By Harold Wright

SPACE-AGE ELECTRONIC PROJECTS FOR BOATS *part one*

MODERN electronics can make operating a power boat a safer, more pleasurable experience. Various sensors, distributed around your boat, permit monitoring a number of things from a single, strategically located display panel. Among the things you can keep a check on are engine rpm and temperature, fuel level and flow, battery and alternator (or generator) status, sterndrive/rudder position, gas and fume build-up below decks, fluid levels, etc.

In this two-part article, we will be describing several projects particularly suitable for marine monitoring tasks. Each project is independent of the others, which allows you to select the arrangement that best suits your needs. All projects utilize a conventional 10-volt dc regulator to provide power from the boat's 12-to-14-volt unregulated generator/alternator output.

Voltage Monitor. The circuit shown in Fig. 1 employs 11 LEDs to display battery and alternator/generator charger voltage. The display indicates battery failure, operating status of the generator/alternator charging system, and battery overcharge. (If undetected, an overcharge condition can cause the battery to "cook," damaging the plates and producing potentially explosive hydrogen gas. Excessive voltage from the charging system can also damage other electrical/electronic equipment connected to the power line.)

The circuit is built around National Semiconductor's LM3914 dot/bar driver IC as a basic expanded-scale voltmeter. It has a range of 4.4 to 5.6 volts. Adjustment of *R3* produces a displayed range of from 11.35 to 14.5 volts on the 10 LEDs associated with *IC1*. Most manufacturers recommend a "normal" output of 14.5 volts for a properly charging generator/alternator.

The overvoltage warning indicator uses an 18-volt zener diode, *D1*, to trigger *Q1* into conduction if this potential is exceeded on the unregulated power line. When *Q1* conducts, OVERVOLTAGE *LED11* comes on. If desired, *LED11* can be replaced by a flasher circuit such as that shown in Fig. 2, or *Q1* can be used to drive a Sonalert No. SC628 or similar audible alarm.

The unregulated dc voltage from the

A variety of electronic indicators to improve safety and convenience

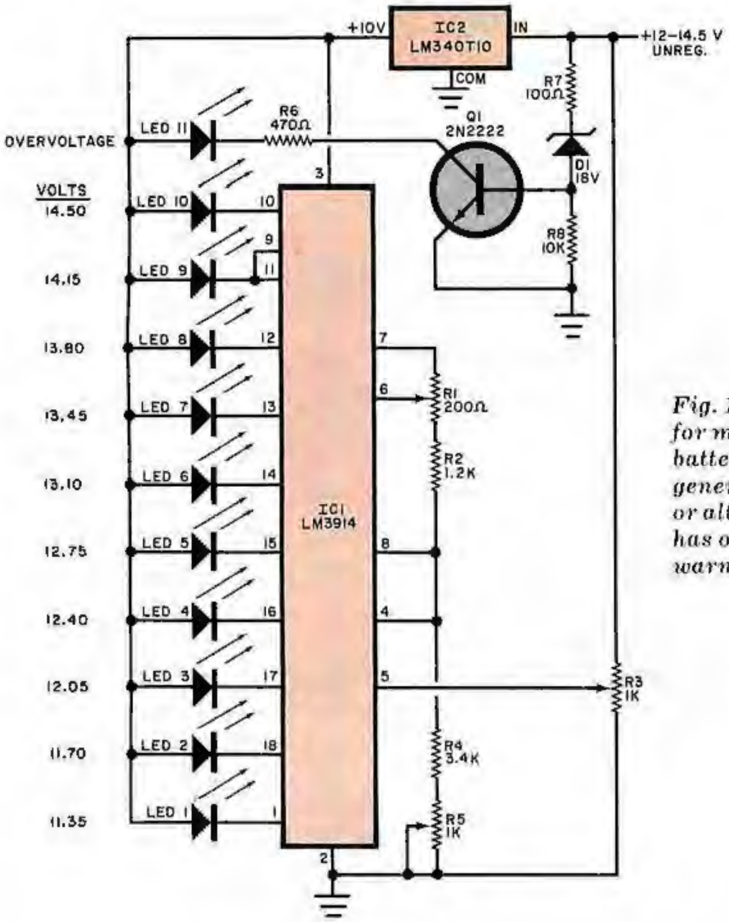

Fig. 1. Circuit for monitoring battery, generator or alternator has overvoltage warning feature.

