Jan. 9, 1962 A. PETRIW 3,016,490
SEMI-COINCIDENCE DETECTOR
Filed Feb. 5, 1959 2 Sheets-Sheet 1

FIG. 1

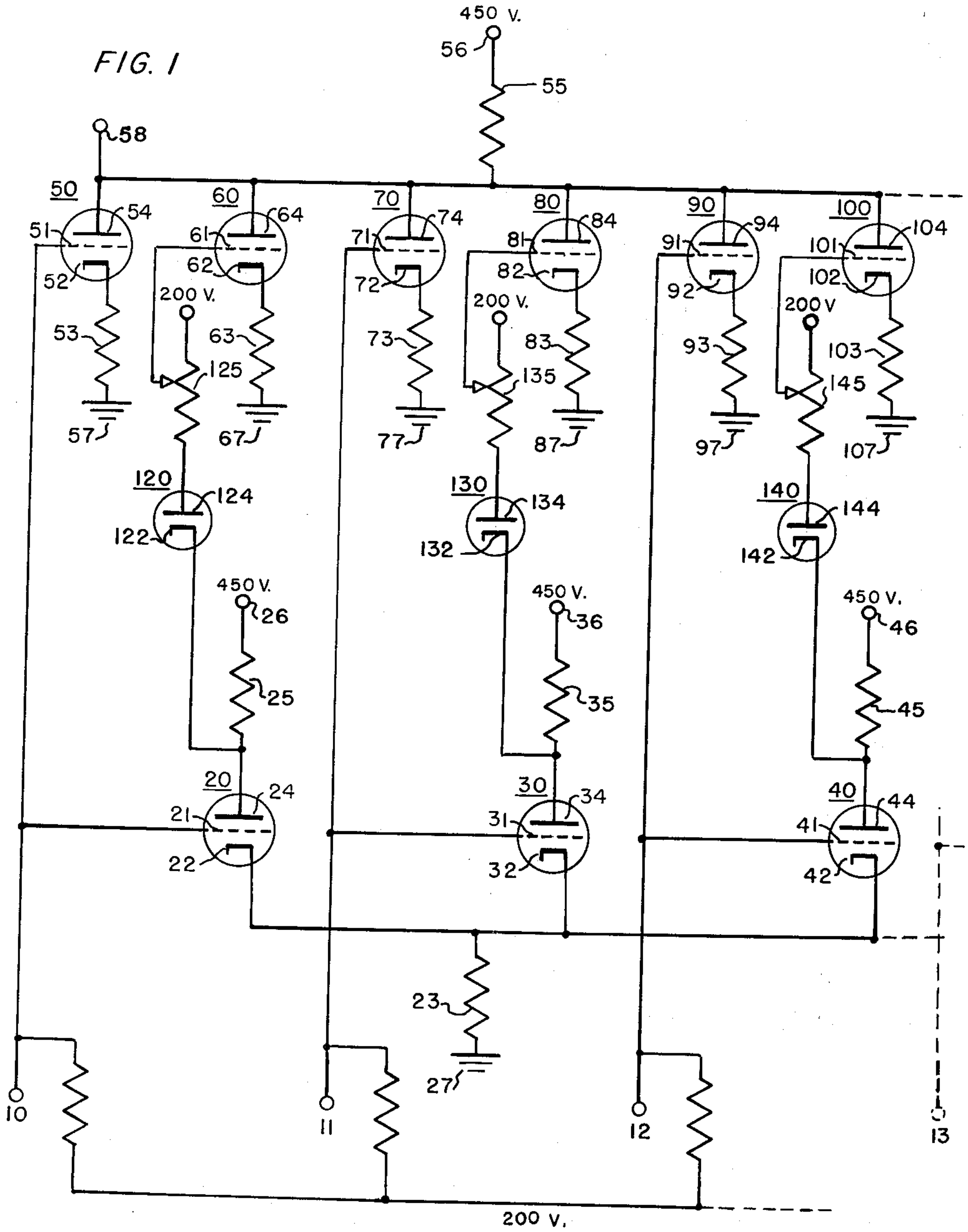


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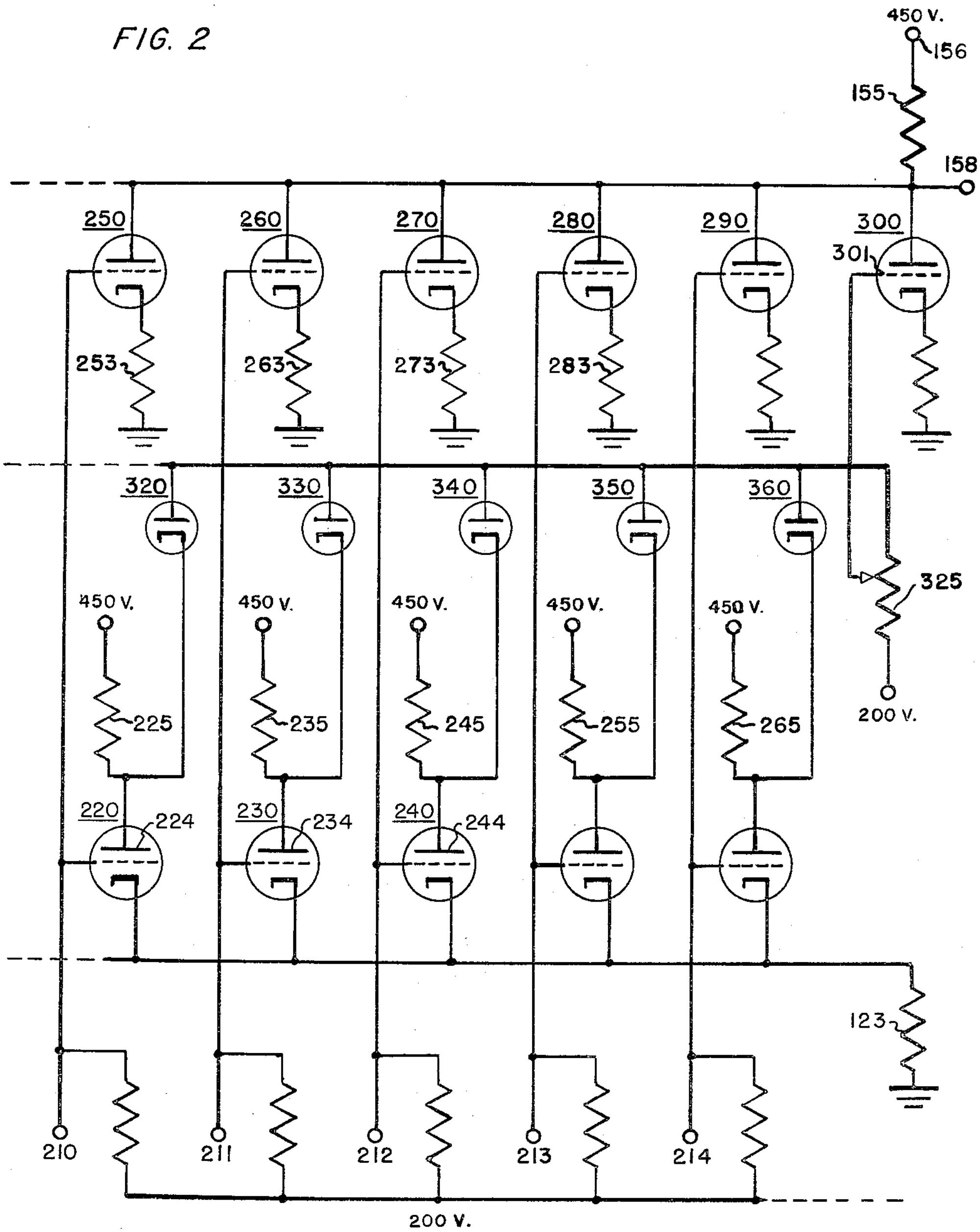
FIG. 2

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# 3,016,490
# SEMI-COINCIDENCE DETECTOR

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1 Claim. (Cl. 328—146)
(Granted under Title 35, U.S. Code (1952), sec. 266)

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 coincidence detectors and particularly to systems for detecting coincident signals in the presence of considerable noise in multiple channel communications. More particularly this invention relates to a device for detecting the presence of coincident signals in the majority of the channels of a multiple channel communication system.

The conventional approaches to the problem of detecting signals coincident in multiple channels rely on the addition of all of the signals in all of the channels so that an output signal is strengthened by the coincidence of several signals in different channels while random impulses are, comparatively, attenuated by the lack of coincidence of corresponding impulses in other channels. On the other hand an extremely strong signal in one channel would produce an output which might be as large as the combined outputs of a plurality of smaller coincident signals.

