GRAHAM & SCHLAGETER, INC.
NAVAL ARCHITECTS
YACHT BROKERS

444 N. LAKE SHORE DRIVE CHICAGO, IL 60611 312/822-0489

October 11, 1985

In our continuing effort to help our customers get the most out of their boats in terms of performance, we have been working over the past few months on a performance prediction package for the S2 27. As an owner of one of these boats, I thought you'd be interested in the details of this package.

The core of this performance prediction package is the velocity prediction program developed at MIT for the MHS rule. This program along with an extensive graphics package we have set up on our HP-9816 and plotter allows us to predict the speed of a boat given certain important speed affecting parameters such as length, displacement, wetted surface, stability, sailplan, along with others and output it in a form that is easy to read and very useful on the sailboat.

Specifically, the package contains the following:

A PERFORMANCE TABLE

For wind speeds of 3, 5, 7, 10, 14, and 20 knots and true wind angles from optimum beat to dead running in 10° increments, this table presents the following data: apparent wind angle, apparent wind speed, boat speed, speed made good, heel angle, leeway angle, flat, and reef. The apprent wind data is particularly useful for sail selection as will be discussed later in this letter. Leeway angle is useful for dead reckoning navigation. Flat is the percentage of power necessary from the sails. Reef is the percentage of total sail area needed. Both of these values are useful as a guide to sail trim.

A POLAR DIAGRAM

This is a plot of boat speed versus true wind angle, similar to the ones used in 12-meters to monitor performance. This plot fills in the gaps for wind speed and angles not directly calculated by the program.

GRAPH OF UPWIND OPTIMUMS

This graph shows, in easy to read form, the optimum values for several variables when sailing upwind. Plotted against true wind speed are the following: apparent wind angle, compass tacking angle, heel angle, speed made good, leeway angle, and boat speed. As this information is plotted against true wind speed this graph fills in the gaps for wind speeds not directly calculated by the program.

GRAPH OF DOWNWIND OPTIMUMS

This is a graphical display of optimum values for several variables when sailing downwind (running). The following variables are plotted against true wind speed: gybing angle, optimum apparent wind angle, and boat speed for this wind angle. It is a quick reference for tacking angles downwind.

TWO GRAPHS OF APPARENT WIND

One is a graph of apparent wind angle versus true wind angle for a given wind speed. The other is a plot of apparent wind speed versus true wind angle, again plotted for the various wind speeds studied. These are perhaps the most useful charts for strategic planning. If you know the true wind speed (with the use of the performance tables you can estimate very closely in the absence of a wind speed device) and the angle of your course to the true wind you can predict both the apparent wind speed and angle, making for much easier sail selection for every leg of the course. If the wind changes during a race, refering to these charts will tell you the effect of the shift or velocity change on the apparent wind for the remaining legs of the course.

INSTRUCTIONS

A detailed set of instructions for utilizing the above information.

The data contained in these graphs and tables could only be duplicated by extensive and diligent record keeping over several sailing seasons. One could also get this information by having the boat measured MHS or by using other performance prediction programs. Both of these alternatives cost at least $600.

Because of the number of S2 27s in the field, we are prepared to offer this package for US$50, or about half the cost of a good compass. In my opinion this package is worth as much as a new sail in terms of increased performance. Important tactical and strategic decisions can now be made with confidence.

To order your package, simply send us a check, indicate whether you have an inboard or outboard, and deep draft or shoal draft and we shall mail you a complete performance package in 1-2 weeks. If you have modified your boat to a rule (such as MORC) we will need a copy of your rating certificate.

If you have any questions, please feel free to call me at the above number.

Sincerely,

Eric Schlageter

Eric Schlageter, N.A.
Graham & Schlageter, Inc.

ES/sp

GRAHAM & SCHLAGETER, INC.
NAVAL ARCHITECTS
YACHT BROKERS

444 N. LAKE SHORE DRIVE CHICAGO, IL 60611 312/822-0489

PREDICTED PERFORMANCE PACKAGE

FOR THE

S2 27

GRAHAM & SCHLAGETER, INC.
NAVAL ARCHITECTS
YACHT BROKERS

444 N. LAKE SHORE DRIVE CHICAGO, IL 60611 312/822-0489

Please find enclosed your copy of the S2 27 Performance Prediction Package. I am sure you will find it very useful in getting the most out of your S2 27.

Although the enclosed information is protected by the copyright laws, there is no way I have of policing "bootleg" copies of our work. I trust that you will respect the fact that we have invested a substantial amount of time and effort in preparing this package and not allow copies to be made of the enclosed information except for your own personal use. Besides, you wouldn't want to help a competitor by giving him this information would you?

If you have any questions or for some reason need an additional copy, please feel free to get in touch with me.

