

- [54] REMOTE DETONATION SYSTEM
- [75] Inventors: Ryozi Shimizu, Chigasaki; Kenji Nakao, Yokohama; Masaaki Oguri, Tokyo; Masakatu Ohgaki, Hiratsuka, all of Japan
- [73] Assignees: OKI Electric Industry Co., Ltd.; Taisei Corporation, Tokyo, Japan
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- [51] Int. Cl..... F42d 3/00
- [58] Field of Search 102/10, 16, 18, 19.2, 102/22, 23, 70.2
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Primary Examiner—Verlin R. Pendegrass
Attorney—C. Yardley Chittick et al.

[57] ABSTRACT

In a remote detonation system wherein a plurality of underwater explosives are detonated simultaneously by command signals sent from a remote control station, there are provided a control station including an oscillator for generating a plurality of frequency modulated waves and a sound wave transmitter for transmitting the frequency modulated waves through the water as frequency modulated command signals; a plurality of detonation control elements, each including a sound wave receiver for receiving the frequency modulated command signals from the control station, means for demodulating the output from the sound wave receiver for reproducing the frequency modulated command signals and ignition means including a plurality of switches which are operated sequentially by the output of the demodulating means; a plurality of electric detonators each connected to the ignition means of the detonation control elements, and a plurality of underwater explosives detonated by the detonations of respective electric detonators.

11 Claims, 9 Drawing Figures

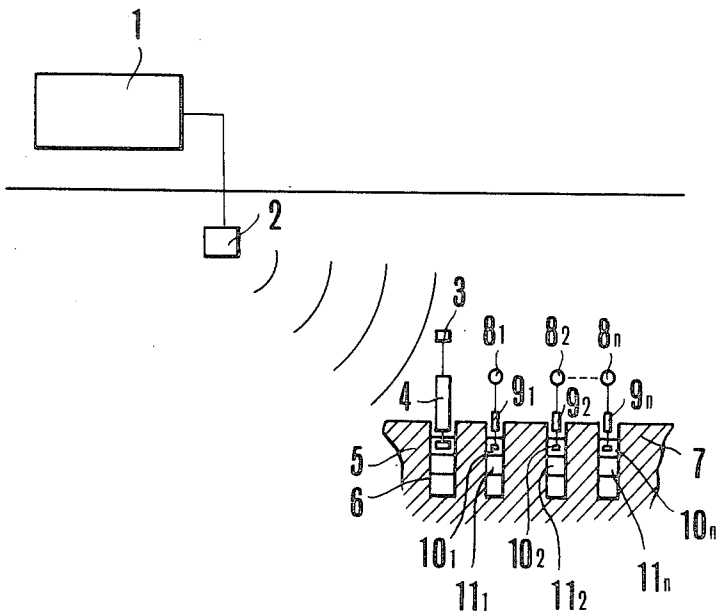


FIG. 1

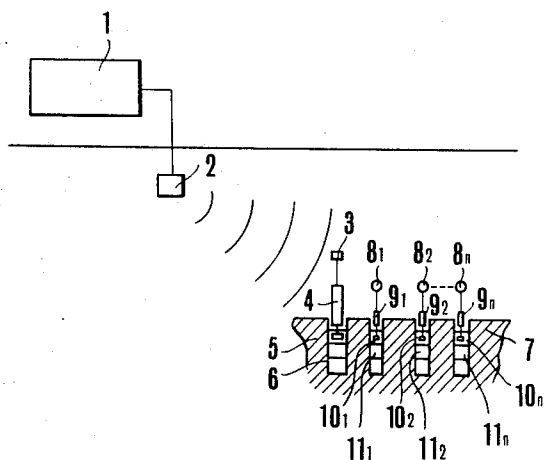
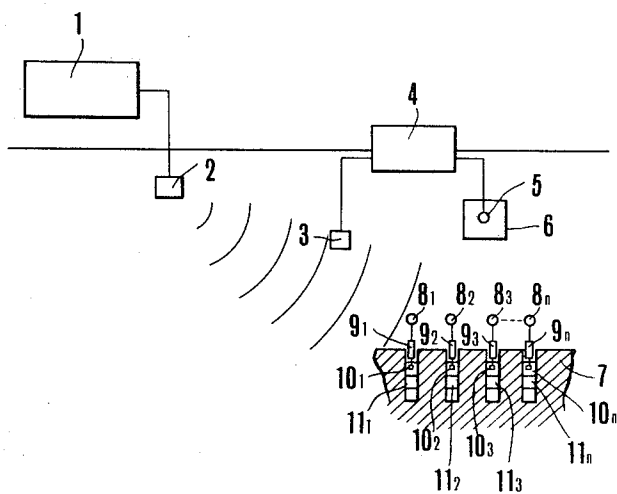


