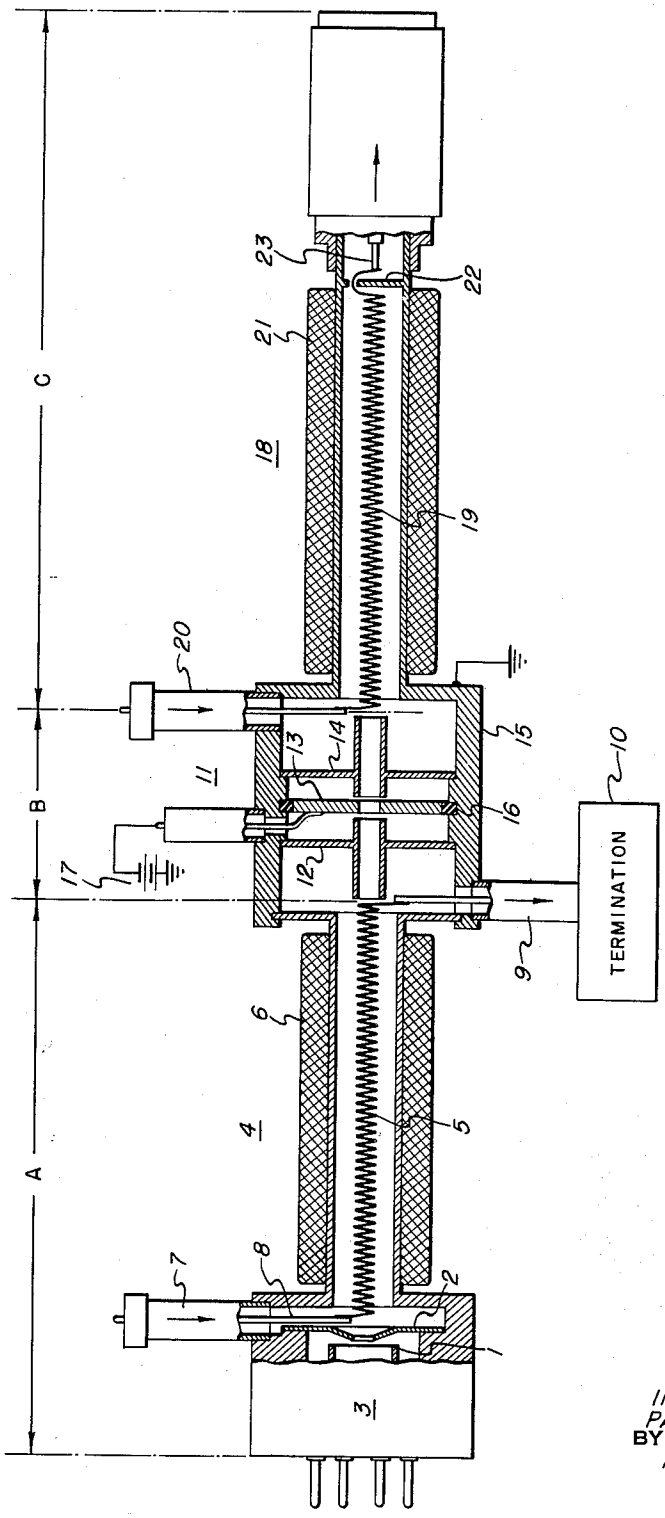
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MICROWAVE LOGICAL DECISION ELEMENT

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MICROWAVE LOGICAL DECISION ELEMENT

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The present invention generally relates to logical decision elements suitable for use in computer configurations and, more particularly, to such an element adapted for response to input signals of extremely short time duration.

The operation of presently available high speed digital computers is limited by the maximum response rate of its constituent logical elements. The minimum realizable response period now is of the order of something less than one microsecond. The attainment of a very substantial decrease in such a response period would open up new horizons of computation. Computers capable of solving extremely complex problems in a reasonable length of time would then be feasible. This would permit the computation of solutions to problems which cannot now be undertaken because of the prohibitively long waiting time involved. The present invention contemplates a new category of logical decision devices which overcomes the response limitations of prior art devices through the utilization of microwave components and techniques.

It is the principal object of the present invention to provide a logical decision element suitable for use in computer configurations and adapted for operation in an extremely short time interval.