A system to overcome this difficulty when it occurs in pairs of channels is described in the Patent No. 2,934,643, issued to the same inventor on a "Coincidence Detector." In this patent a system is described wherein coincident signals on both of a pair of channels are added in the usual way while non-coincident signals produce a negative counterpart of the original in a difference detecting circuit which cancels the original in the final adding circuit. In other words non-coincident signals, regardless of their relative strength, are not only comparatively attenuated but are actually cancelled. This system applies only to pairs of channels.

However, in certain situations more than two channels may be provided and the usable signal may be so weak that it may be necessary or desirable to detect partially coincident or semi-coincident signals that may appear on a majority of the channels. A series of systems to accomplish this are taught in the Patent No. 2,934,644, issued to the same inventor on a "Semi-coincidence Detector," wherein several of the two channel coincidence detectors are combined and interconnected among various combinations of pairs of channels in order that a semi-coincidence of a co-incidence of the majority of channels, can be detected.

These latter systems will pass signals occuring simultaneously in the majority of channels and will also eliminate a substantial part of the noise, or other non-coincident impulses that do not occur simultaneously in a majority of the channels. This performs a valuable function in multiple channel reception and provides a considerably better signal to noise ratio than systems that merely add the coincidence of useful signals and rely on the randomness of noise signals to attenuate themselves. However, these systems require considerable equipment, particularly where a large number of channels are being sampled, and would require highly complex combinations where more than four channels were involved.

It is therefore an object of this invention to provide an improved semi-coincidence detector. It is a further object of this invention to provide an improved semi-coincidence detector having a maximum number of inputs with a minimum of circuitry. It is a further object of

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this invention to provide an improved semi-coincidence detector having a maximum number of inputs with a minimum of circuitry. It is a further object of this invention to provide an improved semi-coincidence detector for detecting the coincidence of signals in the majority of the channels of a multiple channel system and reducing the noise impulses that are not coincident in a majority of the channels of the system.

This and other objects are accomplished by applying a plurality of channels, that are intended to carry coincident signals in the presence of a very considerable noise, to a difference detecting circuit as well as to an adding circuit. The output of the difference detecting circuit is applied out of phase to the same adding circuit to cancel, or substantially reduce, the effect of non-coincident signals. Signals coincident in the majority of the channels, on the other hand, will be added in the normal manner in the adding circuit without appreciable attenuation from the difference detecting circuit.

This invention will be described in more detail and other and further objects of this invention will become apparent from the following specification and the drawings of which FIG. 1 shows a circuit diagram of a three or more channel system of one type and FIG. 2 shows a circuit diagram of a five or more channel system of a slightly different type for accomplishing semi-coincidence detection.

Referring now more particularly to FIG. 1, three inputs **10**, **11**, and **12** are provided to accommodate three channels that will presumably be carrying the same signals simultaneously. These inputs are connected directly to the grids **51**, **71** and **91** of the tubes **50**, **70** and **90** of an adding circuit. The same inputs are directly connected to the grids **21**, **31** and **41** of the tubes **20**, **30** and **40** that are connected to function as a form of difference detecting circuit. The outputs of these last tubes are connected through diodes **120**, **130** and **140** to the grids **61**, **81** and **101** of the tubes **60**, **80** and **100** that are also a part of the same adding circuit.

The adding circuit has a common load impedance **55**, which is connected to the plates **54**, **64**, etc., and an output terminal **58**. The adding circuit is completed by the cathodes **52**, **62** etc., connected through cathode resistances **53**, **63** etc., to the ground terminals **57** etc.

In this drawing similar elements have been similarly numbered for convenience in describing the elements and their duplication of function.

The difference detecting circuit has the cathodes **22**, **32** and **42** of the tubes **20**, **30** and **40** connected together and to ground **27** through a common load resistor **23**. The plates **24**, **34** and **44** are connected to a source of potential **26**, **36** and **46** thru plate load impedances **25**, **35** and **45**. A common source of potential may be used to supply these three plate impedances but separate connections are shown here to reduce the number of line crossings and irrelevant detail. The plates **24**, **34**, and **44** are connected thru the diodes **120**, **130**, and **140** to the appropriate tubes of the adding circuit.

