

Jan. 27, 1948.

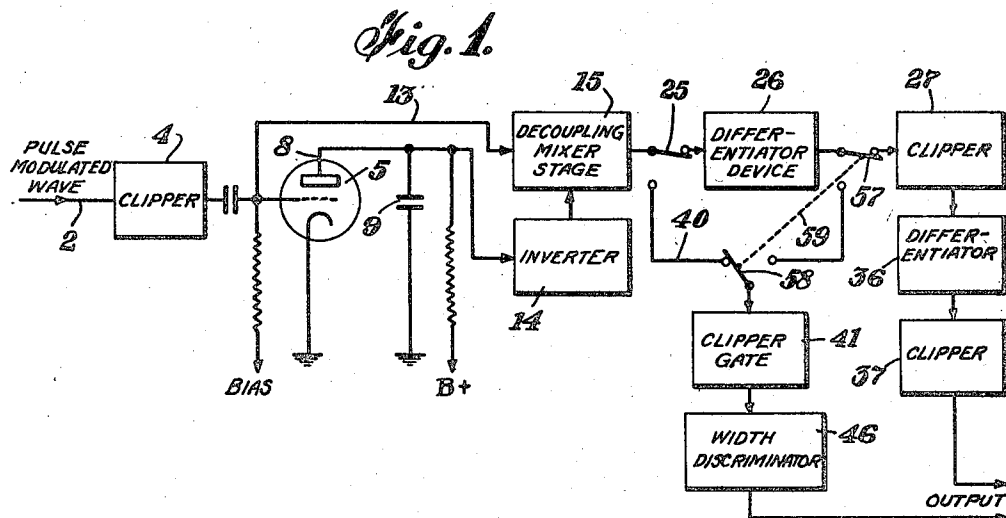
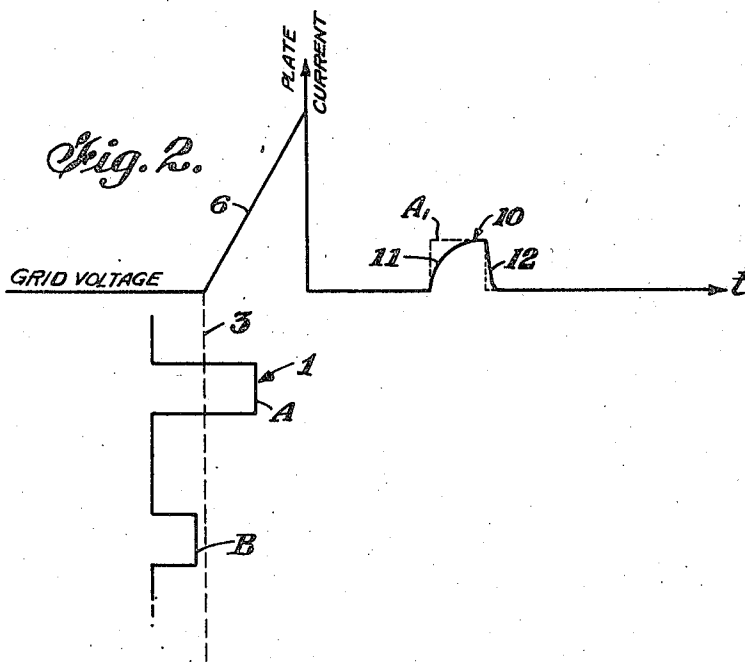
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2,434,922

