

Oct. 22, 1946.

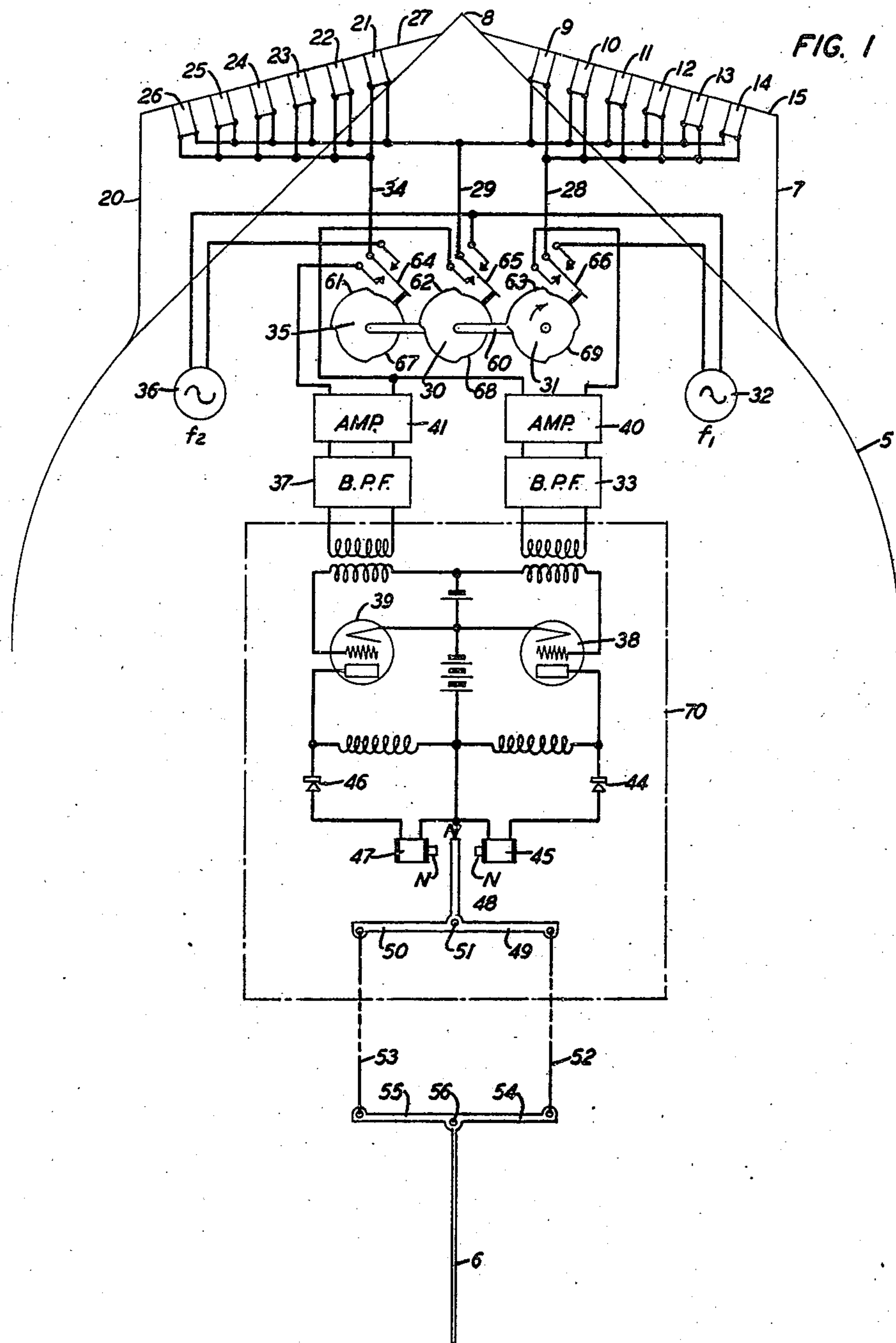
R. W. KING

2,409,632

GUIDING MEANS FOR SELF-PROPELLED TORPEDOES

Filed June 13, 1942

2 Sheets-Sheet 1



INVENTOR
R. W. KING

BY

T. H. Jackson

ATTORNEY

Oct. 22, 1946.

