ANODE

Close the Repeater!

At a recent club meeting, another member approached me with an article for the Anode. He was advocating the closure of our West Rand Repeater using CTCSS using the article to back up his assertion that the interference problem would vanish. The article unfortunately was multiple copy of a copy of a typed article and not really suitable for character recognition. Others have claimed that the 'kerchunker' will go blind soon and not be able to find the mike.

The problem should really be seen as a challenge. The interference - and it is an interfering signal - is generated in close proximity to the repeater site. This problem is not going to go away and will increase in severity as time goes by. We all know or have experience of the interference that our pc's generate as well as the interference our transmitters can produce in other receiving equipment.

A single frequency located near the input frequency of the repeater need only be a couple of microvolts to quiet the receiver and thus lift the squelch. The squelch circuit in most fm receivers is a reverse noise detector. It rectifies the average noise generated to produce a fairly constant dc level. When the level drops due to a signal "quieting" the receiver, the squelch level drops below a set point and opens the audio chain. This squelch

The Reflectometer by 'Cathode Ray'

A READER, sharing my dislike for hazy or uncertain ideas, has cited the reflectometer as an example. He has seen a number of treatises on it, all of which failed to convey to him how it works. On the assumption-which I, knowing him, regard as most reasonable-that if he is puzzled others will be, he has urged me to do something about it.

Students of Q.S.T. and the A.R.R.L. Handbook (for 1957 thru 1959, as

they say over there) will know the reflectometer better as the Monimatch. It has also been called the Directional Coupler. Whatever the name, its purpose is to enable r.f. power travelling along a line or waveguide to be sorted out according to direction of flow, so that the direct and reflected power can be measured separately. This obviously enables the standing wave ratio* to be calculated. In turn this indicates the ratio of mismatch at the far end of the line, which is what

one wants to know when setting up a transmitter for efficiency or when measuring v.h.f. impedances.

> * Incidentally, why is the term "v.s.w.r." (Voltage standing-wave ratio) so often used where there is no point in emphasising voltage particularly? The current ratio is the same, so why not just "s.w.r." ?

The more familiar method of measuring s.w.r. is to have a slot cut

The Reflectometer

along more than half a wavelength of the line, through which a suitable voltmeter probe can be slid. The maximum and minimum readings give the ratio directly. The sliding process is not always very convenient; and if the source of power is a magnetron, which is apt to generate undesired frequencies when badly adjusted, it can happen that the best s.w.r. is indicated when the power-is divided up, amongst the greatest number of such frequencies quite the reverse of the general intention. The reflectometer, on the other hand, can be fixed at any convenient point in the line, and indicates the reflected power directly either in total, or frequency by frequency, according to the type of detector. It is also very easy and cheap to make. Between them, published designs of reflectometer cover frequencies at least from 2 to 3,300 MHz, but the most usual applications seem to be in the v.h.f. band.

At first thought it may appear rather a difficult thing to tell how much of the r.f. power is going each way when it is going both ways at once. Come to that, it's not altogether obvious how to tell which way it is going even when it is all going one way. The ordinary loop aerial can show the line of travel but not the direction along it.

Readers familiar with radio direction finding, however, will remember the old dodge of combining a loop aerial with an ordinary vertical aerial
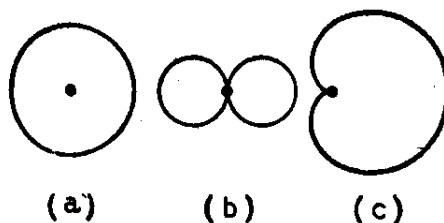

Fig. I. Polar diagrams showing the directivity of (a) an ordinary vertical aerial, (b) a loop aerial, and (c) the well-known direction-finding aerial in which (a) is added to (b)—one loop of (b) being negative.

giving the same amount of output. With the combination aerial facing one way, these two outputs are out of phase and cancel one another; facing the opposite way, they add up to give a maximum. Plotted on a polar diagram, the combined output yields a cardioid or heart-shaped diagram, compared with the ambiguous figure-eight of the loop alone and the omni directional result with the verti-
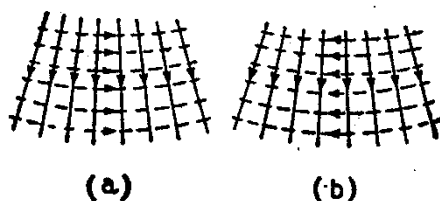

Fig. 2. The continuous lines represent the electric field, and the broken lines the magnetic field, together making an electromagnetic wave travelling at right angles to them, (a) towards you, and (b) away from you.

cal aerial alone-Fig. 1.