The diodes are loaded by the potentiometers **125**, **135** and **145**, coupled to a common source of voltage which acts as a bias voltage for the grids **61**, **81**, and **101** as well as for the diodes. The cathodes **122**, **132** and **142** and the plates **124**, **134** and **144** of the diodes are so connected that, in this case, where only positive input pulses are to be considered, only the negative signals appearing in the outputs of the difference detecting tubes will be applied to the corresponding grids of the adding circuit tubes.

It is noted that grid biasing voltages and conventional grid resistors are necessary to maintain the grids of the several vacuum tubes in both of the drawings at their prescribed operating levels. The requirement of proper grid biasing and the necessary values thereof are well known in the art and need no detailed description here. The biases of the grids **21**, and **51**, **31** and **71**, and **41** and **91** may also be provided by the direct coupling of the input channels **10**, **11** and **12**, if the potentials of the input channels are of the proper relation with respect to other potentials of this circuit to make this possible.

In operation, the difference detecting circuit resembles the conventional forms and has a cathode impedance of as high a value as possible to maintain a substantially constant current condition in this part of the circuit. The cathode level is maintained at the mean level of the input channels and all three grids can vary over a fairly wide range without a substantial change in the grid-cathode voltage relationship and with a minimum corresponding change in the plate current or the voltage across the plate resistors **25**, **35** and **45**. This is the result of the constant current characteristic of this circuit. The resistor **23** could be replaced by a triode or a pentode circuit suitably connected and of adequate current carrying capacity to provide even better constant current characteristics.

The adding circuit is conventional and is shown with six active inputs for the proper accommodation of this version of applicant's device. The vacuum tubes **50—100** of the adding circuit are supplied from a source of potential **56**.

Although three inputs are shown in FIG. 1 a fourth input **13** and certain other dotted connections indicate that additional inputs can be provided, identical to any of the three shown, to accommodate additional channels. Three inputs have been shown for simplicity but any number of inputs may be incorporated in this circuit. The only actual changes necessary for adding more input stages to the difference detecting circuit or the adding circuit would be in the common load impedance **55** and the common cathode load **23** to accommodate the increased current. The power supplies would obviously have to be adequate for the current that would be required.

If three signals are coincident the three grids **21**, **31** and **41** are driven positive in unison. The cathodes **22**, **32** and **42** follow the grid action and no substantial change in voltage across the plate loads **25**, **35** and **45** results. There will be no appreciable negative signal applied at the diodes **120**, **130** and **140** or to the girds **61**, **81** and **101** of the corresponding adding circuit tubes. On the other hand, these positive pulses on **10**, **11** and **12** are also applied directly to the grids **51**, **71** and **91** of the adding circuit and the combined effect of these three signals will produce a substantial impulse across the plate load **55**.

If a signal is received on only two of the channels, the cathodes of the difference detecting circuit will follow the two active grids for the most part, but some increase will result in the grid cathode voltage relationship since the grid having no signal will hold back the cathodes to some extent. Consequently negative going pulses will be developed across the corresponding plate loads. These negative going pulses will be passed by the corresponding diodes and applied to the adding circuit to somewhat attenuate the semi-coincident positive signals. However, the positive input signals applied directly to the adding circuit are substantially greater and will still produce a substantial output. The input grid that had no signal will produce a substantial positive going pulse at the output of its difference detecting tube but this pulse will be blocked by the diode and have no effect on the common adding circuit.

In the event that only one impulse is received—as in the case of noise—on only one channel, the cathode following action in the difference detecting circuit will be a minimum, and a very substantial negative pulse will appear across the plate load of the difference detecting tube whose grid received the impulse. This negative pulse will be passed by the corresponding diode and applied to the adding circuit tube to effectively cancel the original impulse or noise signal. Thus the output of a semi-coincidence detecting circuit as shown in FIG. 1 will have a substantially better signal to noise ratio than that of simple addition circuits relying solely on attenuation by averaging.



Another circuit for semi-coincidence detection is shown in FIG. 2. This circuit has fewer parts, relative to the number of channels accommodated, than the circuit of FIG. 1 for the same random impulse cancellation. In FIG. 2 the inputs **210**, **211**, **212**, etc., correspond to **10**, **11**, and **12** of FIG. 1. Five inputs are shown here although, as in FIG. 1, there is no limit to the number of inputs that could be employed. The differences detecting circuits are in the tubes **220**, **230**, **240** etc., which perform generally the same functions as those of the corresponding tubes of FIG. 1.