Sincerely,

Eric Schlageter, NA

Eric Schlageter, N.A.
Graham & Schlageter, Inc.

ES/sp

NOTES FOR PERFORMANCE PREDICTIONS

Enclosed in this package are the performance predictions for the S2 27. Below is a brief explanation of the tables and graphs as well as suggestions for utilizing the information contained in them.

Before going into the details of how to read and use the data there are some simplifying assumptions made so that these calculations are possible. The first assumption is that the boat is always sailing in smooth water. The size of the real waves will have an effect on boat speed. When sailing upwind in large seas, boat speed may be less than predicted. Sailing downwind in large waves, boat speed may be greater due to "surfing".

Another assumption the program makes is that the yacht is always under control, i.e., broaching is not simulated. There may be some conditions such as beam reaching in heavy air when the predicted speed and heel angle cannot be maintained due to control problems. The final assumption made is that crew weight is always used to minimize heel angle. In very light air it may be advantageous to heel the boat more than indicated to keep the sails full.

Unless otherwise noted, all speeds are in knots and all angles in degrees, with 0° being straight ahead and 180° being straight aft.

PERFORMANCE TABLE

The performance prediction table is simply a tabulation of the data and calculated values for each sailing condition. The first column is true wind speed, which is the wind speed used for all calculations. Because of the wind gradient, this wind speed is taken at a constant height of 10 meters above the water. To correct readings from the masthead anemometer multiply the readings by .96; that is if the masthead instruments say the wind is 10 knots, the actual true wind at 10 meters is 9.6 knots. Wind speed tabulations at 3, 5, 7, 10, 14, and 20 knots are used.

The next column is true wind angle relative to the yacht's heading. This angle varies from 36° (pinching) to 180° (dead downwind). In addition, performance is calculated for optimum beating angle (second line in each table), 60°, 75°, 90°, 105°, 120°, 135°, and optimum running (next to last line in each table).

True wind speed and angle are the input values given the computer; the remaining numbers are calculated. The next two columns of the table are apparent wind speed and angle. These are values at the masthead. Further graphs of apparent wind speed and angles

are given and shall be discussed below. The next two columns are boat speed and VMG (Velocity Made Good). Boat speed is simply speed thru the water. VMG is that component of speed directly into the wind. Note that when true wind is aft of the beam, VMG is negative.

Heel and leeway angles are in the next two columns. Heel angle is a good indicator of how much power is being applied to the boat and as discussed below it can assist in proper sail trim. Leeway angle is the angle that the boat must "crab" through the water in order to produce side force to offset the sail forces. This is useful to know for dead reckoning navigation.

The last two columns are flat and reef and are a general guide to sail trim. Flat is the per centage of total power needed from the sailplan. A flat = 1.00 means that the sails should be as full as possible. A flat = .8 means that the boat only requires 80% of the available power from the sailplan. Reef is the per centage of total span, and by inference area, needed by the boat. A reef = 1.0 means all the sailplan is up. A reef = .9 means the sails are reefed to 90% of total height and areas has been reduced to 81% of total (.9 x .9 = .81).

Although the computer enjoys the advantage of an infinite combination of flat and reef to get the proper amount of heeling and driving force from the rig, your boat does not. These two numbers in conjunction with heel angle should help you trim the sails. If heel angles are consistently larger than predicted, then some sort of de-powering should take place. Flattening can be accomplished on the main by bending the mast more and for a genoa by feathering it more.

POLAR DIAGRAM

The polar diagram is a graphical presentation of boat speed versus wind angle for the six different wind speed conditions we have used. Wind angles are indicated by the numbers around the perimeter of the semi-circle. For a beam wind, the wind is blowing from left to right across the paper. The numbers imbedded in the dashed lines are the wind speeds that the lines represent.

This plot is very useful for monitoring performance over the entire range of wind angles. It is also possible to interpolate between wind speeds to get the expected speed at wind strengths not directly calculated. Asterisks on the graph indicate the optimum upwind and downwind cases.

APPARENT WIND GRAPHS

The next graphs are plots of apparent wind angle versus true wind

angle and apparent wind speed versus true wind angle. With these graphs the navigator can tell with precision what the wind angle and speed will be for every leg of the course, thus assisting greatly in choosing the proper sail for each leg. To use these graphs one needs only to have true wind angle and go to the proper line representing the true wind speed. Then read off the apparent wind speed and angle. For wind speeds not directly shown on the graph (e.g. 10 knots) it is possible to interpolate very closely the correct answers.

