United States Patent

Marilleau

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[54] **DEVICE FOR PRODUCING RECTANGULAR VOLTAGE PULSES OF VERY SMALL WIDTH BETWEEN TWO OUTPUTS**

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[52] **U.S. Cl.** **307/106**, 333/20, 328/56, 328/62

[51] **Int. Cl.** **H03k 3/00**

[58] **Field of Search** 328/56, 59, 62; 333/20; 307/106, 107, 108

[56] **References Cited**

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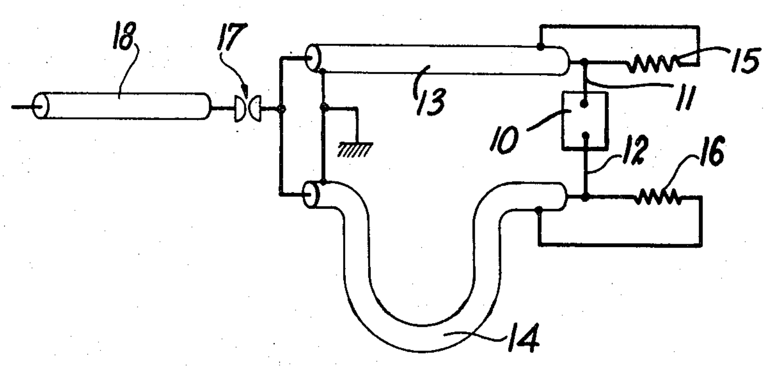
[57] **ABSTRACT**

The device comprises a first transmission line which can be charged, a second transmission line which constitutes the load line and switching means for connecting one end of the charged line to the load line. The load line is made up of two sections having the same characteristic impedance and the charged line has a characteristic impedance which is very substantially lower than that of the load line.