Essentially the same principle is used in the reflectometer. Whether the line has a central conductor (coaxial) or not (waveguide), the space inside is being swept by the electric and magnetic fields which together make up the electromagnetic wavetrain conveying the power along it. Now we know (if we don't we shall in a moment) that the directions of these; two component fields and the direction in which the waves are travelling are all three at right angles to one another. This is a thing that fairly shouts to be illustrated by an animated diagram in colour, but with a little imagination Fig. 2 should convey the essential facts. The invisible feeds are here represented in the usual way by "lines of force," which are fair enough so long as they don't give anyone the idea that the lines really exist or that the fields act only along the lines and not in the spaces between. The electric field is represented by continuous lines and the magnetic field by broken ones. And, of course, the directions marked are those established arbitrarily by convention. The direction of wave motion is at right angles to both sets of lines, (a) towards or (b) away from you.

The novice might ask why it should be the magnetic field that has been reversed in (b).

The Reflectometer

The answer is that it would be equally correct to show reversed electric field. At any given place along the line, these two alternatives alternate at the frequency of the waves. And at any given instant of time, the same two alternatives alternate at half-wavelength distances along the line. If the directions of both fields in either (a) or (b) were reversed it would not affect the direction of wave motion.

Another fundamental point is that in so far as power is being conveyed either way the two fields are in phase with one another.

What, the problem boils down to, then, is to find which way across the cable or waveguide the magnetic field is directed, relative to the direction of electric field. If one places oneself so that the electric field at any instant is downward, then if the magnetic field at the same instant is from left to right the waves are coming towards one; if from right to left, they are going away.

A reflectometer must be made so that it responds to both fields equally. Then if these responses add up to give a double measure from a wave going wholly one way, they will cancel out and give no response at all to a wave going wholly the opposite way.

The essential feature of all reflectometers, then, is a device for responding simultaneously to electric and magnetic fields. It has appeared in two main forms. In one (which includes the Monimatch), there is a short length of rod or wire
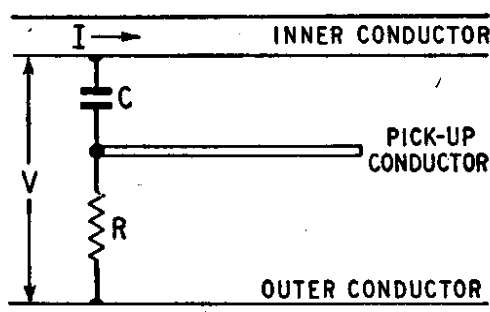

Fig. 3. The basic principle of a reflectometer is the coupling of a pick-up conductor to both electric and magnetic fields in such a way that the two effects cancel out for either direct or reflected wave as desired.
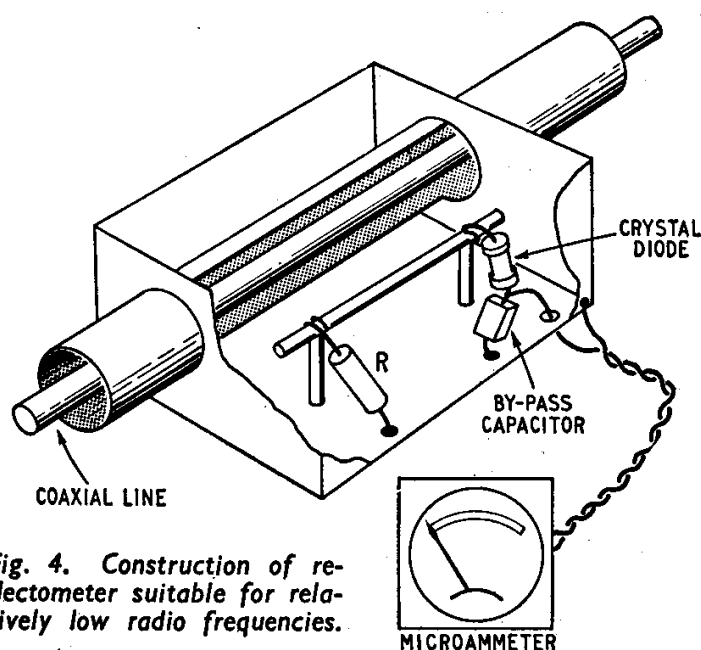

