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Emergency Distress Signaling Devices

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Electronics Division

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A study was made of some of the factors involved in providing suitable emergency distress signaling devices to aid in the location of lost personnel or vehicles. One factor particularly considered was a suitable source of electrical power. The magnesium sea-water battery with tunnel diode converter is proposed as being particularly applicable as a power source for marine environments. With the possible exception of size and weight this power source would best meet the following requirements: low cost, reliability, indefinite shelf life, small size and weight, ruggedness, capability of automatic activation, and adequate lifetime for location by search parties.

Several typical devices using sea-water batteries with tunnel diode converters were devised, including an audio device to be located by sonar-equipped search vessels, a visual (flashing light) device, and three radio transmitters to transmit SOS's or audible tones. Considerations of the three radio transmitters indicate a preference for vhf operation. Although developed primarily as distress signaling devices, some of the devices might also be useful as markers for marine buoys or small boats or as navigational beacons.

INTRODUCTION

There is a definite need for an emergency signal to emanate from the vicinity of personnel or vehicles in distress to facilitate their location by searching parties. For example, a surprising number of aircraft have been undetected for long periods of time, even though they crashed in close proximity to large cities, and frequently the survivors have died from exposure, because they were not located promptly. It has been categorically stated by the U.S. Coast Guard in their Paper 34-64/SC107-5 dated January 7, 1964, that if a suitable signal could be emitted from the person or vehicle in distress, then its location could be determined promptly, whereas without it the search can be extremely difficult and time-consuming.

This report has been written to discuss some of the problems involved in producing suitable distress signals, particularly with respect to appropriate power sources, and to indicate some possible solutions, including audio, radio, and visual devices.

POWER SOURCES

The strength and range of the emitted signal will depend largely upon the power source available, and the operation should be completely independent of any power system installed in the vehicle, since a power system in the vehicle probably would not survive in an extreme emergency. It should have the maximum power possible within the limitations of size and weight that can be tolerated, and it should have an indefinite shelf-life but be capable of immediate or even automatic actuation in the event of an emergency.

These requirements impose serious restrictions on the power source, as can be seen when examining the capabilities of the most obvious types, the conventional dry-cell and the rechargeable battery. These devices are undesirable because they require periodic maintenance or replacement caused by deterioration with time, whether they are used or not. More sophisticated or complicated devices might not be capable of activation by injured personnel or be of use when there are no survivors.

Under certain circumstances and within the above limitations, one of the newer power sources might be employed such as thermoelectric generators, thermionic generators, fuel cells, or solar cells, but a simple, low-cost, dependable system would be difficult to develop.

Because of these problems, and because so many of these devices would be used in marine environments, a proposed power source is the sea-water battery, where sea water is used as the electrolyte in a single cell consisting of magnesium and nickel (or nickel-plated) plates (1-5). In use,

NRL Problem E01-05; Project RR 008-03-46-5675. This is the final report on this particular phase of the problem; work is continuing on other phases of the overall problem. Manuscript submitted November 23, 1964.

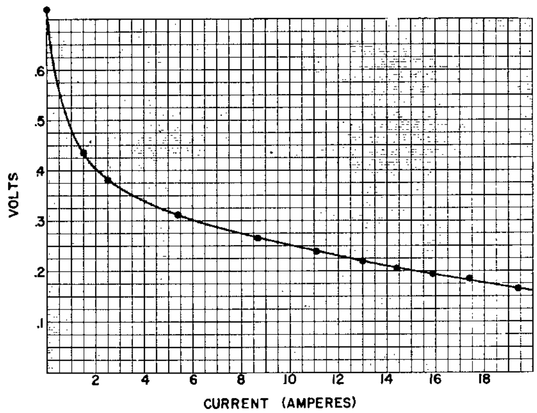

Fig. 1 – Typical load curve for a magnesium sea-water battery

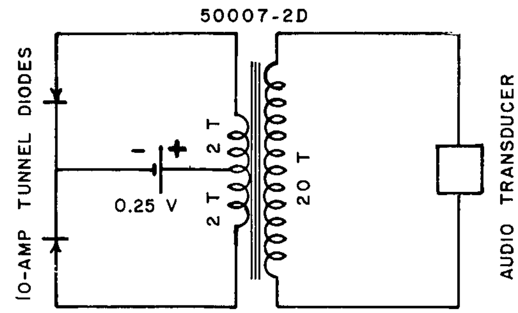

Fig. 2 – Circuit for an audio distress signaling device

the magnesium is sacrificially eroded to produce an electrical output. The sea-water battery has the advantages of utilizing relatively inexpensive materials and would have an indefinite shelf-life without any maintenance. Detailed characteristics of the cells will not be covered in this report, but will be published as the subject of a subsequent NRL report. However, a typical load curve for such a cell is illustrated in Fig. 1.