12 Claims, 9 Drawing Figures



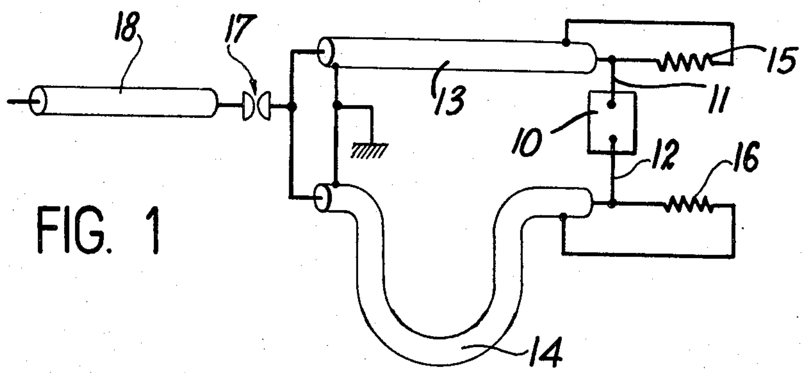


FIG. 1

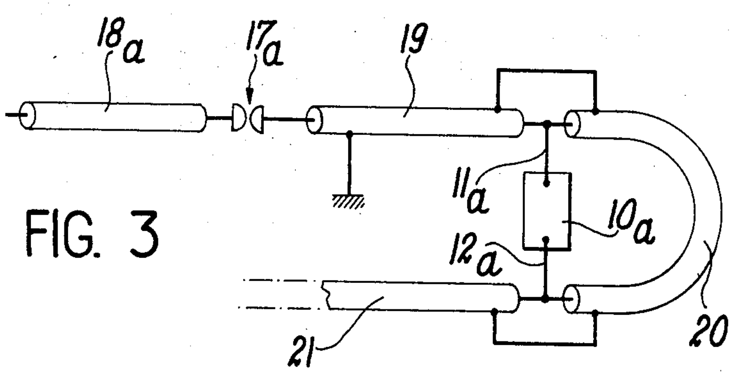


FIG. 3

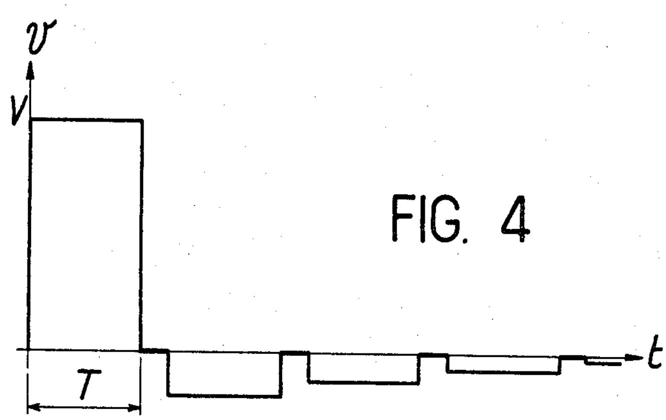


FIG. 4

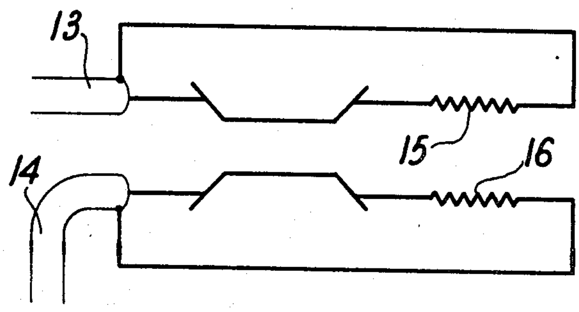


FIG. 2

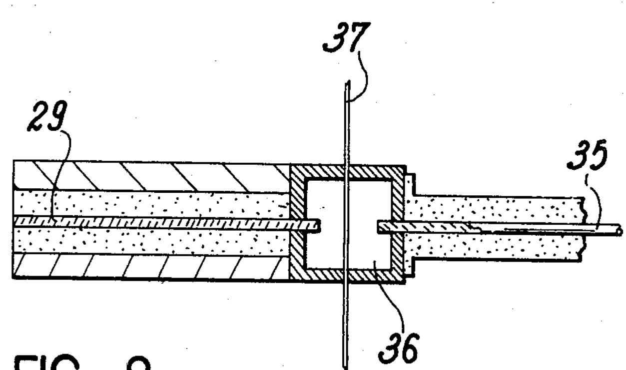


FIG. 8

FIG. 5

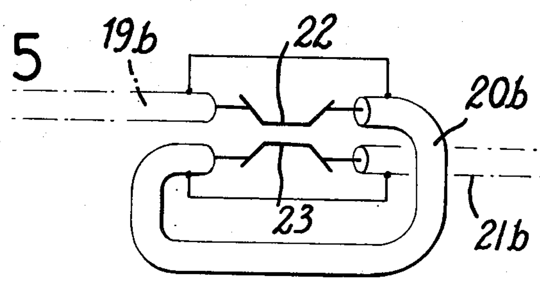


FIG. 6a

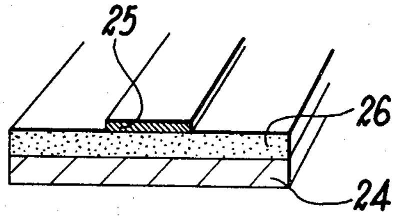
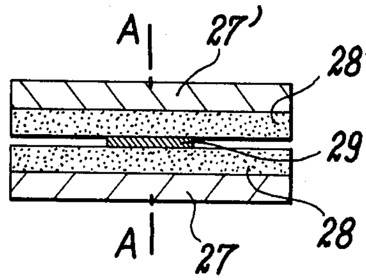


FIG. 6b



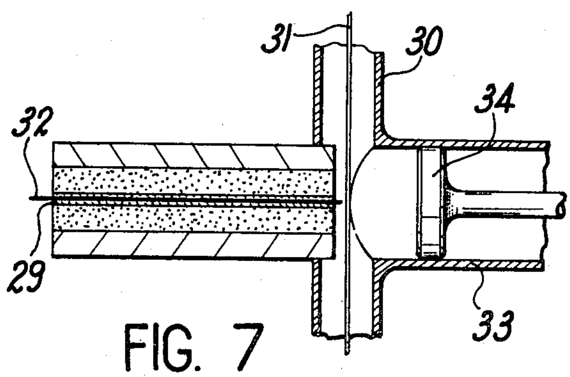


FIG. 7

DEVICE FOR PRODUCING RECTANGULAR VOLTAGE PULSES OF VERY SMALL WIDTH BETWEEN TWO OUTPUTS

This invention relates to a device for delivering rectangular voltage pulses of very small width to a receiving element. Among the potential applications of a device of this type, there can be mentioned in particular the control of image converter tubes of the bi-planar diode type having a uniform electric field (and involving either proximity focusing or magnetic focusing) and the Kerr or Pockels cells. It is known that, in all these cases, it is necessary to deliver to the receiving element a rectangular voltage pulse having a well-determined height V and time-width T.