FIG. 2



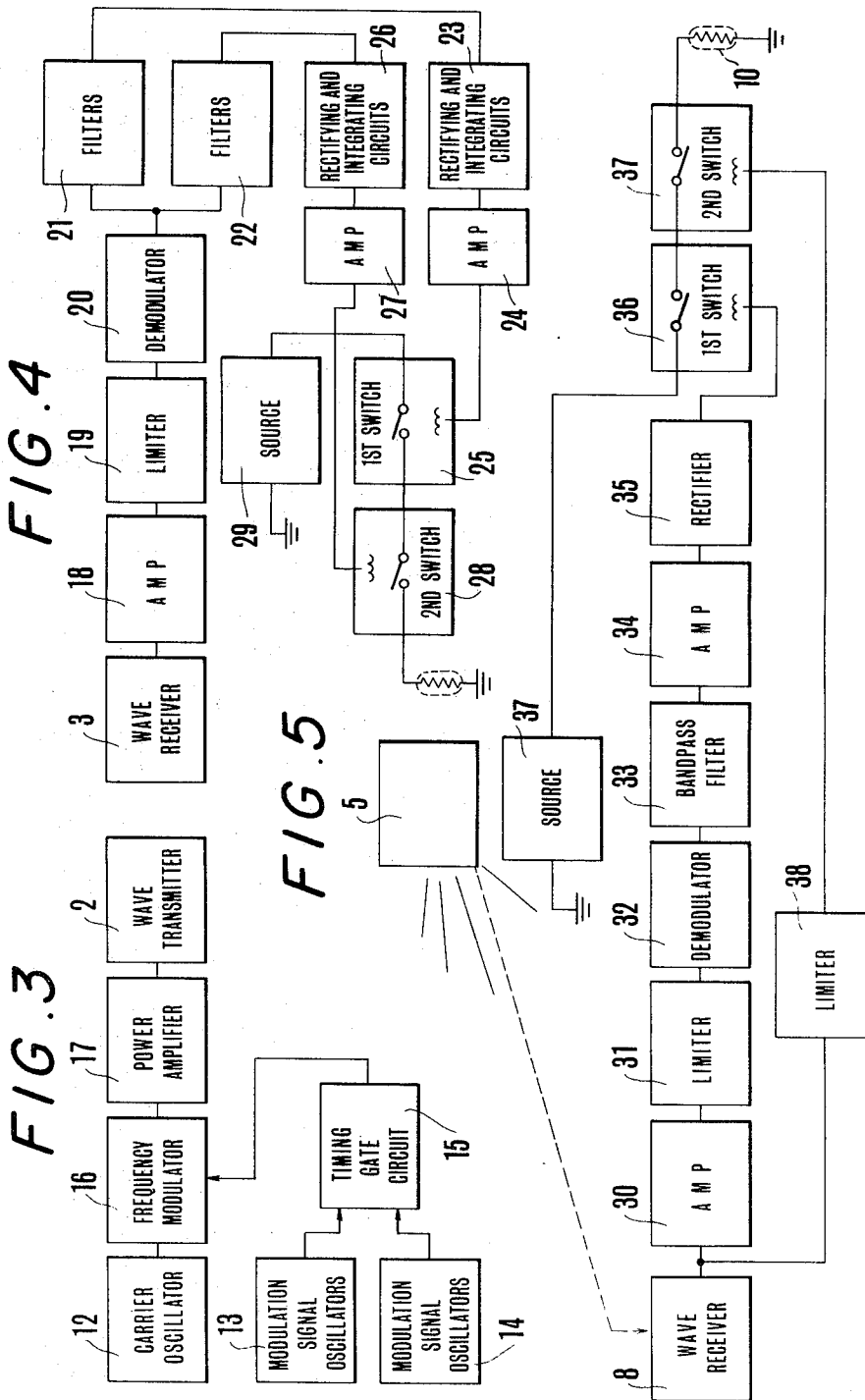


FIG. 6

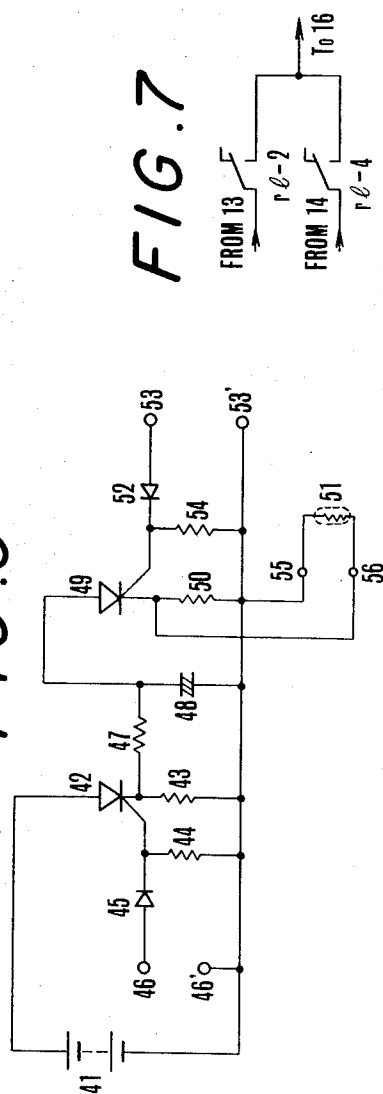


FIG. 7