The sea-water battery has not been used previously because of its relatively low voltage; it has become practical with the advent of the tunnel diode converter to step up the low voltage available (5-7). The tunnel diode converter requires an input of 0.25 volt (for germanium tunnel diodes), and this falls on the relatively flat portion of the load curve of the magnesium sea-water battery, thus making these two components especially compatible.

Single, conventional sea-water battery cells tested at NRL are generally not suitable as long-time power sources because of the formation of calcareous deposits. Such power sources will probably require either different materials or the use of sequential cells. However, the conventional cell is perfectly feasible for short-time operation of emergency distress signals (approximately 72 hours). A further modification could be made by adding dry salts in the bottom of the cell so that it could be activated by the addition of *fresh* water and thus free it from a dependence on a marine environment.

Because of the advantages of the sea-water cell and high-current tunnel diodes as the power supply for marine distress signals, all of the devices in the following pages of this report are designed for use with this type of power supply.

AUDIO SIGNAL DEVICE

The simplest marine distress signal device is shown in Fig. 2 and consists of a simple high-current tunnel-diode inverter designed for operation at a suitable audio frequency and powered by a single magnesium sea-water cell. The load is a suitable audio transducer.

Such a device could be mounted on the *inside* of a submarine (or other vehicle) and, when flooded, would automatically become activated and produce an audio signal to enable sonar-equipped search vessels to pinpoint the location of the disabled vessel, even if there were no survivors. It might also be applied to damaged surface vessels or aircraft submerged in lakes or shallow water.

The extreme simplicity and reliability of this device may recommend its use for other applications.

RADIO-FREQUENCY TRANSMITTERS

Introductory Statement

Included in this section are three devices which have been operated in the laboratory as emergency radio-frequency distress transmitters. Each has its advantages and disadvantages as a practical device, which will be discussed in the explanation of each unit. Since their mode of operation differs, all are included on the assumption that among the techniques employed, some may be useful for distress signal or other applications.

Simple 500-kc/sec Radio Transmitter

The simplest of these devices consists of a single high-current tunnel diode used in a relaxation oscillator circuit powered by a sea-water battery and feeding an output circuit tuned to 500 kc/sec as shown in Fig. 3. The antenna was a single loop approximately 14 inches in diameter.

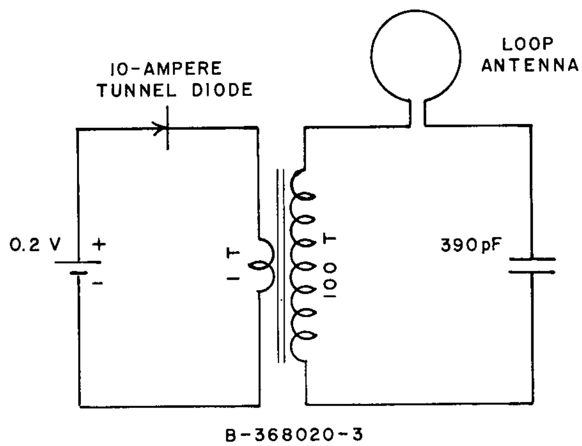

Fig. 3 – Circuit for a simple 500-kc/sec transmitter

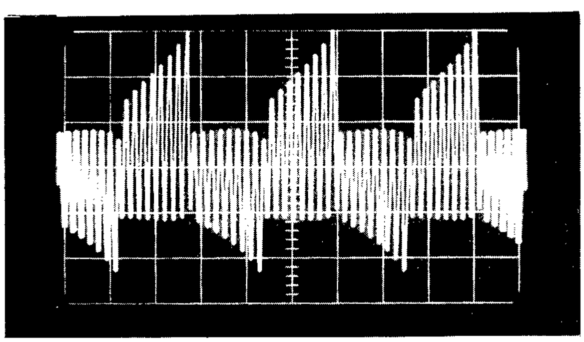

Fig. 4 – Output of simple 500-kc/sec transmitter

Since the tunnel diode oscillator produces a square wave output in the audio range, it serves to shock-excite the output circuit, which is tuned to resonate at 500 kc/sec. This produces the damped output wave shape shown in Fig. 4, which was taken across the transformer secondary winding. The high frequency represents the 500-kc/sec carrier, which is automatically modulated at the audio frequency of the tunnel diode oscillator circuit. This audio tone would be heard on a radio receiver tuned to 500 kc/sec. Since the Federal Aviation Agency recommended that a modulation frequency sweeping between 2000 and 2300 cps 2 to 3 times a second be used as an emergency distress signal for aircraft, it was considered that the proposed circuit could easily be so employed by merely altering the tunnel diode oscillator frequency in a cyclical manner. The extreme simplicity of the circuit gives promise of providing a low-cost, highly reliable device.