OPTIMUM UPWIND AND DOWNWIND GRAPHS

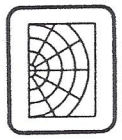
These graphs give the optimum values for several variables in both the upwind direction and downwind direction. These values are all plotted versus true wind speed so as to cover the entire range of wind speeds. The data plotted for the downwind condition is gybing angle, apparent wind angle, and boat speed. One note is that in light airs, the 3 and 6 knot conditions specifically, there are usually a loft of waves relative to the wind speed and this violates our "smooth water" assumption. You may find that except in the very flattest of waters that your gybing angles will be greater than shown on the graph. You could go so far as to make a note on this graph for a "rough water" gybing angle.

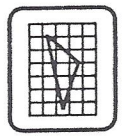
The upwind optimums plot apparent wind angle, compass tacking angle, heel angle, leeway angle, speed made good and boat speed against true wind speed. Again, in light airs and some chop, the compass tacking angles and apparent wind angles may be greater due to the fact that these are "smooth water" data.

The asterisks on the graph are for calculated points. The curves are drawn using a cubic spline curve and are an approimation of the values between the calculated points.

GRAND PRIX PAC

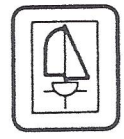

Performance


Polar Plot


Wind Plot


Wind Equations


Upwind


Downwind

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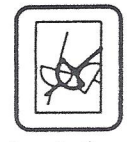
Hydrostatics


Comparative Performance

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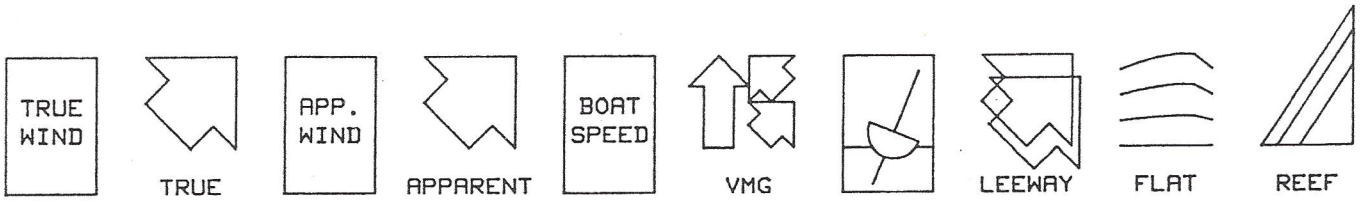

3.0 knots

	36.0	4.3	23.2	1.420	1.149	1.0	8.2	1.00	1.00
	44.0	4.6	28.6	1.900	1.367	1.2	5.5	1.00	1.00
Tack	**48.4**	**4.7**	**30.9**	**2.098**	**1.393**	**1.2**	**4.8**	**1.00**	**1.00**
	52.0	4.8	32.7	2.237	1.377	1.2	4.3	1.00	1.00
	60.0	4.8	36.5	2.477	1.238	1.2	3.6	1.00	1.00
	70.0	4.7	41.3	2.656	.908	1.2	3.0	1.00	1.00
	80.0	4.4	46.6	2.727	.473	1.1	2.5	1.00	1.00
-------	84.2	----------	^ Genoa	/	Spinnaker v	----------			
	90.0	4.1	51.8	2.785	0.000	1.1	2.0	1.00	1.00
	105.0	3.5	61.7	2.674	-.692	.8	1.5	1.00	1.00
	120.0	2.8	75.7	2.395	-1.198	.5	1.0	1.00	1.00
	135.0	2.2	96.4	2.023	-1.431	.2	.6	1.00	1.00
Gybe	**142.7**	**1.9**	**109.7**	**1.835**	**-1.461**	**.1**	**.4**	**1.00**	**1.00**
	150.0	1.8	123.5	1.666	-1.443	.1	.3	1.00	1.00
	165.0	1.7	152.0	1.459	-1.409	0.0	.2	1.00	1.00
	180.0	1.7	179.9	1.358	-1.358	0.0	.1	1.00	1.00

5.0 knots

	36.0	7.1	23.2	2.314	1.872	2.1	8.5	1.00	1.00
	44.0	7.5	28.7	3.030	2.179	2.4	5.8	1.00	1.00
Tack	**46.6**	**7.6**	**30.2**	**3.195**	**2.196**	**2.4**	**5.4**	**1.00**	**1.00**
	52.0	7.7	33.2	3.483	2.144	2.4	4.6	1.00	1.00
	60.0	7.7	37.5	3.793	1.897	2.4	3.9	1.00	1.00
	70.0	7.5	42.9	4.023	1.376	2.3	3.3	1.00	1.00
-------	78.9	----------	^ Genoa	/	Spinnaker v	----------			
	80.0	7.1	48.3	4.146	.720	2.3	2.6	1.00	1.00
	90.0	6.6	54.1	4.232	0.000	2.1	2.2	1.00	1.00
	105.0	5.6	64.8	4.069	-1.053	1.6	1.6	1.00	1.00
	120.0	4.5	78.9	3.706	-1.853	1.0	1.0	1.00	1.00
	135.0	3.6	98.5	3.226	-2.281	.5	.6	1.00	1.00
Gybe	**144.8**	**3.2**	**114.8**	**2.893**	**-2.364**	**.3**	**.3**	**1.00**	**1.00**
	150.0	3.0	124.4	2.720	-2.356	.2	.3	1.00	1.00
	165.0	2.8	152.2	2.404	-2.322	.1	.2	1.00	1.00
	180.0	2.8	179.9	2.242	-2.242	0.0	.1	1.00	1.00

