HAM TIPS

RCA

A PUBLICATION OF THE RCA TUBE DIVISION

Vol. XVI, No. 4

December, 1956

VISUALIZING SWR

'SWR Circle' Clarifies Mistaken Theories

By Morton Eisenberg*, W3DYL

Most amateurs have a working knowledge of Standing Wave Ratio (SWR) and are aware that it is preferable to have minimum SWR on feeders so that power lost in the antenna feeder is kept to a minimum. However, this writer has heard numerous remarks on the air which indicate that many theories exist on the subject of how the SWR can be varied, including the erroneous idea that SWR can be varied by changing the length of the feeder.

To help clear the air of such misinformation, this article contains a graphical presentation of the relationship between the SWR on a transmission line and the length of the line. The presentation, usually referred to as the "SWR Circle," shows how the feed-point impedance can be found when the SWR and electrical length of the transmission line are known.

The SWR on the transmission line between the transmitter and the antenna coupler, "A" in Figure 1, can be varied by tuning and adjusting the coupler by inserting a device such as an impedance bridge in the "A" line. In this manner, a "flat" or nonresonant line (SWR = 1.0) can easily be realized.

The SWR circle applies to the "B"-line. coupler to antenna or, if no coupler is used, transmitter to antenna. Although optimum tuning of the transmitter and coupler assures that the maximum rf power is being transferred to the feeder terminals, it has no effect on the SWR.

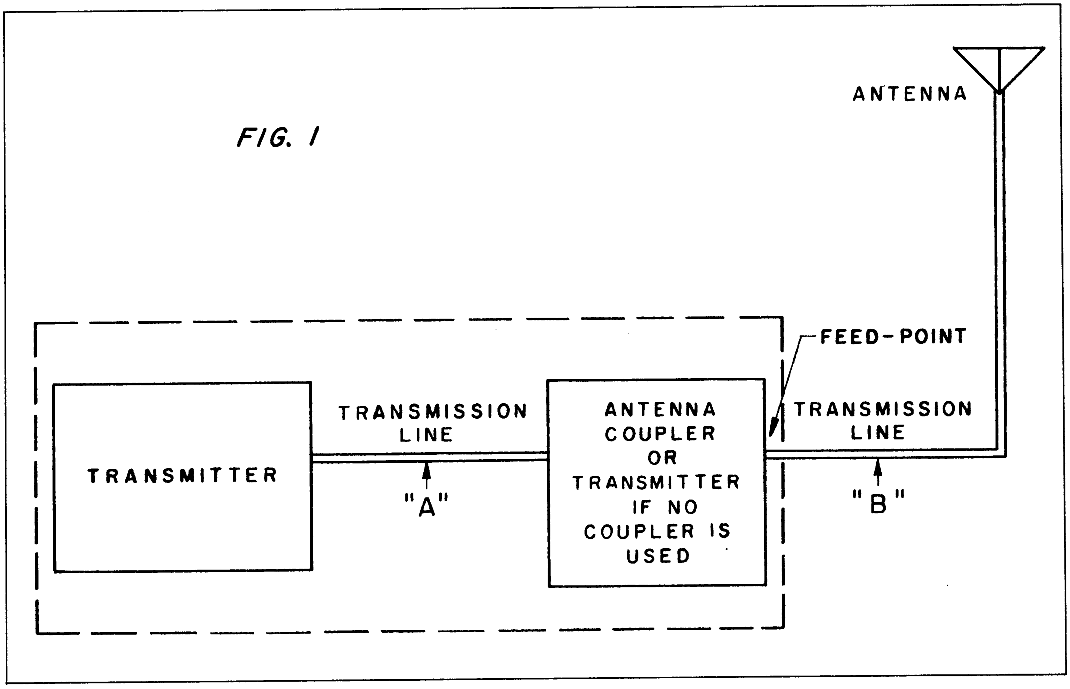
*Defense Electronic Products Division, Camden, N. J.