Fig. 4. Construction of reflectometer suitable for relatively low radio frequencies.

fixed parallel to the inner conductor of the coaxial line, so that it is magnetically coupled to the said inner conductor and a.c. flowing therein, generates an e.m.f in it. Being located in the electric field between inner and outer conductors, it also has an e.m.f. between it and the outer conductor. This pick-up rod is dimensioned and connected so that the two e.m.fs equally operate on a suitable indicator, either in phase or 180 degrees out of phase.

Constructional details vary, but they have to take account

Close the repeater!

level is also used to enable the transmitter in the repeater at a frequency 600kHz higher. In some poorly designed repeaters the output of the transmitter can 'leak' to the receiver and cause desensing of the receiver. This would lower the effective sensitivity of the receiver and drop the squelch. A time delay of the transmitter key would then ensure a 1 to 2 second delay whilst the transmitter stays on air. The receiver would probably also take a fraction of a second to recover and thus the transmitter would be off for the better part of a second.

Why should we 'close' the repeater and exclude the majority of radio amateurs? This goes against everything that Amateur Radio is about. Surely the right thing to do is to correct the problem at the source? This can be done with a little effort and can reduce the spurious and annoying transmissions.

Some years back I had the repeater in my clutches. I coupled the 70cm and 2m repeaters together so that we could cross band transmit the bulletin on both 2m and 70cm. At the same time we had been suffering a lot of "kerchunking". It seems that hams can't always be certain that their equipment is working and feel the need to 'ping' the repeater for assurance. I am afraid I upset them

Ten Commandments of Electronics

1. Beware the lightning that lurketh in an undischarged capacitor, lest it cause thee to be bounced upon thy buttocks in a most ungentlemanly manner

2. Cause thou the switch that supplies large quantities of juice to be opened and thusly tagged, so thy days may be long on this earthly vale of tears.

3. Prove to thyself that all circuits that radiateth and upon which thou worketh are grounded, lest they lift thee to high-frequency potential and cause thee to radiate also.

4. Take care thou useth the proper method when thou taketh the measure of high-voltage circuits so that thou doth not incinerate both thee and the meter; for verily, though thou has no account number, and can be easily replaced, the meter doth have one, and, as a consequence bringeth much woe onto the Supply Department.

5. Tarry thou not amongst those who engage in intentional shocks, for they are surely non-believers and are not long for this world.

6. Take care thou tampereth not with interlocks and safety devices, for this will incur the wrath of thy seniors and bringeth the fury of the safety officer down about thy head and shoulders

7. Work thou not on energized equipment, for if thou doeth, thy buddies will be buying beers for thy widow and consoling her in ways not generally acceptable to thee.

8. Verily, verily I say unto thee, never service high-voltage equipment alone, for electric cooking is a slothful process and thou might sizzle in thine own fat for hours on end before thy maker sees fit to end thy misery and drag thee into his fold.

9. Trifle thou not with radioactive tubes and substances, lest thou commence to glow in the dark like a lightning bug, and thy wife be frustrated nightly and have no further use for thee except thy wage.

10. Commit thou to memory the works of the prophets, which are written in the instruction books, which giveth the straight dope and which consoleth thee, and thou cannot make mistakes

    author unknown

"Mad March Hare" - Boot Sale !

Once again the sun was kind to us and the rain stayed away. The Boot Sale on the 3rd of March was again visited by large numbers of Radio Amateurs hoping to catch that elusive bargain.

A large quantity of brown liquid (RF!) was consumed in the 'beerfest hall'. The usual high standard of wors rolls were eaten by a ravenous horde.

If you inspect the picture below closely, you may make out the 'hot sauce' bottles. These are not distilled 6146's but a home remedy for all sorts of appetite suppressants.

During the afternoon, the club's HF rig was fired up and operated. CW and voice contacts were made even with the internal social QRM.

