Are You at Optimum Trim?

"Arvel Gentry tells how to make your own
Sailboat Performance Recorder"

By Arvel Gentry

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Ocean racing skippers are relying more than ever on the many different types of marine instruments. Wind speed, boatspeed and wind direction indicators have become almost indispensable on all-out racing machines, not only for general navigational purposes, but to help the skipper and crew keep the boat performing at its best. But another important and new use for these instruments is to help the crew tune a boat and adjust the sails for best performance.

However even with all this equipment, sailboat performance is still subject to many variables. Wind speed and direction, sea conditions, sail trim, the helmsman's concentration – are all constantly changing. These variations make it very difficult to gather good performance data at any instant of time. All the needles are constantly moving and an "eyeball" averaging process is necessary to get a reading.

Now, this is not too bad if you are only interested in knowing if you are going about five knots. But, what if you have changed helmsmen and you want to know if the new one is really sailing 1/10th of a knot better. Or you're trying to see if a change in sail trim, or maybe a sail change, is what is giving you that 1/10th of a knot instead of, perhaps, an increase in wind speed. Ocean races are won and lost by tenths of knots.

In the 1970 America's Cup campaign, Bill Ficker faced these same problems on Intrepid. Without the use of a pace boat as a trial horse, he and his crew relied upon careful performance testing using an onboard instrumentation system. This consisted of boatspeed indicators, apparent wind velocity and direction indicators, and a speed recorder that continually recorded boatspeed.

Two years ago I wondered if I couldn't use this same approach as I started to equip my own 23' MORC boat. Excellent marine sensors and indicators were available, but the most important part of the system, the speed recorder, was not. I would have to build up my own. The results of my efforts are shown in Figure 1; it is a device I call the Sailboat Performance Recorder.

Now don't get me wrong, I'm not trying to sell anything. You can do just as I did – make up your own recorder using the available components I'm about to describe. The cost? Only a little more than what you would pay for one of your other marine instruments: well within a small boat budget. After two years of using the Sailboat Performance Recorder, I'm firmly convinced that it's the most important piece of equipment on my boat. But, what is it? How is it used? And, how can you make your own?

The Sailboat Performance Recorder is an instrument that records the boatspeed on a continuous strip of paper, and once every minute it automatically switches to record a short record of apparent wind speed. It gets its input signals from the boat's conventional knotmeter and wind speed instruments. Other important information such as apparent wind angle, sail trim conditions, sail combinations, etc., are written by hand right on the strip of paper as it goes through the recording window or on the viewing extension. The signal traces on this strip of grid paper can then be examined to determine very accurately the average boat speed and windspeed for the sailing

