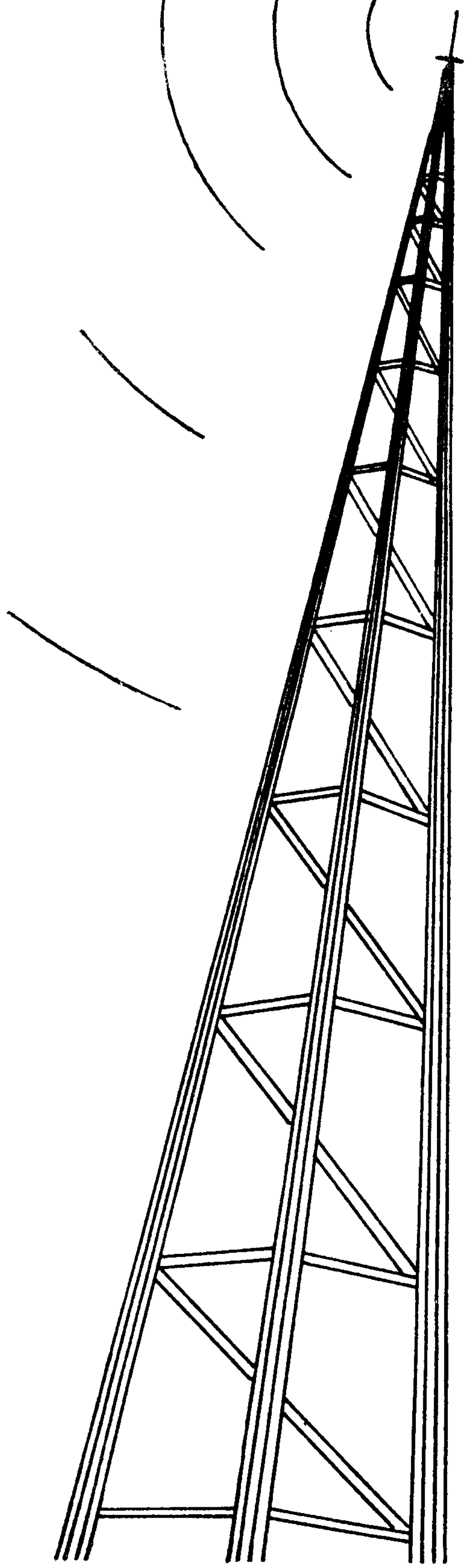
QSX PE



ZS2PE

FREQUENCIES:

Bulletin	3640 Khz 7107 Khz
National Call	145,5 Mhz
P.E. Repeater	145,05/65
Grahamstown	145,20/80
Lady's Slipper	145,10/70
Cockscomb	

Port Elizabeth Branch of the South African Radio League

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Cocoa Beach FL 32931

High Q Antennas

—stop worrying about swr

When a friend of mine once proudly told me that his ordinary eighty meter dipole had a band-edge swr of about 1.8:1, instead of congratulating him, I said, "Oh, isn't that too bad." Well, he almost flipped. But after we started to talk a bit about antenna losses, his pride turned to consternation. Actually, his antenna was an inverted V, quite low, with the ends about seven feet from the ground. There were enough trees and bushes nearby to provide losses. And, in addition, the ground was sandy, so there were losses from that, too.

When the same antenna was later relocated with a better overall height, without nearby trees and bushes, sure, his swr went up, but so did the overall antenna performance.

Although I am in favor of special antennas, such as the parallel stub double bazooka, discones, bow ties, and others that can lower swr because of their basic broadband characteristics, I am concerned at low swr in an ordinary dipole. It generally means high losses. So take a good look at lossy objects near your antenna that might be causing problems. Although any object near an antenna can induce both resistive losses and a change in the antenna reactance and Q, to simplify thinking, I will disregard such changes in reactance for two reasons. First, a change in antenna reactance is not a power loss, and, second, it would be almost impossible to predict such reactance changes in an amateur antenna system.

And that is why I thought it would be both interesting and useful to expand some basic antenna theory into a presentation that will relate antenna resistance, Q, and swr. The graphical presentation allows for easy understanding without having to delve through pages and pages of complicated mathematics that too often obscure what one is really trying to say. Radio amateurs come from all walks of life, and the high mathematics of the specialist can and always should be boiled down to a level where they are easily understood by all of us.