Once again we thank the organising team for a splendid day at the club.

Close the repeater!

rather badly. I put into the receive squelch and transmit key a small circuit that detected audio above a medium level. It effectively stopped a silent mike being used to key the repeater. I monitored the input with another receiver and waited. After a while several stations were transmitting continuously on the input, hoping to hear something on the output. The circuit and repeater remained in operation for quite a while until the repeater was replaced.

If we are going to close our repeater, I think we should de-install it from its current site and sell it to another, more interested and active Radio Amateur group. The West Rand Club certainly doesn't seem to be interested in the interests of other hams.

The Reflectometer

(Continued from page 3)

of the fact that the e.m.f. induced by magnetic coupling is proportional to the mutual inductance and the *rate of change* of current flowing in the "primary". So its peak is displaced 90 degrees from the current peak. And because the voltage between the two line conductors is *in* phase with the current through them, the pick-up circuit must be arranged to give a 90 degrees phase shift between the line voltage and the resulting voltage fed to the indicator. The usual way of doing this is shown in Fig. 3. The pick-up conductor is connected to the inner conductor through a small capacitance C—its self-capacitance is usually enough—and to the outer conductor through a resistance R which is very low in comparison with the reactance of C. The phase of the current driven by V through C and R in series is therefore determined almost entirely by the reactance, so it leads V by nearly 90 degrees. So it is nearly in phase, or 180 degrees out, with the e.m.f. induced in the pickup conductor by I. Provided that the length and spacing of the pick-up are right, these two voltages are equal, so the voltage between the pick-up and outer conductor is a measure of the power travelling along the line in one direction only. Power in the other direction makes the voltages cancel out, to give no reading.

It will be obvious that Fig. 3 is rather too theoretical. For one thing, if C is self-capacitance it will be distributed all along the pick-up. And what about the indicator?

Fig. 4 shows a practical design for 4 to 15 MHz, described by 0. Norgorden in U. S. Naval Research Laboratory Report No. 3538 of 1949. The coaxial line has half of the outer conductor cut away for a distance which is a small fraction of the wavelength. The screening is maintained by a surrounding metal box, inside which is installed the pick-up unit shown, differing from Fig. 3 only in C being distributed over the whole length of the conductor, and the addition of a crystal diode and microammeter as an indicator. R is of the order of 100 Ohms, and the resistance R. of the meter is chosen to give it a suitable range in relation to the r.f. power used. For purposes of analysis the distributed capacitance between pick-up and inner conductor is assumed to be concentrated at the points where the connections are made, as in Fig. 5. This assumption seems to be justified in practice. So as not to interrupt ourselves with a lot of algebra at this point, the working has been exiled to an appendix. The upshot of it all is that the condition for no meter reading, when all the power is flowing in the direction causing the inductive and capacitive responses to oppose one another, is

$$M \cdot R * C * Z_0$$

where M is the mutual inductance between the inner and pick-up conductors, C = C1 + C2, and Zo is the characteristic impedance (= V / I) of the line.

A procedure for achieving this condition is to terminate the line with an accurately matched load and feed it with power. The spacing between conductors (which determines M and C), or R, is then varied to give zero reading.
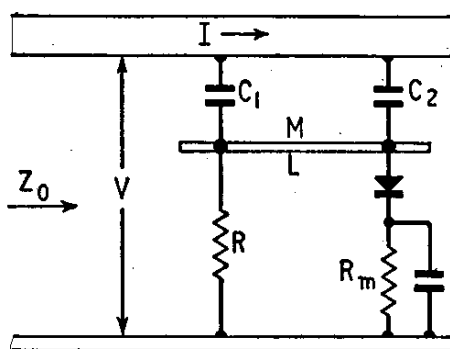
The instrument having been

Fig. 5. Approximate equivalent circuit diagram of the Fig. 4 type of reflectometer.
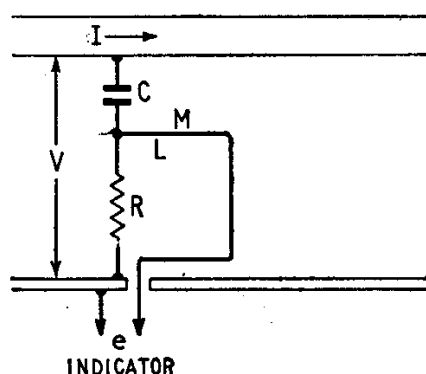
The Reflectometer

set up correctly, any reading indicates reflected power. To indicate direct power for comparison, the mutual in-