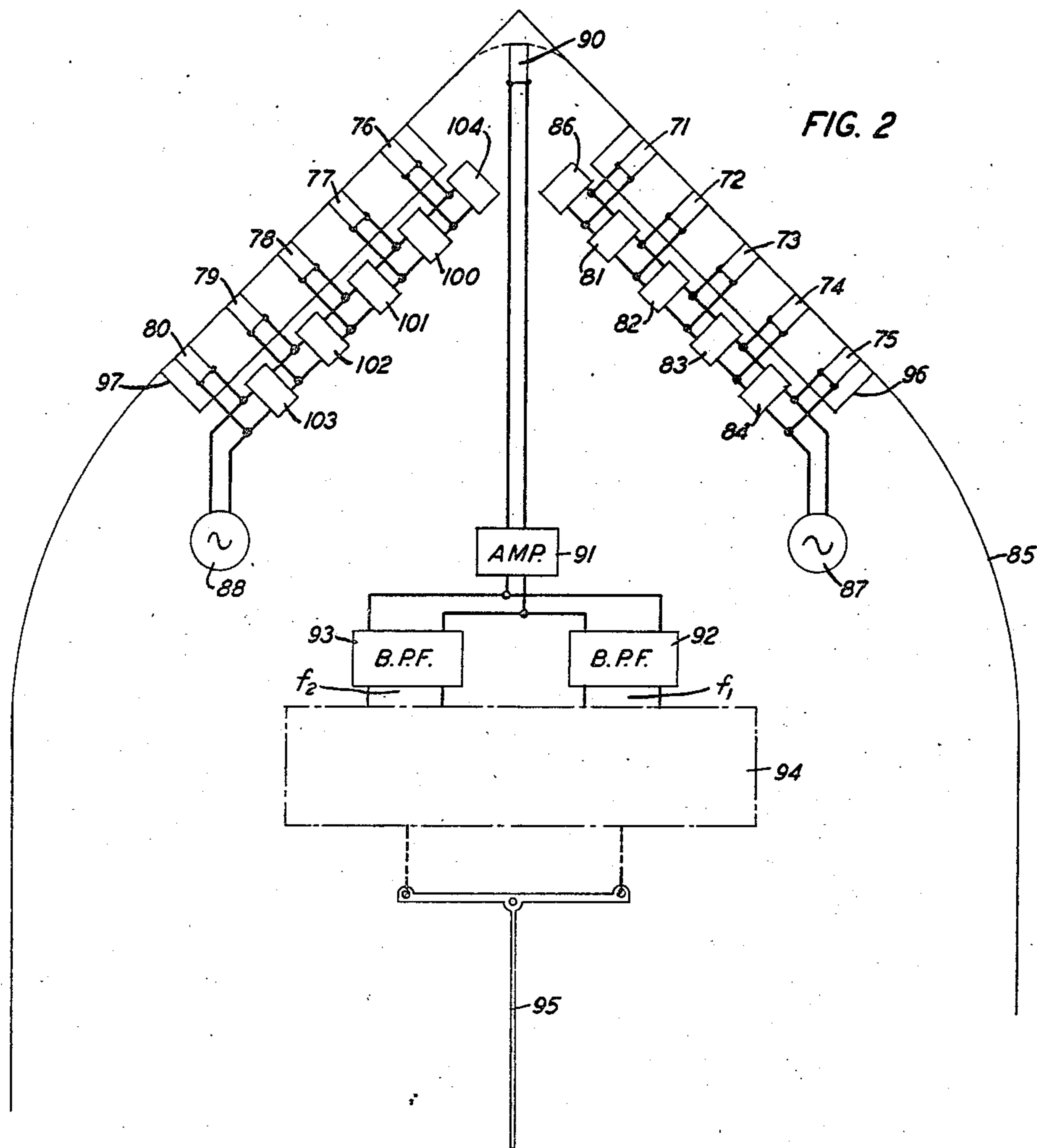
R. W. KING

2,409,632

GUIDING MEANS FOR SELF-PROPELLED TORPEDOES

Filed June 13, 1942

2 Sheets-Sheet 2



INVENTOR
R. W. KING

BY

T. H. Jackson

ATTORNEY

UNITED STATES PATENT OFFICE

2,409,632

GUIDING MEANS FOR SELF-PROPELLED
TORPEDOESRobert W. King, Short Hills, N. J., assignor to
American Telephone and Telegraph Company,
a corporation of New York

Application June 13, 1942, Serial No. 446,889

6 Claims. (Cl. 114—23)

1

This invention relates to guiding means for self-propelled torpedoes, whereby the torpedo after being launched in the water in the vicinity of a moving vessel will be automatically guided in the proper direction to cause the torpedo to collide with the vessel.

