By Harold Wright

SPACE-AGE ELECTRONIC PROJECTS FOR BOATS *part two*

LAST MONTH, we showed you various ways to use the LM3914 dot/bar display driver in instruments for your boat, new approaches to water-level detection, and a rudder-angle indicator. In this second and final part, concentration is on bilge-water warning systems, electrical-system transient protection, and a unique digital tachometer.

Bilge Alarm. There are a number of ways to provide bilge-water warning. One of the simplest is the float-actuated-switch system shown in Fig. 10. Here, a sealed tube containing a reed switch is surrounded by a float with a built-in magnet. The float rides up and down the tube with increasing and decreasing water level, closing and opening the switch's contacts.

With the actuating switch assembly placed low in the bilge, the float lifts with rising water level. At some predetermined point, the contacts of the reed switch close and the alarm sounds or/and an indicator light comes on. Alternatively, the system can be rigged to automatically turn on the bilge pump as well as sound an alert.

There is nothing electronic about the system shown in Fig. 10, but it is so simple that it is just about foolproof. While you can fabricate your own float switch if you wish, it is hardly worth the effort because all-plastic units for boats are available from marine hardware stores at low cost.

A second bilge alarm is shown in Fig. 11. Here, a pair of electrodes is sealed in an insulating housing that is mounted low in the bilge. A small screen surrounds the probe-like elements to prevent bridging by debris.

In fabricating the probe shown in Fig. 11, two small brass bolts are mounted on a small disc of insulating board and are connected through a pair of resistors to a water-tight cable that goes to the instrument panel. The disc fits one end of a ¾" (19.1-mm) plastic plumbing fitting. Then the whole rear of the assembly is filled with epoxy to seal in the probe ends, resistors, and cable connections. When potting is finished, there should be no place, except at the probe tips, where moisture can bridge the circuit.

When water bridges the probe tips, the SCR fires and actuates the alarm. The Sonalert alarm will continue to sound, even after the water level drops below the point where it bridges the probe tips, until the switch is opened. To

Projects in this concluding part cover a bilge-water alarm, a tachometer and voltage-transient protection

rearm the alarm, simply close the switch.

A third type of bilge alarm is illustrated in Fig. 12. This system is designed for boats with multiple bilge spaces that are separated by watertight bulkheads. An audible alarm and a visual indicator to tell you which bilge has water in it are required in this system.

The sensors in this circuit are LM1830 fluid-detector ICs. When water bridges the probes, the output of the associated IC goes high and turns on the pair of transistors connected to it. Output connections to the transistor switches are arranged so that water entering any bilge space and bridging its probes will activate the Sonalert but will light only the LED labelled for that bilge. You can duplicate the circuit for each bilge to be protected. The only thing in common among the circuits is the Sonalert.

Shown in Fig. 12 is a method for marking the safety panel area where the LEDs are mounted. Using the layout shown, you know instantly which of the bilges is leaking (by its lighted LED) when the alarm sounds.

The transistors can be replaced by a DIP transistor array, provided the outputs can sink enough current to drive the Sonalert. You can use a high-power alarm sounder by replacing the Sonalert with a relay whose contacts can handle the bigger alarm's current. If you use this arrangement, be sure to install a protective diode across the relay's coil.

Tachometer. The circuit shown in Fig. 13 consists of a basic 0-to-2.4-volt meter system and a frequency-to-voltage (f/v) converter. The voltmeter portion made up of *IC1* and *IC2* features 20 divisions, each represented by a LED. The *IC3* f/v converter accepts varying-frequency pulses from the engine's ignition points and converts them into proportional dc voltages with constant updating.

Using a system like that shown makes possible an economical solid-state alternative to the traditional analog meter. It is free from parallax errors and is much easier to read and interpret than the analog meter, too. At night, readability increases, and the red emission of the LEDs has little effect on night vision.

The two LED drivers are cascaded by connecting mode pin 9 of *IC1* to pin 1 of *IC2*. Pin 9 of *IC2* connects to pin 11 to produce dot operation. Internal IC operation requires *R1* to be connected across *LED9* (pin 11 of *IC1*) to obtain proper operation. Resistor *R2* sets the scale of *IC1* to half the voltmeter range. Because 1.2 volts should be generated across it, this resistor should have a 1% or better tolerance. Also, since 2.4 volts is generated across it, *R3* should be rated at 1% or better tolerance. These resistors also program the ICs to deliver 10 mA to each LED.

