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TUNNEL DIODE FAST DISCRIMINATOR CIRCUIT

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A type of fast integral discriminator, employing tunnel diodes arranged in a bridge-like configuration, is examined.

The discriminator has been designed to operate in series with a 125 ohm cable, to allow the driving pulse to be used for other purposes. The mismatching introduced using the circuit and components in fig. 1 is less than 5 %.

The pulse to be discriminated travels along the cable in the direction shown by the arrow. If its amplitude is such as to let a current greater than I_p to flow in each arm of the bridge, tunnel diodes TD2 and TD3 switch into their high impedance region and an output pulse of 0.4 V appears at the secondary windings of the transformer, while the driving pulse, reduced in amplitude keeps on travelling to the right. When the discriminator switches on, the reduction is 0.4 V, independently of threshold setting; if it is not switched on, the reduction is less than 5 % of trigger pulse amplitude. In the above mentioned case only tunnel diodes TD2 and TD3 have been effective, whereas TD1 and TD4 behave like resistors. Should the polarity or the direction of propagation of driving

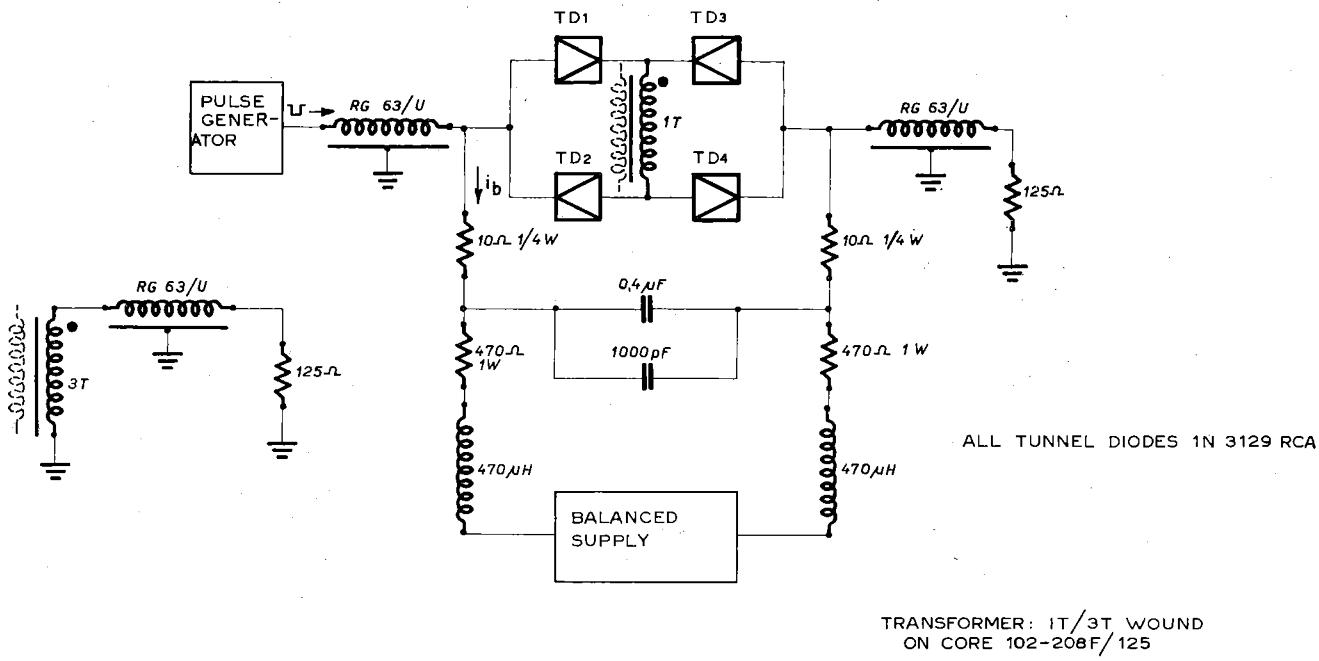

Fig. 1. Tunnel diode discriminator circuit.

pulse be reversed, then TD1 and TD4 will be effective and the output of the transformer will be of opposite polarity. 3.5 ohm resistors may be used instead of TD2 and 3, or TD1 and 4, when the bidirectionality feature is not needed. The resistors used are shown in fig. 7.