The invention is based on the principle that when supersonic compressional energy waves are transmitted through still water there is little or no reflection of the wave energy back to the source while a considerable amount of reflection occurs if the water is turbulent or agitated. In accordance with this invention, the torpedo is provided with means for radiating in a forward direction two beams of supersonic compressional wave energy of different frequencies but of the same intensity, one beam being inclined to one side of the forward axis of the torpedo and the other beam being inclined to the other side of the said axis. The torpedo also includes means responsive to the energy of the two frequencies reflected back to the torpedo for steering the torpedo in a direction determined by the relative intensities of the reflected energies of the two frequencies, whereby when the relative energies are unequal, the torpedo will be steered to the right if the reflected energy is greater for the beam transmitted to the right of the forward axis of the torpedo or will be steered to the left if the reflected energy is greater for the beam transmitted to the left of the torpedo forward axis. However, the torpedo will be steered in a straight course as long as the reflected energies of the two beams are of substantially equal intensity. When such a torpedo is launched in the wake of a moving vessel, the apparatus just described insures that the torpedo will automatically follow the wake and strike the stern of the vessel.

Referring to the drawings:

Fig. 1 represents schematically torpedo guiding means in which the apparatus is arranged to transmit periodically the two supersonic beams and is conditioned to receive the reflected energies of the two beams during the time intervals when no transmission takes place; and

Fig. 2 discloses a torpedo steering device in which the apparatus is similar to that of Fig. 1 except that transmission and reception take place simultaneously.

In Fig. 1 is disclosed a self-propelled torpedo 5 having a rudder 6 adapted to be automatically controlled by the apparatus of the invention. Mounted on a forward extension 7 located on the right side of the bow 8 is a series of piezo-

2

electric crystals 9 to 14, inclusive, which when electrically energized are adapted to transmit compressional wave energy in a beam substantially at right angles to their mounting surface 15. These crystals, 9 to 14, inclusive, are also adapted to translate vibrational energy received from the water into corresponding electrical energy. On the opposite side of bow 8 is another extension 20 of the torpedo on which is mounted a corresponding series of piezoelectric crystals 21 to 26, inclusive, which when electrically energized are adapted to transmit vibrational energy in a beam substantially at right angles to their mounting surface 27. The direction of the beam radiated by crystals 9 to 14, inclusive, is slightly to the right of the forward axis of torpedo while the direction of the beam transmitted by crystals 21 to 26 is slightly to the left of the forward axis of the torpedo.

Crystals 9 to 14, inclusive, are connected in parallel across leads 28 and 29 and by means of the rotatable commutators 30, 31, the crystals are adapted to be connected alternately to a source 32 of a frequency f_1 and to the input terminals of a preliminary amplifier 40 leading to a band-pass filter 33. Similarly, crystals 21 to 26, inclusive, are connected in parallel across leads 29 and 34 and by means of commutators 30, 35, are adapted to be connected alternately to a source 36 of a frequency f_2 and to the input terminals of a preliminary amplifier 41 leading to a band-pass filter 37. It is to be assumed that amplifiers 40, 41 have the same amplification factor.

The band-pass filters 33 and 37 are designed to transmit only the frequencies f_1 and f_2 , respectively. The output terminals of filter 33 are connected to the input of an amplifier 38 while located in the output of this amplifier are a rectifier 44 and the winding of an electromagnet 45. Similarly, the output terminals of filter 37 are connected to the input of amplifier 39 and the output circuit of amplifier 39 includes a rectifier 46 and the winding of an electromagnet 47. The common armature 48 for the two electromagnets is so polarized that it is repelled by equal and opposite forces when currents of the same amplitude traverse the windings of the two electromagnets 45 and 47. For example, the adjacent ends of the cores of the two electromagnets and the free end of armature 48 may all be of the same polarity as indicated in the figure. Armature 48 has two arms 49 and 50 extending in opposite directions from pivot 51; and the outer ends of arms 49 and 50 are suitably connected by wires or cables 52, 53 to rudder arms 54, 55 which

extend in opposite directions from the pivoting axis 56 of the rudder. When equal currents flow through the windings of the two electromagnets 45 and 47, it follows that armature 48 will remain in a central position equidistant from the adjacent ends of the cores of the electromagnets, whereby rudder 6 is maintained in alignment with the longitudinal axis of the torpedo. However, if current through the winding of one of the electromagnets, 45 for example, should become greater than the current through the winding of the other electromagnet, the free end of armature 48 would be moved toward electromagnet 47 to cause a counter-clockwise movement of rudder 6, as a result of which the torpedo would be steered to the right of the direction it appears to be travelling in Fig. 1. Similarly, if the current through winding 47 should become greater than the current through winding 45, armature 48 will be moved to the right, thereby causing a clockwise movement of rudder 6 from its central position as shown in Fig. 1.