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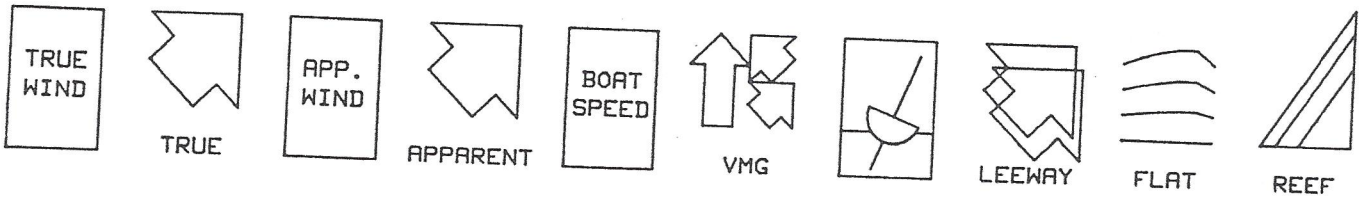

7.0 knots

	36.0	9.8	23.0	3.093	2.503	3.4	9.0	1.00	1.00
	44.0	10.3	28.9	3.973	2.858	3.8	6.3	1.00	1.00
Tack	**46.4**	**10.4**	**30.4**	**4.168**	**2.875**	**3.9**	**5.8**	**1.00**	**1.00**
	52.0	10.5	33.7	4.561	2.808	4.0	5.0	1.00	1.00
	60.0	10.5	38.2	4.982	2.491	3.9	4.2	1.00	1.00
	70.0	10.2	43.8	5.296	1.811	3.7	3.5	1.00	1.00
	77.2	---------- ^ Genoa / Spinnaker v ----------							
	80.0	9.7	49.5	5.500	.955	3.8	2.8	1.00	1.00
	90.0	9.0	55.7	5.565	0.000	3.4	2.3	1.00	1.00
	105.0	7.7	66.6	5.380	-1.392	2.5	1.7	1.00	1.00
	120.0	6.3	81.2	4.896	-2.448	1.6	1.1	1.00	1.00
	135.0	5.1	101.0	4.277	-3.024	.8	.6	1.00	1.00
	150.0	4.3	125.9	3.658	-3.168	.4	.3	1.00	1.00
Gybe	**159.7**	**4.1**	**143.1**	**3.390**	**-3.179**	**.3**	**.2**	**1.00**	**1.00**
	165.0	4.0	152.8	3.280	-3.168	.2	.2	1.00	1.00
	180.0	4.0	179.9	3.078	-3.078	.1	.1	1.00	1.00

10.0 knots

	36.0	13.6	22.6	4.019	3.252	7.5	9.5	.93	1.00
	44.0	14.2	28.7	5.187	3.731	12.3	6.9	1.00	1.00
Tack	**45.8**	**14.3**	**29.9**	**5.384**	**3.750**	**12.7**	**6.5**	**1.00**	**1.00**
	52.0	14.3	33.8	5.832	3.591	13.1	5.6	1.00	1.00
	60.0	14.1	39.1	6.155	3.078	12.1	4.9	1.00	1.00
	70.0	13.6	45.8	6.375	2.180	9.7	4.2	1.00	1.00
	73.3	---------- ^ Genoa / Spinnaker v ----------							
	80.0	12.9	52.5	6.557	1.139	10.4	3.4	1.00	1.00
	90.0	12.1	59.8	6.620	0.000	6.3	2.8	1.00	1.00
	105.0	10.5	71.6	6.517	-1.687	3.8	2.0	1.00	1.00
	120.0	8.9	85.6	6.228	-3.114	2.4	1.2	1.00	1.00
	135.0	7.3	103.5	5.748	-4.064	1.4	.6	1.00	1.00
	150.0	6.3	127.5	4.996	-4.327	.7	.3	1.00	1.00
Gybe	**160.4**	**6.0**	**145.4**	**4.623**	**-4.355**	**.5**	**.2**	**1.00**	**1.00**
	165.0	5.9	153.6	4.497	-4.344	.4	.2	1.00	1.00
	180.0	5.9	179.9	4.230	-4.230	.2	.1	1.00	1.00