In Figure 2, the SWR circle is plotted for a 52-ohm cable. Similar SWR circles can be drawn for any other cable characteristic impedance and the procedure will be described later in this article.

Referring to Figure 2, suppose an SWR of 2:1 is measured on the "B"-line because a 52-ohm coaxial feeder is terminated by a 26-ohm resistive antenna impedance. Depending on the feeder length, the feed-point impedance could be 26 ohms resistive at Point X, 104 ohms resistive at Point Y, or any one of the infinite number of complex impedances, such as Point Z. Point Z represents a feed-point impedance of 65 ohms resistive in series with a 39-ohm inductive reactance. The convenient way to write this mathematically is: $65 + J39$.

Point X is the feed-point impedance which is found when there is no feeder, or when the feeder length is equal to a half-wavelength or any multiple of a half-wavelength. Point Y is the feed-point impedance when the feeder is equal to a quarter-wavelength or odd multiples of a quarter-wavelength. The feed-point impedance at Point Z is due to the feeder length being equal to one-eighth-wavelength.

It should now be clear that varying the length of the feeder cannot vary the SWR on the "B" line, nor can it vary the feeder losses per foot. When the feeder length is increased, simply "go around the SWR circle" in a clockwise direction. Remember that one full trip around the SWR Circle is equal to a half-wavelength of feeder.



The use of different feeder lengths to obtain variation in feed-point impedance is known to hams as "pruning the feeder to get the antenna to load." "Pruning the feeder" is sometimes necessary because of the limited impedance-matching capabilities of the coupling circuits. In this manner, a feed-point impedance which will more easily match the feeder to the transmitter (or coupler) can be obtained. *It is important to note* that although the feeder length has been changed, the SWR remains constant. You are simply going to another point on the SWR circle.

The SWR on transmission line "B" can be adjusted for minimum only by doing one of the following: (1) changing the transmitter frequency, (2) adjusting the length of the antenna element or elements, or (3) adding or adjusting a matching device at the junction of the antenna and the feeder.

Adjusting SWR for Receiver Feeders

The SWR situation on the receiver feeder is slightly different from the problems arising in transmitter feeders. In this case, the SWR is a result of a mismatch of the input impedance of the receiver and the characteristic impedance of the feeder. Consequently, the SWR can be adjusted to 1.0 by the use of a coupler at the input terminals of the receiver. This coupler is only necessary, of course, if the input impedance of the receiver is not equal to the characteristic impedance of the feeder.

Other SWR Circles

For various cable characteristic impedances, SWR circles can be drawn by the procedure in the following example:

To draw a circle where the SWR = 3:1, with a 300-ohm line, the circle would cut the 100-ohm point $\left(\frac{300}{3} = 100\right)$ and the 900-ohm point (300 x 3 = 900) on the horizontal axis. The center to be used for the compass would be $\frac{900 + 100}{2} = 500$. Setting the compass to a distance equivalent to $\frac{900 - 100}{2} = 400$ units, with 500 as the center, will complete the job.

The SWR circle is an extremely simple method of visualizing the effect of an antenna-to-line mismatch on the feed-point impedance. It is also an easy, more understandable way of showing that varying the feeder length is a futile way to minimize losses. The SWR (or the loss) remains unchanged. To accomplish a change in SWR (or to eliminate a line loss) for any specific frequency would require a climb up to your "sky-piece."