The two frequencies f_1 and f_2 transmitted by the two banks of piezoelectric devices are preferably supersonic frequencies of the order of 50,000 cycles per second. For example, one of the frequencies may be 50,000 cycles per second and the other 40,000 or 60,000 cycles per second. After pulses of these frequencies of equal intensity are sent out through the water by the crystals and the frequency sources 32 and 36 are disconnected, the two crystal banks 9 to 14, inclusive, and 21 to 26, inclusive, are adapted to receive any energy of these frequencies reflected back to the torpedo because of the turbulence of the water into which the frequency beams are directed. The amount of reflected energy for each beam will be determined by the extent and amount of the turbulence of the water through which each transmitted beam passes. If the torpedo is travelling along the central portion of the wake of a moving vessel, the two radiated beams encounter turbulent water for substantially the same distance; and hence when commutators 30, 31 and 35 connect the two crystal banks to the filters 33 and 37 of the receiving channels, the intensity of the energy of frequency f_1 passed by filter 33 will be substantially equal to the intensity of the energy of frequency f_2 passed by filter 37. Hence, equal currents will flow through windings 45 and 47 to maintain rudder 6 in its normal position in substantial alignment with the longitudinal axis of the torpedo. This condition will be maintained as long as the wake to be followed by the torpedo lies in a straight line. As soon as the torpedo starts to enter a curved portion of the wake, for example, curving to the right as viewed from the stern of the torpedo, the turbulent water encountered by the beam from crystals 21 to 26 will be smaller in extent than the amount of turbulent water encountered by the beam from crystals 9 to 14. This will cause the current in winding 45 to be greater than the current in winding 47 and the resulting movement of armature 48 will cause a counter-clockwise movement of rudder 6 to change the direction of travel of the torpedo so as to tend to equalize the amount of turbulent water encountered by the two radiated beams. The position of rudder 6 will therefore be automatically changed as required to steer the torpedo along the center of the wake until the stern of the moving vessel is reached.

In a preferred manner of operating the ap-

paratus of Fig. 1, the connection of the two crystal banks to the two frequency sources 32 and 36 to send out pulses of these frequencies is followed by a silent interval of no transmission or reception and the silent interval is followed by a period in which the reflected energy is received to control the steering mechanism.

As shown in Fig. 1, commutators 30, 31 and 35 are mounted on a rotatable shaft 60. When the cam portions 61, 62 and 63 of maximum radius engage springs 64 to 66, respectively, it is obvious that the associated electrical contacts will be closed to connect source 32 to crystal bank 9 to 14 and to connect source 36 to crystal bank 21 to 26. These segments 61, 62 and 63 are followed by portions of an intermediate radius in which the crystal banks are disconnected from both the transmitting apparatus and the receiving apparatus, after which the springs 64 to 66 are engaged by cam portions 67, 68 and 69 of minimum radius to close the associated contacts in an obvious manner to cause the crystal bank 9 to 14, inclusive, to be connected to filter 33 and to cause the crystal bank 21 to 26 to be connected to filter 37. Further rotation of the shaft 60 brings the springs 64 to 66 into engagement with other cam portions of intermediate radius to give another silent interval before sending out further pulses of frequencies f_1 and f_2 . As shown in Fig. 1, the transmitting interval, the receiving interval and the silent interval are of equal duration but they may have other relative values if desired.

The crystals employed in the transmission and reception of the supersonic compressional wave energy may be, for example, of quartz or Rochelle salt, but if the latter is used, it will be desirable to protect the crystals from the sea water while still permitting a free transfer of vibratory energy between the crystals and the sea water.

The apparatus of Fig. 2 is quite similar to that of Fig. 1 except that in Fig. 2 the apparatus is arranged for simultaneous transmission and reception of the compressional wave energy.