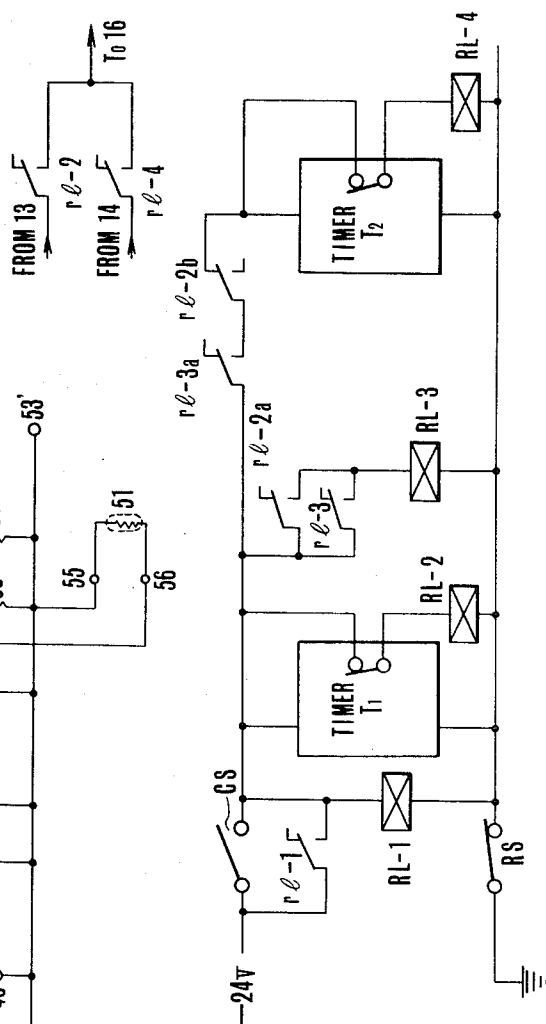


FIG. 8

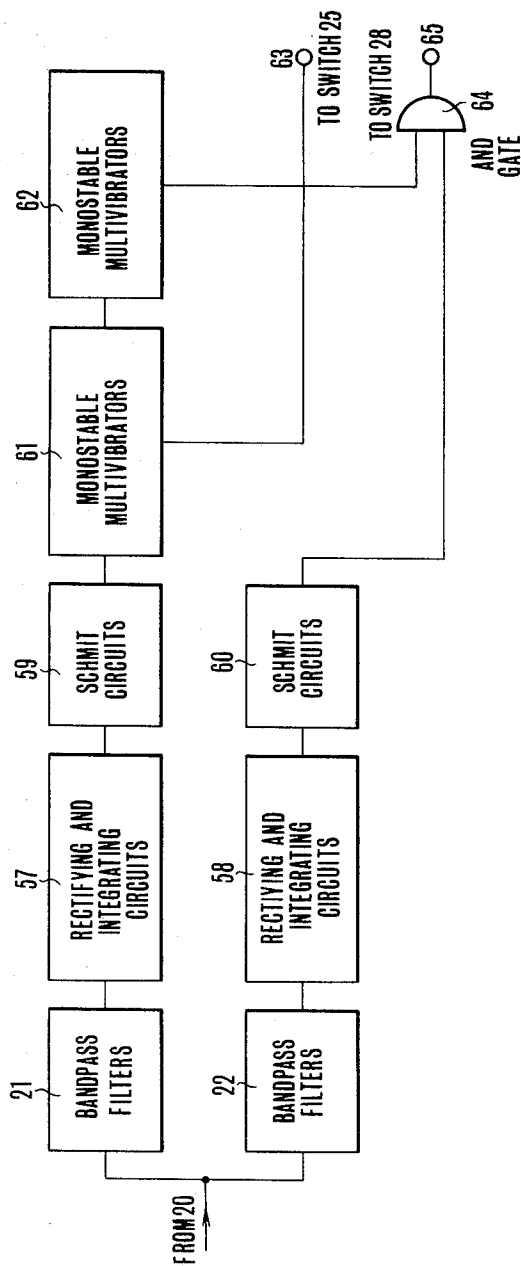
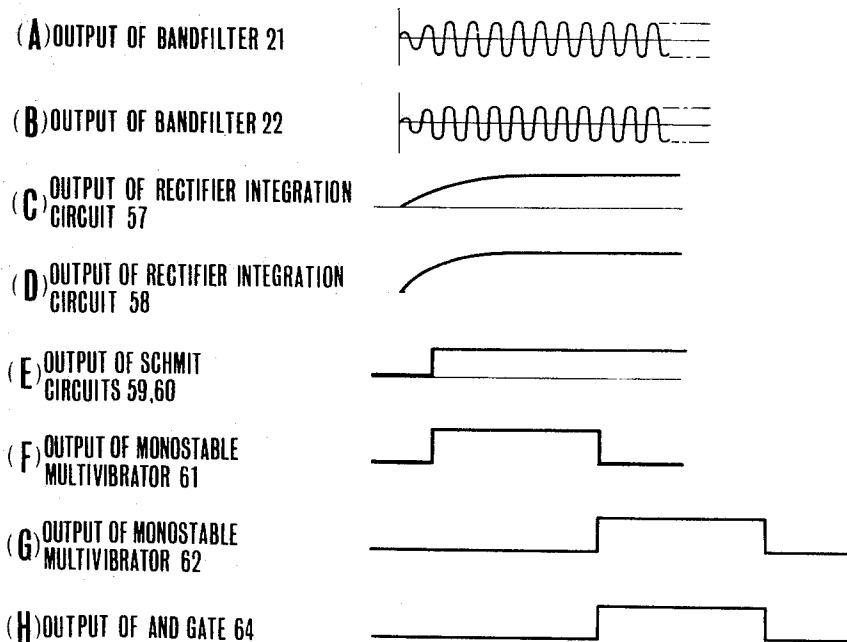