A charge-pump frequency-to-voltage (f/v) converter, high-gain op-amp/comparator, and an uncommitted output transistor are contained in *IC3* (Fig. 14).

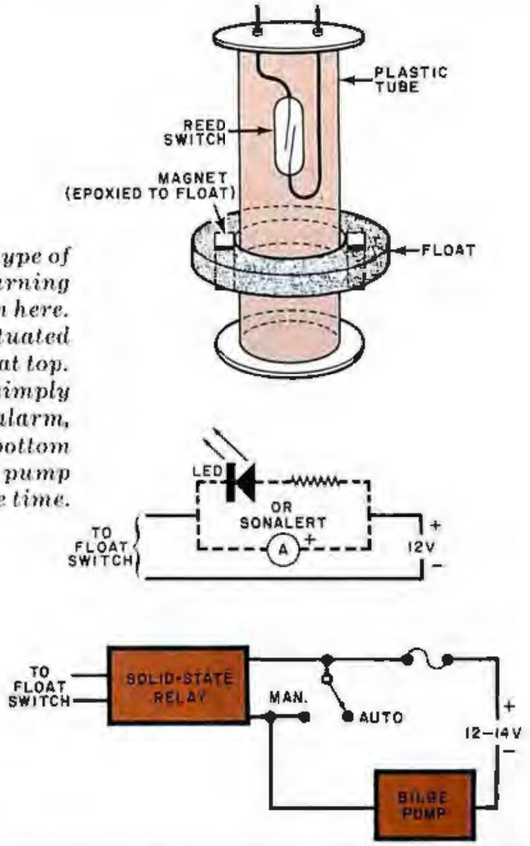


Fig. 10. A simple type of bilge-water warning system is shown here. Details of float-actuated switch are at top. Circuit in center simply actuates LED or alarm, while that at bottom turns on bilge pump at the same time.

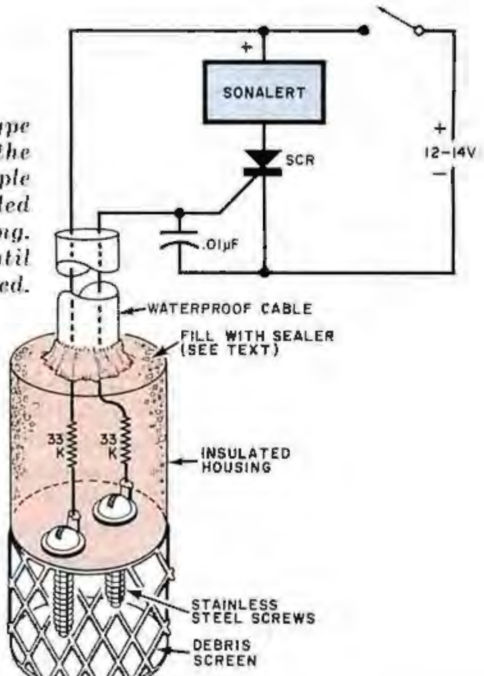


Fig. 11. In this type of bilge alarm, the electrodes are simple steel screws sealed in insulated housing. Alarm sounds until switch is opened.

A Schmitt-trigger device is used for the input. It features a built-in hysteresis to provide clean switching if noise is present on the input signal. In the 14-pin DIP LM2917N version of the IC, an internal zener diode also maintains calibration stability.

In Fig. 13, *R5*, *R6*, and *C1* condition the input signal from the points. A stable-temperature-characteristic capacitor must be used for *C2*, which is the timing capacitor for the charge pump. Potentiometer *R9* serves as the discharge path and doubles as the scale calibration control. Charge-pump filtering is provided by *C3*. The uncommitted emitter of the internal output transistor is connected to *R10*.

The input signal for the voltmeter is taken from *R10*'s wiper. This allows the output of the tach section to be matched to the voltmeter's full-scale range. (Although this could be accomplished via *R9*, better linearity is possible when the full output of the tach circuit is used and then reduced in level to match the requirements of the voltmeter.) Biasing for the internal op amp is obtained with *R7* and *D2*.