In Fig. 2, the two banks of crystals 71 to 75, inclusive, and 76 to 80, inclusive, are mounted on streamlined portions of the torpedo body 85 on opposite sides of the longitudinal axis of the torpedo with each bank aligned to send out a beam of compressional wave energy in a horizontal direction more widely divergent from the forward axis of the torpedo than is the case for the construction of Fig. 1. In general, it is not desirable to have the radiated beams projected out in directions diverging as much as ordinarily would be the case for the construction shown in Fig. 2. Hence for such a physical relation of the two banks of crystals such as shown in Fig. 2, it will generally be preferable to insert time delay networks in the transmission path between the frequency sources and the crystals so that the general direction of the beam from crystals 71 to 75 will be only slightly to the right of the forward axis of the torpedo and the direction of the beam from crystals 76 to 80 will be only slightly to the left of the forward axis of the torpedo.

For this purpose a multisection time delay network 81 to 84, inclusive, is shown in the transmission path between frequency source 87 and the crystal bank 71 to 75, the various crystals being connected to intermediate points of the network so as to swing the beam from the crystal bank to a direction more nearly approach-

ing the forward axis of the torpedo. The end of the time delay network remote from source 87 is terminated by a suitable impedance 86 for a purpose well understood in the art. A similar multisection time delay network 100 to 103 is shown connected in the transmission path between frequency source 88 and the crystal bank 76 to 80 with the remote terminals of the network terminating in a suitable impedance 104. For details of the construction of such time delay networks, reference may be made to the book by T. E. Shea on "Transmission Networks and Filters," published in 1929 by D. Van Nostrand and Company, New York, particularly pages 215 and 216; and reference may be had to the F. Lange United States Patent 1,971,688, issued August 28, 1934.

It will be apparent from Fig. 2 that source 87 of frequency f_1 is connected at all times to the crystal bank 71 to 75, whereby the crystal bank will transmit continuously compressional wave energy of the frequency f_1 and similarly the crystal bank 76 to 80 will transmit continuously compressional wave energy of the frequency f_2 derived from source 88. The energy of these two frequencies f_1 and f_2 reflected back toward the torpedo from the surrounding turbulent water is received by a separate crystal 90 and the electrical energy developed by crystal 90 after amplification by amplifier 91 is impressed on the band-pass filters 92 and 93, filter 92 being designed to pass only frequency f_1 and filter 93 being designed to pass only frequency f_2 . The outputs of the two filters 92 and 93 are utilized for steering the torpedo in the same manner as previously described for the apparatus of Fig. 1 and block 94 is intended to include that part of the control apparatus surrounded by the dotted line 70 in Fig. 1, whereby the rudder 95 is automatically controlled in accordance with the relative intensities of the reflected energies of frequencies f_1 and f_2 to maintain the torpedo in the wake of the moving vessel.

In the apparatus of Fig. 2 it is desired that the receiving crystal 90 receive compressional wave energy only after reflection from the turbulent water ahead of the torpedo and hence it is advisable to protect crystal 90 from any energy of frequencies f_1 and f_2 which might be communicated directly to crystal 90 through the body of the torpedo. For this purpose, the transmitting crystals 71 to 75 may be mounted in a block 96 of resilient material and crystals 76 and 80 mounted in a similar block 97 to isolate receiving crystal 90 from the transmitting crystals.

It will be obvious that this invention is not limited to the use of any particular number of piezoelectric crystals for the transmission of each compressional wave energy beam and the number employed may be smaller or greater than the number actually shown in the drawings. It is also to be understood that other modifications of the disclosed apparatus may be made without departing in anywise from the spirit of the invention as defined in the appended claims.

What is claimed is:

1. In combination, a self-propelled torpedo adapted to be launched in the water in the wake of a moving vessel, means for projecting from said torpedo a beam of compressional waves of a first supersonic frequency in a substantially horizontal direction inclined to one side of the forward axis of the torpedo, means for projecting from said torpedo a beam of compressional waves of a second supersonic frequency in a sub-

stantially horizontal direction inclined to the opposite side of the forward axis of the torpedo, means associated with said torpedo for receiving the energy of said first and said second frequencies reflected by said wake back toward said torpedo and means controlled by said reflected energies for guiding said torpedo toward said vessel.

2. In combination, a self-propelled torpedo adapted to be launched in the water in the wake of a moving vessel, means for projecting from said torpedo a beam of compressional waves of a first supersonic frequency in a substantially horizontal direction inclined to one side of the forward axis of said torpedo, means for projecting from said torpedo a beam of compressional waves of a second supersonic frequency in a substantially horizontal direction inclined to the opposite side of the forward axis of said torpedo, means associated with said torpedo for receiving energy of said first and said second frequencies reflected by said wake back toward said torpedo, a rudder for said torpedo, means for holding said rudder in substantial alignment with the longitudinal axis of said torpedo when the reflected energy of said first frequency is substantially equal to the reflected energy of said second frequency and for moving said rudder away from said aligned position when the reflected energy of one of said frequencies is greater than the reflected energy of the other of said frequencies.