Now that I've decried high math, and also to prove my point, I'll show how simple, easily understood and explained calculations will be used for those who want to do a bit of figuring on their own. Specific calculations will be shown for those who have rf bridges and would like to translate their measurements into useful information. My calculations will show rf bridge measurements can easily be translated into swr and Q. And, by showing how the curves were derived, you should understand them a bit better.

Conditions and Stipulations

In order to keep the basic math and concepts as simple as possible and yet not lose the overall concept of the presentation, the following conditions and stipulations are made.

1. A basic eighty meter dipole, resonant at 3.75 MHz, will be used as reference. Its characteristics will be described as a simple series circuit with R being the antenna resistance at resonance. The antenna inductive reactance will be shown as X_l, and the capacitive reactance will be shown as X_c.

2. It will be assumed that the antenna resonant resistance will stay the same over the entire band. It does vary to some degree, but this assumption is quite common in simplified antenna analysis.

3. The swr values will be shown for the band-end condition of 3.5 MHz. The values of swr at 4.0 MHz, if calculated, would be found to be slightly lower, but this in no way invalidates the aim of understanding concepts.

4. Q is designated as antenna inductive reactance divided by antenna resistance at the resonant frequency, which, as I said, was chosen to be 3.75 MHz.

5. A feedline impedance of fifty Ohms will be used for

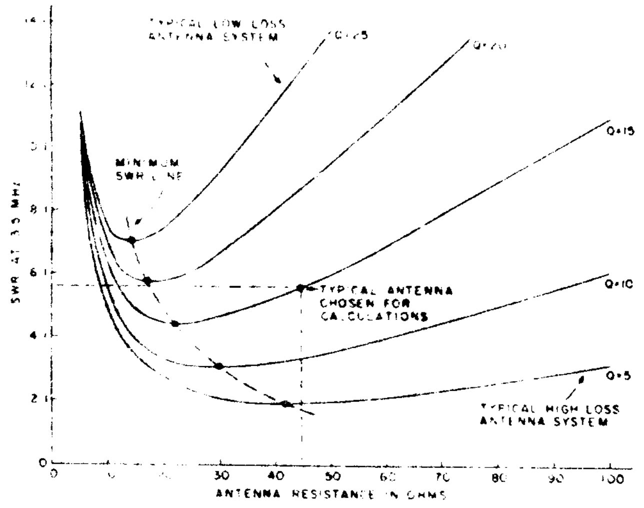

Fig. 1.

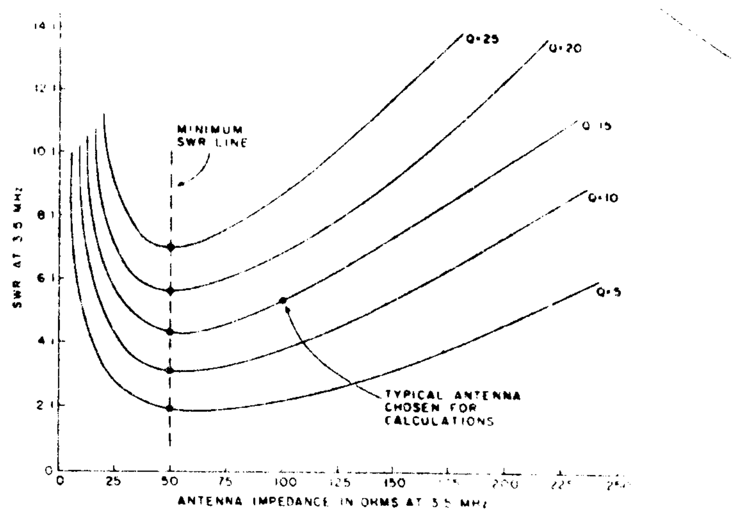

Fig. 2.

the Q curves, Q equals 5 to Q equals 25, shown. Fifty Ohms was chosen, as that is the value of feedline impedance used by most amateurs. However, an additional curve will be shown for a specific stipulated antenna to show how swr can vary with feedline impedance for a given aerial. The specific antenna will be the same as the one chosen for the calculations, namely one of 44 Ohms resistance with a Q of 15, which means an antenna with a resistance of 44 Ohms and a capacitive reactance of 91 Ohms at 3.5 MHz. By using a specific antenna with numerical values, it will be very simple to show how rf bridge antenna measurements can be translated into swr and Q later on.