Up to the present time, two types of devices have essentially been employed for delivering rectangular pulses of very small width. The first type makes use of a coaxial line which is terminated in its characteristic impedance and in the receiving element and a second line which has the same characteristic impedance as the first, which is charged to double the voltage to be delivered to the receiving element and is then closed on the first line by means of a high-speed switch usually consisting of a triggered spark-gap. This device makes it possible to obtain pulses which have a very fast rise time but nevertheless has a disadvantage in that it restores only one-half of the charging voltage. This makes it necessary to make use of a high-voltage supply having double the value of the required operating voltage and to choose a spark-gap having a static voltage performance which is double the operating value; in consequence, the stray inductance of said spark-gap is also doubled. Moreover, the pulse which is delivered to the receiver remains rectangular only if the product of the capacitance of the receiver and of the characteristic line impedance is very distinctly lower than the pulse width T.

The second known type of supply device makes use of a transmission line which is usually coaxial and constituted by two sections having the same characteristic impedance but different propagation times and a storage capacitor which is first charged and then closed on both sections at the same time by means of a high-speed switch. The rectangular pulse having a height equal to the charging voltage of the capacitor is then collected between the two line-section ends remote from those on which the storage capacitor is closed. This device has the disadvantage of requiring a capacitor having a very high capacitance in order that the decrease in voltage during the pulse time should remain acceptable.

This invention proposes a device for producing voltage pulses which meets practical requirements more effectively than those which have been employed heretofore, especially insofar as the above-mentioned disadvantages are largely removed. This device is capable of delivering rectangular voltage pulses of very small width between two outputs and comprises a first transmission line which can be charged, a second transmission line which constitutes the load line and switching means for connecting one end of the charged line to the load line. The main feature of said device is the fact that the characteristic impedance of the charged line is substantially lower than that of the load line.

In a first embodiment, the load line is constituted by two sections which have the same characteristic impedance and are of different length, said sections being supplied in parallel by the charged line. In a second embodiment, the load line is constituted by a plurality of sections which are supplied in series by the charged line. The charged line can be coaxial or can preferably have a flat structure.

Further properties of the present invention will become apparent from the following description in which a number of embodiments of said device are given by way of explanation but not in any limiting sense, reference being made to the accompanying drawings, in which:

FIG. 1 represents a first embodiment of a device according to the invention in which the load line is constituted by two sections having different lengths and supplied in parallel;

FIG. 2 represents an alternative embodiment of a the device of FIG. 1;

FIG. 3 represents a second embodiment of a device according to the invention in which the load line is constituted by two sections supplied in series;

FIG. 4 shows diagrammatically the waveform of the voltage which is collected between the outputs of the device according to the invention;

FIG. 5 represents an alternative embodiment of the device of FIG. 2;

FIGS. 6*a* and 6*b* represent two flat line structures which are intended to be employed in the device according to the invention;

FIG. 7 illustrates the use of a flat-structure line in the device shown in FIG. 1;

FIG. 8 illustrates the use of a flat-structure line in the device shown in FIG. 3.

A first type of device according to the invention is illustrated in FIG. 1. This device is intended to deliver rectangular voltage pulses to a receiving element **10** and this latter is constituted, for example, by an image-converter tube of the proximity-focusing type which is placed between two outputs **11** and **12**. This device comprises a coaxial load line constituted by two sections **13** and **14** having the same characteristic impedance but unequal lengths in order to have transit times whose difference is equal to the time-width T of the pulses to be delivered. Two impedances **15** and **16** having the same characteristic impedance Z_c serve to terminate the load line at both ends of this latter. The receiving element **10** is placed between the outputs **11** and **12** on the input side of the impedances **15** and **16**. The two sections **13** and **14** of the coaxial load line are supplied in parallel by means of a high-speed switch **17** which preferably consists of a triggered spark-gap from a common coaxial or flat open line **18** having a characteristic impedance z_c which is substantially lower than the characteristic impedance Z_c. By "substantially lower" is meant a value which is at least five times smaller ; in practice, the value given to z_c will usually be 10 times smaller than Z_c (approximately 5 ohms instead of 50 ohms, for example). By means of a circuit which is not illustrated, the line **18** is intended to be charged to a voltage which is substantially equal to the voltage to be delivered to the receiving element **10**.

Under these conditions, at the moment of discharge of the line **18**, the two sections **13** and **14** carry rectangular voltage pulses having a height *V*. There is thus obtained between the outputs **11** and **12** a rectangular pulse having an amplitude *V* and a width T which corresponds to the difference between the propagation times of the rectangular pulses in the two sections of the coaxial load line.