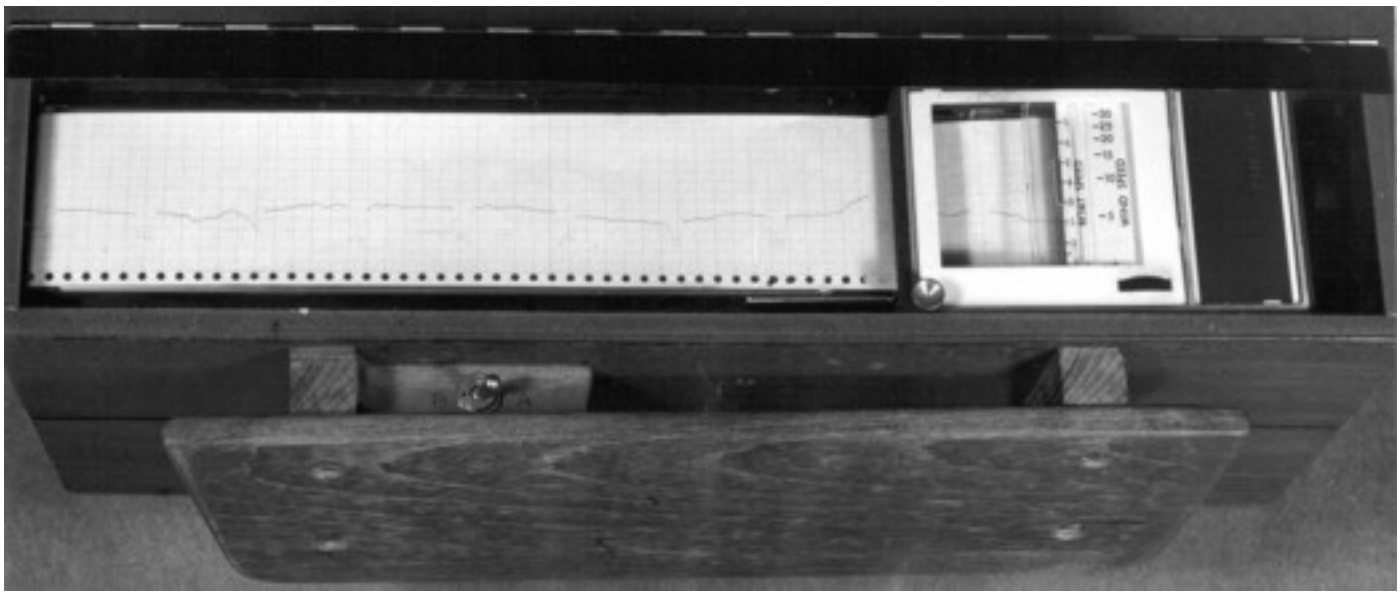

Figure 1. Sailboat Performance Recorder mounted in portable box.

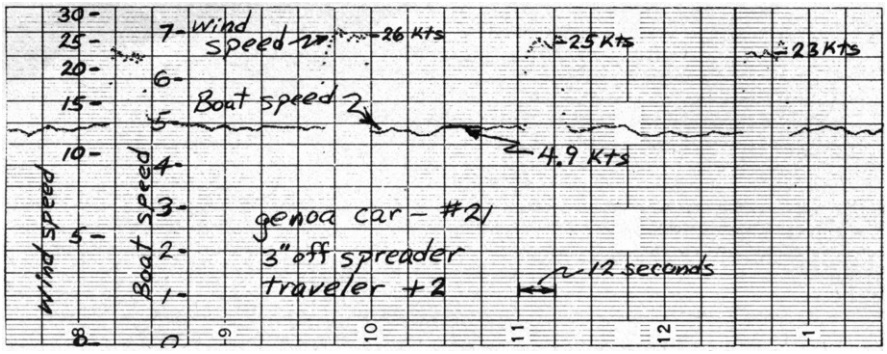

Figure 2. Typical output from strip can be marked to show when changes in trim took place.

conditions present.

This check of the record can be made just after the signals are recorded, or many hours later when a great number of records can be evaluated and compared. A typical output strip from the recorder is shown in Figure 2. Boatspeed is linear and can be read directly from the grid lines. However the wind speed is non-linear because of the output signal from the Telcor wind instrument that I used. Wind speed is read with a small calibration scale, and this has turned out to be an advantage because it gives good accuracy at the lower wind speeds where you need it.

The Sailboat Performance Recorder consists of a commercially available strip recorder, control and filter circuits to prepare the boat instrument signals for the recorder, a relay switching circuit to change automatically the recorded signal, and a housing box to protect the instrument as well as make it portable. The recorder I used was a 10 millivolt DC Rustrak recorder which is used in many non-boating electronic applications. The rest of the required electronics, the control, filter and switching circuits, are very simple and you can wire them up yourself. Or, if you're not so inclined, you can have your local marine radio repairman do it for you.

I use the Sailboat Performance Recorder in tuning/practice sessions and in actual races. The procedure used in the testing sessions is simple and straightforward. Once the boat is stabilized for a given set of sail and boat trim conditions, the recorder is turned on. It then automatically records the boatspeed on a continuous strip of paper. Periodic short wind speed records are also made by the automatic switching system.

At the end of the test run, I turn the recorder off, change the sail settings, and repeat the procedure on the next test. Other significant information is written right on the strip paper with a pencil, and this usually includes the compass heading, relative wind direction and any sail setting data (distance off spreader, genoa car position, halyard tension, etc.). Sometimes this information is written on a separate test log sheet or is recorded on a cassette magnetic recorder for subsequent correlation with the strip recorder, wind speed, and boatspeed traces.

The strip recorder has a viewing extension so that about 10 minutes of the strip record is in view before the paper feeds back into the recorder take-up spool. I consider this an important feature. If the recorder did not have this extension and the paper stayed within the recorder, it is not so useful in a real sailing application.

At the end of a test day, I take the paper from the recorder and study and compose the records. If a given change in sail trim between two records gives an increase in average boatspeed (and the recorded wind speeds have not changed significantly), then I have found a way of making the boat go faster. Each test condition is usually repeated several times to verify the actual amount of speed improvement. The same type of procedure is used in testing different sail combinations.