Losses and Swr

If you could conveniently neglect antenna losses, you would realize that a low swr antenna has several advantages. Low swr means that the loss in your feedline is a bit less for the same power transmitted at a high swr. Low antenna swr also means that it is much easier to match your transmitter which is designed for a 50-Ohm load into your 50-Ohm antenna feed system. And, if your transmitter does not have good matching capability at high swr loads, this can mean, in some cases, lowered equipment efficiency. And, also, a high swr can cause excessive voltages and currents to be developed in your transmitter. So low swr does have advantages. But, if your low swr is obtained by a lossy antenna system, you haven't gained anything. You are actually losing some of your power to trees, bushes, roofs, or what have you. So low swr isn't always the blessing you might have thought it to be.

You know that Q in a tuned series circuit is both a figure of merit and also a function of selectivity. Also, briefly, the lower the Q, the less the selectivity. If you think of the Q of an antenna circuit, you realize that the antenna resistance is not just a loss resistance. The antenna resistance is made up of two components: a radiation resistance, which is desirable, and a loss resistance, which is undesirable. Like a tuned circuit, the lower the resistance, the higher the Q, and the higher the Q, the higher the selectivity. High selectivity means a high swr. So basically, the higher the Q, the higher the swr. And, all things being equal, the higher the Q, the less your losses, and the more efficient your antenna is. Antenna losses from outside sources are coupled into your antenna just like the resistance that can be coupled into a tuned circuit. Although complicated engineering measurements and calculations can be used to differentiate between useful radiation resistance and useless loss resistance, such an analysis is far beyond the scope of this article. To emphasize the desirability of keeping losses down, don't worry about a high swr. It means that, if your antenna resonates properly at your center frequency, your band-end swr just shouldn't worry you. But if it's low, you had better start looking at what the causes are.

The Graphs

And now to look at what the curves tell. Fig. 1 is a plot of antenna resistance versus swr for five different values of Q. The curves are shown for the band end of 3.5 MHz. One thing is immediately apparent – the lower the Q, the lower the swr, and the higher the antenna losses. You also see that, for a specific value of antenna Q, there is one value of antenna resistance that gives the lowest possible value of swr. And you also see that two different antennas both having the same value of Q can have differing values of swr. To show this point, I'll pick off some values from the Q-equals-15 curve. At an antenna resistance of 44 Ohms, you have an swr of 5.6:1. But, if the antenna resistance drops to 21.75 Ohms, the swr drops to 4.38:1. If the antenna resistance was to drop even lower, the swr would increase.

Although the factors of Q and antenna resistance are not readily controllable in an ordinary dipole antenna, it clearly shows that differing antenna systems can show differing values of swr. In addition, you know that antenna resistance among other things is dependent upon height. This is why it is impossible to make any broad generalizations about swr. That's all the more reason it should be more thoroughly understood.

On Fig. 1, you can, as a matter of interest, connect the points of minimum swr for the various Q curves and see how minimum swr relates to Q and antenna resistance. As a further interesting item, I'll say now and later show that, at all of these points of minimum swr, the antenna impedance at the band end of 3.5 MHz is fifty Ohms. And this value of impedance is the same numerical value of the feedline which I had established as fifty Ohms as the reference. But it is very necessary to say numerical value, as the antenna impedance, as you shall see, is a complex quantity made of resistance and reactance. It is only at the resonant frequency that the antenna ever looks like a pure resistance.