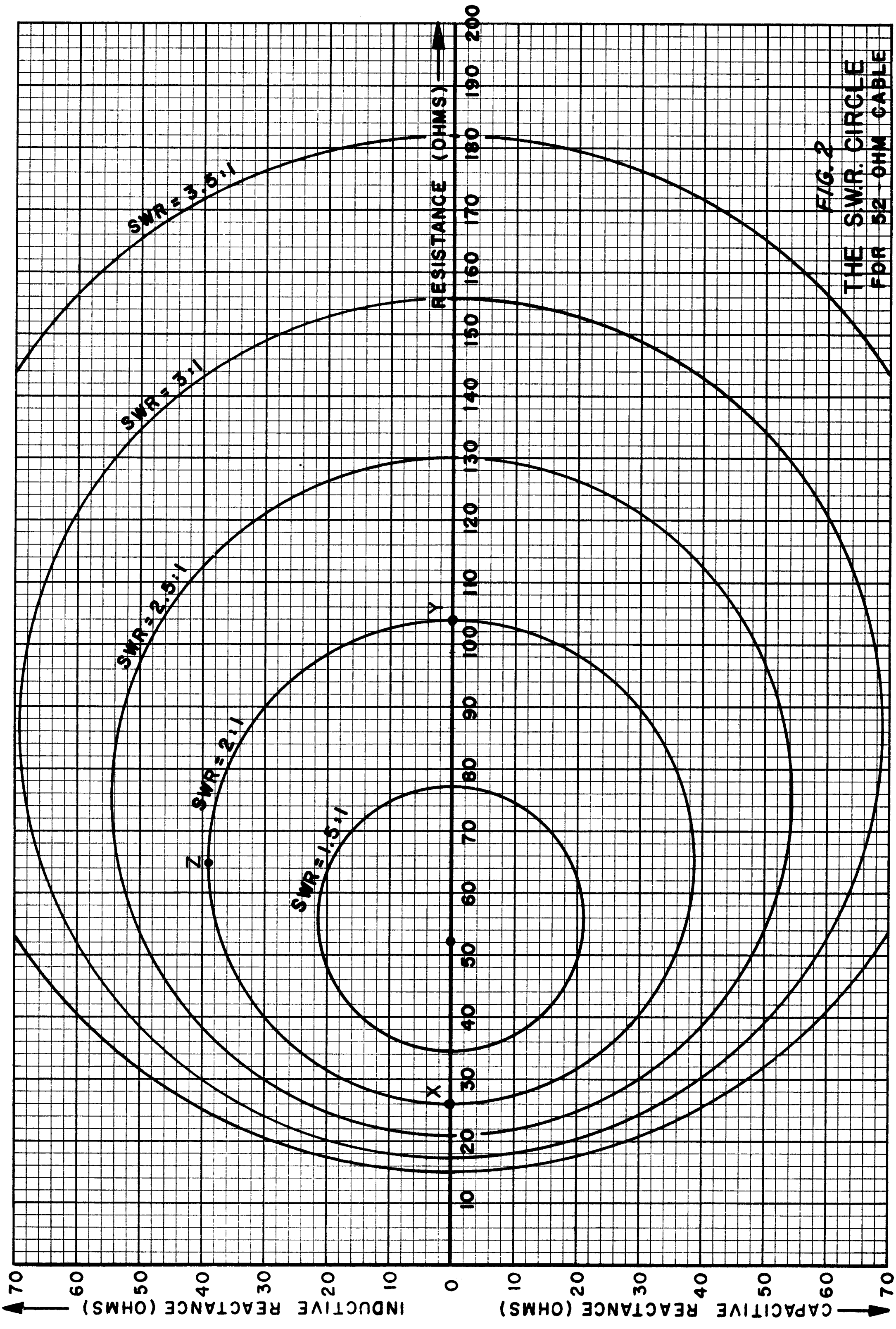


FIG. 2
THE S.W.R. CIRCLE
FOR 52 OHM CABLE

WHEN MAILING
PLACE POSTAGE HERE

Tmk(s) ®

From your local RCA distributor, headquarters for RCA receiving and power tubes.

RCA HAM TIPS
is published by the RCA Tube Division, Harrison, N. J. It is available free of charge from RCA Distributors.

•

Harvey Slovik, Editor
Robert Leedy,
Technical Editor

FORM 3547 REQUESTED