PULSE AMPLITUDE SELECTOR SYSTEM

Filed Nov. 2, 1944

5 Sheets-Sheet 1



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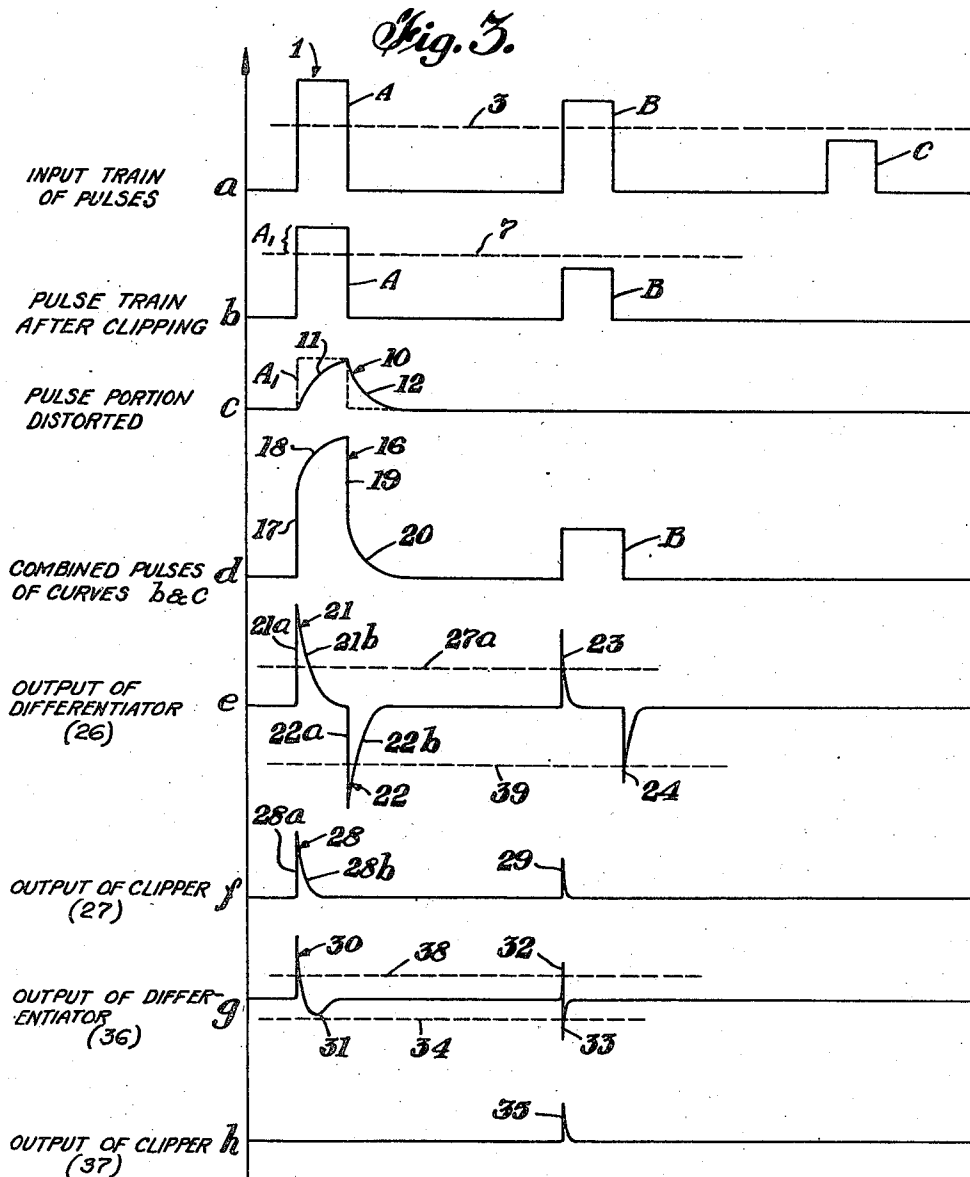
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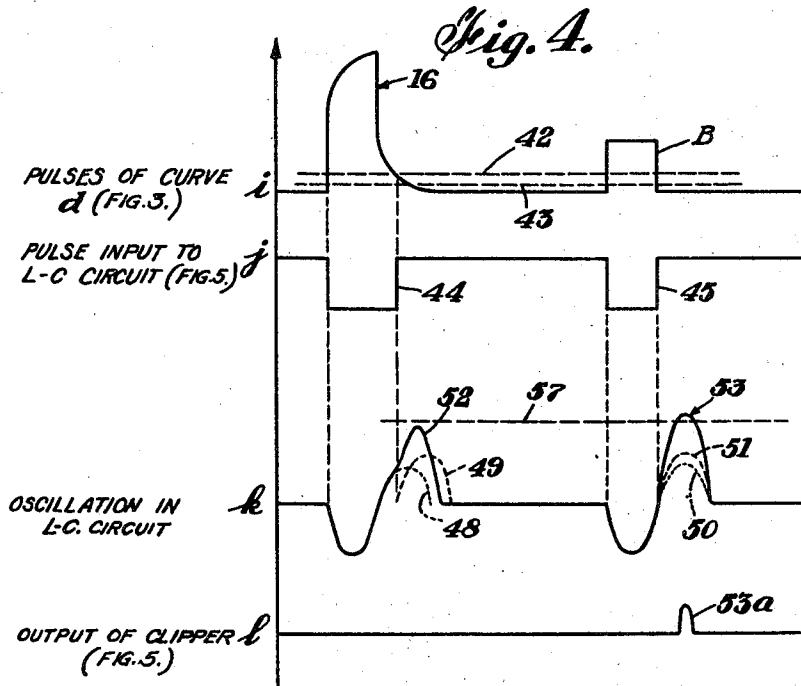
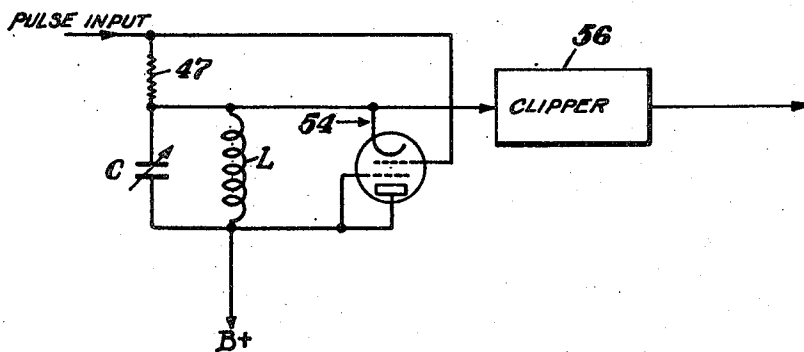


Fig. 5.



