has been all over the globe as Radar Officer . . . 3ATC was at UNO Conference at San Francisco . . . wants some articles on antennae . . . 1GB is all set again after a spell with the RCCS . . . 4AIJ in St. James, Manitoba, listens to 4IU, 4SO, and 4RO . . . who doesn't hear 4RO! . . . wants a simple superhet for 10 as an article . . . Annual meeting of the British Columbia Amateur Radio Association elects Pres., 5ND, Vice-Pres., 5BJ, and 5HA as Secretary . . . another live organization from the west coast . . . tnx for FB letter Fred and we may take you up! . . . we also learn that University of B.C. has a Ham Club headed by Cec Yip 5GO with Ralph Gordon as Secretary . . . Halifax Ham Club is back in swing again and has had meetings at which they elected 1LZ, 1MZ, 1FB, 1NQ, and ex-1EF as slate of officers . . . tnx for FB letter Ed . . . 3AEJ is plagued with an apartment QTH but he sez that isn't going to stop him . . . 4AY will soon be cranked up on Ten . . . 3AER sez Amateur Radio was great help to him in Navy . . . joined as Ordinary Telegraphist and ended as Lieut. 4AEQ has letter elsewhere in issue . . . 2EC of Trois Rivieres is cranking up the old rig and is anxious to get going again . . . 5AGT is unpacking the rig silent in the attic since '39 . . . 4FS comes forth with a newsy letter and some good suggestions . . . tnx Don . . . nice letter from Derek Marshall of Newfoundland's Amateur Radio Association who tells us to expect a visit from their President VO1D . . . 4LN will be on shortly from Vermillion, Alta. . . . 3ATW/5XC is with RCAF PF and looks forward to brass-pounding again shortly . . . 5AEB would like QSOs with some ex-RCAF chums . . . he's on 28,652 kc. for a coupla hours each noon (PST) . . . Ron Matthews is handle . . . 5AIE sez first thing he saw when he returned from O/S was XTAL . . . 1EL was in RCMP during war and before and sends us application of 1IJ in Chipman, N.B. . . . welcome fellas . . . 1GH is with CBC in Sackville and wants to know where 3EO is now? . . . how about some cover pix Merrill . . . with some sort of radio as a subject? . . . 5EO is with TCA in Lethbridge . . . 5NT is at the Radio and Electrical game in Vancouver . . . 5KC wishes XTAL much success and writes letter that has our chest out . . . tnx Al . . . 4KC/3WN is with the CP Depot of Comms after 5 years in RCAF . . . 1IE sez to look for him on 1FL's 28 MC job . . . ex-4XS QSYed from Alta to B.C. and is awaiting new call . . . 5AHV is impatiently awaiting the return of 80, 40, 20 . . . 4ARX had to keep his fingers on a key when QRT '39 came so he upped and joined the RCAF to continue operating! . . . 4AHH just left Hagersville and is back home in Calgary with discharge . . . 3UO in Cardinal, Ontario, sez that there are 5 hams in town . . . 3AHR is ready to go on 80 and 20 and 3XS is looking over new ham gear and ready to go back on again . . . (?) . . . 4OT lives in WATTS, Alta.! . . . only active ham around that part of the country . . . no power line . . . uses a Johnson model 6D15 driving two hi-voltage generators both running from 6 volt car generators . . . all of which gets him 200 and 500 volts DC. Rcvr get pwr fm 32 volt batt and one B batt. . . . Now if there isn't good ham spirit . . . think of the difficulties this lad has surmounted . . . we'll do our best to get some dope in XTAL on ptble power arrangements in the near future . . . tnx for nice note Jack . . . 3AOQ and Mrs. Horton were hosts at the formation of the 1,000 Island Radio Club, where Pres. 3EJ, Vice-Pres., 3AOQ, and Sect., 3WG as well as 3JE, 3AAB, 3AM and 3QB were agog over eats, old gear, and chatter about individual and club activities-to-be . . . how about those QSLs, Bert? . . . and Lou Gold, Toronto, LL. 4267, would be glad to act as a partner to any would be ham . . .

A Broad Band Antenna

By W. W. H. DEAN, VE2RU*

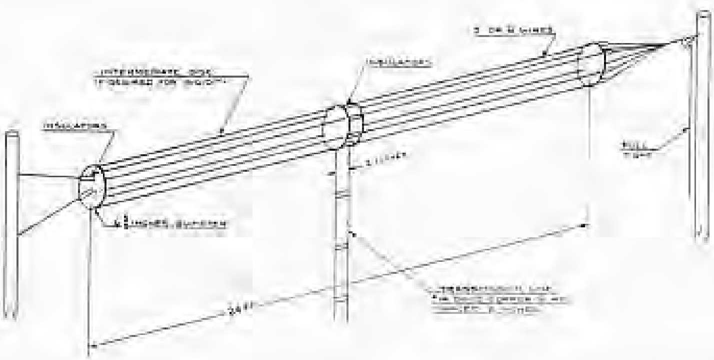
Amateur antennas are probably the weakest link in a great many "ham" stations and for a very understandable reason. Adjustment has been critical and most amateurs do not have the facilities and in many cases the knowledge to properly prune the antenna (and feeder system) for the optimum conditions. The fact that it is strenuous and tedious work is probably almost as much of a deterrent. With these thoughts in mind, the advantage of a system that would be relatively simple to construct and install can be readily appreciated.