PARTS LIST (Fig. 1)

D1—18-V, 1-W zener (1N3026B or similar)
IC1—LM3914 dot/bar driver (National)
IC2—10-V, 1-A positive voltage regulator (LM340T10 or similar)
LED1, LED2, LED3, LED11—Discrete red LED
LED4, LED5, LED6—Discrete yellow LED
LED7, LED8, LED9, LED10—Discrete green LED
Q1—2N2222 transistor
R1—200-ohm, pc multiturn trimmer pot
R2—1200-ohm, ½-W resistor
R3, R5—1000-ohm, pc multiturn trimmer pot
R4—3400-ohm, ½-W resistor
R6—470-ohm, ½-W resistor
R7—100-ohm, ½-W resistor
R8–10,000-ohm, ½-W resistor
Misc.—Perforated or printed-circuit board; suitable enclosure; IC sockets (optional); light hood; red filter; etc.

PARTS LIST (Fig. 2)

C1—4.7-µF, 15-V electrolytic
C2—0.01-µF disc capacitor
IC3—555 timer
R9—1000-ohm, ½-W resistor
R10—100,000-ohm, ½-W resistor
R6, R7, R8, D1, LED11, Q1—Same as Fig. 1

PARTS LIST (Fig. 3)

C1—0.001-µF disc capacitor
C2—0.05-µF disc capacitor
IC1—LM1830 fluid detector (National)
LED1—Bright red LED
R1—470-ohm, ½-W resistor
Misc.—Suitable stainless probe; cable; 10-V regulated dc source; etc.

boat's electrical system is maintained at 10 volts by *IC2*. This potential was selected so that regulation occurs whether the boat's engine is running or stopped. The regulator can be used as the 10-volt source for all circuits described in this article. A GE-MOV V27ZA60 or similar suppressor can be installed between the regulator's input and ground for voltage-spike protection.

A color-coding scheme should be used for *LED1* through *LED10* to simplify interpreting the display. Therefore, *LED1, LED2, LED3,* and *LED11* should be red to gain your immediate attention. Since *LED4, LED5,* and *LED6* indicate "caution" conditions, they should be yellow. Safe voltage levels are indicated by *LED7* through *LED10*; hence, these LEDs should be green.

Circuit construction is neither critical nor complicated. Except for the LEDs, all components can be mounted on perforated board or on a printed-circuit board of your own design. In either case, it is a good idea to use sockets for the ICs. The 11 LEDs should be mounted on a separate panel, with each LED identified according to the voltage it represents. (*LED11* should be identified by the legend OVER or OV for overvoltage.) The display panel itself should be hooded and faced with a neutral-density filter to permit seeing it in daylight. Incidentally, since *IC1* can deliver up to 30 mA, small incandescent lamps can replace the LEDs for better visiblilty.

Lead dress is not critical, but to avoid any possibility of oscillation, all ground leads should go to pin 2 of *IC1*.

Once the project is assembled, connect a precision dc voltmeter between pins 4 and 6 of *IC1* and adjust *R1* for a reading of 1.20 volts. Then connect the voltmeter between pin 5 and ground and adjust *R3* for a reading of 4.94 volts. Adjust *R5* until *LED5* comes on.

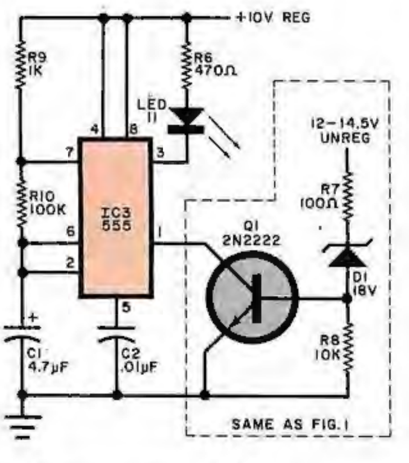

Fig. 2. Overvoltage indicator has a flash rate of 1.5 Hz.

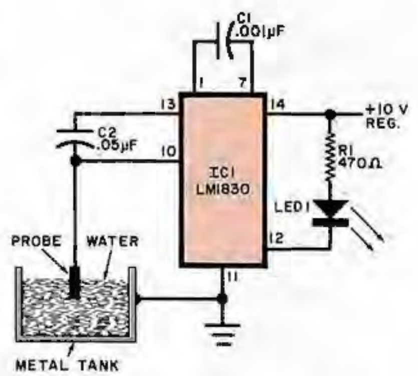

Fig. 3. Low-level detector flashes LED when probe in tank is exposed.

Now, using an adjustable dc power supply, set its output voltage to 14.5 volts and make sure that *IC2* is delivering 10 volts at its output. Adjust *R3* until *LED10* (14.5 volts) comes on. As the input to the project is varied from 11 to 14.5 volts, the LEDs should progressively light. Set the input to 18 volts and verify that *LED11* (or optional flasher) comes on or the audible alarm sounds.