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Fig. 6.

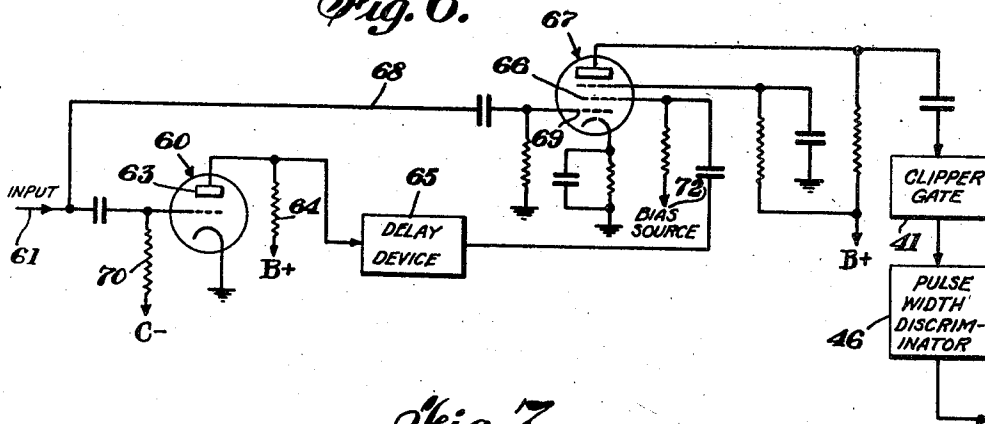
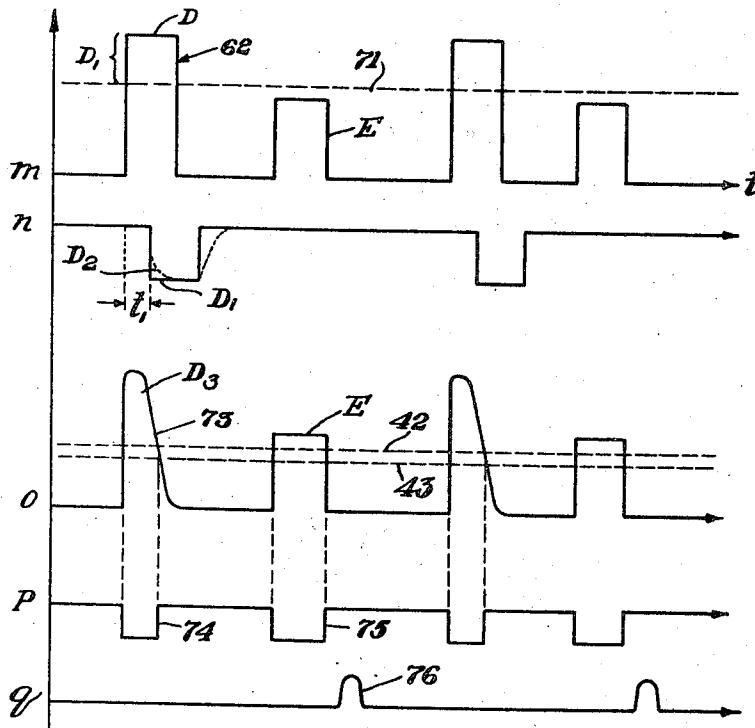


Fig. 7.



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Fig. 8.