In the April issue of the I.R.E. Proceedings Brown and Woodward in an article entitled "Experimentally Determined Impedance Characteristics of Cylindrical Antennas" present data complete with curves showing the impedance of antennas of varying diameters and lengths. Using this information, antennas may be calculated which will work satisfactorily across any of the higher frequency bands (20 meters up) with no tuning or readjustment whatsoever. Indeed, their construction need not be very accurate, although best results will be obtained by sticking fairly closely to the optimum calculated values.

The antennas as calculated are all vertical working against ground. However, the example which is now given is a horizontal dipole for the reasons stated later. The data which is for the so-called quarter-wave antenna may be used by considering the dipole as two quarter-wave elements with their ground ends facing each other. The impedance will then be twice that for a single section and the feed system will be balanced with respect to ground. A practical antenna to cover the 28 to 29.7 m.c. band will now be worked out.

First considering the feeder system, it seems that a balanced open wire line is the best for general amateur use. It is cheaper than concentric line and is somewhat easier to splice and terminate. It does, of course, require more care in installing to keep it in the clear so as to avoid unbalance, and it is somewhat harder to bring into the shack. Although the choice may be open to considerable argument, an open wire line is used for the example.

Five hundred ohms is chosen as the line impedance, as this gives practical dimensions (No. 14 solid wire spaced two inches). The antenna is then chosen so



BROAD BAND ANTENNA FOR 10 METERS
ALTERNATIVE METHODS OF SUPPORT SHOWN

*27 Drayton Road, Pointe-Claire, Que.

that it presents an impedance of approximately 500 ohms to the transmission line over the entire band. From the curves given in the above article, this works out to a length of 24 feet and a diameter of 6⅝ inches. This may be constructed as shown in Fig. 1, by fastening five or six wires between rings or discs of the proper diameter. With the resultant spacing between wires this is almost equivalent to a solid cylinder. The antenna is in two sections separated in the middle exactly two inches by insulators. The feeders terminate across this gap. The outside ends of the antenna are probably best supported by using one insulator for each wire in the cage and bringing the supporting wires together at the center point. Alternatively, the end disc may be sufficiently strong to allow a single insulator to be attached in the center, or two insulators may be used with two separate supporting wires to prevent the antenna from rotating in the wind and straining the feeders.

The entire assembly should be stretched as tight as possible to prevent sagging and swaying which would alter the shape of the cage too much, although the antenna is not critical in this respect. The end supporting discs may be rings or solid sheets, or may be made from insulating material if the wires are all bonded together by a jumper. The center discs must be solid metal, as the capacity between them is necessary to give the correct antenna impedance. All joints, of course, must be securely soldered.

The antenna has been calculated for optimum conditions at 28.8 mc but the standing waves produced on the line due to antenna mismatch within the entire band will be less than 1.25 to 1. It is extremely unlikely that the line itself will be balanced as well as this. The line may be coupled to the P.A. tank coil by means of an adjustable link and a slight readjustment in coupling should take care of the impedance variation. In case anyone is worried about standing waves on the line it should be remembered that a ratio of 2 to 1 will cause very small additional losses but it will make more adjustment of the coupling link necessary.

If it is desired to use this type of antenna on any band the dimensions may be found as follows. Divide the length (and diameter) by the middle frequency of the band desired and multiply by 28.8. The center spacing and transmission line dimensions will remain the same. Due to the fact that the center spacing is not changed the area of the center discs must be changed in proportion to the change in frequency. For example, if the antenna is for one-half the frequency, the antenna diameter (and the disc diameter) will be doubled, but one-half the area should be cut out of the center of the disc (a hole 9½ inches in diameter in the center of a 13¾ inch diameter disc). If the frequency is doubled the diameter is halved, but the disc diameter should be chosen so it has twice the area of the antenna—actually 4 11/16 inches. The wires in this case will be connected in from the edge of the disc on a diameter of 3 5/16 inches.

Provided the antenna is mounted in the clear, and well removed from wires, etc., which might absorb appreciable power, it may be cut, assembled and put in place with assurance that it will load up properly and that the feeders will have very small standing waves. The antenna efficiency will be as good as that of a half-wave dipole operating at its resonant frequency and it will have a similar field pattern.

The pattern will be modified somewhat due to each half of the antenna being approximately one-half electrical wavelength instead of one-quarter wavelength, the two halves being in phase. This will sharpen the broadside pattern somewhat.