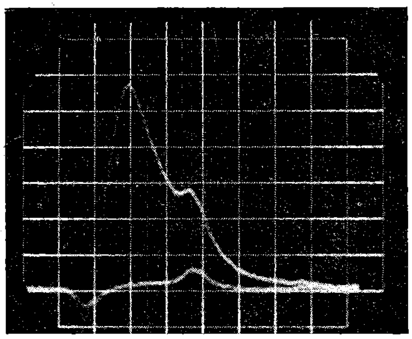

Fig. 2. Output pulse for pulses slightly below and above threshold: vert. 1 V/cm, hor. 4 ns/cm.

The advantages of using bridge-like arrangements are well known[1]). Using two tunnel diodes instead of one (for instance TD2 and TD3), doubles the output pulse, bringing it to a level (0.4 V) which is more suitable for driving directly subsequent transistor circuitry*. Using the transformer in the output instead of the input[2]) makes the recovery time for pulses below threshold independent of the transformer recovery time and practically negligible; another very useful consequence is the complete independence (within measurement accuracy, 1 ns) of input to output pulse delay, from input overvoltage.

The transformer turns ratio may be changed within a factor 3 to achieve a compromise between output pulse level and time definition (including recovery time). Figs. 2 and 6 show the wave forms obtained with 1 : 3 and 1 : 1 turns ratio transformer, respectively. Note that in both cases the difference between peak currents of the two switching tunnel diodes is 5 %.

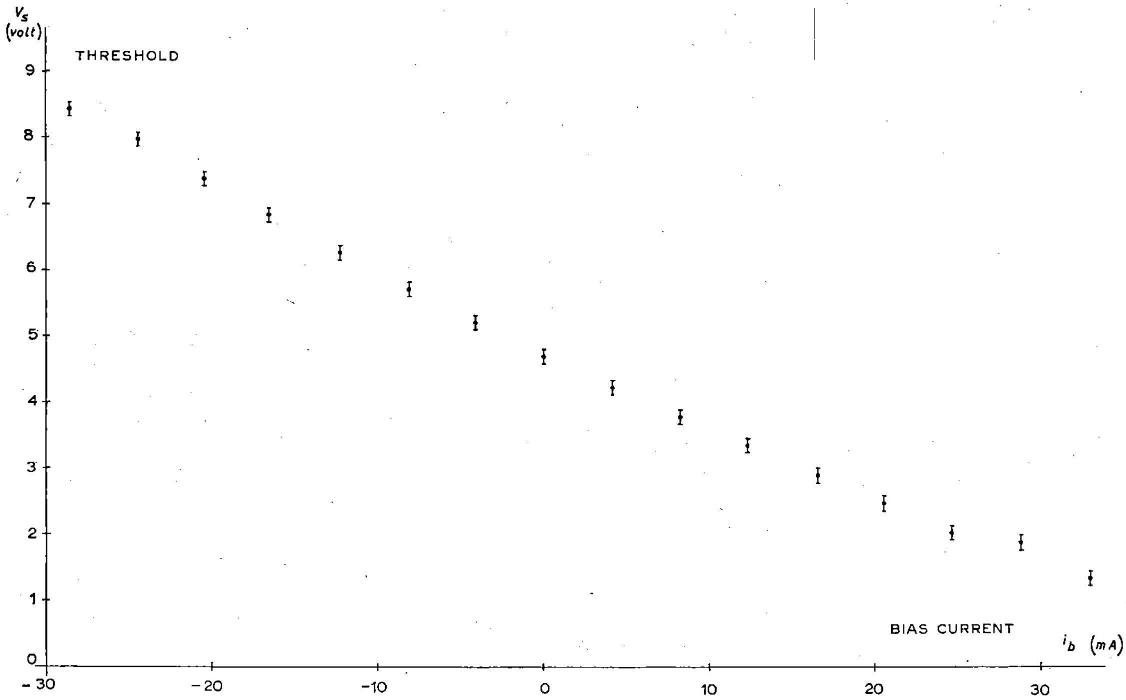

Fig. 3. Discriminator threshold vs bias current.

[1]) H. Ur, Proc. Int. Conf. Instr. H. E. Phys., Berkeley (Interscience Publishers, N. Y., 1961) p. 45.

* It should be pointed out that the discriminator cited in ref. [2]) was intended for use as a timer based on zero crossing of photomultiplier pulses.