The Sailboat Performance Recorder is also used in actual racing conditions. All sail selection and trim changes are checked ***before*** and ***after*** they are made by reading the average boatspeed and wind speed from the strip recorder. This is especially helpful on longer races when there are no other boats close by to compare with visually. On short day races I leave the strip recorder running during the entire race. It is very interesting to look back on these records and see if the boat was sailed up to its full potential, and to see how much time was lost in bad spinnaker sets, etc.

A strip recorder makes it very easy to gather the data necessary to construct a complete speed polar for your boat. Such a polar will help in making the proper sail selection for different wind conditions. The recorder is also useful in making a direct and accurate comparison of the performance of different helmsmen. During very short races, the cassette magnetic tape recorder can be used to record supplementary data such as apparent wind angles, sail trim changes and crew positions.

The main use of the recorder in all these applications is to determine accurate average boatspeeds and wind speeds over a period of sailing time. This is very difficult to do just by looking at the knotmeter and wind speed dials. Most important of all, the strip recorder provides a permanent record for later study under more relaxed non-sailing conditions.

My recording instrument itself is a Model No. 2194 Rustrak Recorder (range 0 to 10 millivolts) with a 12volt DC unregulated drive motor (10 rpm). The actual paper chart speed is determined by the drive motor rpm and the interchangeable gear train selected. Rustrak gear train # 15 and the 10-rpm motor gives a paper speed of 75" per hour. After trying several different paper speeds, this speed seems to be best for most applications. With the 75"/hr

paper speed, one roll of paper will last 10 hours. The other Rustrak item needed is the Model 223 Chart Viewing Extension. The total cost of the Rustrak recorder and accessories is approximately $250 (Rustrak Instrument Div. Gulton Industries, Manchester, New Hampshire 03103).

The only other item is the chart paper itself. A number of different recorder chart paper styles are available from Rustrak. I use style WB chart paper which gives a full scale reading of 7.5 knots with grid lines at 1/10 knot intervals.

Once you have the strip recorder and your knotmeter and wind speed instruments you'll have to build circuits to hook the recorder and instruments together. This consists of circuits to fine-tune the recorded signals so that they match the marine instruments, and to dampen the recorded traces to aid in giving a better average boatspeed and wind speed readings. The boatspeed circuit is shown in Figure 3. The variable resistance at R2 is the control used to adjust the recorded signal trace so that it matches exactly the knotmeter instrument reading. The value of resistor R1 will depend upon which knotmeter you use. I used a Telcor knotmeter with the R1 value shown in Figure 3.

The wind speed connection circuit is shown in Figure 4. Again, the Telcor wind speed indicator was used and R3 had a fixed value of 3.3K. However with other brands, I would recommend that R3 be variable as shown. Consult your own instrument manufacturer for the proper values to use for resistors R1 and R3 in these circuits, or calculate them yourself using the equation given in the Rustrak owner's manual.

These resistors must step the marine instrument signals down so as not to exceed the maximum 10 millivolt signal tolerated by the Rustrak recorder. The capacitors in the circuits are all electrolytics and are used to help smooth out and filter the signals to minimize the trace wiggles. The different amounts of filtration and the different character of the boatspeed and wind speed traces makes it very easy to tell which is which.

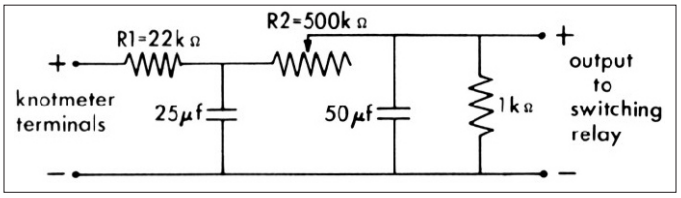

Figure 3. Boatspeed circuit.

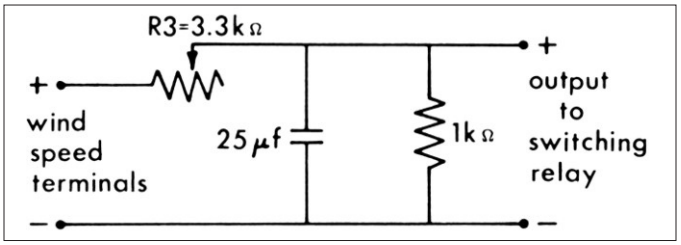

Figure 4. Wind speed circuit.