Other values of transmission line impedance may be used and with some juggling it should be possible to obtain good operation on more than one band (say 20, 15 and 10 meters). It is hoped that further examples may be worked out and presented in future issues. In the meantime, anyone interested in figuring this information out for himself will find the curves in Brown and Woodward's article very easy to interpret.

—□—

QSL's?

On page 40 is reprinted our old Association QSL card. We still have several thousand. The cards are printed in red on canary stock. They are offered for the cost of imprinting in black, your call letters and address plus postage at $1.25 per 100, $3.00 per 300, or $3.75 per 500, postpaid. Drop the Association a card and a sample will be forwarded.

TURN TO PAGE 28

for

"XTAL 28"

Resonant Transmission Line Sections - Part III

By A. P. H. BARCLAY*

(3) As Transmission Line Supports

As we have previously seen, a quarter-wave shorted resonant section of transmission line at its resonant frequency has a very high impedance (high voltage and low current) at its terminals. Hence, if it is connected across a transmission line having a moderate impedance, it will not apply any load. We can therefore make use of such a section as a metallic insulation for a transmission line, which in terms of its resonant wavelength is a highly efficient insulator. However, this only holds true if the wavelength is restricted to that for which the system was designed, since at wavelengths either side at wavelengths either side of resonance, the quarter-wave section is no longer a quarter wavelength long, and thus places capacities or inductive reactance across the line.

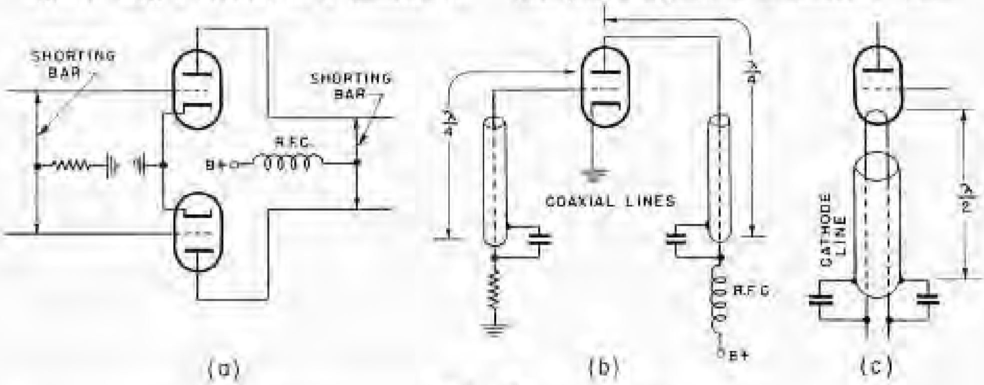


FIG. 13

For example: We have an open wire line of 200 ohms or so operating on 500 Mc. and want to support it on quarter wavelength long stubs. The stubs would be most convenient if made the same characteristic impedance as the line. The only problem left is to find out what length the stubs should be. From our formula previously enumerated,

$$1 \text{ Wavelength (in feet)} = \frac{984 \times K}{\text{Frequency (in Mc)}}$$

K in this case = 0.975, so a quarter wavelength (in feet) will equal $\frac{984 \times 0.975}{500} \times \frac{1}{4} = 0.28$ ft.

So our supports will be made up .28 ft. long, spaced the same as the line spacing and with a short at their bottom end. This problem of course may be similarly worked out for coaxial lines.

(4) As a Reactance Element

Since a section of transmission line may be used as a low-loss inductive or capacitative reactance, it can be put to many uses along this line. One such is in tuning out the reactance of a load. If we have a 73-ohm transmission line several wave lengths long and terminate it in a

*Rogers Majestic Ltd., Toronto.

APPLICATION FORM

I hereby make application for (renewal) (new) membership in the Association. One dollar is enclosed which entitles me to membership and subscription to XTAL for one year from date of application.

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73-ohm resistor and then find that there are standing waves on the line (indicating that it is not properly matched) we can be reasonably sure that the resistor must have some reactance. By connecting a half-wavelength section of line having an adjustable shorting bar in parallel with the load resistor, the shorting bar may be adjusted until we have no standing waves, i.e., a matched condition. We cannot only correct the match but we can also tell approximately the value of the reactance of the resistor by measuring the length of line added, transfer it into terms of wavelength and then use Figure 8 of Part 1 to determine the reactance.

(5) As Frequency Control of Elements
To obtain high stability in oscillator circuits it is necessary to have high "Q" circuits. At the shorter wavelengths it is difficult to make a high "Q" resonant circuit of inductance and capacity. Since resonant line sections have high "Q" possibilities (low loss and efficient oscillation capabilities), they are very useful in this regard.