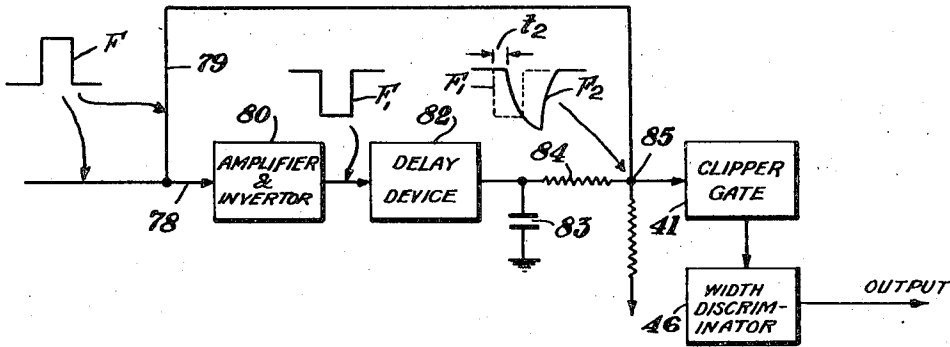
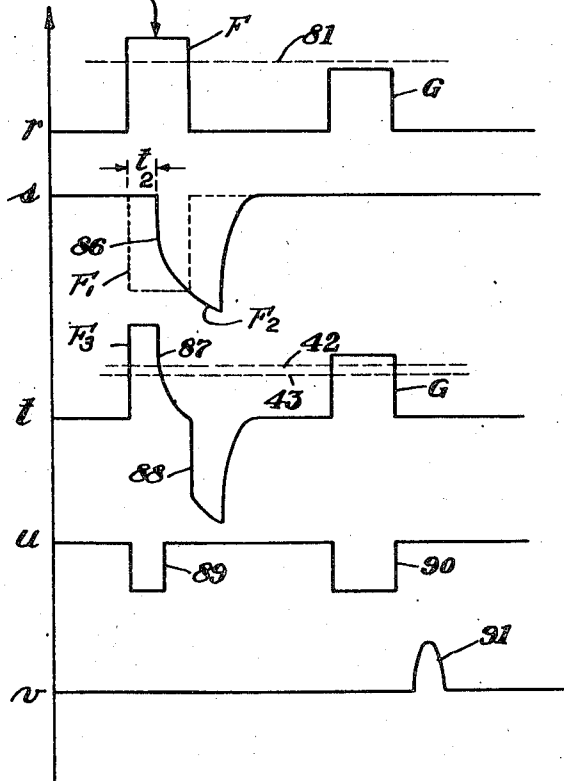


Fig. 9.



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PULSE AMPLITUDE SELECTOR SYSTEM

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Application November 2, 1944, Serial No. 561,554

23 Claims. (Cl. 250—27)

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This invention relates to radio pulse systems and more particularly to systems for discriminating between pulses in accordance with the amplitude of the pulses. This application is a continuation in part of my copending application Serial No. 467,516, now abandoned, filed December 1, 1942.

Excluding the condition of superposition of pulses, there exist three possibilities of relative amplitude variation during interference between series of wanted and unwanted electrical pulses substantially the same time duration on width. These possibilities are where the amplitude of the unwanted pulse is smaller, equal to, or larger than the amplitude of a wanted pulse. Where the unwanted pulse is smaller, it may be eliminated by simple clipping. The probability of two different sources of pulses having the same amplitude and thus causing interference at a receiver is so small as to be negligible. However, the elimination of unwanted pulses of greater amplitude than wanted pulses has heretofore presented a more difficult problem.

It is an object of this invention to discriminate selectively between pulses differing in amplitude so as to eliminate unwanted pulses regardless of the magnitude of their amplitude relative to wanted pulses.

The method of my invention may, for example, comprise distorting the leading or trailing, or both edges of the unwanted pulses of amplitude greater than the amplitude of the wanted pulses to reduce the slope. Such distortion varies the width at least in some part of an unwanted pulse so that by width discrimination of a part of the distorted pulse portion taken between predetermined amplitude levels and the corresponding pulse portion of the wanted pulse, pulse energy corresponding to the wanted pulse only can be obtained.

In place of the gate clipping and width discrimination steps, the unwanted distorted pulses and the wanted pulses may be otherwise processed, such as by a differentiating and clipping operation. Differentiation of the pulses provides derivation pulses of one polarity corresponding to the leading edges of the input pulses, and derivation pulses of opposite polarity corresponding to the trailing edges of the input pulses. The derivation pulses corresponding to the distorted edges will have, after one or more differentiating operations, smaller amplitudes than the other derivation pulses. The derivation pulses resulting from the differentiating step are clipped at a level at least as high as the amplitude of the pulses de-

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rived from the distorted edges, thereby obtaining a pulse output in accordance with the occurrence of the wanted input pulses.

The distortion of leading and/or trailing edges of the larger amplitude pulses may be accomplished by producing dissimilar pulse potentials in response to the larger amplitude pulses which are combined or applied in one way or another to the larger amplitude pulse energy so as to distort either its leading or trailing edge, or both, thereby distinguishing the unwanted pulses from the wanted pulses by a difference in one or more shape characteristics other than amplitude. When the pulses are differentiated, the distorted edge or edges will not produce pulses increasing and decreasing sharply in amplitude. Instead, the distorted edges of the input pulse produce upon differentiation blunt or curved pulses which, in many cases, may be of smaller amplitude than the pulses produced by differentiation of the wanted pulses. Should the blunt pulses thus produced by the distorted edges be of greater amplitude than the pulses produced from the edges of the wanted pulse, the differentiating operation may be repeated and, since the blunt pulses corresponding to the edge of the distorted pulse become less and less sharp, they can be eliminated or at least reduced to such an amplitude that a clipping operation will completely eliminate the effect of the larger input pulses.

The dissimilar pulse potentials used for distorting the unwanted pulses may be produced by different methods. For example, each larger input pulse may be clipped and the clipped portion distorted by condenser action, or it may be displaced in time relative to the input pulse, or both. The dissimilar pulse potential and the input pulse may be combined either by an algebraic mixing action (addition or subtraction), or by altering, by means of the dissimilar pulse potential, the gain of an amplifier to which the input pulses are applied.