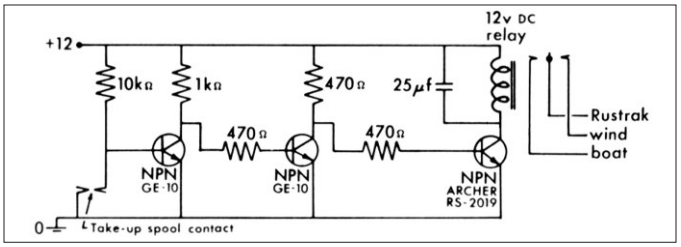

Figure 5. Switching circuit.

Once the input signals are ready for the strip recorder, you need a means of automatically switching the signals, for the recorder is only able to record one signal at a time. The circuit for this is shown in Figure 5. To activate the switching circuit, I use the flange on the Rustrak recorder take-up spool itself. I added a small contact point insulated from the recorder frame and that rides on the spool flange. The circuit is broken whenever the contact point is lifted by a piece of tape on the flange. Splicing tape used for magnetic recording tape seems best for this.

The width and number of tapes on the spool flange control how often the switch is made between boatspeed and wind speed. Two 1/4" pieces of tape give about 12 seconds of wind speed every minute. The transistorized switching circuit shown in Figure 5 controls the relay that actually switches the signals being sent to the Rustrak recorder.

To drive the recorder and switching relay circuit you need a 12-volt battery source. Normally, the recorder can be powered by the boat's 12-volt battery. However, with the Telcor windspeed instrument, the Rustrak recorder had to be driven by a separate 12-volt source because of the +6-volt reference voltage used by Telcor. Because of this, and the desire to make the unit completely portable, I included a Rustrak rechargable battery pack (model 154A-12-400) though a regular 12-volt dry cell can be used just as well.

The final task is to build a box to hold and protect the recorder and control circuits from the marine environment. I attached a small hatch board to the box so that it could be conveniently positioned in the companionway. Since the unit is portable I can take the whole box home after a race to remove the paper and recharge the battery.

The top of the box is a hinged piece of Plexiglas to keep out spray. A manual switch is added at the battery source to turn the recorder on and off. I also added a double throw switch so that I could record boatspeed only, wind speed only, or have the signals switched on automatically. Figure 6 shows all the unit components; the battery is in the bottom of the box. Then the two circuit boxes go in on top and they are followed by the Rustrak recorder. The battery and circuit boxes lie underneath the chart-viewing extension.

If making your own recorder, connecting, and switching circuits is too much work for you, contact Signet Scientific Company, 129 E. Tojunga Ave., Burbank, California 91503. I believe they now are selling strip recorders for use with their instruments at about $500 per single channel device. I am told that some of the new large ocean-racing boats are ordering as many as four and five of these recorders to record everything from wind speed,

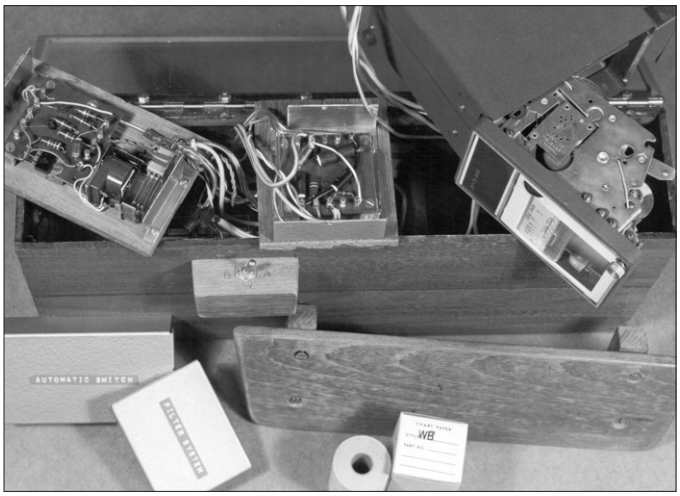

Figure 6. Detail of Sailboat Performance Recorder components.

boatspeed, heading, rudder angle; probably even the heartbeat of the helmsman! However, if you are on a small boat budget, you can make your own Sailboat Performance Recorder as I did, and still have virtually the same equipment as the big boys!