The "Q" of a line is given by the ratio of its inductive reactance to its resistance. So for high "Q" we desire high reactance and low resistance. The "Q" of an open wire line is a maximum when the ratio of the space between the wire centres to the radius (half-diameter) of one wire is 6.19:1. For a concentric line, the "Q" is maximum when the ratio of the inner diameter of the outer conductor to the outer diameter of the inner conductor is 4.22:1. The "Q" of a line is best when its effective electrical length is a quarter wavelength long. Naturally any measures which are taken to cut down the resistance (such as silver or gold plating) will result in increasing the "Q". Open lines are most generally used in push-pull oscillator circuits and coaxial lines in single-tube oscillator circuits. A point to be remembered is that the line is always going to be shorter than a true quarter-wavelength due to the loading effect of the tube element capacities.

Fig. 13 (a) shows a typical two-tube circuit using resonant line circuit elements. Fig. 13 (b) shows a typical circuit using only one tube. The output may be tapped off in either case from a suitable point on the lines which gives an impedance match to the load or transmission line.

At the very high frequencies it is no longer possible to effectively ground the filament with capacities, since the filament lead wires have appreciable reactance. To overcome this it is possible to use a half wave shorted line which includes in its length the filament leads. This effectively puts the filament at ground potential. Fig. 13 (c) shows such a scheme. The capacities at the end of the line provide the low impedance short for R. F. without shorting out the filament voltage.

DX-28 mc.

5DY reports that 5ZM has a QSP from a W working portable in Japan. He also reports H.M.C.S. Uganda is leaving for the east coast about the time this is read, and her complement includes several hams. They are to go via Cape Horn, and the boys aboard hope to keep in contact with VE via h.f. radio. Those aboard include ex5EN (the Captain), 5AJV and VE3—, Lt.-Cdr. Miles.

LU, HC, HJ, and OA, K6, and K7 have been heard in Victoria. 4RO worked many K6 phones, including K6MVV. LU7AZ, LU3DH, and XE1AM were also snagged. VE1's are the most consistent VE's in 'Peg. The Ontario gang have worked HC, K6, OA, TI, XE, etc., but on the whole conditions have been very erratic and poor the past month. Old logs show that January was always like that. However, predictions show there'll be much hot DX in the months to come. So, don't wait, get the rig perking on ten.

3KE and 3BCO worked some juicy stuff soon after we were on ten. A partial list worked is FP7A (France), CX1T, G7AA, W8KAY/KB6, F8DX, HB9CX, CT1JS, EI5X, TI2DX, F3WT on c.w. and EA1D on phone. During early January they snagged OQ5AE on 28,250 and ZS6U. VP2AT was heard Jan. 20th. (Seems some one once told us Ottawa was a punk spot for DX).

The old band really came to life February 2nd, and it was a great pleasure to hear the G's pounding through. VE's from coast-to-coast were able to renew many years old acquaintances, both with the G's they met overseas, or QSOed before the war.

TUBE CHARACTERISTICS

Some tube types carried in the Manufacturers Radio Tube Committees ads in XTAL may be strange to some of you. The EF50 is the same as the VR91, a H.F. Pentode amplifier. Base lock in 9 pin British type. Fil. voltage 6.3 @ .325 amps. Pl. voltage 300 @ 12.5 ma. Transconductance, 5200 to 7800 micro mhs.

The E1148 is a H.F. triode. Base 5 pin octal. Fil voltage 6.3 @ .19 amps. Plate voltage 300 @ 20 ma. Plate dissipation 3.5 watts, power input to plate 6 watts.

The 1299 is a fil. type beam power amplifier. Base 8 pin lock in. Fil. voltage 1.4 @ .22 amps. Plate voltage from 90 to 150 @ 8.5 to 10.2 ma.

The CK1006 and CK1007 are full wave gas rectifiers. CK1006 is medium 4 pin base. Fil. voltage 1.75 @ 2 amps. Inverse voltage 1800 max. Peak plate current 660 ma. Output 620 D.C. volts @ 220 ma. The CK1007 is octal 5 pin base. 1 volt @ 1.4 amps. max. Inverse voltage 1080. Peak plate current 360 ma. Output current 120 ma.

The RK60 is similar to a 5Z3.

Space does not permit complete specifications. If you desire further information drop a card to your Association's HQ.

"CQ XTAL 28"

Little has been done in celebration of one of hamdon's biggest historical events—the return of some of our bands for amateur communication. XTAL thinks that something like a colossal hamfest should be held to mark this day of days. Transportation and distance makes such an event impractical but communication does make possible a real stupendous get-together, and here is how we'll do it!

PUT—A shooting match for the ambitious guys that are ready to squirt signals on ten. They're gonna have their battle with WATTS as weapons!

TAKE—A scramble for the lazy critters who either haven't the ambish to get up to ten, or, just prefer to sit and wait for 80-40-20; and of course, for the fellows who haven't as yet acquired tickets. These lads can joust with SENSITIVITY as a weapon!

TIMES—9 a.m. to 7 p.m. Eastern time Sunday, March 17th.
9 a.m. to 7 p.m. Eastern time time Sunday, March 24th.

Transmitting—

SCORING—5 points for each QSO multiplied by the number of Provinces, States in the U.S.A. and Countries.
Receiving—5 points each station HEARD multiplied by the number of Provinces, States, and Countries.