FIG. 9



REMOTE DETONATION SYSTEM

BACKGROUND OF THE INVENTION

This invention relates to a remote detonation system, more particularly a novel system for simultaneously detonating a plurality of explosives loaded in an under-
water rock by using a frequency modulated signal transmitted from a remote control station.

Heretofore, in order to explode an underwater rock with explosives by a signal transmitted from a remote control station it has been the practice to drill a plurality of openings through the rock, charge explosives provided with electric detonators in respective openings, electrically connect the detonators in series or parallel, and connect the detonators to a control switch located in the remote control station through an electric cable whereby the plurality of explosives are detonated simultaneously. Such a system, however, requires to use a submersible cable and to connect it with respective electric detonators in water. For this reason, there are such disadvantages that the cable is broken by a tidal current, that the electrical connections between the cable and the electric detonators are damaged and that the cable becomes tangled. Thus, the working efficiency is low so that it has been impossible to use such a system in deep water.

To eliminate the use of an electric cable it has been proposed to use ultrasonic waves. However, ultrasonic receivers associated with the detonators often respond to underwater noises thus there is probability of causing unexpected detonations resulting in disasters. Furthermore, where it is necessary to detonate a large underwater ground area by using a large number of explosives it has been difficult to simultaneously detonate them due to the difference in times of the arrival of the supersonic waves to respective detonators, thereby decreasing the efficiency of detonation.

SUMMARY OF THE INVENTION

Accordingly, it is an object of this invention to provide a new and improved remote induction detonation system using ultrasonic wave and capable of safely and accurately detonate a detonator without the fear of any miss-detonation caused by miss-connection or breakage of a cable and which is not required to use any underwater cable or electrical conductor which should be connected to the detonator under water.

Another object of this invention is to provide a novel remote induction detonation system using ultrasonic wave which can safely and simultaneously detonate a plurality of detonators from a remote point without being interfered by underwater noises even in applications where the conventional system using an electrical cable is not practical due to a rapid tidal current or a large depth.

A further object of this invention is to provide a novel remote induction detonation system utilizing ultrasonic wave wherein a main detonator is firstly detonated by a command signal transmitted from a remote control station and then a plurality of auxiliary detonators are detonated simultaneously by the cooperation of said command signal and the percussion wave generated by the explosion of the main detonator.

Still further object of this invention is to provide a novel detonation control circuit or element which accurately responds only to the detonation command signal for electrically detonating the detonator.

According to this invention there is provided a remote detonation system wherein a plurality of underwater explosives are detonated simultaneously by command signals sent from a remote control station, characterized in that there are provided a control station including an oscillator for generating a plurality of frequency modulated waves and a sound wave transmitter for transmitting the frequency modulated waves through the water as frequency modulated command signals; a plurality of detonation control elements, each including a sound wave receiver for receiving the frequency modulated command signals from the control station, means for demodulating the output from the sound wave receiver for reproducing the frequency modulated command signals and ignition means including a plurality of switches which are operated sequentially by the output of the demodulating means; a plurality of electric detonators each connected to the ignition means of the detonation control element; and a plurality of underwater explosives detonated by the detonations of respective electric detonators.

BRIEF DESCRIPTION OF THE DRAWINGS

Further objects and advantages will become apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

FIGS. 1 and 2 are diagrams to show basic arrangements of slightly different remote detonation systems embodying the invention wherein in the arrangement shown in FIG. 1 both the main detonator and a plurality of auxiliary detonators are installed at a substantially equal underwater level whereas in the arrangement shown in FIG. 2 the main detonator is located at a higher underwater level.