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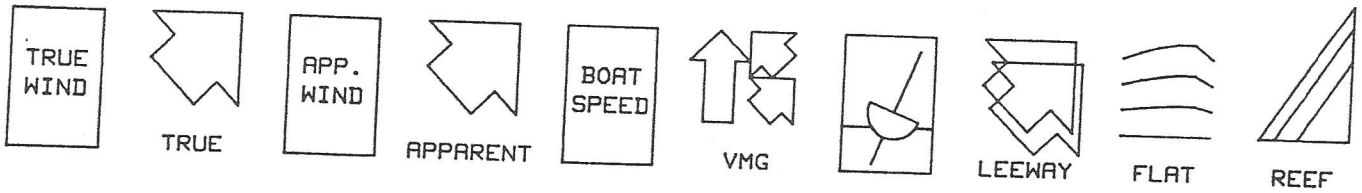

14.0 knots

	TRUE WIND	TRUE WIND	APP. WIND	APP. WIND	BOAT SPEED	VMG	LEEWAY	FLAT	REEF
	36.0	18.0	21.7	4.667	3.776	16.3	9.6	.73	1.00
Tack	**43.1**	**18.3**	**27.3**	**5.692**	**4.156**	**21.0**	**7.1**	**.76**	**1.00**
	44.0	18.3	28.0	5.772	4.152	21.2	7.0	.76	1.00
	52.0	18.0	33.5	6.274	3.863	23.3	6.1	.81	1.00
	60.0	17.6	39.3	6.602	3.301	24.1	5.6	.90	.98
	70.0	16.7	46.7	6.915	2.365	24.5	5.1	1.00	.98
	80.0	16.1	55.0	7.175	1.246	20.8	4.4	1.00	1.00
	84.7	----------	^ Genoa	/	Spinnaker	v	----------		
	90.0	15.2	63.3	7.378	0.000	19.2	3.4	1.00	1.00
	105.0	14.1	76.8	7.468	-1.933	8.2	2.4	1.00	1.00
	120.0	12.3	91.7	7.233	-3.616	3.5	1.5	1.00	1.00
	135.0	10.5	109.3	6.842	-4.838	2.0	.8	1.00	1.00
	150.0	9.3	130.4	6.348	-5.498	1.2	.4	1.00	1.00
	165.0	8.6	154.5	5.967	-5.763	.7	.2	1.00	1.00
Gybe	**168.0**	**8.5**	**159.6**	**5.898**	**-5.770**	**.6**	**.2**	**1.00**	**1.00**
	180.0	8.5	179.9	5.697	-5.697	.4	.1	1.00	1.00

20.0 knots

	TRUE WIND	TRUE WIND	APP. WIND	APP. WIND	BOAT SPEED	VMG	LEEWAY	FLAT	REEF
	36.0	23.7	20.1	4.623	3.740	20.0	11.3	.61	.90
Tack	**43.3**	**24.1**	**27.5**	**5.878**	**4.276**	**23.0**	**7.8**	**.77**	**.83**
	44.0	24.0	28.1	5.941	4.273	23.2	7.7	.78	.83
	52.0	23.6	34.4	6.470	3.983	24.7	6.7	.88	.80
	60.0	23.0	40.8	6.827	3.414	25.4	6.1	.98	.79
	70.0	22.0	49.1	7.191	2.460	25.5	5.4	1.00	.82
	80.0	20.9	57.7	7.525	1.307	25.8	4.7	1.00	.86
	86.7	----------	^ Genoa	/	Spinnaker	v	----------		
	90.0	19.7	67.1	7.839	0.000	25.4	3.6	1.00	.88
	105.0	18.0	81.5	8.364	-2.165	23.9	2.8	1.00	1.00
	120.0	17.4	96.8	8.509	-4.254	8.2	1.8	1.00	1.00
	135.0	15.6	114.5	8.083	-5.715	3.1	1.0	1.00	1.00
	150.0	14.2	134.5	7.612	-6.592	2.0	.6	1.00	1.00
	165.0	13.4	156.6	7.279	-7.031	1.3	.4	1.00	1.00
Gybe	**172.8**	**13.2**	**168.7**	**7.141**	**-7.085**	**1.0**	**.3**	**1.00**	**1.00**
	180.0	13.2	179.8	7.051	-7.051	.8	.2	1.00	1.00