There are a number of ways to assemble the tach. The LEDs can be arranged in a vertical column, with the highest rpm at the top, or you can opt for

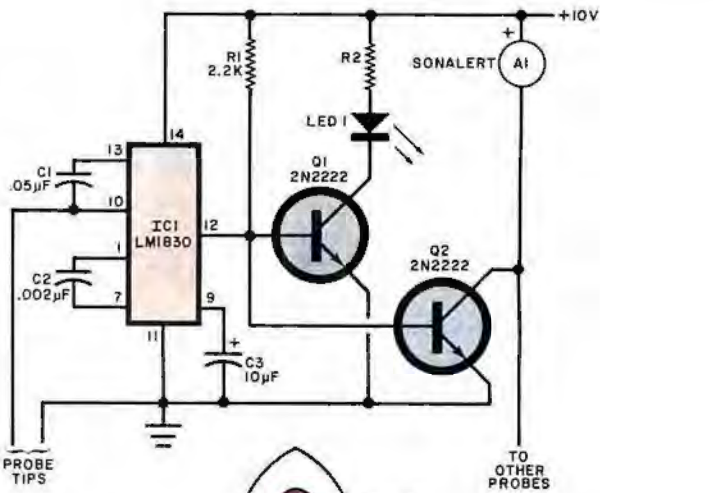
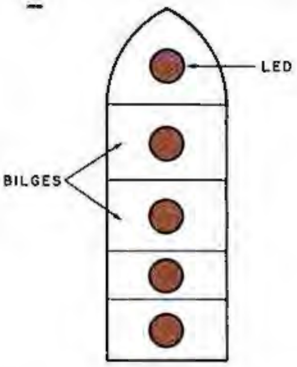


Fig. 12. Circuit above is an alarm system for boat with multiple bilge spaces. Visual and audible signals are used to indicate which bilge has water in it. LEDs are mounted in diagram as shown at right to show each area.



PARTS LIST (Fig. 12)

A1—Sonalert SC628 or similar
C1—0.05-µF disc capacitor
C2—0.002-µF disc capacitor
C3—10-µF, 6-V electrolytic
IC1—LM1830 (National)
LED1—Bright red LED
Q1, Q2—2N2222 transistor
R1—2200-ohm, ½-W resistor
R2—To suit LED current

PARTS LIST (Fig. 13)

C1, C2—0.02-µF capacitor
C3—1-µF, 12-V electrolytic
D1—18-V zener (see text)
D2—1N914
IC1, IC2—LM3914 Dot/Bar Driver (National)
IC3—LM2917N 14-pin F/V Converter (National)
IC4—10-V, 0.5-A positive regulator
LED1 through LED20—Bright red LED
R1, R6—20,000-ohm, ½-W resistor
R2—1100-ohm, 1%, ½-W resistor
R3—2400-ohm, 1%, ½-W resistor
R4—10-ohm resistor (see text)
R5, R7—10,000-ohm, ½-W resistor
R8—470-ohm, ½-W resistor
R9—100,000-ohm, multi-turn pot
R10—10,000-ohm, multi-turn pot