3. In combination, a self-propelled torpedo adapted to be launched in the water in the wake of a moving vessel, means for projecting from said torpedo a beam of compressional waves of a first supersonic frequency in a substantially horizontal direction inclined to one side of the forward axis of said torpedo, means for projecting from said torpedo a beam of compressional waves of a second supersonic frequency in a substantially horizontal direction inclined to the opposite side of the forward axis of said torpedo, means associated with said torpedo for receiving energy of said first and said second frequencies reflected by said wake back toward said torpedo, said receiving means comprising a first filter passing said first frequency and suppressing said second frequency and comprising a second filter passing said second frequency and suppressing said first frequency, an electromagnet responsive to the output of said first filter, an electromagnet responsive to the output of said second filter and steering mechanism for said torpedo differentially controlled by said electromagnets.

4. A self-propelled torpedo adapted to be launched in the water in the wake of a moving vessel and comprising a source of a first supersonic frequency, a source of a second supersonic frequency, a bank of piezoelectric crystals adapted to be connected to said first source for sending a beam of compressional wave energy in a substantially horizontal direction slightly inclined to the right of the forward axis of said torpedo, a second bank of piezoelectric crystals adapted to be connected to said second source for sending a beam of compressional wave energy of said second frequency in a substantially horizontal direction slightly inclined to the left of the forward axis of said torpedo, means for intermittently connecting said sources to said banks, steering mechanism for said torpedo, and means responsive to the energies of said frequencies reflected back to said torpedo during periods when said banks are disconnected from said sources for controlling said steering mechanism.

5. In combination, a self-propelled torpedo

7

adapted to be launched in the water in the wake of a moving vessel, a bank of piezoelectric crystals mounted on the forward under-water portion of said torpedo on one side of the bow of said torpedo, a second bank of piezoelectric crystals mounted on the forward under-water portion of said torpedo on the other side of the bow of said torpedo, means effective during certain time intervals for causing the crystals of said first bank to transmit compressional wave energy of a first supersonic frequency in a general direction inclined slightly to one side of the forward axis of said torpedo, means effective during said certain time intervals for causing the crystals in said second bank to transmit compressional wave energy of a second supersonic frequency in a general direction inclined slightly to the other side of said forward axis, means during other time intervals for receiving from said first bank electrical energy developed by said first bank when said first bank is subjected to compressional wave energy of said first frequency reflected back to said first bank by the turbulent water in the vicinity of said first bank, means during said other time intervals for receiving from said second bank electrical energy developed by said second bank when said second bank is subjected to compressional wave energy of said second frequency reflected back to said second bank by the turbulent water in the vicinity of said second bank, steering mechanism for said torpedo and means differentially controlled by said two receiving means for controlling said steering mechanism.

6. In combination, a self-propelled torpedo adapted to be launched in the water in the wake of a moving vessel, a bank of piezoelectric crystals mounted on the forward under-water portion

8

of said torpedo on one side of the bow of said torpedo, a second bank of piezoelectric crystals mounted on the forward under-water portion of said torpedo on the opposite side of the bow of said torpedo, means for causing the crystals of said first bank to transmit compressional wave energy of a supersonic frequency in a direction inclined slightly to one side of the forward axis of said torpedo, means for causing the crystals of said second bank to transmit compressional wave energy of a second supersonic frequency in a direction inclined to the other side of said forward axis, a piezoelectric crystal mounted on the forward portion of said torpedo substantially mid-way between said banks and subjected to compressional wave energy of both of said frequencies reflected back to said crystal by the turbulent water in the vicinity of said banks, whereby electrical energy of both of said frequencies is developed by said crystal, means for preventing said banks from transmitting through the body of said torpedo to said crystal any substantial amount of compressional wave energy of said first and said second frequencies, an electrical filter connected to said crystal for passing electrical energy of said first frequency and suppressing electrical energy of said second frequency, a second filter connected to said crystal for passing electrical energy of said second frequency and suppressing electrical energy of said first frequency, a rectifier in the output of said filter, a second rectifier in the output of said filter, an electromagnet in circuit with each of said rectifiers, steering mechanism for said torpedo and means differentially controlled by said electromagnets for controlling said steering mechanism.

ROBERT W. KING.