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Polar Plot

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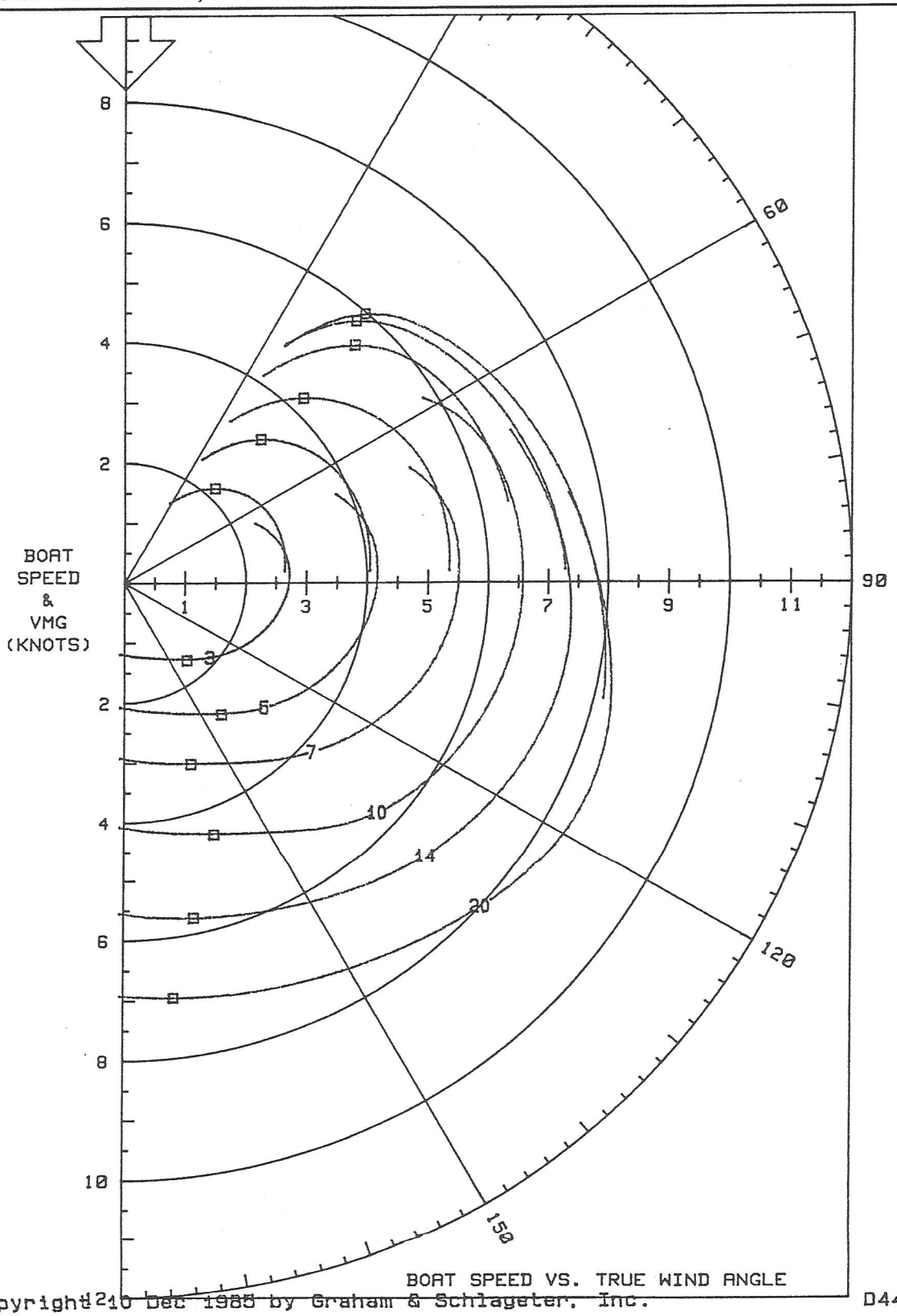