Another object is to provide a high speed switching device which utilizes one input microwave signal to inhibit the amplification of a second input microwave signal.

A further object is to produce a microwave frequency device for performing a basic logical function over a broad band of input signal frequencies in an extremely short time interval.

An additional object is to provide a logical decision element having a very short response time and producing signal gain.

Another object is to provide means for producing a stream of electrons and for gating the same during an extremely short time interval.

These and other objects of the present invention, as will appear from a reading of the following specification, are accomplished in a preferred embodiment by the provision of a composite microwave tube structure adapted to receive two microwave input signals and operative to produce an output microwave signal upon the simultaneous conditions that one of the input signals is present and the other is not. The composite microwave structure essentially comprises three distinct signal handling regions connected in cascade. In the first of the regions, means are provided for producing an electron beam and for accomplishing interaction between said beam and one of said input signals when present. The second region includes a device for selectively translating to the third region the beam at the output of the first region depending on whether said interaction has taken place. The beam is passed only where no interaction occurred; otherwise, the beam is blocked. The third region performs the function of selectively amplifying the second of said input signals in the sole event that an electron beam is present at the output of the second region; said second of the input signals is attenuated in the absence of such beam. In short, the second input microwave signal is amplified only when there is no first input microwave signal. The over-all function is that of a decision element which

performs the logical operation A-not, B, conventionally symbolized by the notation $\bar{A}B$.

A plurality of means are available for accomplishing interaction between the first input microwave signal and the electron beam and, separately, for selectively translating the beam. For example, the interaction may be such as to produce longitudinal velocity modulation of the electron beam in the presence of the first input signal. In this case, the criterion for selective translation of the beam is the average longitudinal velocity of the beam resulting from the interaction. Alternatively, the interaction between the first signal and the electron beam may produce transverse deflection of the beam. The corresponding basis for selective translation then is the deviation of the beam from the path that would be traversed by the beam in the absence of the first signal.

For a more complete understanding of the present invention reference should be had to the following specification and to the sole FIGURE which is a cut-away sectional view of a preferred embodiment.

The composite microwave tube structure of the figure essentially comprises three distinct signal handling regions respectively represented by the letters A, B and C. Region A includes conventional traveling wave tube amplifier **4** whose well known broad band characteristic is particularly advantageous for responding to input microwave pulses of extremely short time duration. The electron beam for tube **4** is produced by electron gun **3**. Only focusing electrode **1** and accelerating anode **2** of electron gun **3** of tube **4** are shown for the sake of simplicity. The electron beam generated by gun **3** travels to the right axially through helix **5** in a conventional manner. The electron beam is focused by the steady magnetic field generated by electromagnet coil **6**. The microwave signal input to tube **4** is applied via coaxial line **7** whose center conductor **8** is directly connected to the input end of helix **5**.

As is well understood, when the phase velocity of the electromagnetic microwave signal traveling along helix **5** is made nearly the same magnitude as the velocity of the electrons passing axially through the helix, interaction between the traveling wave and the electron beam takes place. The interaction is such to produce longitudinal modulation of the beam within helix **5** and amplification of the traveling wave. The consequent amplification of the traveling wave is of no particular significance to the present invention. For this reason, after the amplified traveling wave is coupled out at the end of helix **5** by coaxial line **9** it may be dissipated, if desired. Termination **10** is provided for such a purpose.

The amplification of the traveling wave results in the extraction of kinetic energy from the beam. Thus, in addition to producing longitudinal velocity modulation of the beam, the interaction also produces a retardation of the average velocity of the beam flowing axially through helix **5**. Maximum velocity is imparted to the electron beam in the absence of interaction, i.e., in the absence of an applied input microwave signal. Because of the broad band characteristic of tube **4**, the average velocity of the electron beam can be controlled essentially instantaneously by the application to axial line **7** of microwave pulses of extremely short time duration even of the order of one millimicrosecond.

The function of region B of the composite microwave tube is to selectively translate the beam at the output of tube **4** to the input of the apparatus of region C only in the case where no interaction has occurred between the electron beam and traveling wave within tube **4**. The apparatus of region B comprises an electron beam velocity sorter **11** which transmits electrons having velocities above a predetermined minimum value while rejecting electrons

having velocities below said certain value. As previously described, maximum beam velocity at the output of tube 4 occurs in the absence of an input signal in coaxial line 7. The function of the velocity sorter 11, therefore, is to pass such maximum velocity electrons and to block the passage of all others.