FIG. 3 shows a block diagram of one example of a control station used in this invention;

FIG. 4 shows a block diagram of a detonation control circuit associated with the main detonator;

FIG. 5 shows a block diagram of a detonation control circuit for the auxiliary detonators;

FIG. 6 shows connection diagram of an ignition circuit for igniting a detonator;

FIG. 7 shows a block diagram of one example of the timing circuit used in the control station used in this invention;

FIG. 8 shows a block diagram of one example of a timing circuit utilized in a detonator of this invention and

FIG. 9 shows waveforms of various circuit elements utilized in the timing circuit shown in FIG. 8.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The remote detonation system shown in FIG. 1 comprises a control station 1 for transmitting a plurality of frequency modulated command signals through an ultrasonic sound transmitter 2 immersed in water, a main detonation control element 4 located at the bottom of the water and provided with a sound wave receiver 3 for receiving the frequency modulated command signals transmitted from transmitter 2. An electric detonator 5 is included in the detonation control element 4 for detonating an explosive 6. There are also provided a plurality of sound wave receivers 8₁, 8₂ . . . 8_n arranged to receive the frequency modulated command signals transmitted from the transmitter 2 and the percussion wave generated by the detonation of the main explosive

6 for actuating detonation control elements $9_1, 9_2, \dots, 9_n$ respectively which are connected to electric detonators $9_1, 9_2, \dots, 9_n$ associated with auxiliary explosives $11_1, 11_2, \dots, 11_n$ loaded in the holes on the rock at the bottom of the water.

A plurality of frequency modulated command signals radiated by ultrasonic wave transmitter 2 of the control station 1 propergate through the water to be received by the wave receiver 3 of the main detonation control element 4 and a plurality of wave receivers $8_1, 8_2, \dots, 8_n$ of the auxiliary detonation control elements $9_1, 9_2, \dots, 9_n$. The main detonation control element 4 located at the bottom of the water operates to sequentially demodulate and detect a series of the frequency modulated command signals which are received by wave receiver 3 for detonating electric detonator 5 and explosive 6 by the output of the main detonation control element 4. On the other hand, wave receivers $8_1, 8_2, \dots, 8_n$ of the auxiliary detonation control elements $9_1, 9_2, \dots, 9_n$ operate to receive predetermined signals among a series of the frequency modulated command signals and an intense percussion wave generated by the explosive of the main explosive 6, thereby energizing respective electric detonators $10_1, 10_2, \dots, 10_n$ by their outputs in response to the predetermined signals and the percussion wave for simultaneously detonating auxiliary explosives $11, 12, \dots, 11_n$.

In the modified embodiment shown in FIG. 2, the detonation control element 4 is floated on the surface of the water, and wave receiver 3, and a detonator 5 associated with the main explosive 6 are suspended from and electrically connected to the detonation control element 4. The levels of the wave receiver 3, the detonator 5 and the main explosive 6 may be relatively shallow.

As above described, the control station 1 utilized in this invention is designed to generate a plurality of frequency modulated command signals but for the sake of brevity it is herein assumed that the control station generates two such signals. In the embodiment shown in FIG. 3, there is provided a carrier wave oscillator 12 for supplying a carrier wave of frequency f_0 (for example 20 KHz) to a frequency modulator 16. There are also provided modulation signal oscillators 13 and 14 for generating modulation signals of frequencies f_1 (for example 500 Hz) and f_2 (for example 400 Hz). The modulation signal f_1 from the modulation signal oscillator 13 is supplied to the frequency modulator 16 for a predetermined interval through a timing gate circuit 15, whereas the modulation signal f_2 from the modulation signal oscillator 13 is supplied to the frequency modulator 16 for another predetermined interval also through the timing gate circuit 15. As a result, the output from the frequency modulator 16 comprises, a command signal produced by frequency modulating the carrier wave f_0 with signal f_1 followed by a command signal produced by frequency modulating the carrier wave f_0 with signal f_2 . These two frequency modulated command signals are amplified by a power amplifier 17 and then radiated into the water through the ultrasonic wave transmitter 2. The ultrasonic waves are received by the main and auxiliary wave receivers 3 and $8_1, 8_2, \dots, 8_n$.

Referring now to FIG. 4, the two frequency modulated command signals received by the receiver 3 of the main explosive 6 are amplified by an amplifier 18 and their amplitudes are limited to a constant level by a lim-

iter 19. The outputs of the limiter are demodulated by a demodulator 20 and are then separated into two command signals f_1 and f_2 by bandpass filters f_1 and f_2 having narrow passbands. After being amplified by an amplifier 23, the signal f_1 is rectified by a rectifying and integrating circuit 24 to close a first switch 25 of the ignition circuit 25. Although the detail of this switch will be described later, it is constructed such that it is maintained in the closed condition for a predetermined interval once it has been closed. On the other hand, the command signal f_2 from the bandpass filter 22 appears later than the output signal f_1 from the bandpass filter f_1 and the signal f_2 is used to close a second switch 28 through an amplifier 26 and a rectifying and integrating circuit 27. When first and second switches 25 and 26 are closed in this manner, an ignition circuit that can be traced from a source of supply 29 to the ground via first and second switches 25 and 28 and the electric detonator 5 is closed to detonate the detonator 5 and hence the main explosive 6.