For a better understanding of the methods of my invention and of systems by which the methods may be practiced, reference may be made to the following detailed description to be read in connection with the accompanying drawings, in which:

Fig. 1 is a schematic illustration of a circuit by which the selective discrimination between the pulses in accordance with amplitude may be effected;

Figs. 2, 3 and 4 are graphical illustrations showing the steps of operation by which pulses of intermediate amplitude can be selectively re-

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moved from a train having pulses with amplitudes less than, equal to, and greater than the wanted intermediate pulses;

Fig. 5 is a schematic wiring diagram of a pulse width discriminating circuit;

Fig. 6 is schematic illustration of another system by which the method of this invention may be practiced;

Fig. 7 is a graphical illustration useful in explaining the operation of the system of Fig. 6.

Fig. 8 is a schematic illustration of a further system of the invention; and

Fig. 9 is a graphical illustration useful in explaining the operation of the system of Fig. 8.

Referring to Figs. 1, 2 and 3 of the drawings, a pulse modulated wave or pulse train *i* is applied to the input 2 of the system of Fig. 1. The train *i* is shown in Fig. 3, curve *a*, to contain pulses A, B and C wherein the pulse B is the wanted pulse which may be modulated in either time or width with intelligence. The pulses A and C which are larger and smaller in amplitude, respectively, than pulse B may comprise two additional channels of intelligence or merely represent dummy or interfering pulses.

Since the most difficult discrimination exists where the wanted and unwanted pulses are of substantially the same width and have leading and trailing edges of substantial identical slope, I have chosen to illustrate my invention with pulses of that characteristic.

The pulses C of less amplitude are eliminated by first clipping the train of pulses along the amplitude level represented by line 3 by passing the wave through a clipper 4. The output of the clipper 4, curve *b*, is applied to a tube circuit having a vacuum tube 5 which is biased in accordance with the dynamic curve 6 shown in Fig. 2, whereby only the upper portion A₁ of the larger amplitude pulses, which extends beyond level 7, appears in the anode circuit 8 of the tube. Connected between the anode circuit 8 and ground is a condenser 9 adapted to be charged upon the occurrence of plate current whereby the pulse portion A₁ will be distorted. This distortion provides an output pulse 10 having curved leading and trailing edges 11 and 12 substantially as shown in Fig. 2, and curve *c*, Fig. 3. Energy of the pulses A and B is shunted by a connection 13 about the tube 5 and inverter 14 to the mixer stage 15 which may be a conventional double triode stage with plates in parallel. The pulse 10 combines in the plate circuit of the mixer stage with the larger amplitude pulse from which it is produced. This combining of the pulse 10 with the pulse A results, where both are of the same polarity, in a pulse 16 the leading and trailing edges of which are distorted as indicated by curve *d*. The lower leading edge portion 17 of the pulse 16 is substantially vertical but the upper leading edge portion 18 curves from the vertical to the trailing edge portion 19, in accordance with the curved leading edge of pulse 10, thereby eliminating the sharp upper left hand corner substantially as indicated by the overlapping pulse shapes of curve *c*. The upper trailing edge portion 19, curve *d*, is substantially vertical while the lower trailing edge portion 20 is curved according to the trailing edge of pulse 10. Thus, the upper left hand corner and the lower right hand corner of the pulse A (new pulse 16) are curved so that subsequent differentiation of the pulse produces pulses 21 and 22, curve *e*, the trailing edges of which have slopes correspond-

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ing to the curvatures of the portions 18 and 20, respectively.

The pulse output at 25 (Fig. 1) may be applied to a known differentiating device 26 whereby alternate positive and negative pulse derivations 21, 22 and 23, 24, curve *e*, are produced corresponding in time with the leading and trailing edges of the pulse 16 and the pulse B, respectively. The vertical portion 17 results in a vertical rise 21*a* and curved portion 18 results in an exponential drop substantially as indicated at 21*b*. The leading and trailing edges 22*a* and 22*b* resulting from the trailing edge portions 19 and 20 are similarly shaped in a negative direction. Differentiation of the pulse B results in sharper positive and negative pulses 23 and 24 than the pulses 21 and 22, the pulses 23 and 24 corresponding, respectively to the leading and trailing edges of the pulse B.

Should it be desired to obtain a pulse output in accordance with the leading edges of the pulse B, the positive pulses 21 and 23 may be threshold clipped at 27 as indicated by the line 27*a* and the peak portions 28 and 29 resulting therefrom, curve *f*, differentiated. The derivations of such a differentiation of pulse 28 are a sharp positive pulse 30, curve *g*, corresponding to the vertical edge 28*a*, and a blunt negative pulse 31 corresponding to the sloping edge 28*b*. Differentiation of pulse 29 results in positive and negative pulses 32 and 33 both of which correspond substantially in time to the leading edge of pulse B. The pulse 31, curve *g*, resulting from the sloping edge 28*b*, curve *f*, is of smaller amplitude than pulse 33. By clipping the negative pulses 33 at a level 34 beyond the pulse 31, a unidirectional pulse 35, curve *h*, is obtained corresponding substantially to the occurrence of the leading edge of the pulse B.