[2]) Q. Kerns, A. Bjerkè and T. Nunamaker, Proc. Int. Conf. Instr. H. E. Phys., Berkeley (Interscience Publishers N. Y., 1961) p. 62.

Using the 1 : 3 transformer, the recovery time after a single pulse just above threshold (defined at 5 % overdrive for a second pulse to give an output) is 20 ns. For this measurement both the trigger pulses were 5 ns long. The variation of the output pulse height vs input overdrive is shown in fig. 4. Such large variation does not effect the use of the device as a trigger with very fast input characteristics. The threshold variation as a function of polarization current is shown in fig. 5. Threshold variation vs pulse length is shown in fig. 5.

Using the 1 : 1 transformer, the recovery time

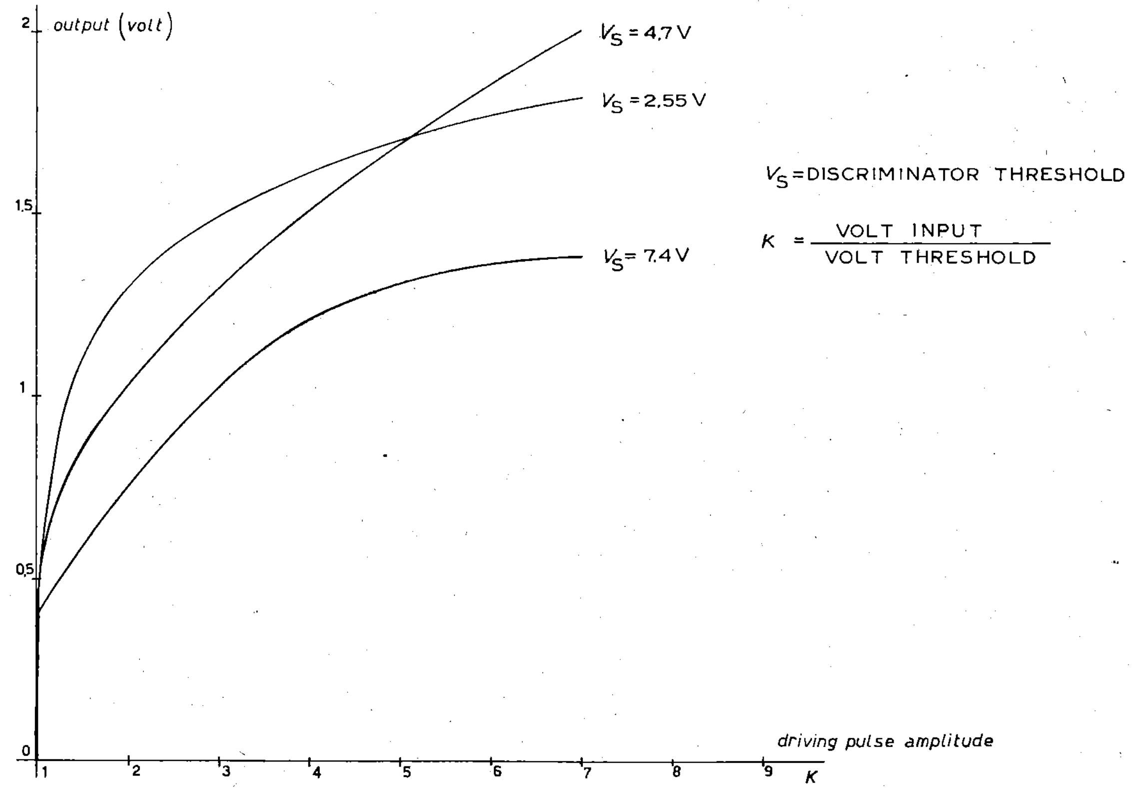

Fig. 4. Discriminator output vs driving pulse amplitude.