Fig. 6. Circuit diagram of loop type of reflecto-meter.

ductance must be reversed in sign. This could obviously, but inconveniently, be done by reversing the whole reflectometer in the line. The same effect is produced by interchanging R and the indicator. In the Monimatch it is done by having two reflectometer units and switching the microammeter from one to the other. Details of a constriction in which the pick-up wires are mounted end-to-end, with a common resistor R in the middle, are given by L. G. McCoy in Q.S.T., Oct. 1956, and in the 1957 A.R.R.L. Handbook, p.516. A more compact version, with separate wires lying head-to-tail on opposite sides of the inner conductor, is described in Q' S. T., Feb. 1957, and in the 1958 Handbook, p.530. A still more compact version, in which the first arrangement is adapted to a length of flexible coaxial cable wound into a hank, and balance is

obtained by varying R, is shown in the 1959 Handbook, P.530.

The other main variety is the rotatable loop type, which is tending to supersede the foregoing, presumably because it is more suitable for higher frequencies and is applicable to waveguides. It is also easier to adjust. But the differences are more mechanical than electrical. Fig. 6 shows that electrically it is essentially the same as Fig. 5, except that the loop may be shaped to put extra capacitance at one end. The algebra used for Fig. 5 can easily be adapted for Fig. 6 by putting C2 = 0 and C1 = C, and the result is the same, apart from quantities small enough to neglect. Mechanically, the loop is arranged so that it can be rotated from outside through 180 degrees. So its kinship with the d.f. aerial is more obvious.

This continuous rotability makes it easier to tell whether the capacitive and inductive couplings are

equal. If C is too small or too large in relation to M, either there will be two zero readings each side of the position where the loop lies along the line, as in Fig. 7(a), or no zero at all, (b). These diagrams, incidentally, are just cartesian versions of what come out as cardioid in the polar form (Fig. 1).

Besides being proportioned for equal capacitive and inductive e.m.fs, a reflectometer pick-up device must extend along the line for only a small fraction of a wavelength-which means a very small loop in centimetre waveguides not be large enough to cause appreciable reflection or absorption of the transmitted power itself. At the same time it must be sensitive enough to indicate small amounts of reflected power.

Suppose, for example, that standing-wave ratios at least down to 1.05 are to be measurable. That is to say,

$$\rho = 1.05 = V + v / V - v$$

Where p is the s.w.r. and V and v the voltages of the direct and reflected waves. From this we get

$$v / V = \rho - 1 / \rho + 1 = 0.0244$$

The ratio of reflected to direct power is equal to the square of this, 0.0006. The power taken by the reflectometer
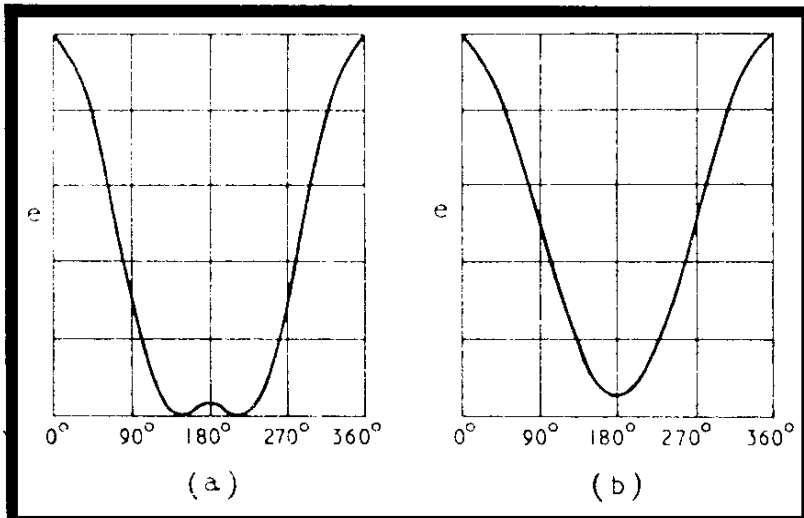
The Reflectometer

Fig. 7. Variation of response as the loop in Fig. 6 is rotated through one whole turn, with the magnetic coupling (a) too tight, (b) too loose, compared with the electric.

ought not to be more than a like fraction of this power, or 0.00000036; in other words, a loss of at least 65 dB between the lowest power to be monitored and that available for the indicator. If the reflectometer is to be used over a band of frequency there is a further loss, because the voltages picked up are proportional to the rate of change, and hence the frequency, of the wave voltage and current.