BOAT SPEED VS. TRUE WIND ANGLE

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Wind Plot

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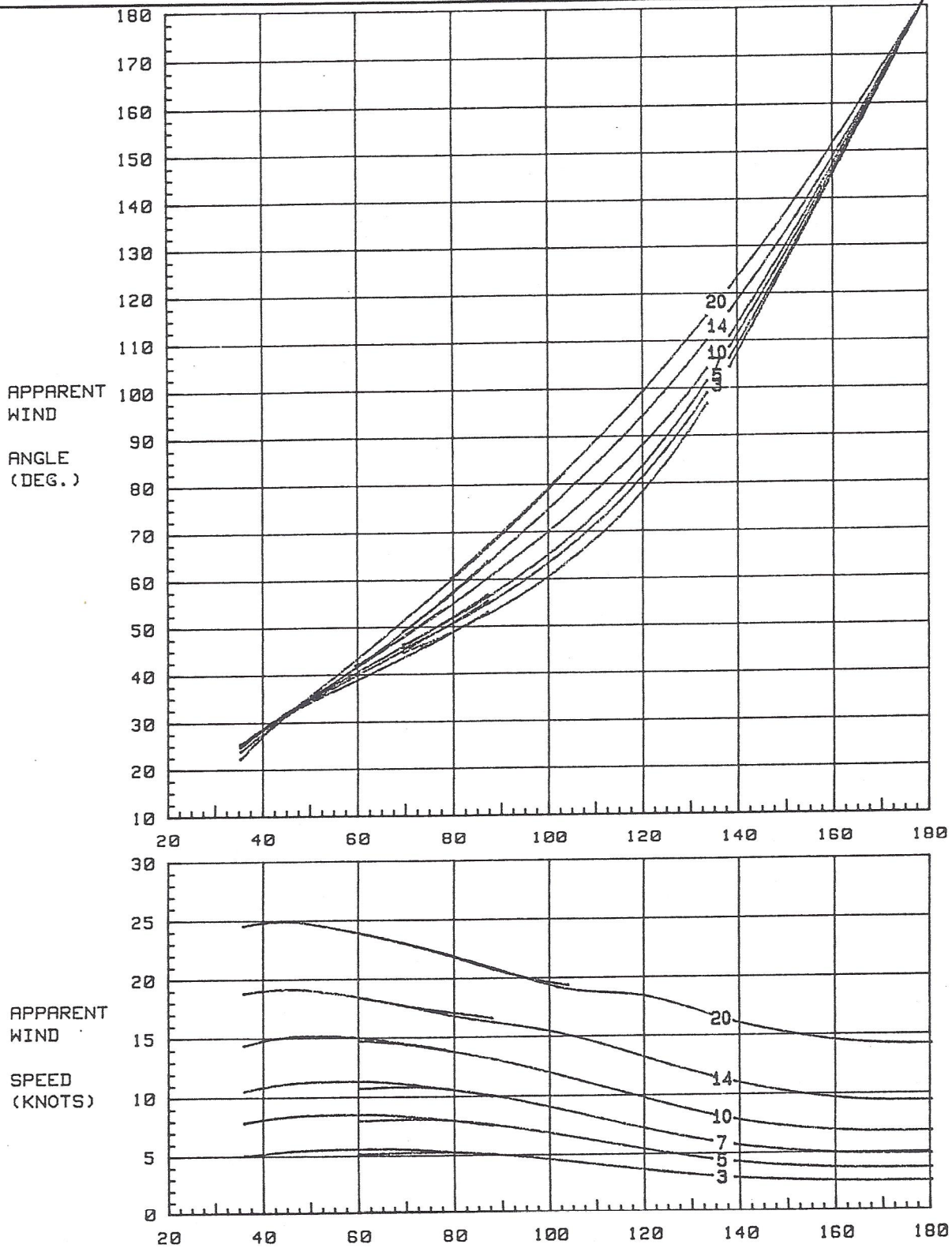

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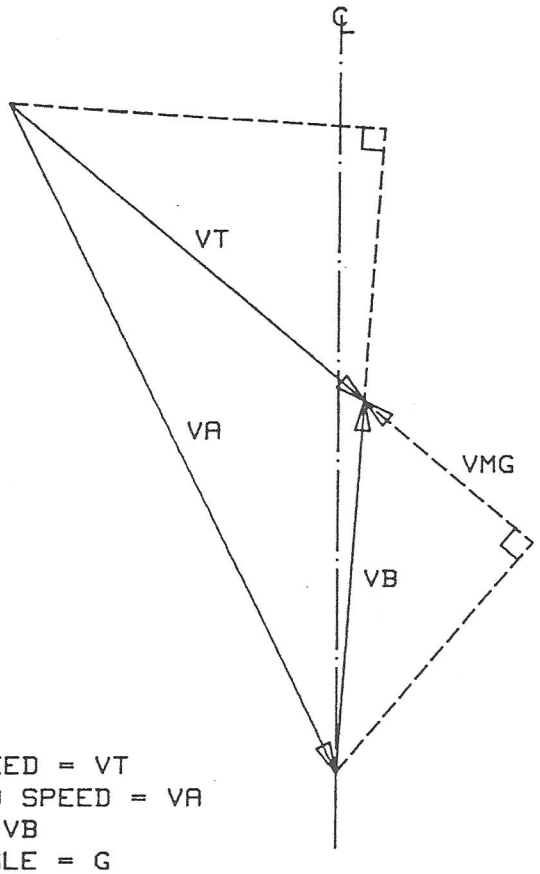

TRUE WIND SPEED = VT
APPARENT WIND SPEED = VA
BOAT SPEED = VB
TRUE WIND ANGLE = G
APPARENT WIND ANGLE = B
LEEWAY ANGLE = L
UPWASH ANGLE = E
HEEL ANGLE = H