As shown in FIG. 5, in a detonation control element, the frequency modulated command signals received by a wave receiver 8 are amplified by an amplifier 30 and the amplitudes of the signals are limited to a definite level by the operation of a limiter 31. The outputs from limiter 31 are demodulated by a demodulator 32 and are then supplied to a bandpass filter 33. As above described, since the auxiliary detonation control element is designed to detect only a predetermined signal among a number of frequency modulated command signals received by the receiver 8, the bandpass filter 33 is designed to pass only the command signal having frequency f_1 . Accordingly, the filter 33 produces an output only when the command signal is modulated by frequency f_1 . The output from the demodulator 33 closes a first switch 36 via an amplifier 34 and a rectifier 35. Under these conditions, as has been described herein above, since the main explosive 6 has already been detonated, an intense percussion wave generated thereby is received by the wave receiver 8 and a signal from this receiver is transformed into a high voltage pulse wave having a steep wavefront by means of a limiter 38 and this pulse wave exceeds the predetermined level to close a second switch 39 in the ignition circuit. As a result, current flows through an electric detonator 10 from a source 37 via first and second switches 36 and 39 thus detonating simultaneously the auxiliary explosives. Since the limiter 38 may comprise a well known combination of a resistor, a constant voltage diode and a diode, its detail will not be described.

FIG. 6 illustrates one example of an ignition circuit utilized in the main and auxiliary detonation control elements shown in FIGS. 4 and 5. The ignition circuit shown in FIG. 5 comprises a source 41 which corresponds to the source 29 or 37 shown in FIG. 4 or FIG. 5. A series circuit including a first silicon controlled rectifier element 42 and a load resistor 43 is connected across the source 41. The gate electrode of the silicon controlled rectifier element 42 is connected to the negative pole of source 41 via a stabilizing resistor 44 and to a terminal 46 which receives the demodulated command signal f_1 through a diode 45 connected to pass current only in the forward direction, whereas the cathode electrode of the rectifier element 42 is connected to the negative pole of the source 41 through a charging resistor 48 and a capacitor 44 which are connected in series. There is also provided a second silicon con-

trolled rectifier element 49 with its anode electrode connected to the juncture between resistor 47 and capacitor 48. The cathode electrode of the silicon controlled rectifier element 49 is connected to the negative pole of the source 41 through a load resistor 50 to the same negative pole through an electric detonator 51 (corresponding to the detonator 5 or 10 shown in FIG. 4 or FIG. 5). The gate electrode of the rectifier element 49 is connected to an input terminal 53 through a diode 52, the input terminal 53 being connected to receive the second command signal (that is the command signal f_2 in the main detonation control element shown in FIG. 4 or the output from limiter 38 in the auxiliary detonation control element shown in FIG. 5). A resistor 54 is connected between the gate electrode of the second silicon controlled rectifier element 49 and the negative pole of source 41 for the purpose of stabilizing the operation of the gate electrode.

In operation, the positive voltage of the first command signal impressed across the input terminals 44 and 46' is applied to the gate electrode of the first silicon controlled rectifier element 42 through diode 45 thus turning ON the rectifier element 42. When turned ON the silicon controlled rectifier element 42 charges a capacitor 48 of a relatively large capacity through the charging resistor 47. When the second command signal is impressed across input terminals 53 and 53', after the capacitor 48 has been completely charged up, this command signal is applied to the gate electrode of the second silicon controlled rectifier element 49 through diode 52 thus turning ON this rectifier element 49. Conduction of the rectifier element 49 discharges capacitor 48 through electric detonator 51 thus detonating the same. It is to be understood that the resistance value of the load resistor 50 of the silicon controlled rectifier element 49 is made sufficiently larger than that of the electric detonator 51 thus ensuring a large current to flow through the detonator 51.

As above described, the circuit shown in FIG. 6 operates to turn ON the first silicon controlled rectifier element 42 for charging the capacitor 48 when it receives the first command signal and to detonate the electric detonator when it receives the second command signal after completion of the charging of the capacitor. Accordingly, the electric detonator is detonated only when the first and second command signals arrive consecutively or serially. In other words, the detonator will not be operated when the two command signals are received at the same time or in the opposite order. When connecting the ignition circuit with the electric detonator in the field, that is when connecting the detonator across terminals 55 and 56, even when the silicon controlled rectifier elements 42 and 49 are inadvertently turned ON, it is possible to limit the current flowing through the detonator to a small value not to ignite the same because the resistance value of the charging resistor 47 is set to a high value.

FIG. 7 is a connection diagram showing a detailed connection of the timing gate circuit 15 shown in FIG. 3. As shown, the timing gate circuit 15 comprises a detonation command switch CS, a reset switch RS, timers T_1 and T_2 , relay coils RL-1, RL-2, RL-3 and RL-4 and relay contacts operated thereby. When the detonation command switch CS is closed, relay coil CL-1 is energized which is maintained in the energized condition by a self-holding contact r1-1. Energization of relay coil RL-1 energizes relay coil RL-2 through a contact of

timer T_1 . As a result, contact r1-2 of relay coil RL-2 is closed to apply the signal f_1 generated by the modulation signal oscillator 13 to the frequency modulator 16. Concurrently therewith relay coil RL-3 is energized by relay contact r1-2a and is self-held by its self-holding contact r1-3. When relay coil RL-2 is energized, one of its contact, not shown, disconnects the timer T_1 from source -24V, but the timer T_1 continues to operate for a preset interval. Upon termination of this preset interval, relay coil RL-2 is deenergized to open its contact r1-2, thus interrupting the supply of the signal f_1 to modulator 16. Concurrently therewith, relay coil RL-4 is energized through contacts r1-3, r1-21 and the contact of timer T_2 . Accordingly, the output f_2 from modulation signal oscillator 14 will be applied to frequency modulator 16 via contact r1-4. The supply of output f_2 to the frequency modulator 16 is terminated when the interval set in timer T_2 has elapsed. In this manner, by using the timing gate circuit it is possible to send out sequentially two types of command signals from a single wave transmitter 2.

