TWO TYPES OF WAVEGUIDE SWITCHES

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In the design of Century Electronics' multiple function test set, the problem of waveguide switching between the various functions arose. The problem could have been solved by using sheer force, but space, weight, and economic requirements ruled out this approach. A study was accordingly made to see if new techniques could be used, and from this study two useful types of switches evolved.

Before describing the techniques used it will be well to outline the general approach. The requirements of various switching systems are seldom the same, and the manufacturer of switches, as with any other components, must therefore anticipate all the possible features a customer might desire. In the manufacture of a complete equipment, however, the designer can use shortcuts with relative unconcern and thus save time and trouble.

Feature number one in this design was that isolation from an arm in use to an idle arm did not have to be more than about 20 db. Secondly, the isolation from the inside of the waveguide structure to the outside was to be as large as possible. The third feature was that three decibels could be sacrificed on some of the functions, provided, of course, that the exact amount to be sacrificed was known (plus or minus some tolerance).

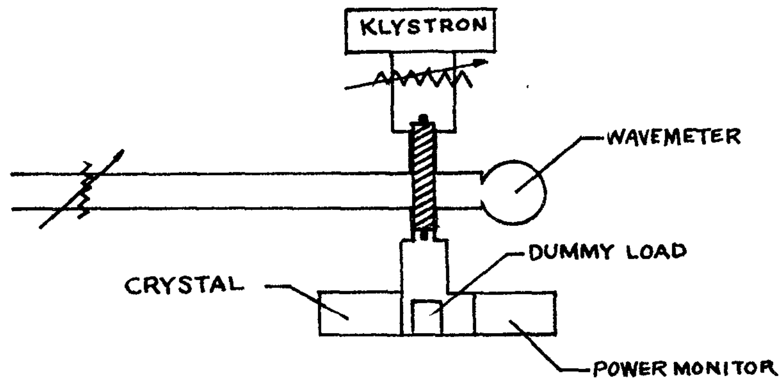

Figure 1

Figure 1 shows the first of the two switch arrangements evolved. On the left of the drawing is the input-output flange with the precision calibrated attenuator. In the center is the switch chamber with its dielectric slug. It may be slid up between the oscillator section and the center chamber or may be slid down between the center section and the crystal mount-power monitor section. The steps on the end of the dielectric section are matching sections. If the tubes connecting the three sections are well below cutoff for the frequencies used when the dielectric is air, the choice of an appropriate low loss high dielectric constant material will then cause these holes to be substantially above cutoff. It is clear that such a device can be used successfully over a limited band of frequencies, but it is not generally recognized that even as wide a band as 8500-10,000 megacycles per second can be covered rather easily.

The obvious choice is to use as high a dielectric as possible consistent with losses, availability, costs, etc. -- for example, fused quartz with a dielectric constant of 3.8 and a very low loss factor. Quartz is difficult to handle but the shape required is simple. (A mixture of titanium dioxide and polystyrene would also be good.)

The dielectric filled guide should be about 25% above cutoff for the lowest frequency to be passed. This means that the above cutoff characteristics (dielectric in the guide) will be reasonably constant. Then when the dielectric slug is removed the typical result is $1.25/\sqrt{3.8}$, or 0.64 of cutoff at the low end of the band. At the top frequency the tube is 0.75 of cutoff. Putting it more simply, the attenuation in the tube is from 21 to 24 db per diameter based on the TE_{11} mode of excitation.[1]

Going back to the illustration, it can be seen that for use as a spectrum analyzer the slug would be in the lower position and the klystron would have approximately the proper attenuation if the beyond cutoff tube were about $\frac{1}{2}$ diameter long ($10\frac{1}{2}$ to 12 db). As a signal generator the $10\frac{1}{2}$ to 12 db is about right for the coupling to the power monitor. The $1\frac{1}{2}$ db variance over the band could easily be taken care of in a number of ways.

The choice of whether to use the crystal or the power monitor is merely left up to the external circuit switches. With the E arm of the magic tee well terminated, the isolation between the crystal mount and the power monitor is sufficient.