If, for example, you took

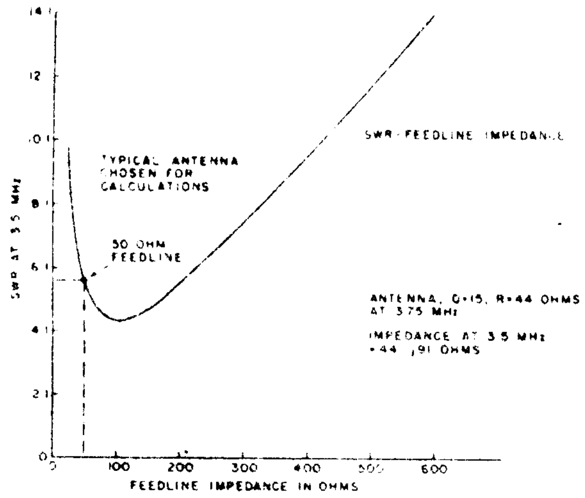

Fig. 3.

the point of minimum swr on the Q-equals-15 curve and measured the impedance at 3.5 MHz, you would find it to be equal to R equals 21.75 Ohms and X equals 45.1 Ohms capacitive reactance. The absolute value of the impedance Z equals:

$$\sqrt{R^2 + X^2} \text{ equals } \sqrt{21.75^2 + 45.1^2}$$

equals 50 Ohms impedance. And you would find that the swr at this impedance would be 4.38:1. To show this relationship even more clearly, Table 1 indicates all of the relevant data for different values of Q. Fig. 2 shows a plot of antenna impedance Z versus swr for the Q curves.

The curves of Fig. 2 and the data of Table 1 tell that, even though the impedance is fifty Ohms for the minimum value of swr, you have to think about the resistance and reactance values rather than just the impedance Z. At the low swr, low Q, the antenna has a predominantly resistive component. At the high Q-curve, the antenna is predominantly reactive. It also tells that, if you want to make any meaningful antenna measurements, you will need a bridge that can measure both R and X. A bridge that will only measure the absolute quantity Z can very easily lead to erroneous conclusions. But simple rf bridges to measure R and X can be easily built or obtained commercially. There is nothing more conducive to learning about antennas than making your own measurements and calculations and analyzing the results.

Conclusions

The curves themselves show the various interrelationships between Q, swr, and antenna resistance along with the concept of a minimum swr. It is now clear that a low swr on an ordinary dipole means a lossy antenna system, and also that a low swr is really not something to be proud of. A high-Q antenna

R	X	Q	swr	Z
10	48.99	35.47	9.90	50
15	47.70	23.03	6.51	50
20	45.825	16.59	4.79	50
25	43.3	12.54	3.73	50
30	40	9.65	3.00	50
35	35.71	7.38	2.46	50
40	30	5.43	2.00	50
45	21.79	3.50	1.60	50

Table 1. This table shows minimum swr values of different antennas of varying Q at the band edge of 3.5 MHz. It indicates how widely the values of X and R can vary, even though the impedance looking into the feedline antenna system is 50 Ohms (complex impedance) in each case.

Fig. 4.

would be far more praiseworthy. Get off the low swr kick, and think about high Q and antenna efficiency. You'll find it pays off. High swr can be handled by means of a simple antenna coupler or matchbox, if your transmitter doesn't load out properly without one. Or, as I mentioned, specialized antennas designed to give broadband performance, such as the parallel stub double bazooka (August, 1977, *73 Magazine*), the discone, or the bow tie, can be utilized. The curve of Fig. 3 is important in that it shows the relationship of swr to feedline impedance for a specific antenna. The antenna values chosen are 44 Ohms resistance and a Q of 15. This means a band-end impedance of 44 Ohms resistance and 91 Ohms capacitive reactance at 3.5 MHz. You see that, at a feedline impedance of fifty Ohms, the swr is 5.6:1. But, if a feedline impedance of 600 Ohms is used, the swr goes up to 13.95:1. And yet the antenna is the same in both cases. This shows one other variable that can affect your swr value.

It is hoped that these observations will lead to a better understanding of why a dipole often acts as it does and also that they will encourage the experimentation that is really a fun thing in our fascinating hobby of amateur radio.

Calculations

Let's first draw a simple dipole antenna at resonance at 3.75 MHz and represent it as the series circuit of Fig. 4. If you assume a resistance of 44 Ohms and a Q of 15, it is easy to calculate the inductive and capacitive reactance in Ohms: $X_l = X_c = Q \cdot R = (15)(44) = 660$ Ohms.

Now, if you tune the antenna to 3.5 MHz, the

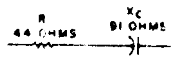

Fig. 5.

inductive reactance will decrease to: $X_l = (660)(3.5 \text{ MHz}/3.75 \text{ MHz}) = 616$ Ohms.