Velocity sorter 11 includes three apertured discs 12, 13 and 14 connected in tandem along the axis of the electron beam. All three discs consist of electrically conductive material. Discs 12 and 14 are electrically connected to shell 15 which encases the over-all composite microwave tube. Disc 13 is supported within shell 15 by a circular disc of dielectric material 16 which electrically insulates metallic disc 13 from shell 15. Disc 13 is maintained at a negative potential relative to grounded shell 15 by means of a D.C. source generally represented by numeral 17.

An electrostatic field is generated between discs 12 and 13 which retards the motion of the electron beam axially emerging from the output end of helix 5. An equal but opposite electrostatic field is generated between discs 13 and 14 which acts to accelerate any electrons which succeed in penetrating the aperture of central disc 13. The negative potential applied by source 17 to central disc 13 is selected so as to permit only the passage of beam electrons having maximum velocity at the output of helix 5. This maximum velocity, as previously discussed, occurs only in the absence of interaction between the electron beam and the traveling wave within tube 4. This, in turn, occurs only in the absence of an input microwave signal at coaxial line 7. The negative potential applied to disc 13 is sufficient to repel substantially all electrons traveling at lesser velocities which lesser velocities result from interaction, i.e., from the presence of an input microwave signal applied via coaxial line 7.

Assuming that no input microwave signal is applied to tube 4, the electrons emerging through the aperture of disc 13 are accelerated back to substantially the same interaction velocity which exists at the output end of tube 4. The accelerated electrons are applied to the input end of the apparatus of region C.

Region C comprises a second traveling wave tube 18 essentially identical to traveling wave tube 4. A second microwave signal is applied to helix 19 via coaxial line 20. The accelerated electrons passing through disc 14 are maintained in a focused beam for axial passage through helix 19 by the steady magnetic field generated by electromagnet coil 21. The electron beam exiting from the helix 19 of tube 18 is captured in a conventional manner by means of collector 22. Collector 22 is apertured off the axis of helix 19 to permit the output of helix 19 to be coupled to the inner conductor 23 of an output coaxial line (not shown). In the presence of an electron beam flowing through helix 19, conventional interaction takes place between said electron beam and the microwave signal applied via coaxial line 20 whereby said microwave signal is amplified.

In operation, the composite microwave tube structure of the sole figure is adapted to receive two microwave input signals at 7 and 20 and is operative to produce an output microwave signal (coupled out by the coaxial line including center conductor 23) upon the simultaneous satisfaction of the two conditions that a microwave signal is present at 20 and that no microwave signal is present at 7. In the absence of a microwave signal at coaxial line 7, no interaction takes place within tube 4 and maximum axial velocity is imparted to the electron beam emerging at the output end of helix 5. Velocity sorter 11 permits such maximum velocity electrons to escape through aperture 13 and, after acceleration, into the input end of helix 19 of tube 18. Upon the further condition that a microwave signal is applied via coaxial line 20, the microwave signal is amplified and is coupled out by the output coaxial line which includes center conductor 23. Thus, the presence of a signal at the output coaxial line is indicative of the presence of the signal on input coaxial line 20 and the absence of a signal on input coaxial line 7. The over-all function is that of a decision element which performs the logical operation A-not, B.

It will be seen that the composite microwave tube is a coincidence device by nature. Therefore, the duration of the output microwave signal is commensurate with the shorter of the durations of the two applied input signals. For example, the same millimicrosecond output microwave signal will be produced upon the application of a one millimicrosecond signal via coaxial line 20 in the continuous absence of a signal on coaxial line 7 as will be produced upon the application of a continuous microwave signal via coaxial line 20 and a discretely discontinuous microwave signal on coaxial line 7 wherein the duration of the discontinuity (absence of signal) is one millimicrosecond.

An illustrative device for the generation of microwave pulses having durations of the order of a millimicrosecond is disclosed in the article "The Regenerative Pulse Generator" by C. C. Cutler published in the February 1955 Proceedings of the IRE, volume 43, page 140. Discretely discontinuous microwave signals having a discontinuity (signal absence) duration of the same order may be produced by employing the generator of the aforementioned publication in combination with the composite microwave tube of the present invention. In this case, the generated millimicrosecond pulses of microwave energy would be applied to coaxial line 7 while a continuous microwave signal is applied to coaxial line 20. There would thus be produced a discontinuous output microwave signal having a discontinuity duration equal to that of the pulse applied by coaxial line 7, namely, of the order of a millimicrosecond.