Fluid-Level Indicator. Fluid level monitoring is important in a boat. You should always know, for example, the water level in the expansion tank of the engine's heat exchanger, the level in the galley's fresh-water tank and in the bilges, etc. The circuit shown in Fig. 3 is suitable for low-water-level monitoring. The IC contains a voltage regulator, oscillator, detector, and an output transistor capable of driving a LED, audible alarm, or low-current relay.

Conventional water tanks are usually metal-cased and grounded to the electrical system, which simplifies the job of sensing water levels. As shown in Fig. 3, when the probe tip is immersed in the water, the circuit is in a static state. However, when the water level drops and exposes the probe tip, the probe-to-ground circuit opens. This couples *IC1*'s internal oscillator signal to its internal detector via *C2*, presenting an output at pin 12. Frequency of oscillation is determined by the value of *C1*, which with the value shown is about 6000 Hz.

If the water tank is metal, only one probe is required, since the metal tank serves as the other element of the probe. This circuit can be used with the expansion tank of a closed system as illustrated in Fig. 4. As long as the water system is full, the output remains off. If the water level drops below the probe tip, the alarm turns on. (Note: glycol-type coolant is not electrically conductive, which precludes the use of this device where antifreeze is used.)

Four detectors can be used to keep tabs on the level in the galley's fresh-water tank as shown in Fig. 5. The probe is fabricated from a length of plastic U channel, with the probe elements themselves made from stainless-steel screws that protrude through the channel at suitable intervals. The wiring is laid flat in the U channel and secured in place with epoxy cement or silicone-rubber adhesive.

The actual detector used for the multiple probes is illustrated in Fig. 6. In this circuit, when each probe tip is covered by the water, its associated detector output goes high and sends its transistor into conduction to cause its LED to light. Hence, with a full tank of water, all the LEDs are lit. As the water level drops, the probe tips are successively exposed and extinguish each LED in turn. The EMPTY LED is optional. Its probe should be located in the plastic U channel so

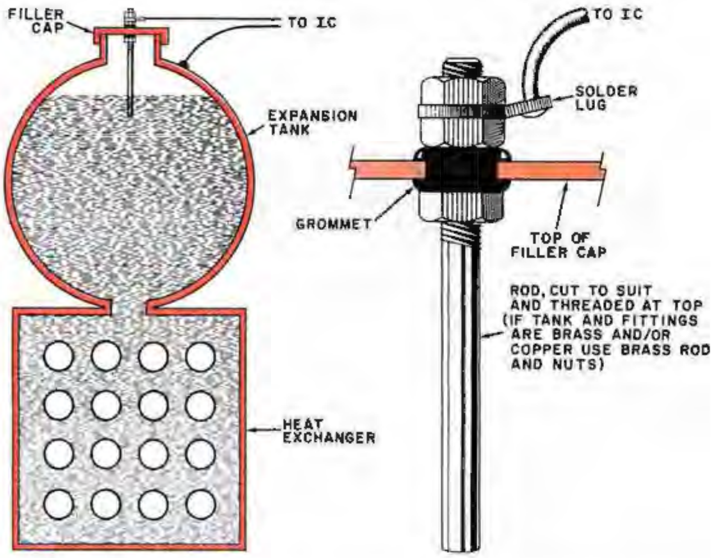

Fig. 4. Low-level warning device for closed system. Washers and lug should be covered with silicone rubber. Leakage here would produce a "full-tank" indication.

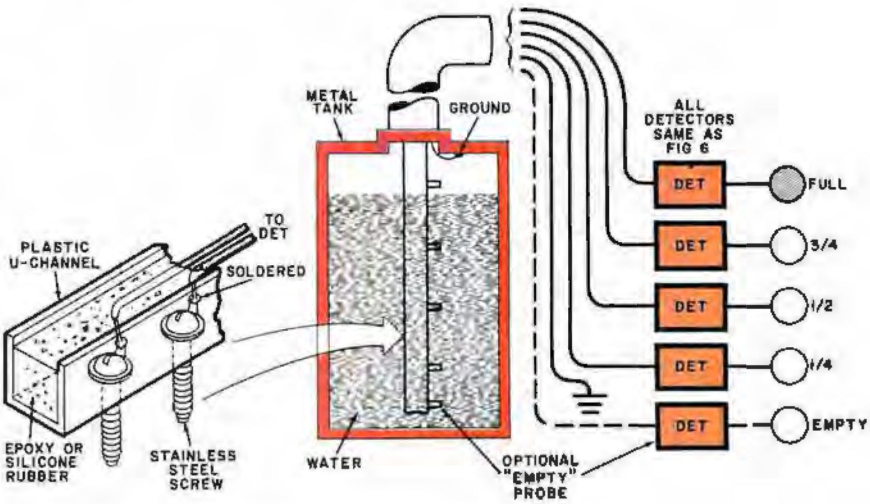

Fig. 5. Fresh water tank guage that displays liquid level on a set of LED readouts.