FIGS. 3 and 7 illustrate an embodiment of this invention wherein a plurality of command signals are transmitted sequentially from a control station and these serial command signal waves are received by remote detonation control elements. However, it should be understood that the same object can be accomplished by simultaneously transmitting a plurality of command signals from the control office, receiving these command signal waves at the remote detonation control elements, transforming these simultaneously received control signal waves into trains of serial signals, and supplying the trains to respective ignition circuits. In such a modification, it is not necessary to use the timing gate circuit shown in FIG. 3 and the circuit between the bandpass filters 21 and 22 and switches 25 and 28 of the detonation control element shown in FIG. 4 may be replaced by the timing circuit shown in FIG. 8. More particularly, as shown in FIG. 8, the output from the bandpass filter 21 is supplied to a rectifying and integrating circuit 57 and the output thereof is coupled to a Schmit circuit 59. The output from the Schmit circuit 59 is applied to serially connected monostable multivibrators 61 and 62. On the other hand, the output from the bandpass filter 22 is applied to a Schmit circuit 60 through a rectifying and integrating circuit 58. The output from monostable multivibrator 61 is supplied to a terminal 63 leading to the first switch 25 of the ignition circuit shown in FIG. 4, whereas the outputs from Schmit circuit 60 and monostable multivibrator 62 are coupled to a terminal 65 leading to the second switch 28 via an AND gate circuit 64.

In the arrangement shown in FIG. 8, since first and second control signals f_1 and f_2 arrive at the inputs and bandpass filters 21 and 22 at the same time, the inputs to these filters are shown by waveforms A and B, respectively, of FIG. 9. These waveforms are transformed into waveforms C and D by the action of the rectifying and integrating circuits 57 and 58. Schmit circuits 59 and 60 are triggered respectively by the outputs of the rectifying and integrating circuits 57 and 58 to produce waves as shown by FIG. 9E. The output from Schmit circuit 59 triggers the monostable multivibrator 61 for supplying to the monostable multivibrator 62 and terminal 63 a pulse, FIG. 9F, having a pulse width determined by the time constant of the monostable multivibrator 61. The output supplied to terminal 63 is used

to operate the first switch 25. The output from the monostable multivibrator 62 is shown by FIG. 9G and is supplied to AND gate 64 together with the output, FIG. 9E, of Schmid circuit 60 so that an output, FIG. 9H, corresponding to the logical product of these two signals is applied to terminal 65 for operating the second switch 28. As above described, by using the timing circuit shown in FIG. 8, it is possible to convert plurality of command signals which are received simultaneously into sequential or series command signals for sequentially closing the switches of discrete ignition circuits.

In the embodiment of the auxiliary detonation control element shown in FIG. 5, instead of using circuit elements 30 through 35 which are used for processing the signals for actuating the first switch 36 by detecting a prescribed command signal it is also possible to use a well known mechanical or electrical timer which is constructed to operate for a predetermined interval for closing the first switch 36 and maintaining the same in the closed condition, the predetermined interval corresponding to the interval in which the detonation command signal is transmitted from the control station.

Various types of the processing circuit may be substituted for the processing circuit including various circuit elements starting from the bandpass filter to the switches shown in FIGS. 4 and 5. Thus for example, it is also possible to apply the output from the bandpass filter to a differentiating circuit for driving the monostable multivibrator with the differentiated signal. The output of the monostable multivibrator is then integrated for operating the switch with the output of the integrator. Alternatively, the output from the bandpass filter may be applied to a slicer for driving a flip-flop circuit with the sliced output from the slicer. The output of the flip-flop circuit is integrated for operating the switch with output from the integrator.

Although in the embodiments shown in FIGS. 4 and 5 the main and auxiliary detonation control elements are used for inducing the detonation of the auxiliary explosives by the percussion wave generated by the detonation of the main explosive, it will be clear that the invention is by no means limited to these particular embodiments and that instead of using auxiliary detonation control elements, it is also possible to use a plurality of main detonation control elements, each constructed as shown in FIG. 4.

Further, although in the foregoing embodiments, two types of the frequency modulated command signals were used it is also possible to use three or more types of the frequency modulated command signals from the standpoint of safety. In such a case, it is necessary to use switches in the ignition circuit of the same number as that of the frequency modulated command signals.