RULES—Frequency limits must be strictly observed. Off-frequency operation will result in disqualification. Contestants in "PUT" section will not be eligible for a prize in the "TAKE" section.
Copies of logs must be sent to CAROA HDQTRS., 2498 Yonge St., Toronto 12, bearing date stamp no later than March 30th. Be sure your call, name, QTH, and times of contact or "heards" are listed.
Phone—CW, Phone-Phone, or CW-CW contacts are permissable.

Only one contact with a station counts.

OFFICIAL CALL—"CQ XTAL". Three times three, of course! Dust off those receivers and crank up the ole rig 'cuz the prizes are worth going after. What's more, you're gonna be able to make new contacts, and remember, DX counts just as much. There's just one kitty in the woodpile—NOT MORE THAN ONE STATION WORKED OR HEARD WITHIN 20 MILES WILL COUNT IN THE FINAL TOTAL.

Diagnosing The Weather

By W. H. ANDERSON, VE3AAZ*

Some Pointers on Identifying Weather Conditions Possibly Affecting Radio Wave Propagation

In the explanation of certain high-frequency phenomena, increasing resort is being made to the examination of the coincident meteorological conditions, primarily on the assumption that the atmosphere presents some sort of discontinuity surface which serves to reflect or refract radio waves.

This discontinuity will probably be parallel, or an acute angle, to the earth's surface, and at a distance of from a few hundred to several thousand feet above the ground. Such a condition may exist as a boundary plane between two or more masses of air of different characteristics, or it may occur in a single mass with a particular temperature distribution.

The likelihood of such a situation existing aloft can often be detected on the ground by observation of one or more factors such as the clouds, wind direction, relative outside temperature (whether warmer or colder than seasonal, and rising or falling) especially if supplemented by reference to a "storm guide" or other similar instrument which is actually a barometer or "air-pressure meter."

The presence of two or more contiguous masses of air is generally due to what is known as "frontal" action. This occurs in low-pressure areas, which themselves are the result of certain physical laws. The air lying over different bodies of land and water are heated to different temperatures by the sun. When air is warmer than its surroundings, it rises and spreads out above and the weight of the column of warm air above a certain point (which is the value indicated by a barometer) will become less, in other words, a "low-pressure area" develops.

The principles of mechanics then come into play and, in the case of the "low," air from surrounding areas begins to come in toward the centre to balance up the pressures. This air is in turn warmed and the cycle is maintained. The situation is further complicated by the fact that the angular velocity of the earth's surface varies from the poles to the equator, being greatest at the equator and zero at the poles. This is apparent as a point on the equator will have to travel farthest to come back to its original position, while theoretically there is a point at the centre of the earth's axis that does not revolve at all. These facts combined with the friction effects on the earth's surface result in two conditions: 1. The air drawn into a low does not travel directly inward, but assumes a spiral pattern, being deflected to the right in the northern hemisphere and to the left in the southern. 2. The low (and high) pressure areas tend to

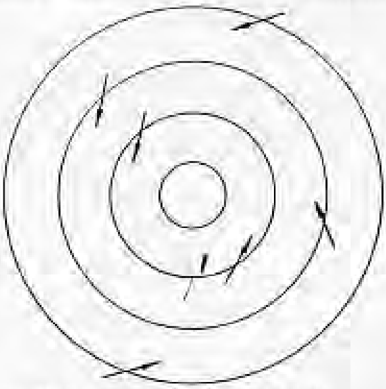

FIG. 1.—"IDEAL" LOW IN NORTHERN HEMISPHERE.

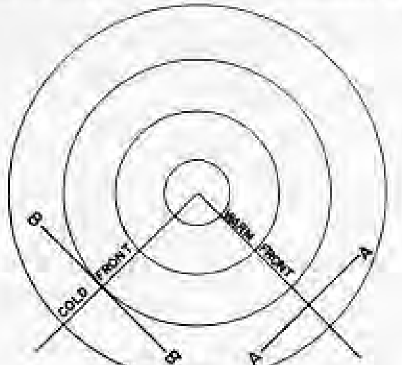

FIG. 2.— FRONTS ASSOCIATED WITH A LOW PRESSURE AREA.

*c/o T.C.A., Moncton Airport, Moncton, N.B.

move across the country in a general west to east or southwest to northeast direction.

Fig. 1 is a horizontal plane through an ideal low in the northern hemisphere with the solid lines indicating points of equal air pressure, and the arrows indicating the direction of air movement—an arrow pointing from left to right indicating a west wind, and so forth. From this figure it may be noted that an observer east of the centre would experience easterly or southeasterly winds, while an observer north of the centre would have northeasterly winds, etc.; also that all points ahead of the centre will have falling pressure, and all behind, rising pressure.

Now, due to the fact that the various air currents being drawn into the vortex of a low from different directions are almost certain to be of different temperatures, further distinct effects are noted.