Should one clipping and differentiation be insufficient to reduce the pulse energy resulting from portion 18 or 20, curve *d*, to less amplitude than the pulse energy resulting from the leading or trailing edge of pulse B, additional differentiating and clipping operations may be made as indicated at 36 and 37. This would be necessary if the clipping level were chosen at 38 instead of at 34, curve *g*.

If a unidirectional pulse is desired corresponding to the trailing edge of the pulse B, the negative pulses 22 and 24, curve *e*, are threshold clipped as indicated by the clipping level 39, curve *c*. The output of this clipping operation is differentiated in the same manner as described in connection with the pulses of curve *f* and if necessary the clipping and differentiating operations may be repeated should the slope of the edge 22*b* be too sharp.

While I have described above a differentiating and clipping operation, such as set forth in my copending application Serial No. 561,553, filed of even date herewith, for discriminating between distorted unwanted pulses and wanted pulses, it will be clear that other processing means may be employed once the unwanted pulse has been distorted.

As hereinbefore mentioned, gate clipping and width discriminating operations may be employed. By moving contact 25 (Fig. 1) to connection 40 pulse energy such as shown in curve *d*, Fig. 3 and curve *i*, Fig. 4, is then applied to clipper gate 41. The gate 41 may be of any known clipper arrangement wherein the pulse energy is clipped between two gate limits such as indicated at 42 and 43 on curve *i*. The portions

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clipped between limits 42 and 43 may or may not be amplified depending upon the clipper circuit. Preferably the pulse portions are amplified and then applied as negative pulses, such as indicated at 44 and 45, curve *j*, to a pulse width discriminator 46.

The pulse width discriminator may be of any known construction capable of distinguishing between two or more different width characteristics. A suitable circuit for this purpose is disclosed in the copending application of E. Labin and applicant, Serial No. 487,072, filed May 15, 1943, assigned to Federal Telephone and Radio Corporation. In Fig. 5, I illustrate such a circuit. The input pulses 44 and 45, which are of constant amplitude, are applied through a resistor 47 to an L-C circuit which is tuned to a frequency, the period of which is substantially twice the duration of the wanted pulse 45. The leading and trailing edges of the pulses applied to the tuned circuit shock excite the circuit so that when the desired pulse width is applied, the shock effects of the leading and trailing edges thereof add accumulatively, as indicated at 48, 49 for pulse 44 and 50, 51 for pulse 45, curve *k*, and produce output undulations as indicated at 52 and 53, respectively. For pulses of greater and lesser width than the wanted pulse 45, the shock excitation effects of the leading and trailing edges thereof do not occur exactly in synchronism with the half period of the tuned frequency so that the shock effect of the trailing edge opposes more or less the oscillatory energy established by the leading edge of the same pulse. Thus, the undulations resulting from pulses of greater or lesser width than the width of the wanted pulses are of less amplitude than those obtained from the wanted pulses.

In order to prevent the trailing oscillations produced by one input pulse from interfering with oscillations established by the next input pulse, a damping circuit 54 is provided whereby all oscillations following the first undulation of positive polarity are eliminated. For a more thorough description of the pulse width discriminating circuit, reference may be had to the aforementioned application, Serial No. 487,072.

The resulting undulations which correspond to the wanted pulses are thereafter separated from undulations produced from the unwanted pulses by a clipper 56 which clips and amplifies the peak portions extending above level 57 as indicated by output pulse 53a, curve *L*. It will thus be clear that a discrimination is made of the difference in width of the pulse portions obtained by clipping between limits 42 and 43, curve *i*, whereby undulations corresponding only to wanted pulses *B* are obtained.

Before applying the pulse output of mixer 15 to the clipper gate 41, it may be first differentiated at 26. I accordingly provide movable switch contacts 57 and 58, ganged as indicated at 59, for connecting the output of differentiator 26 to the clipper gate 41. When this connection is made, contact 25 will of course be positioned to connect mixer 15 with differentiator 26. By appropriate adjustment of the gate limits of gate 41, either the positive or negative pulses of curve *c*, Fig. 3, as may be desired, are clipped, thereby providing a pulse output of constant amplitude, the pulses of which vary in width according to the pulse portions clipped by gate 41.