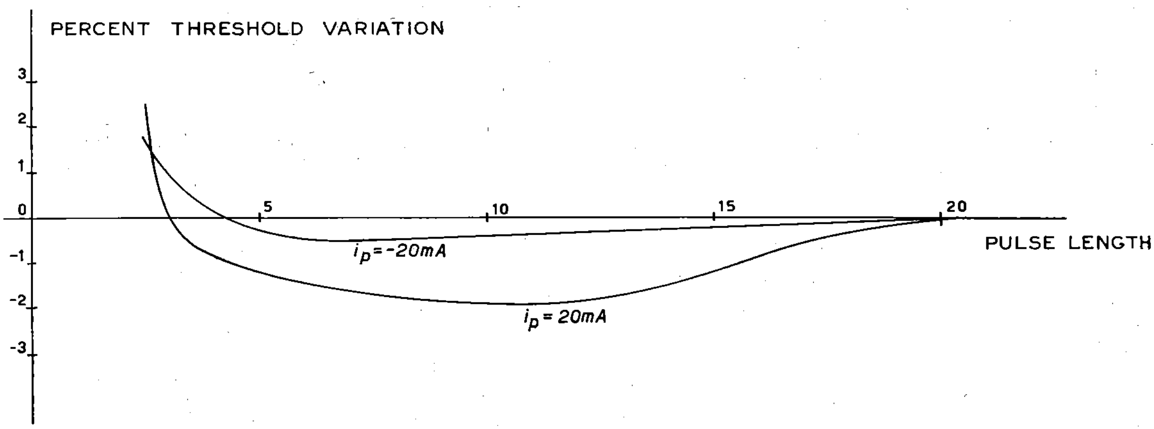

Fig. 5. Discriminator threshold vs pulse length. Error on experimental points is 0.5 %.

becomes somewhat greater, depending on bias and load conditions. The output pulse height, however, increases only by 20 % for an input over-drive variation between 1 and 10.

The performance of the device has been tested with a burst generator, giving 100 μs bursts of 15 ns pulses spaced 70 ns. The threshold for the burst was found to be 20 % higher than the threshold for a single pulse, this being obviously due to the effect of the inductive output coupling.

A burst below threshold, however, was found practically ineffective on the single pulse threshold, as expected.

Another mounting arrangement, using commercial resistors instead of germanium resistors, has been tested. The only noticeable change in performance, probably due to parasitic inductance, was the minimum pulse length, 8 ns, for which the threshold is kept constant.

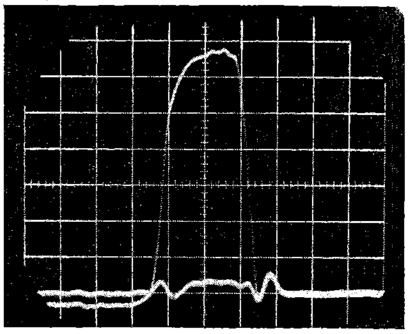

Fig. 6. Output pulse for a IT/IT transformer: vert. 0.05 V/cm, hor. 4 ns/cm.

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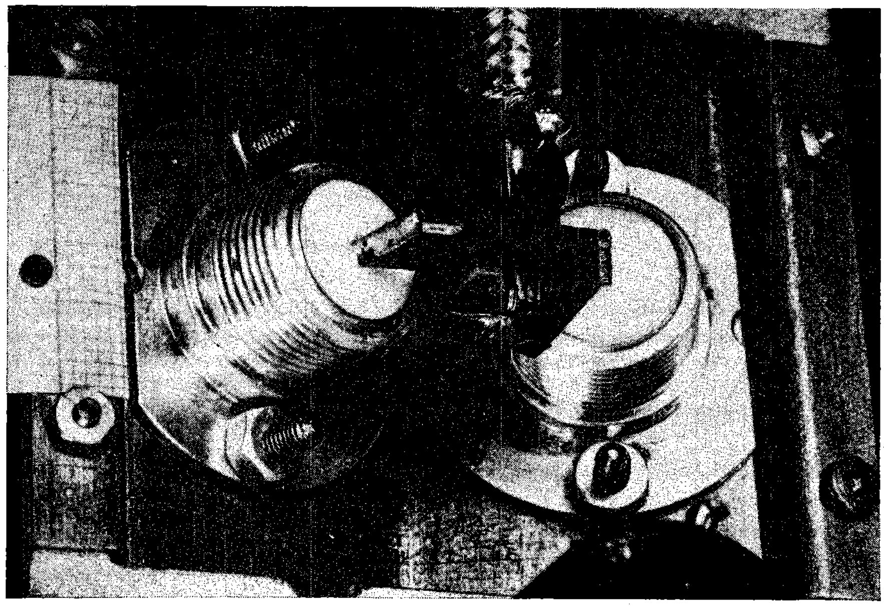

Fig. 7. Component layout shown in bottom view of chassis with polarization circuit removed. At right, p-type germanium 3.5 ohm resistors with contact surfaces electrolitically gold-plated.