What is claimed is:

1. A remote detonation system comprising a control station including oscillator means for generating a plurality of frequency modulated waves and a sound wave transmitter for transmitting said frequency modulated waves through water as frequency modulated command signals; one or a plurality of detonation control elements, each including a sound wave receiver for receiving said frequency modulated command signals from said control station, means for demodulating the output from said sound wave receiver for reproducing said frequency modulated command signals and ignition means including a plurality of switches which are

operated sequentially by the output of said demodulating means; a plurality of electric detonators each connected to said ignition means of said detonation control element; and a plurality of underwater explosives detonated by the detonations of respective electric detonators.

2. A remote demodulation system comprising a control station including oscillator means for producing a plurality of frequency modulated waves and a sound wave transmitter for transmitting said frequency modulated wave through water as frequency modulated command signals; a main detonation control element including a first sound wave receiver for receiving said frequency modulated command signals from said control station, means for demodulating the output from said sound wave receiver for reproducing said frequency modulated command signals, and ignition means including a plurality of switches which are operated sequentially by the output of said demodulating means; an electric detonator connected to said ignition means of said main detonation control element; a underwater main explosive detonated by the detonation of said electric detonator; a second sound wave receiver for receiving said frequency modulated command signals from said control station and the percussion wave generated by the detonation of said main explosive; a plurality of auxiliary detonation control elements, each including means for selectively demodulating the output from said second sound wave receiver for reproducing only a predetermined one of said frequency modulated command signals, level setting means connected to said second sound wave receiver for detecting and transforming the received percussion wave into an electric signal, and ignition means including switch means operated by the outputs of said demodulating means and said level setting means; a plurality of auxiliary electric detonators each connected to said ignition means of said auxiliary detonation control element; and a plurality of underwater auxiliary explosives each detonated by the detonation of said auxiliary electric detonator.

3. The remote detonation system according to claim 1 wherein said oscillation means of said control station comprises a carrier wave oscillator, a plurality of modulation signal generators, a frequency modulator connected to said carrier wave oscillator, a timing gate circuit for sequentially applying the outputs of said plurality of modulation signal generators; and a power amplifier to amplify the output from said frequency modulator for supplying the amplified output to said sound wave transmitter.

4. The remote detonation system according to claim 2 wherein said oscillation means of said control station comprises a carrier wave oscillator, a plurality of modulation signal generators, a frequency modulator connected to said carrier wave oscillator, a timing gate circuit for sequentially applying the outputs of said plurality of modulation signal generators; and a power amplifier to amplify the output from said frequency modulator for supplying the amplified output to said sound wave transmitter.

5. The remote detonation system according to claim 2 wherein the demodulating means of said main detonation control element comprises means for detecting a plurality of simultaneously received frequency modulated command signals and timing means for arranging in parallel the outputs of said detecting means.

6. The remote detonation system according to claim 2 wherein said auxiliary explosives controlled by said auxiliary detonation control elements are located at the bottom of water.

7. The remote detonation system according to claim 1 wherein two types of said frequency modulated command signals are used.

8. The remote detonation system according to claim 2 wherein two types of said frequency modulated command signals are used.

9. The remote detonation system according to claim 3 wherein the demodulating means of said main detonation control element comprises an amplifier for amplifying the output of said sound wave receiver, a limiter for limiting the amplitude of the output of said amplifier, a demodulator for demodulating the frequency modulated output of said limiter, a plurality of bandpass filters for filtering respective command signals out of the output from said demodulator, and a rectifying and integrating circuit to rectify and integrate the outputs from said bandpass filters for operating said switches of said ignition means.

10. The remote detonation system according to claim 8 wherein said timing circuit comprises a first rectifying and integrating circuit responsive to the detected output of a first command signal, a first Schmit circuit triggered by the output from said first rectifying and integrating circuit, a first monostable multivibrator triggered by the output from said first Schmit circuit, a second monostable multivibrator triggered by the output from said first monostable multivibrator, a second rectifying and integrating circuit response to the detected

output of a second command signal, a second Schmit circuit triggered by the output from said second rectifying and integrating circuit, an AND gate circuit connected to receive at its inputs the output from said second monostable multivibrator and the output from said second Schmit circuit, means responsive to the output of said first monostable multivibrator for actuating a first switch of said ignition means, and means responsive to the output from said AND gate circuit for actuating a second switch of said ignition means.

11. The remote detonation system according to claim 8 wherein said ignition means comprises a source of supply, a series circuit including a first silicon controlled rectifier element and a load resistor, said series circuit being connected across said source, a first input terminal connected to the gate electrode of said first silicon controlled rectifier element for receiving a first input signal, a second series circuit including a charging resistor and a capacitor, said second series circuit being connected across the cathode electrode of said first silicon controlled rectifier element and the negative pole of said source, a second silicon controlled rectifier element with its anode electrode connected to the junction between said charging resistor and said capacitor, means to connect an electric detonator across the cathode electrode of said second silicon controlled rectifier element and the negative pole of said source, and a second input terminal connected to the gate electrode of said second silicon controlled rectifier element for receiving a second input signal.

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