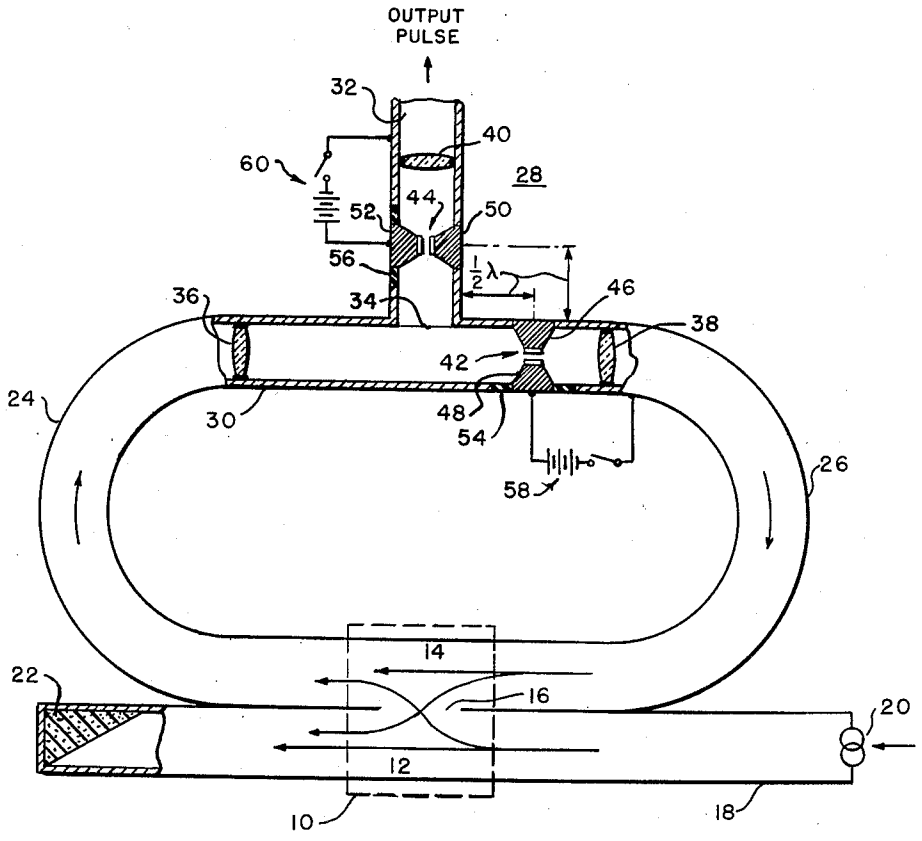
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EQUIVALENT HIGH-POWER PULSED MICROWAVE TRANSMITTER

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EQUIVALENT HIGH-POWER PULSED MICROWAVE TRANSMITTER

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The invention described herein may be manufactured and used by or for the Government for governmental purposes, without the payment of any royalty thereon.

This invention relates to microwave pulse transmission systems and more particularly to a pulsed transmission system utilizing a travelling-wave ring resonator.

The utilization of a reentrant closed waveguide travelling-wave ring resonator loop as microwave power multipliers has been known for some time. While such multipliers have heretofore been adapted only for testing microwave components at high power while using a low power microwave source, the advantages of utilizing the multiplied power as a transmitted pulse has long been recognized in the art. It is therefore an object of the present invention to provide a pulse transmission system utilizing a microwave power multiplier of the travelling-wave resonator closed loop type which is driven by a relatively low microwave source.

In accordance with the present invention the pulsed microwave circuit includes a source of relatively low incident power which is coupled to a reentrant closed loop waveguide such that the incident power is multiplied within the loop. The reentrant closed loop waveguide includes an evacuated waveguide structure filled with an ionizable gas and having a longitudinal waveguide branch and a waveguide branch orthogonally positioned thereto. Discrete multipactor type switches are mounted across each of the waveguide branches and respectively spaced a distance of one-half wavelength of the operating frequency from the junction of the longitudinally and orthogonally positioned waveguide branches. Also included are means for simultaneously activating the multipactor switches such that the incident power is multiplied in the closed waveguide loop when the multipactor switch in the longitudinal waveguide branch is energized and the switch in the orthogonal waveguide branch is deenergized, and the multiplied power is derived from the orthogonal waveguide branch when its associated multipactor switch is energized and the switch in the longitudinal waveguide branch is deenergized. The conditions for the energized and deenergized states of the multipactor switches are set forth hereinbelow.

For a better understanding of the invention, together with other and further objects thereof, reference is had to the following description taken in connection with the single FIGURE of the accompanying drawing.