PARTS LIST (Fig. 6)

C1—0.002-µF disc capacitor
C2—0.05-µF disc capacitor
C3—10-µF, 15-V electrolytic
IC1—LM1830 fluid detector (National)
LED1—Bright red LED
Q1—2N2222 transistor
R1—2200-ohm, ½-W resistor
R2—470-ohm, ½-W resistor
Misc.—10-V dc regulator; interconnecting cable; etc.

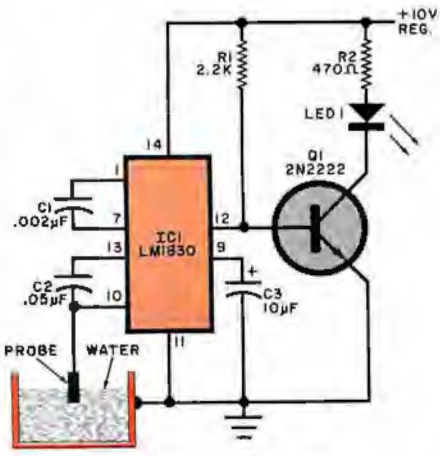

Fig. 6. High-water detector for grounded metal tank.

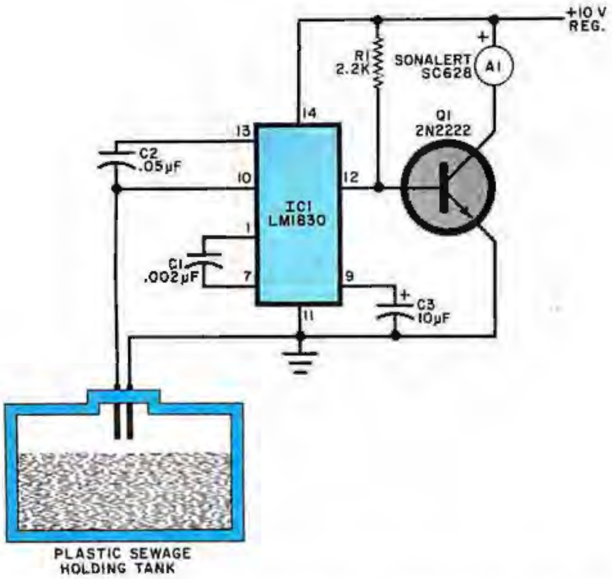

Fig. 7. Full sewage holding tank warning system. Alarm sounds when sewage touches stainless steel probes.

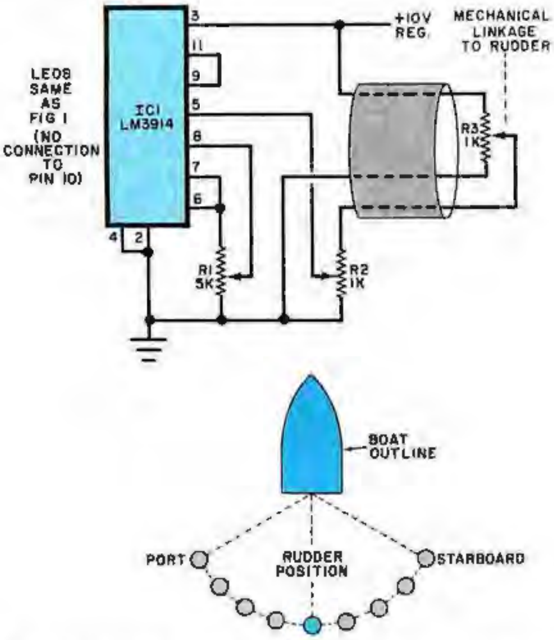

Fig. 8. Rudder/stern drive position indicator uses same LED readout as Fig. 1. LEDs are mounted in arc to indicate position.

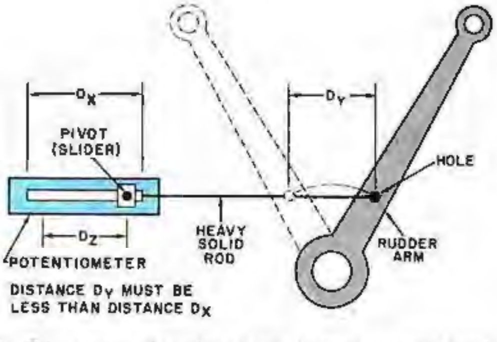

Fig. 9. Diagram showing how to make mechanical connection between rudder arm and slide potentiometer.