For instance, the winds from the north generally consist of cool or cold air, while those from the south will be warm. Consequently there will be a line extending from the centre approximately southeast, where warm air will encounter colder air. The warm air, being lighter, will override the cool—this surface of discontinuity being termed a "warm front". Similarly, cold air will encounter warm air along a line roughly southwest of the centre. The cool air will, due to its greater density, undermine the warm, and a so-called "cold front" will develop. The warm and cold front associated with a low pressure area as shown in Fig. 2 are the fundamental meteorological phenomena, and to a great extent all major weather disturbances may be traced to them. They are somewhat analagous to capacitive and inductive reactance in the radio sphere.

A vertical section of the warm front (taken along AA in Fig. 2) is depicted in Fig. 3, and of a cold front (taken along BB in Fig. 2) is shown in Fig. 4. Each mass of air has a personal history depending on where it originated, its age, and the path it has traversed to its present position. As a result, not all warm fronts and cold fronts exhibit the same characteristics. However, a few generalities may be drawn.

To an observer stationed southeast of an advancing low, its forerunners would probably appear as a thin sheet of high lacy clouds. Then as the front approached, the clouds would become lower and darker—alto-stratus, then low ragged clouds (stratus) and possibly some precipitation would occur. When the warm front passed, a shift in wind direction would probably be noted, with the wind now more southwesterly and the temperatures higher, the skies clearer, and the barometer rising. As the speed of a warm front is fairly slow (15-30 miles per hour) and its slope only about 1/150, a given point will be under the influence

FIG. 3.— VERTICAL SECTION THROUGH A WARM FRONT

FIG. 4.— VERTICAL SECTION THROUGH A COLD FRONT

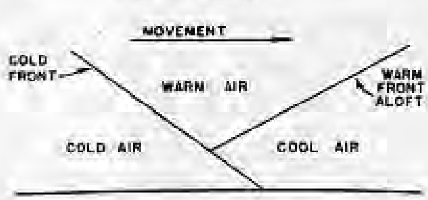

FIG. 5.- VERTICAL SECTION THROUGH A COLD-FRONT OCCLUSION

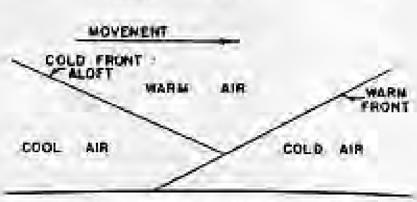

FIG. 6.— VERTICAL SECTION THROUGH A WARM-FRONT OCCLUSION

of this type of discontinuity for a considerable time before frontal passage.

Generally speaking, a cold front does not display any such visible harbingers. However, the barometer generally begins to fall fairly rapidly. The frontal passage is usually marked by the wind shifting to the west and increasing in velocity, the temperature dropping sharply and the barometer rising markedly. A storm may accompany and follow the frontal passage. Due to the speed of the front (from 25-40 m.p.h.) and the slope of the discontinuity being rather steep, this discontinuity will exist over a point for only a relatively short period after frontal passage.

Due to the aforementioned greater speed of the cold front, it will eventually overtake the warm front and what is termed an "occlusion" will result. This is an exceptionally complex occurrence. Fig. 5 shows a vertical section through such an occlusion when the air behind the cold front is the coldest air mass involved. This is termed a cold-front occlusion and the discontinuities are many and quite difficult to analyze from the ground, as there is a warm front aloft as well as the cold front on the surface. Fig. 6 depicts a warm-front occlusion. This occurs when the air ahead of the warm front is the coldest involved in the system. When a system occludes, it often stagnates, thus providing a complex set of discontinuities for protracted periods.

The second general classification of discontinuities are those which occur in a single air mass. One such type generally occurs late at night or during early morning during periods when the small, white, rapidly moving clouds (cumulus) are in evidence during hours of sunlight. When the earth cools off after sunset through loss of heat waves directly to outer space, which will occur unless a cloud layer is present to reflect the heat waves back to the earth, the air adjacent to the ground is naturally cooled. Due to the inherent stability of the air and consequent lack of convection currents, together with the fact that air is a poor conductor of heat, only those layers near the earth will be cooled. In fact, they may be cooled to a point where they will no longer be able to retain their moisture in vapor form and a shallow "ground-fog" will form. Now the usual temperature distribution in an air mass is for the temperature to fall off as the height is increased, but due to the situation outlined above, a condition may arise where the temperature will increase with height until a point is reached where the influence of ground ceases, and the regular decreasing temperature condition will exist. This is termed a temperature "inversion," and the level at which the inversion ends is often a definite discontinuity surface, and it is not uncommon to observe smoke and clouds rise normally through the lower air and then hang just below this level.

In employing the suggestions outlined above, it should be borne in mind that, especially in coastal areas, local topography and the weather situation existing over the entire country play an extremely important part and may give rise to quite misleading conclusions drawn on the basis of only one "spot" observation. Furthermore, it must be appreciated that clouds result from other causes than frontal activity, and

(Continued on page 42)

DEAR OM

Editor, XTAL:

Congratulations on your fine issue of XTAL. I hope to see it grow with each issue, both in size and circulation. I think that every Canadian Amateur should get behind this organization and boost it.