Referring now to the figure in the drawing, there is shown at 10 a directional coupler having high directivity and including two sections of hollow rectangular waveguides 12 and 14 having a directional coupling aperture 16 in the common wall between the sections of waveguides 12 and 14. The waveguide section 12 is connected at one end through rectilinear waveguide 18 to a microwave input source indicated schematically at 20, the other end of waveguide section 12 being terminated by a non-reflective load 22. Opposite ends of waveguide section 14 are connected by respective waveguide loop sections 24 and 26 to an evacuated waveguide section 28, herein shown as comprising two orthogonally related rectangular waveguide branches 30 and 32 having a common waveguide junction as at 34 and arranged such that the transverse dimension of waveguide 32 is coextensive with

the longitudinal dimension of waveguide branch 30. The waveguide branches 30 and 32 are sealed by large low-loss non-resonant glass windows as shown at 36, 38 and 40 to provide a vacuum tight seal and the entire sealed area is provided with an ionizable gas such as argon at a pressure in the region of 10^{-9} mm. of Hg. Waveguide loop sections 24 and 26 are terminated by the sealed ends of horizontally disposed waveguide branch 30. As shown, within the orthogonally positioned waveguide branches 30 and 32 there are provided respective high vacuum switches 42 and 44 whose operation depends on an electron multiplying process usually referred to as a multipactor discharge and will hereinafter be referred to as multipactor type switches. Each switch includes a pair of spaced, oppositely arranged, truncated cone shaped electrodes whose opposing ends are coated with a high secondary emission material such as manganese or beryllium copper. The spaced truncated cone electrodes of switch 42 disposed within horizontal waveguide branch 30 are shown at 46 and 48 and the spaced truncated cone electrodes of switch 44 disposed in waveguide branch 32 are shown at 50 and 52. Truncated cone electrodes 48 and 52 are electrically isolated from their respective waveguide branches by suitable vacuum tight dielectric seals as at 54, 56 and, as shown, respective positive D.-C. bias sources 58 and 60 are connected across each of the high vacuum switches 42 and 44. Each bias source may have a value of several hundred volts and each is provided with an on-off switch which may be ganged to provide alternate on-off switching of the respective D.-C. bias sources. Multipactor switches 42 and 44 are arranged such that their respective centers are spaced one-half wavelength at the operating frequency from waveguide junction 34. The resonant type multipactor build-up normally provided by the multipactor switches hereinabove described are prevented by the application of the D.-C. biases. The application of the postive D.-C. bias creates an electric field which sweeps electrons out of the ionized region, thus hindering the ionization process. Thus, with the D.-C. bias from source 60 applied to multipactor switch 44, the switch transmits the incident power with very little insertion loss. However, with no D.-C. bias applied to multipactor switch 44, an electron discharge is built up across the electrodes thereof due to the ionization of the gas within the evacuated waveguide section 28 so that a short circuit appears at waveguide junction 34 to effectively provide a continuous waveguide circuit along the longitudinal dimension of waveguide branch 30. Similarly, with no D.-C. bias applied to multipactor switch 42, an effective short circuit will appear across the transverse dimension of waveguide branch 30 at junction 34 due to the electron discharge built up across the electrodes of switch 42. With D.-C. bias applied to switch 42, it transmits the incident power from source 20 with very little insertion loss as hereinafter explained. For purposes of this application, with no D.-C. bias applied, the multipactor switches will be designated as being in the energized or discharge condition, and, with D.-C. bias applied, the multipactor switches will be designated as being in the deenergized or non-discharge condition. With multipactor switch 44, hereinafter referred to as the output multipactor switch, in the electron discharge condition and with multipactor switch 42 in the non-discharge condition, a reentrant or closed loop waveguide section commonly known in the art as a travelling-wave ring resonator is formed by the open ended terminations of waveguide section 14 of directional coupler 10, waveguide loop sections 24 and 26 and sealed-off branch 30. The electrical length of the travelling-wave ring resonator loop is made an integral number of guide wavelengths of the operating frequency.

The operation of the travelling-wave ring resonator as a power multiplier is well known in the prior art and is described in Sferrazza Patent No. 2,875,415, issued February 24, 1959. The power multiplication of such a ring resonator may be briefly described as follows. Assume an incident wave from the source 20 travelling along the waveguide section 12. A portion of this energy is coupled into the waveguide section 14 as a coupled wave, and a portion continues down waveguide 12 as a direct wave to the load 22. The coupled wave travels around the loop formed by loop sections 24 and 26 and evacuated waveguide section 30 which includes multipactor switch 42. At the coupling aperture 16 again this energy is divided, a portion being coupled to the load 22 and a portion recirculating around the closed loop. If the phase of the portion recirculating around the closed loop is such as to add to the coupled wave from the source 20, the energy in the closed loop will be larger than during the first passage around the loop. This build-up of energy will continue with each cycle around the loop until the losses within the loop and absorption of energy by the load 22 exactly balance the output of the source 20. Assuming the attenuation around the loop is zero, a steady state condition will be reached when the energy coupled to the load 22 is exactly equal to the energy output of source 20. There will be partial cancellation at the load 22 of the energy coupled from the loop to the rectilinear guide 18 and the incident energy from source 20 passing through to load 22. Hence, the energy level in the loop during the steady state is at a higher level than the energy level at load 22. Under such circumstances, the smaller the amount of coupling, the greater is the energy stored in the form of a travelling-wave around the closed loop, and the more cycles of the wave in the closed loop before the steady state condition is reached. This is so because of the relatively small increment of energy that is coupled out of the closed loop for each cycle. If the loop is made many wavelengths long, power magnification of 10 and 20 times may be achieved.

