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# AN X-BAND ELECTRONIC ATTENUATOR, SWITCH, AND TR TUBE

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# AN X-BAND ELECTRONIC ATTENUATOR, SWITCH, AND TR TUBE

by

A. E Hastings, Radio Division III

March 1947

Problem No. 0-20R-S

Approved by:

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#### ABSTRACT

An X-band attenuator and switch tube which can be controlled by the voltage on an electrode has been developed. The attenuation can be varied continuously over a limited range with a maximum as high as 40 db. The tube, the X7047, at the same time operates as a conventional TR tube. It has applications in a lobe-switching radar, as an r-f AGC, and as an r-f modulator.

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## AN X-BAND ELECTRONIC ATTENUATOR, SWITCH, AND TR TUBE

## INTRODUCTION

For several years work has been under way at this Laboratory to develop an X-band switching device which could be operated electronically at high rates. Some of the devices evolved were usable, but they generally had very short life or undesirable characteristics. About a year ago there appeared a description\* of a 1B24 TR tube modified for use as an r-f attenuator and switch. Several of these obtained from Sylvania Electric Products, Inc. were found usable.

Additional modifications have been made in the design. These include the addition of a second electrode to make the tube a combined TR and attenuator. Some samples of the modified tube, the X7047, have had acceptable life and characteristics, and the tube is in limited production.

## DESCRIPTION OF TUBE

The standard 1B24 is a tunable X-band TR tube with integral cavity coupled to waveguides by circular irises. The spacing of two cones which form a gap in the center of the cavity controls the tuning. The keep-alive electrode is inserted in the hollow open-end cone. The insertion loss, usually less than 1.5 db without the keep-alive discharge, is increased only 0.2 db with the application of operating potential to the keep-alive electrode. This rise of the insertion loss, although undesirable in the usual application of a TR tube, can be increased to make the tube a controlled switch or variable attenuator.

Ke and Smullin\* have investigated this effect and have shown that the geometry of the keep-alive electrode and the gap, the type and pressure of the gas in the tube, and the current in the keep-alive discharge can be chosen to give an attenuation with discharge as high as 44 db. This attenuation is largely due to reflection. They have also shown that a satisfactory TR design results when the keep-alive electrode is placed at one side of the cavity outside the cone, but that such an arrangement does not make a good switch or attenuator.

It was suggested at this Laboratory that the two designs be combined, and that the usual electrode in the cone be adjusted for maximum control of attenuation and the electrode outside the cone be used for the keep-alive. This arrangement combines in one tube the functions of TR and controllable attenuator. In certain applications where both an attenuator or switch and a TR are required, the use of this tube simplifies the r-f assembly and eliminates the loss from a second tube.

The tube, the X7047, has been developed by the Sylvania Electric Products, Inc., and some acceptable samples have been tested and used at this Laboratory. It is operated from a high-voltage supply through a limiting resistance. The average current is 0.75 milliamperes.

\* MIT Radiation Laboratory Report number 841, October 1945. A low power X-band R-F gas switch by T. S. Ke and L. D. Smullin.

Figure 1 is a photograph of the X7047 tube, and Figure 2 is an X-ray photograph, which shows the control electrode in the hollow cone. The method of mounting in the waveguide is shown in Figure 3. A typical characteristic curve of db attenuation versus voltage on the control electrode is shown in Figure 4.

The tube is adapted to a number of uses. In the radar with high aperiodic lobing rate now being tested here, it makes possible a simple electronic method of lobe switching in the receiver. A report on its use in this system is in preparation.

The tube has been used as the attenuator in the AGC circuit of a receiver for a guided missile of the beam rider type. Successful communication was obtained with an earlier tube used as an r-f modulator.