I read with interest the letter in the September issue by VE3ADR and also those by 3ANX and 3BO in the Oct.-Nov. issue. They both have their good points, but in this magazine of OURS I am sure that there is room for material to satisfy both schools of thought, so let's end this ancient argument of Oldtimer vs. Newscomer.

W. Kirkwood
VE4AEQ
Box 211, Flin Flon, Man.

Editor, XTAL:

. . . . . have a Hallicrafter SX 18 (Sky Challenger) and have been doing a lot of listening on ten during the noon hour. So far, must say the band sounds very good here. All W Districts have been heard and W6's operating portable from Hawaii with R8 signals on fone. Most often hear W6 and the band opens up, then the east coast rolls in. The only VE so far is VE4RO with R9 sigs.

Am nearly all set to go myself soon as I get an OK on my call to use here then will temporarily be using 802 Tritet—RK39 final 46 class B on 28,092 KC Fone and CW.

As my family are all living in Toronto would appreciate call or reports from anyone down there and if possible to arrange sked so that I could talk to the folks back home.

. . . . . XTAL is off to a good start again and looks bigger and better than ever. Congrats OMs and keep up the good work.

Jack Spall, VE8ER
R. C. C. S.
Whitehorse, Y.T.

Editor, XTAL:

I have followed with considerable interest your last two or three issues of XTAL and please allow me to congratulate all of you on the editorial staff for doing a swell job. The magazine is really growing and so is the association.

What are the chances of getting a Communications Dept. started and a Field Organization similar to ARRL. You sure have a solid supporter right here in me on this score.

I guess this is about all I have at this end for now. I just couldn't resist the temptation to drop you a line telling you that I think that you are doing a swell job and wishing you all the success and luck in the world for the future of this, OUR first all Canadian Ass'n.

Ron J. Hesler
VE1KS
Sackville, N.B.

Editor, XTAL:

Have just finished reading the copy of XTAL which you so kindly sent me this month. To put it mildly I was surprised to find that there existed in Canada a group of this type, and to see a magazine of the calibre of XTAL. Its format, makeup and the scope of its articles are excellent and I wish to compliment you on your efforts.

As one who has long been a proponent of a strong Canadian amateur body, I think that you are doing a fine job to fulfil this need. . . . .Please let me know if I can be of any help.

Bernard J. Clancy,
VE4AHD
Lethbridge, Alta.

Editor, XTAL:

"Enjoy yourselves to your **maximum capacity**, not like years ago when a man **overload** his **frame** suffer from **reaction** and then sometimes **choke**. Hi! watts the

(Continued on page 38)

ANTENNA CIRCUIT DESIGN

(Continued from page 14)

Harmonic Suppression

The pi circuit has good harmonic attenuation properties because it normally has two shunt capacities which act as bypass condensers at harmonic frequencies because their reactances to harmonics are low. This property can be further enhanced by using a combination of series inductance and capacity in place of a single condenser, as shown in Fig. 15.

Each of these composite circuits is series resonant at the harmonic frequency, but present a capacitive reactance as required by the original design at the fundamental frequency. They are designed as follows:

1. From Fig. 10 find values of Ca and Ce in mmfds and Lb in microhenries, as before.

2. Then $Lh = K_1\ Lb$ microhenries.
$Ch = K_2\ Ca$ mmfds.

where $K_1 = 0.333$ for 2nd harmonic.
$K_1 = 0.125$ for 3rd harmonic.
$K_2 = 0.75$ for 2nd harmonic.
$K_2 = 0.889$ for 3rd harmonic.

It is quite practical to design the input leg to eliminate the 2nd harmonic and the output leg to eliminate the 3rd harmonic and still obtain good matching.

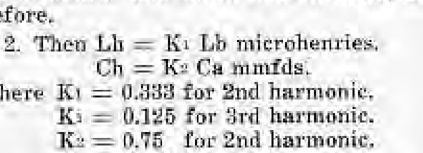

FIG. 16 (a) (b)

Other Applications

The pi circuit can be used to match a Marconi type antenna if additional tuning reactance is included in the antenna circuit proper, as shown in Fig. 16 (a) and (b).

Circuit (a) is used for antennas from ¼ to ½ wave high where antenna reactance is positive, and circuit of (b) for antennas less than ¼ wave high where reactance is negative. The antenna tuning reactance L or C neutralizes the reactance of the antenna and leaves its resistance to be matched by the pi in the normal manner. For vertical antennas having an electrical height of exactly ¼ wave, neither C nor L are required and the antenna may be connected directly to the pi circuit because the antenna impedance is approximately 36 ohm resistance.

A reactive load can be matched directly with the pi circuit without using C or L shown in Fig. 16, but the exact design of the component values is outside the scope of this article.