In Figs. 6 and 7, another system is shown including a triode 60 having an input 61 to which a pulse train 62, curve *m*, may be applied. The

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anode 63 of the tube is connected to a positive potential source through a resistor 64, and is further connected to the delay device 65, which in turn is connected to a control grid 66 of an amplifier tube 67. The input 61 is connected by a connection 68 to the control grid 69 of the amplifier tube 67. The tube 60 is so biased through resistor 70 as to pass a portion *D*₁ of the larger amplitude pulses *D* occurring above a cut-off level 71, curve *m*, Fig. 7. A delay *t*₁ curve *n*, is imposed on the pulse portion *D*₁ by means of the delay device 65 which preferably comprises a resistance-capacitance network. This network together with resistor 64 distorts the clipped energy as indicated at *D*₂. The energy *D*₂ being applied to the grid 66 alters the gain of the amplifier tube 67 which in this circuit is shown to be normally controlled by bias source 72, thereby distorting the input pulse *D* as indicated at *D*₃, curve *o*. The distortion, however, is in the trailing edge 73 of the pulse.

While the pulses *D*₃ and *E* may be differentiated and clipped similarly as described in connection with the parts 26, 27, 36 and 37 of Fig. 1, I preferably subject the pulses to clipper gate 41 and pulse width discriminator 46 which operate similarly as described in connection with Fig. 1. The clipper limits the pulses between gate limits 42 and 43 to produce constant current pulses 74 and 75, curve *p*, the pulse 74 being narrower than pulse 75. By means of discriminator 46 pulse 76, curve *q*, is obtained from pulse 75, the unwanted pulse 74 being eliminated.

In Figs. 8 and 9 I show a further embodiment of the invention in which the delayed pulse portion is mixed with the unwanted pulse for distortion of the trailing edge thereof. The unwanted pulse *F* of the pulse train 77, curve *r*, is applied to input connections 78 and 79, the energy over connection 78 being fed to an amplifier 80 biased to threshold clip the pulses at a level 81 at least as high as the amplitude of the wanted pulse *G*, whereby the upper portion of the unwanted pulse *F* is obtained, amplified and inverted as indicated at *F*₁, curve *s*. The inverted pulse portion *F*₁ is applied to a delay device 82 whereby the pulse portion is retarded an amount *t*₂. It is then applied to a capacitance-resistance circuit 83, 84 where it is distorted as indicated at *F*₂. The resistance 84 is chosen high so that it operates to isolate connection 79 from the capacitance 83. The distorted pulse potential *F*₂ is mixed with energy of the unwanted pulse *F* and the wanted pulses *G* at connection 85. The pulse potential *F*₂ being retarded by an amount *t*₂ relative to the unwanted pulse *F* adds algebraically thereto as indicated by the wave *q*, Fig. 9. The leading edge 88 of the pulse potential *F*₂ subtracts from the trailing portion of the pulse *F* thereby distorting the trailing edge thereof as indicated at 87. The portion of the pulse potential *F*₂ extending beyond the trailing edge of the pulse *F* appears in the wave at 88 as a negative pulse.

Here again, the wave train of curve *t* could be applied to the clipper and differentiator elements of Fig. 1 but instead I show the wave train to be applied to clipper gate 41 for clipping the pulses between limits 42 and 43. This produces constant amplitude pulses 89, 90, curve *u*, which are applied to width discriminator 46 whereby pulse 91, corresponding to wanted pulse *G* is obtained.

While I have described the principles of my invention in connection with several specific systems, it will be clearly understood that this description is made only by way of example. Many

other methods and systems of distorting the larger amplitude pulses may be used. For example, a multivibrator or other pulse generator may be arranged to produce a pulse in response to and dissimilar in shape to the unwanted pulses which, when applied thereto, will result in a pulse whose leading or trailing edge, or both, are distorted. It will be understood, therefore, that the systems herein described are illustrative of the invention only and not restrictive of the scope of the appended claims.

I claim:

1. A method of discriminating between wanted and unwanted electrical pulses of substantially the same width and similar shape characteristics where the unwanted pulse is of amplitude greater than the wanted pulse, comprising distorting said unwanted pulse to render it different in a shape characteristic other than amplitude from said wanted pulse, and thereafter processing said pulses to separate them according to their difference in said shape characteristic.

2. A method according to claim 1 wherein said distorting operation renders at least a part of the unwanted pulse of a width different from the width of the wanted pulse, and said processing operation includes the step of discriminating between the width characteristics of said distorted pulse and said wanted pulse.

3. A method according to claim 1 wherein said distorting operation renders at least a part of the unwanted pulse within the amplitude limits of said unwanted pulse of a width different from the width of the wanted pulse, and said processing operation includes the steps of clipping the pulses between two limits including said part of said unwanted pulse and a corresponding part of said wanted pulse, and eliminating the unwanted part by discriminating between the two parts according to their difference in width.

4. A method according to claim 1 wherein the operation of distorting said unwanted pulse includes decreasing at least in part the steepness of the slope of one of the edges thereof.