THE SYMBOL ^ INDICATES EXPONENTIATION.
THE SYMBOL * INDICATES MULTIPLICATION.
THE LETTER m INDICATES A MEASURED QUANTITY.
THE LETTERS mh INDICATE A VALUE TAKEN AT THE MASTHEAD.

```
L = 69.2 * H/[VB]^3
E = 6.67 * SIN[(180-Bm)/1.667]^2.5 * REEF^2 * FLAT
B = Bm + L - E
VBAUG = COS(B) * VAm
VTMCG = VBAUG - VB

G = ArcTAN {TAN(B) * VBAUG/[COS(H) * VTMCG]}
VTmh = VTMCG/COS(G)
VT = VTmh/(.15055 * COS(H) + .864)
```

S2 27 - SHOAL KEEL INBOARD
for PERFORMANCE PREDICTION

10 Dec 1985

Upwind

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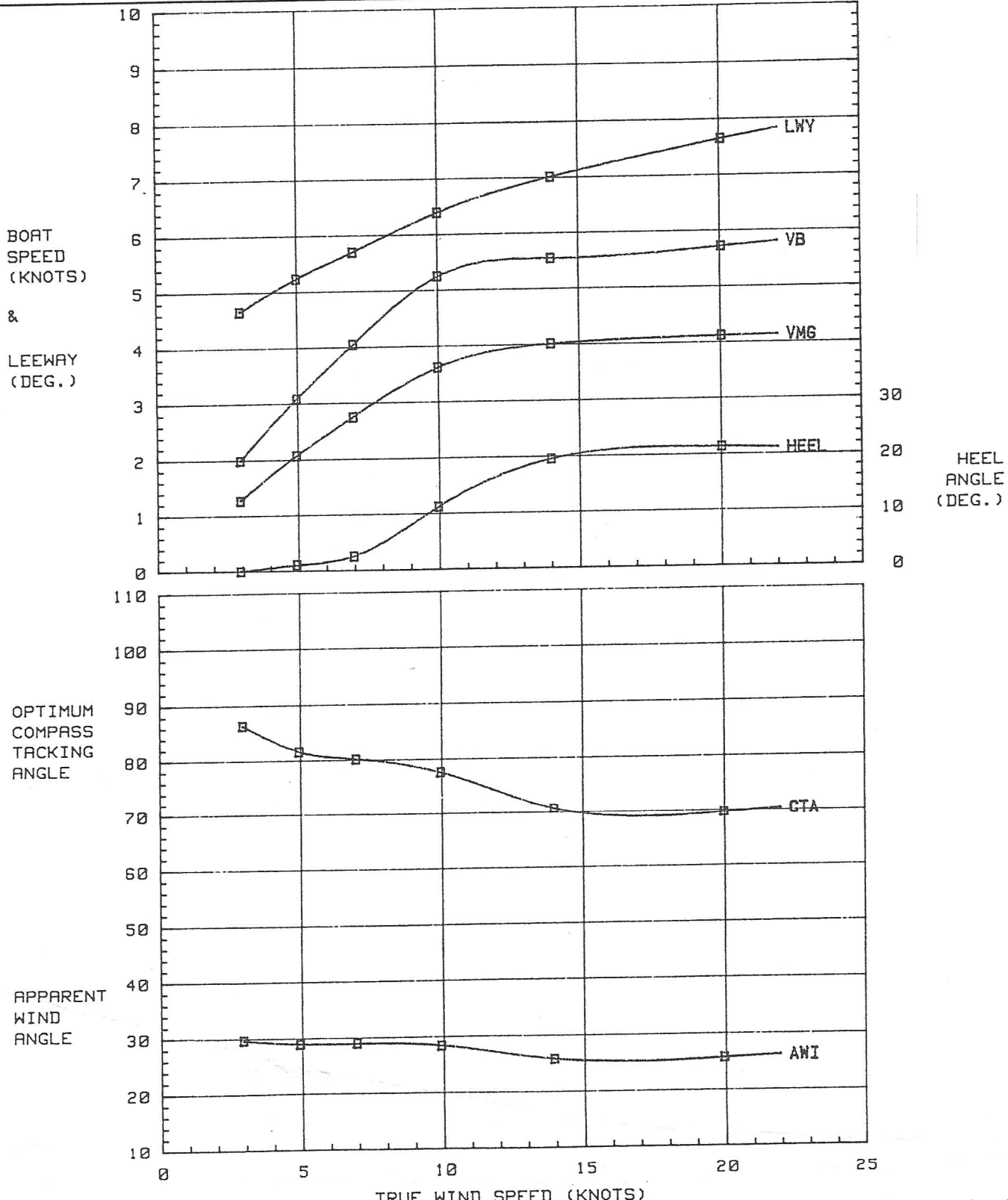

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10 Dec 1985

Downwind

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