The power multiplication of course continues so long as no D.-C. bias is applied to output multipactor switch 44 and D.-C. bias is applied to multipactor switch 42. When the steady state condition within the loop is reached, the D.-C. bias is applied to output multipactor switch 44 and, simultaneously, the D.-C. bias is removed from multipactor switch 42 by any suitable means. During this condition, the power within the loop is passed through evacuated waveguide branch 32 to a utilization circuit such as an antenna, for example. The duration of the output pulses is made to be the same as the duration of the transit time of the wavefront around the closed loop. The nature of the multipactor switch is such that the recovery time will be less than 0.01 microsecond. The output switch 44 is placed on the loop so that in emptying the ring of power, only a minimum part of the energy passes the directional coupler 10.

While there has been described what is at present considered to be the preferred embodiment of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A pulsed microwave circuit comprising a source of relatively low incident power, a reentrant closed loop waveguide ring resonator coupled and responsive to said incident power whereby said incident power is multiplied within said loop, said reentrant closed loop waveguide ring resonator including an evacuated waveguide structure filled with an ionizable gas and having a longitudinal waveguide branch and a waveguide branch orthogonally positioned thereto, discrete multipactor type switches

mounted across each of said branches, and means for simultaneously activating said switches such that the incident power is multiplied in said loop when the multipactor switch in the longitudinal waveguide branch is energized and the switch in said orthogonal waveguide is deenergized, and said multiplied power is derived from said orthogonal waveguide branch when its associated multipactor switch is energized and the switch in said longitudinal waveguide branch is deenergized.

2. A pulsed microwave circuit comprising a source of relatively low power incident wave energy, a reentrant closed loop waveguide ring resonator including an evacuated waveguide structure comprising a first longitudinal waveguide branch and a second waveguide branch orthogonally positioned relative to said longitudinal waveguide branch, said waveguide branches being arranged such that the transverse dimension of said orthogonally positioned waveguide is coextensive with the longitudinal dimension of the other waveguide branch, said evacuated waveguide structure including an ionizable gas, means forming a part of said loop for coupling said incident wave energy into said closed loop, discrete multipactor switch means positioned across said orthogonal and longitudinal waveguide branches whereby the incident signal power is multiplied in said loop when the switch means in said longitudinal waveguide branch is energized, and the switch means in said orthogonal waveguide branch is deenergized, and the multiplied power signal is derived from said orthogonal waveguide when the switch means in said longitudinal waveguide branch is deenergized, and the switch means in said orthogonal waveguide branch is energized.

3. A pulsed microwave circuit comprising a rectilinear input waveguide terminated at one end by energy absorbing means and a source of incident electromagnetic wave energy coupled to the other end of said input waveguide, an evacuated sealed waveguide structure filled with an ionizable gas and including a first longitudinal waveguide branch and a second waveguide branch orthogonally positioned relative to said longitudinal waveguide branch, and having a common waveguide junction, said waveguide branches being arranged such that the transverse dimension of said orthogonally positioned waveguide is coextensive with the longitudinal dimension of the other waveguide branch, a first and second multipactor type discharge switch respectively mounted across said longitudinal and said orthogonal waveguide branches at respective distances one-half wavelength from said common junction, said switches being insulated from respective waveguides in which they are mounted, a directional coupler having four waveguide terminals, two of said waveguide terminals being in coupling relationship with said rectilinear waveguide intermediate said source and said energy absorbing means, a first waveguide section interconnecting the third waveguide terminal of said directional coupler and one end of said longitudinal waveguide branch, a second waveguide section interconnecting the fourth waveguide terminal of said directional coupler and the other end of said longitudinal waveguide branch, discrete biasing voltages respectively in circuit with said multipactor type switches for alternately rendering said switches On and Off, such that when a bias voltage is applied to the first multipactor switch, the third and fourth directional coupler waveguide terminals, said first and second waveguide sections and said evacuated longitudinal waveguide branch form a closed loop to multiply the incident input power, and when a bias voltage is applied to said second multipactor type switch, multiplied power energy is derived through said orthogonal waveguide branch.

4. The pulsed microwave circuit in accordance with claim 1, wherein each of said multipactor switches comprise two opposing truncated cone shaped electrodes with opposing ends coated with a high secondary emission material, the base of each of said truncated cone shaped

electrodes being insulated from its respective associated waveguide.

5. A pulsed microwave circuit comprising a source of relatively low incident power, a reentrant closed loop waveguide ring resonator coupled and responsive to said incident power, said reentrant closed loop waveguide ring resonator including an evacuated waveguide structure filled with an ionizable gas and having a first waveguide branch as an integral portion of said loop and a second waveguide branch having a common junction with said first waveguide branch within said loop but angularly positioned with respect to said first waveguide branch, discrete multipactor type switches mounted across each

of said waveguide branches, and means for activating said switches such that the incident power is multiplied in said loop when the multipactor switch in said first waveguide branch is energized and the switch in said second waveguide branch is deenergized, and said multiplied power is derived from said second waveguide branch when its associated multipactor switch is energized and the switch in said first waveguide branch is deenergized.

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