PARTS LIST (Fig. 7)

A1—Sonalert Model SC268 (or similar) alarm
C1—0.002-µF, disc capacitor
C2—0.05-µF disc capacitor
C3—10-µF, 15-V electrolytic
IC1—LM1830 fluid detector (National)
R1—2200-ohm, ½-W resistor
Q1—2N2222 transistor
Misc.—Stainless probe tips; interconnecting cable; 10-V regulated dc source; etc.

PARTS LIST (Fig. 8)

IC1—LM3914 dot/bar driver (National)
R1—5000-ohm, pc multiturn trimmer pot
R2—1000-ohm, pc multiturn trimmer pot
R3—1000-ohm, linear-taper, slider-type pot
Misc.—LEDs (see Fig. 1); 10-V regulated dc source; three-conductor waterproof interconnecting cable; etc.

that the LED comes on when there is a small safety reserve of water left.

The probes are designed to be removable. This permits you to periodically remove built-up mineral deposits that can produce a conductive path and lead to false indications.

Sewage-Tank Indicator. If you do your boating in an area where the law requires a sewage holding tank, the circuit shown in Fig. 7 will prove to be a handy liquid-level indicator. It employs an audible alarm instead of a LED.

Rudder-Position Indicator. The circuit in Fig. 8 can be a valuable asset to any stern-drive or inboard-engine boat. It allows the person at the wheel to always know the angular position of the rudder or stern drive. The LED display is basically the same as that shown in Fig. 1, except that there is no LED connection to pin 10 of the IC. The LEDs are best arranged in an arc, as shown in Fig. 8. The arc originates at the stern post of the rudder/stern drive that is painted on the enclosure.

The IC is wired as a basic 0-to-5-volt meter and is calibrated by *R1*. Before installation, *R1* must be set so that there is about 1300 ohms of resistance between the terminal that connects to pin 7 of the IC and the wiper, with the remaining 3700 ohms between wiper and ground. The slide-type potentiometer used for *R3* is installed near the rudder and connected to the IC via a length of waterproof three-conductor cable. Its control tab is mechanically connected to the rudder through a short length of stiff rod, as shown in Fig. 9. Because the rudder arm moves in an arc, the rod must be able to pivot slightly where it connects to the rudder and potentiometer.

After assembling the electronics package, connect everything but pin 5 of the IC. Connect a 12-to-14-volt dc source to the unregulated input (before the regulator IC in Fig. 1) and a 5-volt dc source between pin 5 of the IC and ground, with +5 volts going to pin 5. Carefully adjust *R1* until *LED9* just lights. The brightness of the LED will change slightly as this adjustment is made because *R1* controls LED current. This is why *R1* had to be adjusted before applying power. An incorrect setting could pump more than 30 mA into the LEDs, possibly damaging them. Once *R1* had been calibrated, complete the connection from pin 5 of the IC to *R2* and temporarily connect *R3* into the circuit. Set *R3* to its center position and adjust *R2* until *LED5* comes on. This point represents dead center for the rudder during final installation.

As the slider of *R3* is moved to its positive end, *LED6* through *LED9* come on progressively. Moving the slider toward the grounded end of *R3* causes the LEDs to come on in descending order.

Referring to Fig. 9, the pivot point for the drive rod must be carefully chosen. When the rudder arm is hard right or hard left, it must not place mechanical stress on the potentiometer's slider. The range of slider movement should be slightly less than that of the pickup point on the rudder arm.

Care must be taken to prevent the slider of *R3* from going all the way to its stop at either end. If the arm pushed the slider all the way to the ground end of *R3*, *LED1* would extinguish because a small voltage is required to operate the first comparator in *IC1*. This can be accomplished by making distance D_Y in Fig. 9, traversed by the rudder arm pivot point, slightly less than distance D_X. If this is done, when the rudder arm traverses the full swing from hard left to hard right, *R3*'s slider will move only distance D_Z, which is the working range of the potentiometer.

Distance D_Z can be found during calibration. Move the slider toward the ground end and note the point just before *LED1* extinguishes. Repeat the procedure to locate the point at which *LED9* just extinguishes at the other end of *R3*. Some minor trimming might be required to produce a guard band at both ends of the potentiometer.

Coming Up. This completes Part 1 of this article. Next month, we will cover a novel engine tachometer, a bilge-water alarm, and protection for your equipment from transient voltage spikes. ◇