For instance, over a 2:1 frequency band the lowest frequency gives a response 6 dB less than the highest. And there is loss in the pick-up. Allowing, say, a total of 75 dB, the reflected-wave voltage picked up from 10 watts with a s.w.r. of 1.05 in a 70 Ohm line comes out at 4.7mV. This is really too small for a crystal and microammeter.

A sensitive measuring gear using a radio receiver is shown by W. H. Elkin in Marconi Instrumentation, Dec. 1956. Fig. 8 is fairly self-explanatory. It can be worked with an oscillator uncalibrated for output level, but does call for a calibrated piston attenuator with which to measure the ratio of direct to reflected power giving equal receiver output. Alternatively if an output calibrated signal generator is available the input can be varied by its attenuator to get equal receiver response with the reflectometer loop in its two set positions.
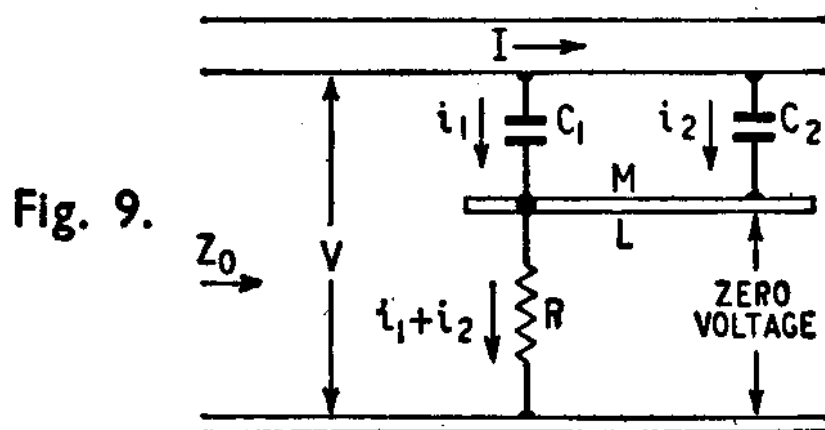
Anyone whose thirst for information on reflectometers, especially
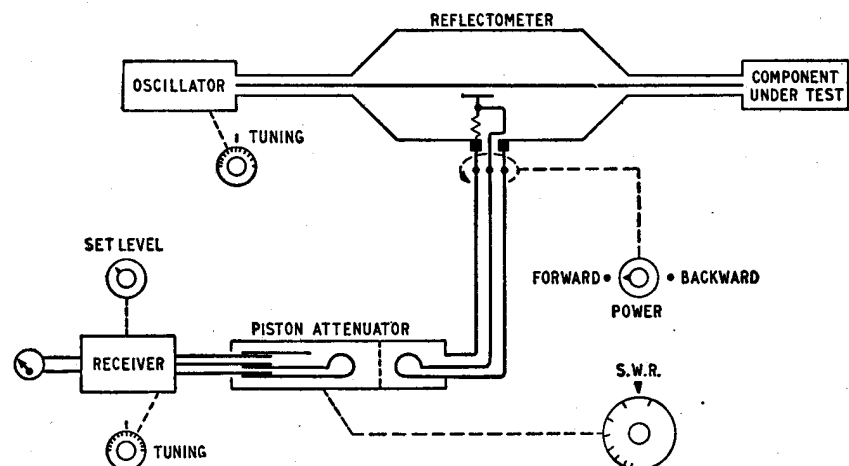
their practical details, has not yet been slaked should refer to this and other literature I have mentioned, and perhaps also an earlier paper by H. R. Allan and C. D. Curling, in Proc. I.E.E., Jan. 1949, which deals particularly with

The Reflectometer

Fig. 9.