The main difference between FIGS. 1 and 2 is in that the outputs of the diodes **320** to **360** have been combined in a common load potentiometer **325** which is tapped to connect to the grid **301** of a single tube **300** in the combined adding circuit. This is possible since it does not matter which difference detecting circuit tube generates the signal-cancelling negative pulse as long as it is applied at its correct level to the adding circuit. The positive pulses generated in the difference detecting circuit are cancelled by the diodes as before.

The incidence of a single positive pulse at one of the inputs will still produce a negative pulse across the output load but the single adding circuit tube will function for any one of the difference detecting tubes and the negative pulse is applied to the single tube in the adding circuit instead of requiring a separate tube in the adding circuit for each of the difference detecting tubes. Each of the inputs **210**, **211**, **212**, etc., is connected directly to the grid of a tube in the adding circuit and to a grid of one of the difference detecting tubes as before.

In operation the cathodes of the difference detecting tubes will follow the potential change of the majority of the input signals applied to the grids. If the majority of the grids receive signals the cathodes will rise and the constant current characteristic of this circuit will result in a minimum change in the grid-cathode voltage relationship and a minimum change in the voltage drop across the corresponding load resistors. If one of the channels does not produce a signal the corresponding tube will draw less current, and a positive voltage change will appear across its plate load. The positive voltage change will be blocked by the corresponding diode so that it will not affect the coincident signals appearing in the majority of the channels of the adding circuit. On the other hand if the majority of the channels have no input signal and an impulse appears in only one channel the corresponding difference detecting tube will draw considerable current and a negative pulse will appear across its plate load resistor. The negative pulse will pass through its diode to the common adding circuit tube to cancel the single positive impulse.

In both of the circuits it is necessary that the negative, correcting voltage produced by the difference detecting circuit be equal and opposite to the original, non-coincident, positive going signal at their grids of the adding circuit tubes. The negative, correcting voltage may have to be adjusted for best results since the circuit parameters and tube characteristics may vary appreciably. The diode loads are provided with variable potentiometer taps in both circuits as a simple means of controlling one set of the voltages. Other methods for controlling voltages are well known and could also be applied here.

The magnitude of the input signals is limited by the amount of grid-cathode potential variation that the difference detecting tubes can tolerate without overloading. The adding circuit tubes can accommodate a much greater input signal variation because of the cathode follower action of the individual stages. Therefore, to bring this circuit to a higher efficiency, voltage dividers can be used to reduce the input signal at the grids of the difference detecting tubes as compared with the signal at the grids of the adding circuit tubes. This reduction can be compensated for by increasing the gain of the difference detecting circuit.

While the typical circuits described herein use vacuum tubes it will be obvious that the same principles and circuitry can be applied to transistors.

In the typical circuit shown in FIG. 1 the adding circuit triodes would be halves of 5151 dual triode tubes. The difference detecting tubes would be halves of 6SU7 dual triode tubes and the diodes would be either halves of 6AL5s or semiconductor diodes of any well known type. The cathode leads of the adding circuit would be 500,000 ohms each, and the common plate load **55** would be 17,500. The plate loads of the difference detecting tubes would each be 250,000 ohms and the common cathode load **23** would be 120,000 ohms. The diode load potentiometers **125**, **135** and **145** would be 1,000,000 ohms. The potential **56** is 450 volts and the potential **26**, **36** and **46** would be 450 volts with respect to ground.

The same elements are applicable to the circuit of FIG. 2, excepting that each of the common loads **155**, and **123** would have a value depending on the number of channels and tubes employed.

Having thus described my invention what is claimed is:

In a circuit for detecting coincident signals in the presence of noise in a communications system having at least three channels; an adding circuit comprising at least six vacuum tubes, each having grid, cathode, and plate electrodes; a first source of potential with respect to ground; a common plate load impedance connecting all of said adding circuit tube plates to said first source of potential; a cathode impedance connecting each of said adding circuit tube cathodes to ground; a difference detecting circuit comprising at least three vacuum tubes, each having grid, cathode, and plate electrodes; a common cathode impedance connecting all of said difference detecting tube cathodes to ground; a second source of potential; a plate load impedance connecting each of said difference detecting tube plates to said second source of potential; at least three rectifier tubes each having a cathode electrode connected to the plate electrode of one of said difference detecting tubes, and a plate electrode connected through a load impedance to the grid of one of a first group of said adding circuit tubes; and each of the grids of the difference detecting tubes connected to one of the grids of a second group of the adding circuit tubes.


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