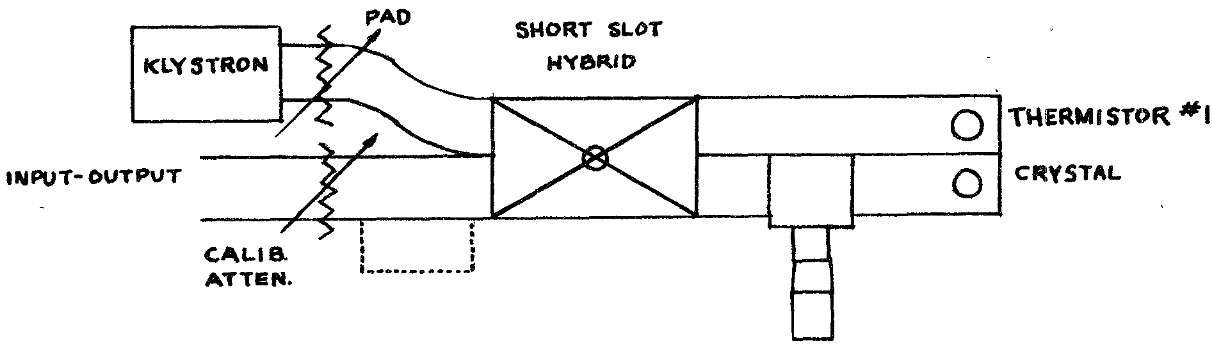

Figure 2

The second of the two switches is much simpler and performs the same functions. In Figure 2, with no switching provisions the equipment will function as a spectrum analyzer with no particular novelty except that 3 db of signal is wasted in the thermistor bridge; however, extreme sensitivity is not a problem with such a device as a spectrum analyzer. Some question may arise on the use of the equipment as a passive power monitor. Assuming there is padding in the local oscillator arm and in the input-output arm, mismatches of the crystal mount do not greatly affect the reading of the

[1] T. Moreno, Microwave Transmission Design Data, McGraw-Hill, 1948; p. 141.

power monitor. (Laboratory tests show changes of not more than a few percent in power readings with extreme changes in the match of the crystal mount.)

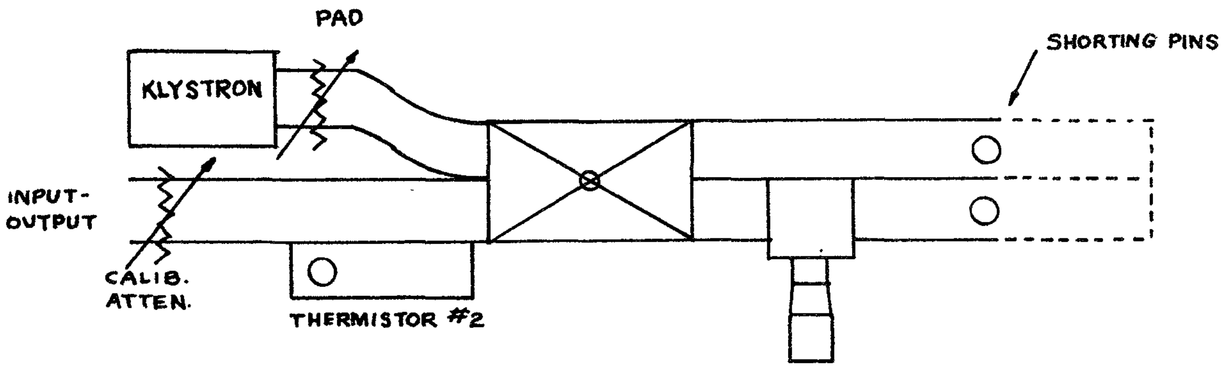

Figure 3

To operate the unit as a signal generator two pins are dropped in the guide equidistant from the short slot coupler.[2] Due to the 90 degree phase shift on going through the slot, the energy from the klystron is reflected out the input-output arm as shown in Figure 3. Because of potential losses through the switching circuitry another thermistor mount is required to monitor outgoing power. Some power about 20 db down gets by the pins, but this does no harm because the external circuits are not connected. Likewise, the impedance match beyond the pins (in the crystal mount and the #1 thermistor mount) does not matter.

For the spectrum analyzer function the switch pins themselves are withdrawn far out of the guide. This leaves only holes of small diameter (far beyond cutoff) and the leakage is therefore very far down. When the pins are inserted they go into chokes and polyiron suppressors which also can be made to keep the leakage very far down -- well below that required for signal generator service.

Because the switch action is simple linear motion with no fingers or other wiping contacts to increase friction, it is simple to use solenoids or mechanical plungers. No particular specifications are necessary on how far or how hard the shorting pins should be inserted.

In this latter switch it is noteworthy that there are no difficult machining operations. The switch assembly can be made of straight pieces of waveguide with only simple milling operations. The remainder of the parts are simple straightforward lathe jobs with reasonable tolerances. Assembly is also simple, which means that the one main assembly has no trick sequences involving many solders of different melting points.

The design of any switch is influenced by what it is to be connected to and by the external physical considerations. If a test set of different size and shape were projected the best solution to the switch problem would be markedly different. However, this problem is typical of what might be encountered and the solution is probably representative.

[2] H. J. Riblet, Proc. I.R.E., February, 1952.