5. A method according to claim 1 wherein the operation of distorting said unwanted pulse includes clipping energy of said unwanted pulse at a level at least as high as the amplitude of said wanted pulse, changing the shape of the clipped portion, and combining the clipped portion and the unwanted pulse.

6. A method according to claim 1 wherein the operation of distorting said unwanted pulse includes clipping the said unwanted pulse at a level at least as high as the amplitude of said wanted pulse, re-shaping the clipped portion to reduce the steepness of at least one of the edges thereof, and combining the re-shaped clipped portion and said unwanted pulse.

7. A method according to claim 1 wherein the operation of distorting said unwanted pulse includes clipping said unwanted pulse at a level at least as high as the amplitude of said wanted pulse, retarding the clipped portion, and combining the clipped portion and energy of said unwanted pulse.

8. A method according to claim 1 wherein the operation of distorting said unwanted pulse includes clipping said unwanted pulse at a level at least as high as the amplitude of said wanted pulse, retarding and reshaping the clipped portion to distort one of the edges thereof and to cause the distorted edge to overlap in time the trailing portion of the unwanted pulse, and com-

binning the clipped portion and energy of said unwanted pulse.

9. A method of discriminating between wanted and unwanted electrical pulses of substantially the same width and of similar shape characteristics where the unwanted pulses are of amplitude greater than the wanted pulses, comprising producing, in response to said unwanted pulses, electrical pulse potentials dissimilar to said unwanted pulses, combining the dissimilar pulse potentials and energy of said unwanted and wanted pulses to produce a difference in a shape characteristic other than amplitude between the unwanted and wanted pulses, and thereafter processing said pulses to separate them according to their difference in said shape characteristic.

10. A method according to claim 9 wherein the pulse potential producing operation includes producing a pulse potential different from the shape of said unwanted pulses.

11. A method according to claim 9 wherein the pulse potential producing operation includes producing the pulse potentials at a given time displacement with respect to the occurrence of said unwanted pulses.

12. A method according to claim 9 wherein the pulse potential producing operation includes producing in synchronism with said unwanted pulses, pulse potentials having a shape dissimilar to the shape of said unwanted pulses.

13. A method of selectively discriminating between electrical pulses of different amplitude to eliminate those pulses of similar shape characteristics and of amplitude different from a given amplitude, comprising threshold clipping the pulses at a level at least as high as the greatest amplitude of those pulses smaller than said given amplitude, distorting the pulses of amplitude greater than said given amplitude to render them different in a shape characteristic other than amplitude from said wanted pulses, and thereafter processing said pulses to separate them according to their difference in said shape characteristic.

14. A system for discriminating between wanted and unwanted electrical pulses of substantially the same width and of similar shape characteristics where the unwanted pulse is greater in amplitude, comprising means to distort at least one edge of said unwanted pulse to render it different in a shape characteristic other than amplitude from said wanted pulse, and means to process said wanted and said distorted unwanted pulses to separate them according to their difference in said shape characteristic.

15. A system according to claim 14 wherein the means to distort the unwanted pulse comprises means for decreasing at least in part the steepness of said one edge.

16. A system according to claim 14 wherein said shape characteristic is pulse width and the processing means includes means to distinguish between said pulses according to their difference in width.

17. A system for discriminating between wanted and unwanted electrical pulses of substantially the same width and of similar shape characteristics where the unwanted pulse is greater in amplitude, comprising means to clip the unwanted pulse at a level at least as high as the amplitude of said wanted pulses, means to change the clipped portion in a shape characteristic other than amplitude portion, means for combining the clipped portion and energy of said unwanted pulse to distort the shape thereof in

accordance with the changed shape of said clipped portion, means to process the distorted unwanted pulse and said wanted pulse to separate them according to their difference in shape.

18. A system according to claim 17 wherein the means for clipping said unwanted pulse includes a vacuum tube, and means to bias the vacuum tube to cut-off at a desired level.

19. A system according to claim 17 wherein the means for changing the shape of the clipped portion includes a circuit having a condenser adapted to be charged and discharged by the clipped portion thereby altering the shape of the leading and trailing edges thereof.

20. A system according to claim 17 wherein the means for changing the shape of the clipped portion comprises a circuit having a delay characteristic adapted to retard the clipped portion a predetermining amount so that said clipped portion overlaps in time the trailing portion of said unwanted pulse.

21. A system according to claim 17 wherein the means for combining said clipped portion and energy of said unwanted pulse includes a mixer tube, and means for varying the gain of said tube in accordance with the potential of said clipped portion.

22. A system according to claim 17 wherein the means for combining said clipped portion and energy of said unwanted pulse includes means for algebraically adding said clipped portion to the energy of said unwanted pulse.

23. A system according to claim 17 wherein said shape characteristic is pulse width and said means for processing said distorted unwanted pulse and said wanted pulse includes means for clipping the pulses between two limits including a distorted part of said unwanted pulse and a corresponding part of said wanted pulse, and width discriminating means for eliminating the unwanted part.

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