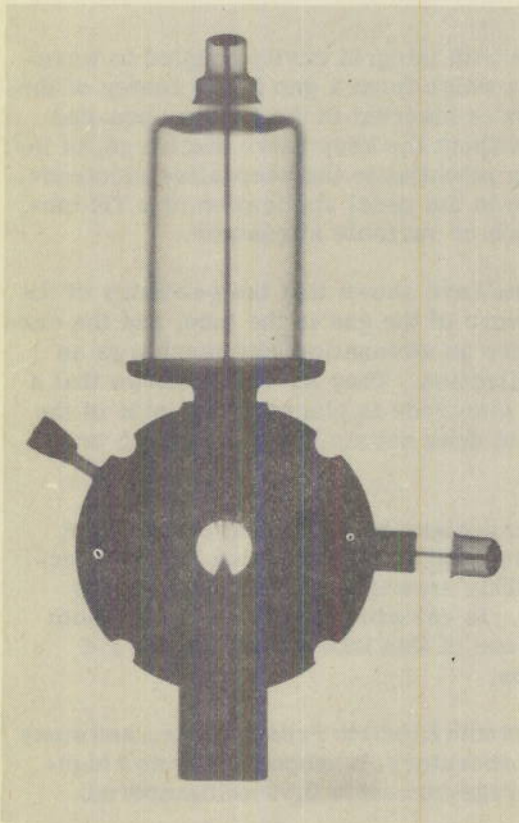


Fig. 2 X-Ray Photograph of X7047

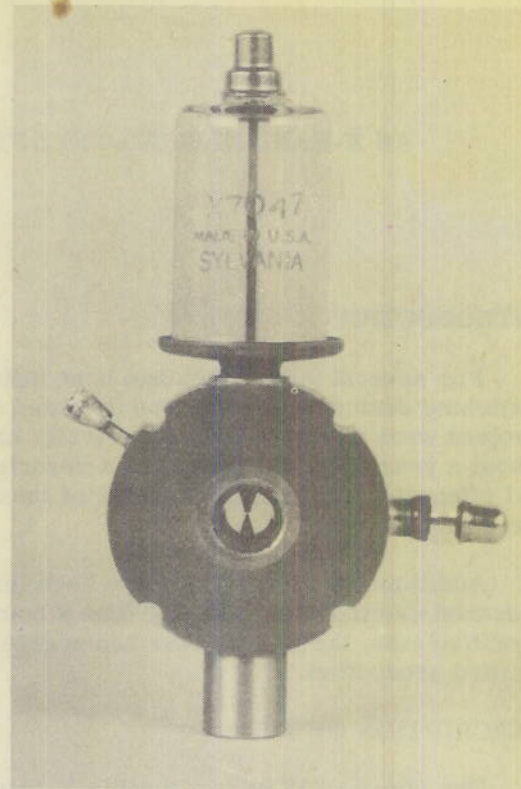


Fig. 1 X7047 Combination TR and Attenuator Tube

A broad-band version of this tube is under development at present. Under development also is a broad-band attenuator tube which will control large amounts of r-f power. This could be used for electronic lobe-switching of a radar transmitter.

\* \* \*

#### ACKNOWLEDGMENTS

Credit at this Laboratory for the successful design of this tube belongs chiefly to Mr. O. F. Foin and Mr. P. J. Allen, who have actively followed its development, made valuable suggestions, and carried out tests. Engineers of Sylvania Electric Products, Inc., who carried out the actual development have been very cooperative

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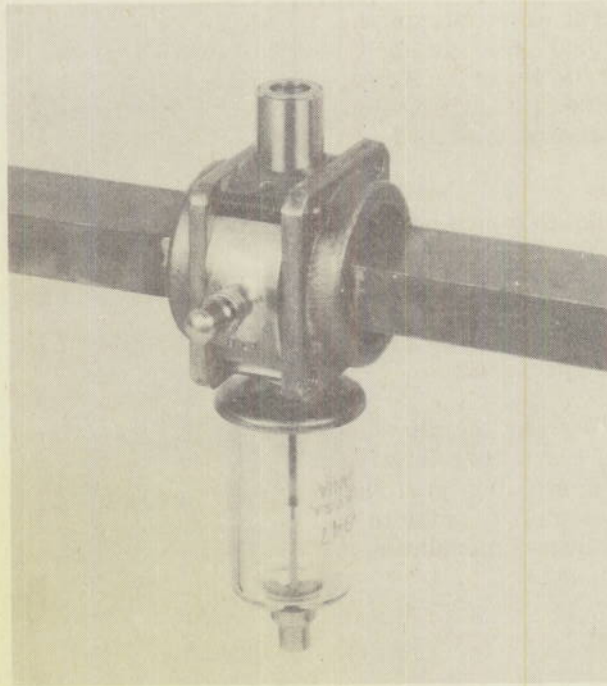


Fig. 3 X7047 Mounted

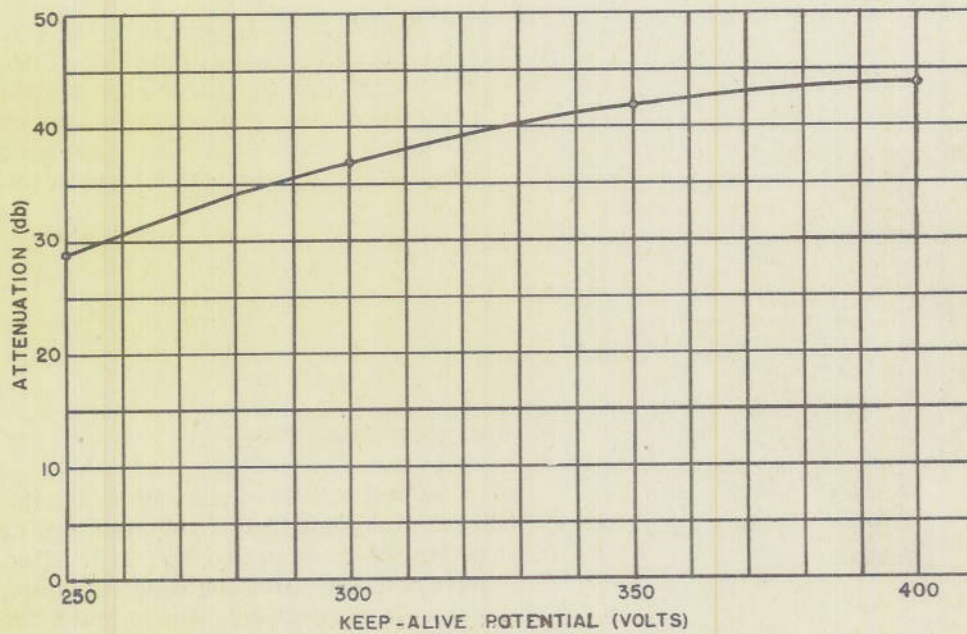


Fig. 4 Average Characteristic of X7047

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