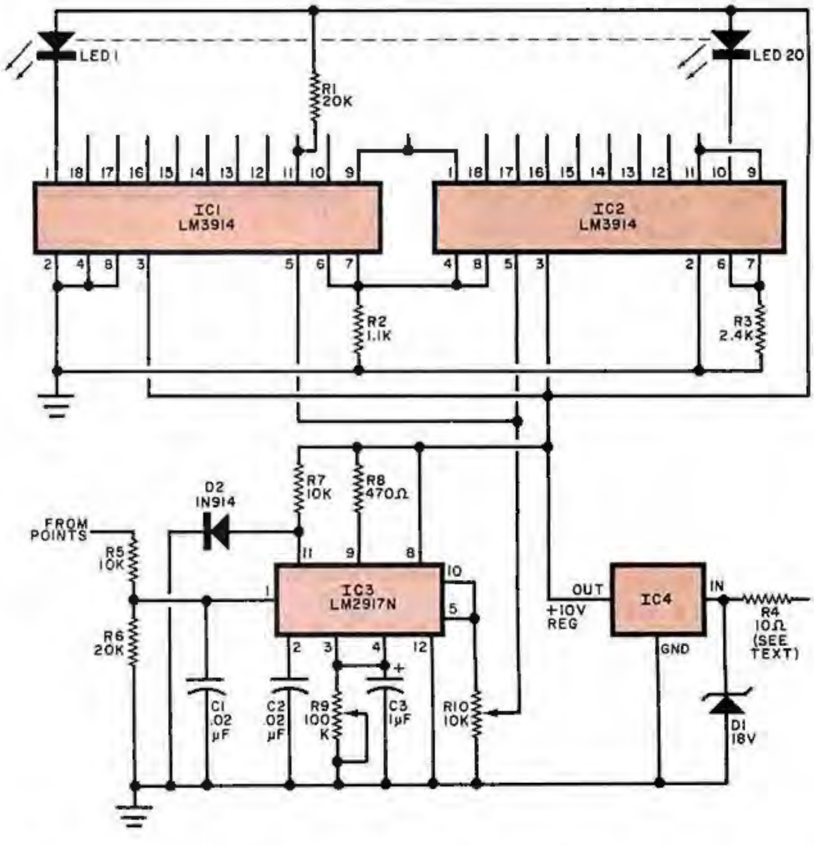


Fig. 13. Circuit for converting pulses from ignition points to voltages which activate LEDs from 1 to 20 to indicate speed.

the more familiar circular arrangement.

When assembling the project, it is best to slightly recess the LEDs behind a red filter to avoid effects of washout in brightlight. Use high-luminosity LEDs instead of the commonly available "standard" LEDs. Finally, to assure maximum contrast and eliminate reflections as much as possible, apply a coat of matte black paint on all surfaces behind the LEDs and the front panel or bezel into which the red filter is set.

Wiring is not critical. However, it is important that you observe the common ground point near pin 2 of *IC1*.

There is a considerable variation in the range requirements for a tachometer for inboard boat engines. Commercial analog tachs are scaled for 6000 rpm and supplied with links to adapt them to all types of engines. With the tach described here, the top end of the range can be chosen to suit the requirements of any given engine.

A 4-cycle engine fires each cylinder once every two revolutions. An 8-cylinder engine running at 4000 rpm would fire 4 × 4000 or 16,000 times per minute. This is equivalent to a tach input frequency of 266.67 Hz. For a 6-cylinder engine operating at 4000 rpm, there are three pulses per revolution, which is equivalent to an input frequency of 200 Hz. Note that this is a linear relationship and can be plotted as shown in Fig. 15.

Following is the calibration procedure for a 6-cylinder engine with *LED20* indicating 4400 rpm. Apply 15 volts from a bench-type power supply to the power leads of the tach. Next, connect the output of a square-wave generator to the tach's input through a 0.1-µF capacitor. Using a frequency counter, set the generator for a high-level output of 220 Hz. Set *R9* near maximum resistance. Using a high-impedance voltmeter, connected between pin 5 of *IC1* and ground, adjust *R10* for a 2.4-volt reading. This should turn on *LED20*. Adjust *R9* until *LED19* extinguishes and *LED20* is at full brilliance. There is some overlap built into the dot drivers so that one LED fades out as the next LED comes on. Slowly reduce the frequency of the generator while observing both the tach display and frequency counter to check the linearity of the tach's scale. It will not be perfect, but it will be better than a quick glance at a standard analog meter.

The calibration procedure for an 8-cylinder engine will be the same as that for the 6-cylinder engine above. The only difference is that you start with a generator frequency of 293.3 Hz.

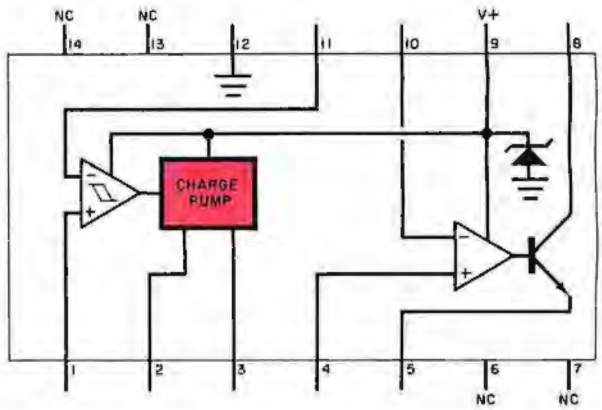


Fig. 14. A charge-pump f/v converter, op-amp/comparator, output transistor and zener diode are contained in LM2917N IC.