The basic circuit was successfully demonstrated in the laboratory using a sea-water battery and a tunnel diode having a peak current of 10 amperes. However, the output, an estimated 1 watt, was considered insufficient for a practical device at 500 kc/sec. Attempts to increase either the frequency or the power without increasing the circuit complexity were unsuccessful because of the inherent capacitance of high-current tunnel diodes. With additional amplification, a usable device might be evolved at some sacrifice of simplicity. However, because of the power required and the antenna problem at 500 kc/sec, further development of this simple transmitter at this frequency was not deemed warranted.

Tunnel Diode-Transistor 500-kc/sec Radio Transmitter

Since difficulty had been encountered in the simple transmitter of Fig. 3 in obtaining both the high frequency and high power simultaneously, the circuit shown in Fig. 5 was investigated. The tunnel diode oscillator, operating directly from the sea-water battery, was used to generate a sine-wave signal at 500 kc/sec, which was then amplified to 12 volts dc by means of transistors powered by a tunnel diode static inverter (not shown) operating off the same sea-water battery.

A smaller tunnel diode (250-ma peak current) was used to simplify the high-frequency problem and obtain a good sine-wave output signal. This signal, shown in Fig. 6, required amplification to obtain the desired power. The circuit, as shown in Fig. 5, has an approximate output of 1 watt, which is not considered sufficient for a practical transmitter at 500 kc/sec. However, the output power can be easily increased to any desired value by simply adding additional amplification stages and

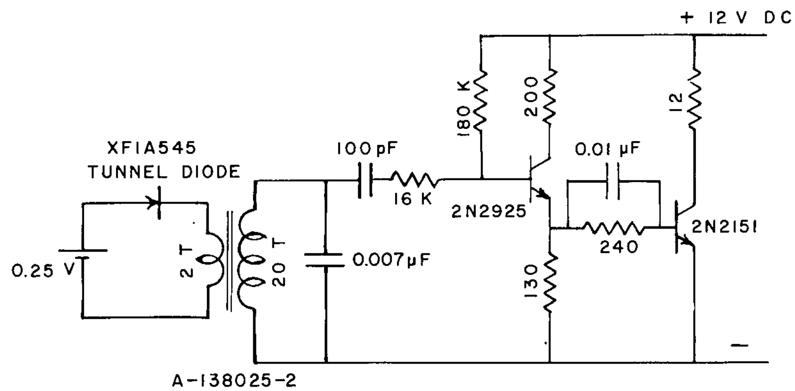

Fig. 5 – Tunnel diode-transistor 500-kc/sec transmitter

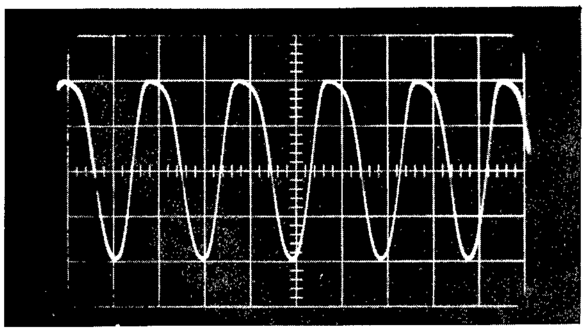

Fig. 6 – Output of tunnel diode-transistor 500-kc/sec transmitter

a larger battery and static inverter. This circuit when operated at 500 kc/sec has the same power and antenna problems encountered in the simplified circuit of Fig. 3 but could be more easily modified for operation at high frequencies to eliminate these problems.

As an alternative to increasing the power, the frequency could be increased to the emergency distress frequencies of 121.5 Mc/sec or 243 Mc/sec, at which frequencies a 1-watt output would probably be sufficient. However, the amplification stages would probably require redesigning for efficient operation at higher frequencies.

The circuit shown in Fig. 5 is incomplete in that some modulation system would need to be added to transmit either SOS's or an audio tone that would be recognized as a distress transmission. The circuit did, however, exhibit an unexpected characteristic, which was highly desirable. The frequency of the signal remained relatively constant for a very wide range of input voltages, which might make additional voltage or frequency regulation unnecessary.

High-Frequency Radio Transmitter

Although a distress transmitter operating at a frequency of 500 kc/sec might be desirable for some applications, it is the author's opinion that the antenna problem and the power requirements for a practical device will probably require that the operating frequency be either 121.5 or 243 Mc/sec. Another alternative to the preceding types of circuits is to use a tunnel diode static inverter to step up the voltage of a sea-water battery to power a vhf radio-frequency transmitter. Since radio transmitters of this type have already been developed, it was not considered desirable to duplicate this development. However, it was desired to demonstrate the operation of the tunnel diode static inverter as a power source for this type of load.