And the capacitive reactance will increase to: $X_c = (660)(3.75 \text{ MHz}/3.5 \text{ MHz}) = 707$ Ohms.

And the difference equals: 707 - 616 = 91 Ohms capacitive reactance.

So the antenna at 3.5 MHz will look like Fig. 5.

The absolute value of antenna impedance will be equal to Z:

$$Z = \sqrt{R^2 + X^2} = \sqrt{44^2 + 91^2} = 101 \text{ Ohms.}$$

The swr is calculated from the basic equation: swr = $(|Z_a + Z_c| + |Z_a - Z_c|) / (|Z_a + Z_c| - |Z_a - Z_c|)$, where Z_a is the antenna impedance and Z_c is the feedline impedance. The notation | | actually means $\sqrt{R^2 + X^2}$ as you shall see when you put actual numerical figures in. The specific value of antenna impedance will be: $Z_a = 44_R$ and 91_X. I have identified the four parts of the swr equation as (1), (2), (3), and (4), as follows, to make the calculations easy: (1) $|Z_a + Z_c|$; (2) $|Z_a - Z_c|$; (3) $|Z_a + Z_c|$; and (4) $|Z_a - Z_c|$. So (1) equals $Z_a + Z_c$, and Z_c, the feedline, is 50_R. (1) of the swr equation $= |44_R - 91_X + 50_R| = |94_R - 91_X|$. This equals

$$\sqrt{94^2 + 91^2} = 130.8.$$

And, also, (1) equals (3).

Now, if you put in figures for items (2) and (4) of the swr equation, you see that (2) = (4) = $|Z_a - Z_c| = |(44_R - 91_X) - 50_R| = |-6_R - 91_X|$. Evaluating, you see that this equals $\sqrt{6^2 + 91^2}$, which equals 91.2 = (2) = (4).

Now, putting (1), (2), (3), and (4) in the swr equation together, you see that swr = [(1) + (2)]/[(3) - (4)] = (130.8 + 91.2)/(130.8 - 91.2) = 222/39.6 = swr = 5.6 at 3.5 MHz.

So you see that it really isn't difficult to calculate swr if you know the resistance

On the local scene we find that Marge ZS2OB has once again pressed the tri-bander into service and is chasing the DX once more.

Andre ZS2BK is also after that elusive DXCC with his recently purchased beam. Several new VHF rigs recently arrived in Port Elizabeth and surrounding areas. Paul ZS2PR is eagerly awaiting the arrival of his new Kenwood as is Selwyn his FT 101.

Sheila has relinquished her ZR call and is now ZS2BF - this stands for "beautiful female" and nothing else! Breda ZR2BW is on the air from Kareedouw using the latest rig from Yaesu and a vertical. A yagi is on the drawing board.

Brian ZS2TY and XYL Sheila recently returned from a short holiday in Div 1. Le Fras ZS2TW and XYL Marie also spent some time near Cape Town.

Brian ZS2GF will shortly be entering the white house in Cape Town for further treatment to his leg. We wish him a speedy and complete recovery.

THE NEXT MEETING OF THE PORT ELIZABETH BRANCH OF THE S.A.R.L. WILL BE HELD ON FRIDAY 16 FEBRUARY AT 8PM. THE VENUE AS USUAL WILL BE THE Y.M.C.A.

IMPORTANT.

The March meeting will feature a guest speaker, OM Tom ZS2TC.

Tom is better known as Major-General T.Cockbain. who is an expert in radar and air defence systems. His talk will be on - "Radar and Electronics. and the air defence of South Africa" This promises to be an extremely interesting evening so make a note in your diaries or on your calender. As a last resort tie a knot in something.

John ZS2JR will be back in P.E. on Monday 19th and it is hoped that he brings with him news of a solar panel from the U.S.A.

Copies of the R.S.G.B. publication "Radio Communication" covering the lsat four or five years were donated by Dudley ZS2AW and will be available for the taking at the meeting.

and reactance of your antenna at 3.5 MHz and know what your feedline impedance is.