Assuming that the charged line **18** has negligible impedance with respect to the impedance of the lines **13** and **14**, it can be of interest to note that said line **18** performs the same function as an ideal storage capacitor (which has infinite capacitance, is geometrically localized and has zero stray inductance). In point of fact, it is possible in practice to construct a line having these properties whereas this is not the case with a capacitor. In other words, the replacement of the ideal storage capacitor by a line of this type makes it possible (as with the second type of known device defined in the foregoing) to obtain a rectangular voltage pulse having a height which is substantially equal to the charging voltage, this result being achieved while overcoming the main disadvantage of this known device which lies in the fact that an ideal capacitor is necessary in order to ensure that the pulse remains rectangular over an acceptable time interval and while also retaining the advantage of the first known device as hereinabove defined, namely that of providing very fast rise times.

Although a coaxial line can be employed for the purpose of constituting the charged line, it is easier to make use of a flat line: in fact, the charged line must have a low characteristic impedance and for this reason the line-insulating medium must have a high dielectric constant. Ceramic materials satisfy this condition and lend themselves more readily to the construction of flat striplines than to the construction of tubes (coaxial lines).

When the load circuit is essentially made up of two electrodes, it may be preferable to adopt an arrangement such that said electrodes are inserted in the propagation line with a view to minimizing reflections. FIG. 2 shows diagrammatically an arrangement of this type which can be employed in particular with certain Kerr cells and converter tubes of the bi-planar diode type. The impedances **15** and **16** which are shown in FIG. 2 can be replaced by two transmission lines having a characteristic impedance Z_c and can supply other elements.

A second type of device in accordance with the present invention is shown in FIG. 3. In this case, the load line is constituted by a plurality of sections which are connected in series with the charged line. For the sake of enhanced simplicity, the components of the device which correspond to those already shown in FIG. 1 are designated in FIG. 3 by the same reference numerals followed by the index *a*. A coaxial line **18***a* having a characteristic impedance z_c is again shown in this figure and can be charged to the load voltage by a circuit which is not illustrated. This line is closed on a coaxial load line having a characteristic impedance Z_c which is substantially higher than z_c by means of a high-speed switch **17***a* such as a triggered spark-gap. The coaxial load line comprises a first connecting section **19** followed in series by a second section **20** having a transit time which is equal to the width T of the pulses to be produced. Provision is made in FIG. 3 for a third section **21** having the characteristics of a line of infinite length which can in any case be replaced by a loop impedance having a value Z_c or alternatively by a coaxial line having a characteristic impedance Z_c which serves to supply other receiving elements. The receiving element **10***a* is connected between the two outputs **11***a* and **12***a* which are placed on each side of the section **20**.

At the moment of discharge, the sections **19** and **20** carry a rectangular voltage pulse having a height V. In consequence, there is collected between the outputs **11***a* and **12***a* a rectangular pulse having an amplitude V and a width T which corresponds to the time of propagation of the rectangular pulse from the output **11***a* to the output **12***a*.

There is shown in FIG. 4 the waveform of the voltage v which is collected between the outputs **11** and **12** or **11***a* and **12***a* as a function of the time t. If E represents the value of the charging voltage of the line **18** or **18***a*, there is obtained in both cases at the time of discharge of said line a rectangular pulse having a height V and a width T followed by a series of negative flat-top pulses. Since the impedance z_c is substantially lower than the impedance Z_c, the height V is practically equal to the value of the charging voltage E; in fact we have:

$$V = [z_c/(Z_c + z_c)]\ E$$

The width T is defined in one case by the difference in transit times of the sections **13** and **14** and in the other case by the transit time of the section **20**. The negative flat-top pulses have an amplitude which is smaller as the impedance z_c is lower. It is apparent that this value of impedance is chosen so as to bring said negative flat-top pulses to a value which is compatible with the requirements of the receiving element.

In the embodiment which is illustrated in FIG. 3, the receiving element **10***a* is connected in shunt on the coaxial load line. This solution is preferable in the case of some types of load elements but in the case of other types (Kerr cells and biplanar diode tubes, for example), it is preferable to adopt the series arrangement which is illustrated diagrammatically in FIG. 5. In the case of this figure in which the elements corresponding to those of FIG. 3 are designated by the same reference numerals followed by the index *b*, it is apparent that the arrangement of the section **20***b* with respect to the electrodes **22** and **23** of the receiving element is such that the width of the rectangular pulse is constant over the entire surface area of the electrodes. The section **21***b* can be employed for supplying an additional receiving element or can alternatively be replaced by a loop impedance having a value Z_c.

The diagram of FIG. 4 relates to a mode of operation of the devices hereinabove described with a charged line **18** or an open line **18***a*. However, it is possible to obtain a pulse of greater width by connecting a storage capacitor to the end of said line.