The Radio Division at the Naval Research Laboratory has recently completed the development of a submarine rescue (radio transmitting) buoy for launching to the surface from sunken submarines to transmit a radio distress signal; it incorporated a vacuum tube transmitter operating at 243 Mc/sec and required a total power input of approximately 10 watts. A tunnel diode static inverter was substituted for the 7.5-volt sea-water-battery-with-transistor static inverter used in this transmitter, and satisfactory operation was demonstrated. Although the magnesium sea-water battery and tunnel diode inverter are not considered practical for this application because of size, weight, and buoyancy limitations, it was shown that such devices can be operated satisfactorily using this power source. Other applications where size and weight are not so critical could employ this power supply advantageously.

Summary Statement

After considering all the problems involved in developing a radio distress transmitter, it is believed that probably the most practical solution would be of a type similar to the last of the three types discussed above and incorporating the following components:

1. The magnesium sea-water cell to provide an inexpensive power source with an indefinite shelf-life and adequate active life for this application.

2. The tunnel diode inverter to provide the high voltages required by the radio transmitter.

3. A completely transistorized or integrated circuit transmitter to eliminate the power drain of vacuum tube filaments. It is believed that relatively simple solid-state logic circuits could provide the modulation signals needed to transmit SOS's (or audio tones). If operated at vhf frequencies (121.5 Mc/sec or 243 Mc/sec), the power requirement would be low (approximately 1 watt) and permit making the battery and tunnel diodes small (approximately 10 amp), the antenna problem would be minimized, and a reasonably small package could be achieved. Every effort should be made, however, to keep the circuitry as simple and reliable as possible and thus minimize the cost.

VISUAL DISTRESS SIGNAL

As an aid to airborne visual search parties to attract their attention to a given area, the flashing light circuit shown in Fig. 7 was developed. It was powered by a magnesium sea-water battery and tunnel diode inverter and produces a reasonably bright flash of light every 30 seconds from the FT-106 flash tube for an input of approximately 1 watt. If a more intense flash is desired, it can be obtained by increasing the 4.7-megohm resistor shown in Fig. 7, but the frequency of the flashes will be reduced proportionately. If both brighter and more frequent flashes are desired, a larger power input will be needed, utilizing a larger battery and inverter. This can be designed for the particular application requirements.

CONCLUSIONS

The general requirements for emergency distress signaling devices are:

1. Low cost to permit widespread use.
2. Reliability.
3. Indefinite shelf life requiring very little or no maintenance.
4. Small size and weight.
5. Sufficient ruggedness to survive a crash.
6. Capability of automatic activation.
7. Lifetime adequate for location by search parties.

With the possible exception of item 4 above, the magnesium sea-water battery with a tunnel diode inverter to step up the voltage is believed to more

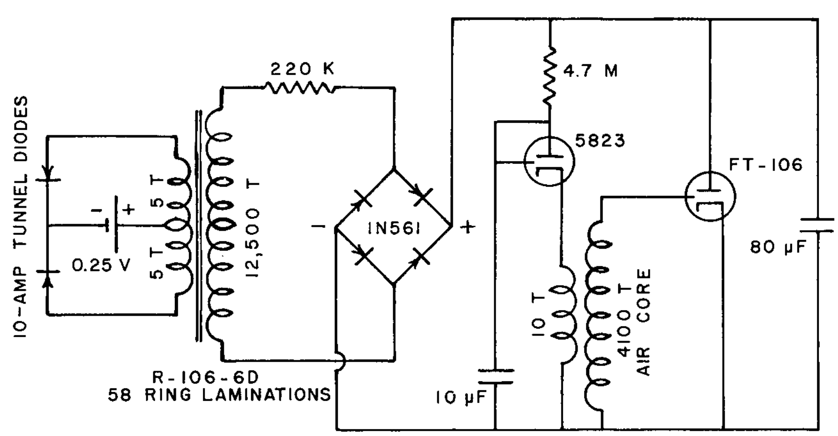

Fig. 7 — Circuit for a visual distress signaling device

nearly fulfill these requirements than any other power source available, particularly for marine applications. This power source can be applied to produce audio, radio, or visual signals, and its use is recommended for consideration.

The devices outlined in this report, although developed primarily as distress signaling devices, might also find application as marine markers for buoys or small boats or as navigational beacons.

ACKNOWLEDGMENT

The assistance of Mr. E. Fred Bryan, Jr., of the Radio Division at the Naval Research Laboratory in making available a high-frequency radio transmitter for demonstration is greatly appreciated.

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Marine applications						
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