(Continued from page 8)
10cm. waveguide technique.

APPENDIX

If the reflectometer is properly made it will give zero reading with power flowing along the line in one direction. In that case the voltage across the detector in Fig. 5 is zero and that arm of the circuit can be omitted, as in Fig. 9. The voltages across C1 and R must add up to V; the voltage across C2 must be the same; and the voltage across the rod and that across R must add up to zero:

$$i1 / j \omega C1 + (i1 + i2) R = V \quad (1)$$

$$i2 / j \omega C2 = V \quad (2)$$

$$(i1 + i2) R + i2 j \omega L - I j \omega M = 0 \quad (3)$$

$$V = I Zo \quad (4)$$

The value of is found from (2) is substituted in (1), from which i1 is found, and both are substituted in (3), where I is replaced by V / Zo from (4). After a bit of manipulation this yields :

$$M / Zo = R(C1 + C2 - C1\omega^2 LC) + j\omega(C2 L - C1 R M / Zo) \quad (5)$$

To make this possible, the "j" term must be zero; i.e.,

$$C2L = C1 R M / Zo$$

or $M / Zo = C2 L / C1 R$

The factor $w^2 L C2$ in (5) is the ratio of the reactance of L to the reactance of C2, and in practice this is much less than 1. (In other words, the pick-up is much too small to resonate at the working frequency). So C1 $w^2 L C2$ can be neglected in comparison with C1 + C2. With then amendments, (5) boils down to

$$M / Zo = C2 L / C1 R \cdot R(C1 + C2) \quad (6)$$

This states how the circuit must be proportioned if the reflectometer is to ignore waves travelling in one of the two directions through it. When the position, of the detector, or the loop itself, is reversed, in (3) is reversed in sign and a reading is given. The current in the detector circuit is then proportional to the current in the line (1) and therefore to the square root of the r.f. power. (There is, of course, mutual inductance between the pick-up and outer conductor, so M is really the coupling to the inner conductor minus that to the outer.) The type of instrument shown in Fig. 4 is reasonably well covered by (6) if C1 = C2 and C1 + C2 = C3 simplifying it to

$$M / Zo = L / R \cdot R C$$

In the loop type with capacitance concentrated mainly at one end (Fig. 6), on the other hand, C2 = 0 and C1 = C; adapting (5) accordingly gives

$$M / Zo = R C / 1 + j \omega CR$$

and since R is made much smaller than the reactance of C, $j\omega CR << 1$ and

$$M / Zo \cdot RC$$

Which is the same as with Fig. 5 except that there is no stipulation about L. Note that within the limits of the approximations the balance condition is independent of frequency, so the setting up is effective over a wide frequency band.

Note: Cathode Ray was the pseudonym used by the author.

The West Rand Amateur Radio Club
26.14122 South - 27.91870 East

P.O. Box 562
Roodepoort
1725

Phone: +27 11 726 6892
Email: john.brock@pixie.co.za

Bulletins (Sundays at ...)
11h15 Start call in of stations
11h30 Main bulletin start

Frequencies
145,625 MHz (West Rand Repeater)
10,135 MHz (HF Relay)

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Please note this has been just been registered. Our site will be up in the new year.

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	Simon			simsny@global.co.za
	Anton			anton@xglobe.co.za
	Keith	ZS6AGF	763 6929	mwbronie@iafrica.com
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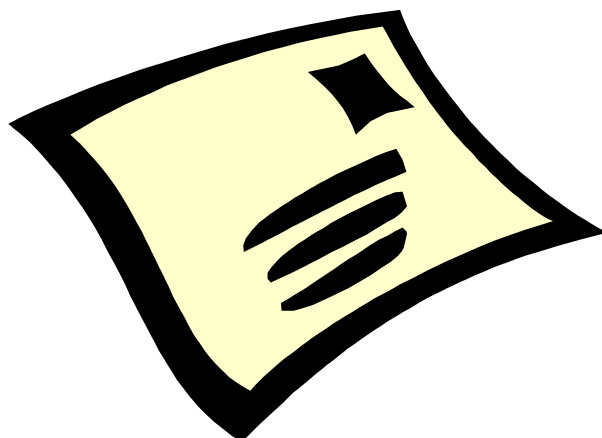
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