The only remaining thing to do is to show how you can calculate the antenna Q. To simplify things, you will have supposedly measured the antenna resistance as 44 Ohms and its reactance as 91 Ohms at 3.5 MHz. By means of the easily derived equation below, you can, with this information, determine the reactance of the antenna at resonance. The equation is as follows: X_1 at 3.75 MHz = [($X_{3.5}$) (3.5 MHz) (3.75 MHz)] / [(3.75 MHz + 3.5 MHz) (3.75 MHz - 3.5 MHz)].

So X_1 at resonance = (91) (3.5) (3.75) / (7.25) (.25) = 660 Ohms.

Knowing that, $Q = X_1/R$ = 660/44 = 15 = antenna Q.

So you see that, with the information given, it will be readily simple to calculate swr and antenna Q if you know the measured values of R and X.

This article has not taken into account line losses, as this would perhaps complicate the general approach desired. But briefly, line losses will decrease both swr and Q values calculated. It is realized that some of the calculations can be done by means of Smith charts. However, as simple hand calculators are almost in common use by all amateurs, I felt that the approach used here would show how to actually do calculations, instead of teaching the specialized approach of the Smith charts. And, lastly, very few amateurs actually have Smith charts in their possession. As the calculations are of value only to those amateurs who have rf bridges, I felt that the general approach would give the most information to most amateurs reading this article. Math is only essential for those who actually are going to use it. It is not necessary to understand general principles. ■

SPEED TRAPPING: Presumed Accuracy

ON 3 March 1978 a significant event took place in the world of speed trapping. Details of five speed measuring devices (or velocity meters) were promulgated in Government Gazette Notice R389 and, in terms of the 1977 Criminal Procedure Act, were from that date on presumed to be accurate.

In terms of the promulgation, an affidavit stating that the prescribed conditions in trapping a speeding car had been fulfilled would be sufficient to prove the car had travelled at a certain speed.

Should the driver dispute the issue, the onus would rest on him to prove to the Court that the instrument with which he was trapped was faulty.

At the time the AA reserved its position by stating publicly that it did not oppose the principle of presumption in this case provided there were built-in safeguards for the innocent motorist. Events were to prove how necessary these safeguards were, as soon after, the AA became involved in a speeding case which was to have country-wide repercussions. Tests conducted by the AA showed that high-powered radio frequency transmissions could produce inaccurate readings in a velocity meter which, it should be noted, was not one of the gazetted five. Although this was dismissed initially as being due to the poor condition of the apparatus, subsequent tests under controlled conditions supervised by experts showed conclusively that the first was not an isolated case.

On the strength of this evidence the AA approached the Department of Justice for its assurance that the five velocity meters deemed to be accurate in terms of the law would not be susceptible to similar interference. Until such assurance could be given, the AA requested that the presumption clause should be lifted or that the velocity meters concerned should be removed from the list. At the time of writing this report this assurance is still awaited.

The AA also requested that all relevant particulars concerning the velocity meter operation be noted on the traffic ticket. Law authorities have pointed out that motorists should in any case obtain whatever additional information they require through their own observations and by asking the operator of the velocity meter at the scene of the alleged offence. The conditions and requirements are lengthy and not always easy to follow or verify.

Hence, for the benefit of motorists, a summary of the various conditions and requirements are set out below. For the complete picture, however, members should examine the original Government Gazette or consult their attorneys or nearest AA office.

Velocity meters: checks and verifications

Motorists should note all general and relevant weather conditions, such as day or night, sunshine, rain, etc. as well as the actual location of the velocity meter in relation to the road and other features.

Ascertain whether the velocity meter used in the speed trap is prescribed in terms of the above Government Gazette. If so, it will be deemed accurate unless it can be shown that any of the following conditions and requirements have not been complied with:

1. **All velocity meters**

1.1 Check whether the velocity meter used is activated by radar or sensor (twin cables across the road.) There are three radar meters, and two sensor meters. (See para 1.5)

1.2 Each meter should be identical in all functional respects to a similar meter submitted to the S A Bureau of Standards for testing.

1.3 Each meter should be overhauled at least every six months and a certificate must be issued to this effect.

1.4 Comparison tests with another velocity meter should be made before and after each series of measurements at the measurement site. Readings obtained from the two meters should not differ by more than 3 percent.