1. The input impedance to the pi circuit is designated Rl' herein because the type for a small subscript L was not available.—Author.

2. In Part I the dynamic load impedance of the P.A. tube was designated RL instead of R subscript L.—Author.

*XTAL, December, 1945.

—□—

DEAR QM

(Continued from page 36)

use of **wiring** in if it **hertz** the **holder**? With the proper **control** of **input** it is possible to enjoy every **plate** even if **loaded** on the **heaviside** and still have room for **currents, nuts,** and a **fig. . 2.**

So may your **table layout** be without **parallel** and yours the happiest **key** and **dial** on earth!"

VE4ARH
Kincaid, Sask.

Editor, XTAL:

Before I go I would like to mention that terrible subject radio. Many times out here at Nanaimo I have heard with sigs R9 from away back in the vicinity of Chicago, and in several cases, as far as Florida, on 31 MC (approx). These were FM carriers and in view of the recent high frequency allocations I thought it worth a mention as having possibilities.

John O. Bolt
exVE3AIF
Nanaimo B.C.


Smooth
PERFORMANCE
• SMOOTHS OUT THE RIPPLES
You too, will appreciate AEROVOX GLs. . . . Here is an aluminum can, electrolytic capacitor with inverted chassis mounting secured by ¾" threaded stud. Everything about AEROVOX GLs spells SMOOTH performance . they are easier to install . . . they ensure trouble-free operation and their in-built quality is typical of all AEROVOX Products.
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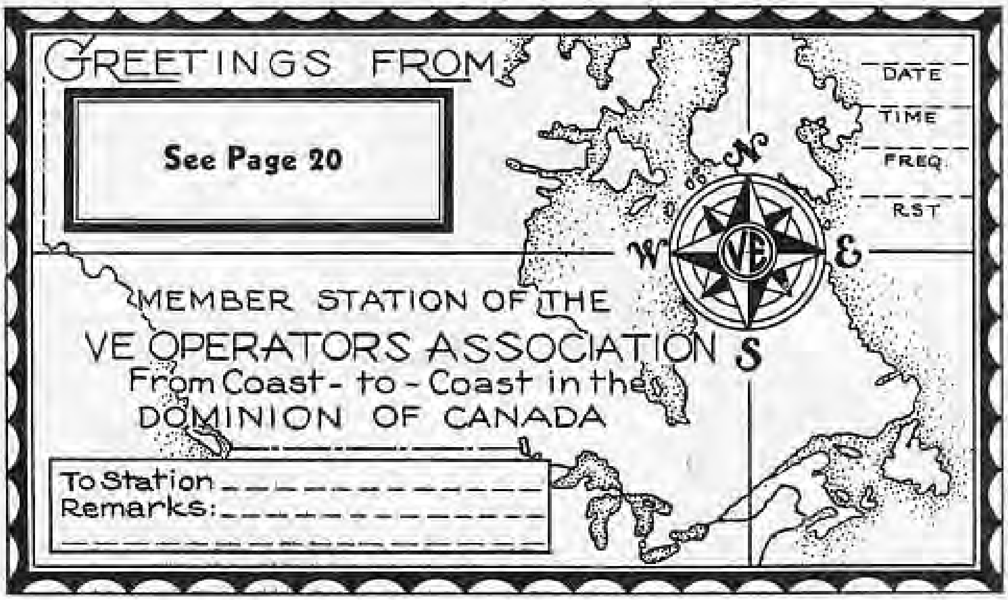

GREETINGS FROM
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From Coast - to - Coast in the
DOMINION OF CANADA
To Station
Remarks:

HAM-ADS

DIAGNOSING THE WEATHER

(Continued from page 34)

are therefore not definitely reliable as the sole criterion for determining the presence of a discontinuity.

On the other hand, as a cloud represents a volume of air that bears a contrast to its surroundings, it might reflect or refract radio waves in the same sense that a discontinuity plane is presumed to do so. Therefore, the presence of a layer of clouds covering four-fifths or more of the sky is justification for believing that some sort of discontinuity exists aloft.

While estimating the height of clouds is a science in itself, the following tabulation will serve as a rough guide.

Full sunlight, very light, lacy clouds 10,000 to 15,000 feet above ground.

Sun dimly visible, sky fairly light, clouds patterned or like frosted glass—6,000 to 10,000 feet.

Sun not visible, slight pattern to clouds, light insterstices—1,500 to 6,000 feet.

Sun not visible, sky ragged and dark —below 1,500 feet.

In conclusion, it must be appreciated that weather analysis is far from an exact science as yet, and the foregoing is necessarily very sketchy, but should enable an observer to determine the likelihood of a discontinuity existing in his locality, and if so, its approximate height.

References:

Aeronautical Meteorology, by Gregg. Pitman.

Various Publications of the U.S. Weather Bureau. Supt. of Documents, Washington, D.C.

Meteorology for Pilots, by Haynes. Supt. of Documents, Washington, D.C.