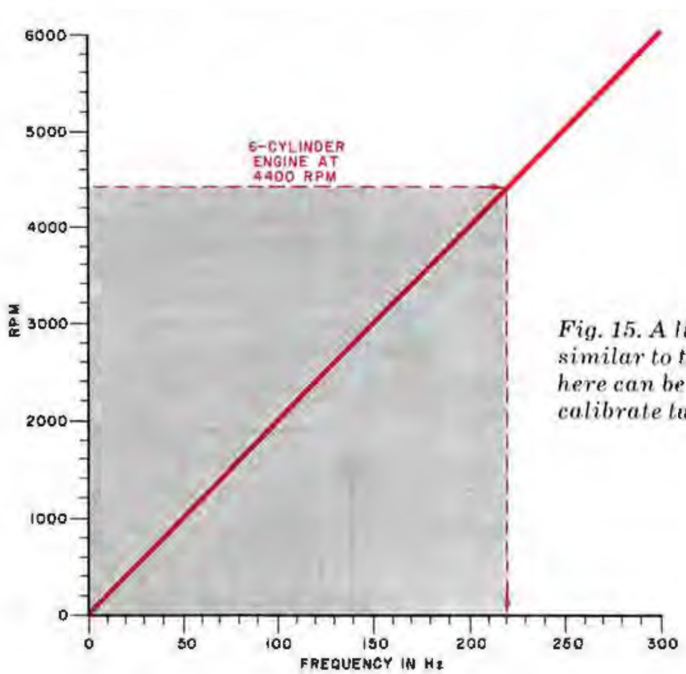


Fig. 15. A linear plot similar to that shown here can be drawn to calibrate tachometer.

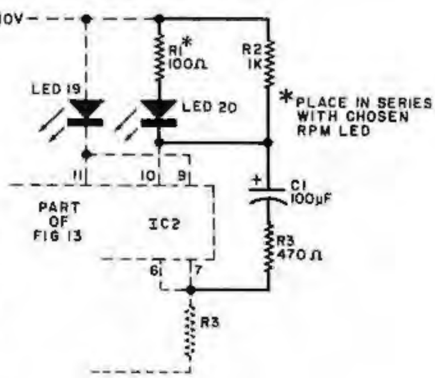


Fig. 16 Tachometer add-on is used to identify critical cruising speed.

PARTS LIST (Fig. 16)

C1—100-µF, 12-V electrolytic
R1—100-ohm, ½-W resistor
R2—1000-ohm, ½-W resistor
R3—470-ohm, ½-W resistor

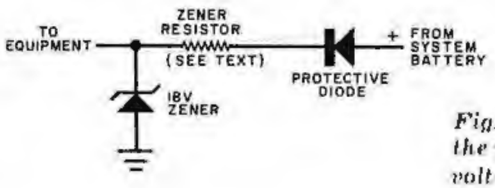


Fig. 17. A series diode is used in the positive supply for reverse voltage protection as shown here.

If your finished tach has a tendency to flicker at low rpm, increase the value of *C3*. Do not overdo this because if the value is raised to 2 μF, the flicker will be reduced, but at higher speeds there may be a tendency for adjacent LEDs to flicker back and forth as a low-frequency oscillation sets in. Of course, a rough running engine is going to produce lots of flicker, which can serve as a reminder to have your engine tuned. The value of *C3* is a compromise. Once you install the tach, it is a good idea to have it checked against a good-quality tachometer.

The circuit shown in Fig. 16 is a useful add-on for the tach. It can be used to identify the critical cruising rpm where fuel economy is at its best or as an over-rpm warning. The LED in the string to which it is connected will flash on and off when the indicated rpm is reached. The flash range is quite narrow. Bear in mind, therefore, that this circuit may not be usable as an attention getter with a rough-running engine. The rpms would be traversing the flash point too rapidly for the circuit to go into action.

Transient Protection. Any mobile electrical system, including that in a boat, can suffer from voltage transients of many kinds. Some transients are capable of destroying solid-state components and systems. Hence, it pays to have adequate transient protection.

There are simple ways to give a large measure of transient protection to home-built projects. GE's MOV transient protectors is one simple way. A second method is shown in Fig. 13, where 10-ohm resistor *R4* and 18-volt zener diode *D1* protect the power input line. If the circuit is to take care of a blown regulator, where 18 volts may be on the line continuously, the division of dissipated power between the zener diode and resistor must be calculated. Once breakdown occurs, the circuit will be carrying well over 1 ampere of current. This means that the power (wattage) ratings of the resistor and diode must be calculated.

Reverse voltage protection is a simple matter of installing a series diode in the +V line, with the diode's anode connected to the + input, as shown in Fig. 17. Each subsystem should be individually protected, both for transients and reverse voltages, to assure maximum security against failure. Of course, one heavy-duty zener-diode circuit can be used for an entire instrument group to handle steady-state overvoltage conditions, but smaller suppressor circuits should still be used on each board. ◇