1.5 Each meter should be tested before every measurement by operating the test button or knob as follows:

Radar Meter	Tuning Fork	Test Readings
DIGIDAR 1-K	96 km/h	188 km/h 96 km/h 96 km/h
MUNIQUIP T3	100 km/h	100 km/h 25 km/h 100 km/h
NOVA DRS-1/StG-O	60 km/h	100 km/h 188 km/h 60 km/h

Sensor Meter	Test Readings
Truvelo M4	Between 172,9 km/h and 176,5 km/h
Speedguard de Luxe	Between 101,1 km/h and 103,4 km/h

▶46

SPEED TRAPPING

(From page 44)

1.6 The method of connecting and operating the meter should be in accordance with manufacturers' instructions.

1.7 The meter should be operated in a well-ventilated position and should not be exposed to direct sunlight. This does not, of course, apply to the sensors and connecting cables.

1.8 The operator of each meter should be thoroughly trained and should have a certificate to prove this.

1.9 The meter should not be used in circumstances in which, to the knowledge of the operator, there is any factor (extraneous to the meter) which could affect the reliability of the readings.

1.10 No radio transmitter may be used by the operator or his assistant while a measurement is being taken.

1.11 Not more than one vehicle may proceed between the sensors or, in the case of a radar meter, within the field of measurement, while a reading is being taken.

2. **Radar Meters**

2.1 Each radar meter should be aimed along the intended measuring site and the effective field of measurement should be established. The places where readings first occur and cease must be marked.

In the cases of Digidar and Muniquip, the angle of measurement in relation to the centre-line of the road should be not less than 10°. In the case of Nova this angle should be not less than 22,5°.

2.2 No radar meter may be operated while its antenna is inside the body of a car or if there is any obstruction between the antenna and the vehicle being measured.

3. **Sensor Meters**

3.1 The sensors should be installed on a straight section of road with a reasonably even surface.

3.2 Sensors should be installed parallel to each other and at right-angles to the centre line of the road. The method of setting out is prescribed and motorists should enquire how this was carried out.

Truvelo sensors should be exactly 1,50 metres and Speedguard 2,50 metres apart, measured by means of an assized bar.

3.3 When sensors are secured across the road they should be tensioned by means of an assized spring-balance gauge to 10N per metre of unstretched length.

3.4 Sensors may not span two lanes of traffic proceeding in opposite directions.

3.5 In the case of the Truvelo meter, a built-in memory facility for storing readings may not be used.

3.6 Should photographic equipment be used in conjunction with the Truvelo meter, the relevant speed reading and the vehicle measured should be photographed simultaneously on the same frame.

Other factors

What of other factors which could affect the readings of a velocity meter? For example, it has been established that if figures are called out, errors could occur in the process of reading and calling them out. Further prospect of error occurs when the same figures are heard and written down. The problem of oral communication is especially serious in South Africa where our two languages have a different order of expressing tens and units. A common error, for example, is the number 79 written as 97 and vice versa.

Dr J D Kies, Director of the Institute for Statistical Research (of the Human Sciences Research Council) asserts that there is an appreciable probability of error obtained in this way in South Africa.

The AA feels this is something the Courts should take a keen look at. In the meantime motorists are advised to consider the possibility of this type of error if the difference between their true speed and the alleged speed happens to be a multiple of nine.

Finally, speed limits are law and motorists are advised to abide by them and not to assume or rely on the possibility that instruments are henceforth inaccurate as the result of radio interference.

"Be on the safe side — don't speed!"

INTERNATIONAL R.A. BEACON PROJECT: CONTINUED.
I.B.P. (28 mhz)

STATION	FREQUENCY IN USE In Use	 Proposed	LOCATION	REMARKS.
VK8	270		Australia	Planning stage.
	272			
	275			
W6IRT	28,888		U.S.A.	Unofficial
ZE2JV	28,332		Salisbury Rhodesia.	

Most beacons identify once a minute.
Only EA2OIZ identifies call 6 times every $3\frac{1}{2}$ minutes with a long carrier between call sign.
The mode is generally F.S.K.
Mainly omnidirectional antennae are use with the rigs generally low-powered from 10 to 50 watts.

Reports may be sent to Alan G3DME
"Altadena"
Southview Road
Crowborough, Sussex. ENGLAND.