Although longitudinal velocity modulation is produced in input region A of the preferred embodiment, the present invention contemplates the use of a broad band microwave device wherein transverse deflection rather than longitudinal velocity modulation of the electron beam is produced as a result of interaction. Microwave means for the transverse deflection of an electron beam are known in the traveling wave cathode ray tube art and are described, for example, in "A High-Sensibility Cathode-Ray Tube for Millimicrosecond Transients" by K. J. Germeshausen et al. in the April 1957 IRE Transactions on Electron Devices, page 152. In this case, it will be necessary to replace velocity sorter 11 by an analogous discriminator adapted to such transverse beam deflection. A suitable discriminator would be an axially apertured metallic plate which would permit the passage only of an undeflected beam (corresponding to no interaction in region A) while blocking a deflected beam (resulting from interaction in region A). By locating the aperture of the plate away from the undeflected beam axis, the logic of the device could be modified. That is, only the deflected beam would be passed to region C whereupon an output microwave signal would be produced in the simultaneous presence of two input microwave signals. The logical function thus performed could be represented by the notation AB.

While the invention has been described in its preferred embodiments, it is understood that the words which have been used are words of description rather than of limitation and that changes within the purview of the appended claims may be made without departing from the true scope and spirit of the invention in its broader aspects.

What is claimed is:

1. A composite microwave tube device having first, second and third signal handling regions connected in cascade; said first region including means for generating an electron beam, means coupled to said beam generating means for producing interaction between said electron beam and a first traveling wave of microwave energy if present, and means for applying said first traveling wave of microwave energy to said means for producing

interaction, whereby said electron beam is modified only in the event of interaction; said second region including means for selectively translating from said first to said third region a predetermined one of said electron beam and said modified electron beam; the third region comprising means adapted to receive a second traveling wave of microwave energy and for effecting interaction between said second traveling wave of microwave energy and the selectively translated one of said electron beam and said modified electron beam if present, whereby said second traveling wave of microwave energy is amplified in the presence of said selectively translated electron beam, means for applying said second traveling wave of microwave energy to the last-named means, means coupled intermediate said first and third regions for preventing the application of said first traveling wave of microwave energy to said third region, and means for coupling out said amplified traveling wave of microwave energy.

2. A composite microwave tube device having first, second and third signal handling regions connected in cascade; said first region including means for generating an electron beam, means coupled to said beam generating means for producing interaction between said electron beam and a first traveling wave of microwave energy if present, and means for applying said first traveling wave of microwave energy to said means for producing interaction, whereby said electron beam is modified only in the event of interaction; said second region including means for selectively translating from said first to said third region only said modified electron beam; the third region comprising means adapted to receive a second traveling wave of microwave energy and for effecting interaction between said second traveling wave of microwave energy and the selectively translated modified electron beam if present, whereby said second traveling wave of microwave energy is amplified in the presence of said selectively translated modified electron beam, means for applying said second traveling wave of microwave energy to the last-named means, means coupled intermediate said first and third regions for preventing the application of said first traveling wave of microwave energy to said third region, and means for coupling out said amplified traveling wave of microwave energy.

3. A gated traveling wave tube amplifier comprising means for generating an electron beam, means for directing said electron beam along an axis, first means connected to said beam generating means for producing longitudinal velocity modulation of said electron beam in response to a first input microwave signal, said electron beam when modulated having an average velocity which is less than a predetermined value, velocity sorting means connected to said first means for selectively translating said electron beam only when the average velocity thereof exceeds said predetermined value; said velocity sorting means comprising first, second and third centrally apertured metallic discs disposed coaxially along said axis, and means for maintaining said apertured discs at potentials whereby said electron beam is decelerated in the region between said first and second discs and accelerated in the region between said second and third discs; second means coupled to said velocity sorting means for producing interaction between the selectively translated electron beam and a second input microwave signal whereby said second input microwave signal is amplified in the presence of said selectively translated electron beam, and means for coupling out the amplified microwave signal.

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