The charged lines employed in the devices which have been described are of the coaxial type but it is more advantageous to construct a line having a very low impedance by making use of a flat line structure. In point of fact, it is always a difficult matter to mount a coaxial line having a low characteristic impedance in series with a spark-gap and a load line while minimizing parasitic reflections. This flat line structure can comprise:

either, as shown in FIG. 6*a*, a ground plane **24** and a flat conductor **25** which are separated by a parallelepiped **26** of dielectric material,

or, as shown in FIG. 6*b*, two ground planes **27** and **27'** and two parallelepipeds **28** and **28'** of dielectric material which are disposed symmetrically with respect to a flat central conductor **29**. It is of interest to employ in the case of the dielectrics **26, 28** and **28'** a material having a very high dielectric constant in order to reduce the thickness of the line and to improve the quality of the transition from flat line to coaxial line.

The transition between a flat line structure of this type and the coaxial load line is preferably effected at right angles, the spark-gap **17** or **17***a* being integrated at the point of transition between the two lines.

In the case of a device having two coaxial line sections supplied in parallel as illustrated in FIG. **1**, the flat line structure makes it possible to integrate the grate the charged line, the spark-gap and the coaxial load line with two sections which are supplied at the same time.

FIG. 7 illustrates this possibility with a symmetrical line structure of the type shown in FIG. 6*b*. (The line which is illustrated is a sectional view along A—A of the line of FIG. 6*b*). A cylinder **30** having an axis at right angles to the plane of the line contains the conductor **31** of the coaxial line which forms the output electrode of the spark-gap. The input electrode of this latter is constituted by the end of the central conductor **29**. Said central conductor is provided with an opening for the insertion of a starting electrode **32**. Finally, a cylinder **33** which can be disposed in the right-hand space in the line of extension of the conductor **29** contains a piston **34** for optimizing impedance matching in order to prevent parasitic reflections. Said spark-gap can contain nitrogen, for example, in order to reduce the interelectrode distance and consequently the stray inductance.

When the load line is constituted by a plurality of sections in series as is the case with the device of FIG. 3, the charged line and the load line can be located in the line of extension of each other. FIG. 8 illustrates this possibility with a symmetrical line structure of the type shown in FIG. 6*b*. The flat central conductor **29** of the charged line and the central conductor **35** of the load line extend into a chamber **36** which can contain nitrogen. The electrodes of the spark-gap are constituted in that case by the opposite extremities of said two conductors whilst the starting electrode **37** of said spark-gap traverses the chamber **36** at right angles to the plane of the charged line. By virtue of this arrangement, an impedance of the charged line which is substantially lower than that of the load line can more readily be obtained; positioning and supply of the starting electrode **37** are also facilitated.

It will be readily apparent that this invention is not limited solely to the embodiments which have been described by way of example with reference to the accompanying drawings and that the scope of this patent also extends to alternative forms of either all or part of the arrangements described which remain within the scope of equivalent means as well as to any application of such arrangements.

What we claim is:

1. A device for producing rectangular voltage pulses of very small width between two outputs and comprising a first transmission line which can be charged, a second transmission line which constitutes the load line and switching means for connecting one end of the charged line to the load line, wherein the load line is constituted by two sections having the same characteristic impedance and wherein the characteristic impedance of the charged line is very substantially lower than that of the load line.

2. A device according to claim 1, wherein the two sections have different lengths and are connected in parallel to the charged line and wherein one of said two outputs is connected at the end of each of said sections remote from the end which is connected to said charged line.

3. A device according to claim 1, wherein the two sections of the load line are connected in series with the charged line and wherein one of said outputs is connected on each side of one of said sections.

4. A device according to claim 1 wherein the charged line is a coaxial line.

5. A device according to claim 1 wherein the charged line has a flat structure.

6. A device according to claim 3, wherein the load line is closed on its characteristic impedance.

7. A device according to claim 3, wherein the load line terminates in a final section which can be assimilated with a line of infinite length.

8. A device according to claim 3, including a receiving element connected to said outputs and connected in shunt on the load line.

9. A device according to claim 3, including a receiving element connected to said outputs and in series with the load line.

10. A device according to claim 1, wherein the charged line is closed at the other end thereof by a storage capacitor.

11. A device according to claim 1, wherein the characteristic impedance of the charged line is at least five times smaller than that of the load line.

12. An electrical circuit for releasing rectangular electric pulses of short time duration between two outputs, comprising: electric transfer line means having two conductors, said outputs being connected to one of said conductors at different locations thereof; an electric line comprising two conductors and having a characteristic impedance much less than the characteristic impedance of said electric transfer line: means for loading said electric line; and fast action switching means for connecting the conductors of said electric line to respective conductors of said electric transfer line means.

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