SECTION 2
THEORY OF OPERATION

1. TRAVELLING WAVE VIEWPOINT

The best way to visualize the THRULINE idea is from the TRAVELLING WAVE viewpoint on transmission lines, which illustrates that the voltages, currents, standing waves, etc., on any uniform line section are the result of two travelling waves:

FORWARD WAVE travels (and its power flows) from source to load, and has RF voltage E and current I in phase, with $E/I = Z_o$.

REFLECTED WAVE originates by reflection at the load, travels (and its power flows) from the load to source and also has an RF voltage $\mathcal{E}$ and current $\mathcal{I}$ in phase, with $\mathcal{E}/\mathcal{I} = Z_o$.

Note that each component wave is mathematically simple, and is completely described by a single figure for power, for instance:

$\overset{\backslash F/}{W}$ = Watts Forward = $E^2/Z_o = I^2 Z_o = EI$

$\overset{\backslash R/}{W}$ = Watts Reverse = $\mathcal{E}^2/Z_o = \mathcal{I}^2 Z_o = \mathcal{E}\mathcal{I}$

Z_o is the characteristic impedance of the uniform line, and simplifies matters by being a pure resistance, usually 50 ohms, for useful lines. The main RF circuit of the THRULINE is a short piece of uniform air type line section, whose Z_o is a very accurate 50 ohms, in which correct measurements may be made.

2. COUPLING CIRCUIT

The coupling circuit which samples the travelling waves is in the Plug-In Element. The circuitry of the Element and its relationship to the other components of the THRULINE are illustrated in the schematic diagram, Figure 2-1. Energy will be produced in the coupling circuit of the Element by both mutual inductance and capacitance from the travelling RF waves of the line section. The inductive currents will, of course, flow according to the direction of the travelling waves producing them. The capacitive portion of these currents is naturally independent of the direction of the travelling waves. Therefore, assuming that the Plug-In Element remains stationary, it is apparent that the coupling currents produced from the waves of one direction will add in phase, and those produced from waves of the opposite direction will accordingly subtract in phase. The additive or "ARROW" direction is, of course, assigned to the forward wave.

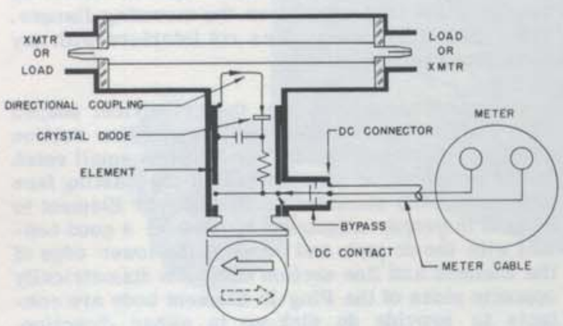

Fig. 2-1. Schematic Diagram

The electrical values of the Element circuits are carefully balanced and so designed that the current produced from the reverse wave will cancel the other almost completely. The resultant is a directivity always higher than 30 dB, which means that the Element is highly insensitive (nulled) to the "REVERSE" direction wave. Being highly directional, the THRULINE Element is sensitive (at one setting) only to one of the travelling waves which produces standing waves by interference. THRULINE measurements are therefore independent of position along standing waves. It may be said that the THRULINE doesn't know, doesn't care, and doesn't need to care where it is along a standing wave.

3. STANDING WAVE RATIO vs. REFLECTED/FORWARD POWER RATIO

As mentioned above, the THRULINE technique uses the TRAVELLING WAVE viewpoint to measure most of the outstanding facts about transmission line operation. Another widely used and related viewpoint, is the STANDING WAVE, which is quite elaborately developed both mathematically and in existing equipment. This technique can be traced to the early development of slotted lines as tools of exploration.

The slotted line is a standing wave instrument, and emphasizes this viewpoint. However, the slotted line is too long, too expensive if good, not portable, and slow in operation. These objections increase rapidly as the frequency drops below 1000 MHz. Whereas the THRULINE is surprisingly quick, convenient, and accurate by comparison. With the exception of phase angle reflection (distance, load to minimum) it tells everything a slotted line will.

The relationships between TRAVELLING WAVES and STANDING WAVE viewpoints are given in most high frequency textbooks.