RESULTS OF MODEL TANK EXPERIMENTS TO DETERMINE THE ACTION OF A SHIP BRAKE.

BY CAPTAIN WM. STROTHER SMITH, U. S. N., MEMBER.

[Read at the twenty-third general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 18 and 19, 1915.]

This paper is presented with the idea of showing the interesting data obtained in the model tank at the Navy Yard, Washington, for use in determining whether or not it was feasible to design and install a brake on the side of a merchant vessel to assist in stopping a steamer when in danger of collision or grounding.

The question of installing such a brake is a financial one and is dependent upon the lessened insurance demanded and the advertisement of such an appliance to increase the passenger list.

This question is not one for the naval architect or marine engineer to solve and is not brought up for discussion on that point.

In the spring of 1910, a set of trials was made on the U. S. S. Indiana off Delaware Breakwater to determine the effect of the Lacoste ship brake. Due to a lack of preliminary investigation, this trial showed very little either for or against the brake and it was some time after that the writer was requested by personal friends to take up the study with a view to designing a practical brake.

After the loss of the Titanic interest was awakened to such an extent that a syndicate was formed and the permission of the Navy Department was obtained to make a series of trials in the model tank, and the results of these trials are now presented to you through the courtesy of the Lacoste Shipbrake Syndicate.

The Wm. Cramp & Sons Ship and Engine Building Company was kind enough to furnish the lines of the S. S. St. Louis, and a model of this vessel was constructed.

Three runs (Nos. 1, 2 and 3) were made to determine the curve of speed and power before fitting any brakes, and the successive ten runs were made with different areas and settings of the brake to determine the resistances and pressures per square foot.

The S. S. St. Louis is 536 feet in length, 62 feet 9 inches beam, and the draught at load line was 28 feet for model experiments, the displacement being about 17,230 tons.

Plate 51 shows the curves of speed and effective horse-power as determined under the following conditions:—

Runs 1, 2 and 3 show the speed and power curve without brakes. The succeeding runs were with brakes as stated.

Runs 4 and 5—brakes, 12 feet 2¼ inches by 14 feet at 80°.

Runs 6 and 7—brakes, 12 feet by 14 feet at 90°.

Run 8—brakes, 12 feet by 14 feet at frame 76, and another pair 8 feet by 18 feet at frame 95, set at 90°.

Run 9—brakes, 10 feet by 14 feet at 90°.

Run 10—brakes, 8 feet by 14 feet at 90°.

Run 11—brakes, 8 feet by 14 feet at 70°.

Run 12—brakes, 12 feet by 13 feet with the top edge placed one foot below the water line. All other runs were made with the top edge at the water line.

Run 13—brake, 8 feet by 21 feet at 80°.

Plate 52 shows the pressures per square foot on the brakes as indicated on the plate by the runs numbered.

The following deductions are made:—

The stopping power varies directly as the projected area opposed at 90° to the fore-and-aft line.

One pair of brakes is more efficient than two, as shown by run No. 8, where the combined area is 624 square feet for the two brakes, the stopping power or resistance opposed is not in the same proportion as the pair of 12 feet by 14 feet, giving 168 square feet.

The pressure per square foot practically decreases as the width of the brake is reduced and, by plotting curves of pressures at various speeds for different widths of brake, it is found that after a certain width is passed the pressure per square foot is not increased.

After these curves were determined, the model was fitted with a pair of brakes 11 feet 8¾ inches (projected area) by 14 feet deep, fitted so as to be tripped and thrown out from the traveling carriage of the model tank. A set of guides was fitted so as to keep the model in position under the carriage, yet allow it to advance freely when the carriage was stopped.

The foot-way along the tank was marked off in equal distances from a certain point far enough from the starting point to allow the carriage to reach the proper speeds. The model was then brought up to speed, the carriage stopped at the determined point, the model released with the brakes thrown out, and the times marked by stop-watches at each marked distance until the model was brought to rest or the limit of the tank reached.

For each speed the model was released with the brakes closed, so a comparison was obtained and shown on Plate 53 of speed reduction per foot traveled and on Plate 54 the speed reduction per second traveled.

As a matter of interesting data, the following table showing the instantaneous stopping effect of a pair of brakes of different sizes has been compiled from the curves shown on Plate 51:—

Size of brake.		Stopping effect at various speeds in effective horse-power speeds.								
Wide.	Deep.	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*
12′	14′	13, 000	15, 500	18, 250	21, 750	23, 250	28, 500	32, 200	35, 250	38, 500
10′	14′	10, 600	12, 750	15, 000	17, 500	20, 000	22, 500	25, 600	28, 300	30, 400
8′	14′	7, 850	9, 500	11, 250	13, 500	15, 500	17, 500	19, 800	21, 900	24, 000
6′	14′	5, 300	6, 400	7, 590	9, 100	10, 460	11, 810	13, 360	14, 780	16, 200
12′	13′	11, 800	14, 100	16, 600	19, 800	21, 100	25, 900	29. 300	32, 000	35, 000
10′	13′	9, 600	11, 600	13, 600	15, 900	18, 000	20, 400	23, 300	25, 750	27, 660
8′	13′	7, 100	8, 600	10, 200	12, 250	14, 100	15, 900	18, 000	19, 900	21, 800
6′	13′	4, 650	5, 650	7, 650	8, 250	9, 500	10, 700	12, 100	13, 400	14, 700
10′	12′	8, 600	10, 400	12, 300	14, 300	16, 000	18, 300	20, 900	23, 175	24, 880
8′	12′	6, 300	7, 700	9, 100	11, 000	12, 600	14, 300	16, 000	17, 900	19, 600
6′	12′	3, 900	5, 050	6, 850	7, 400	8, 500	9, 600	10, 800	12, 000	13, 200
10′	10′	7, 000	8, 600	10, 100	11, 900	13, 300	15, 200	17, 000	19, 300	20, 700
8′	10′	5, 200	6, 400	7, 500	9, 000	10, 400	11, 800	13, 100	14, 500	16, 200
6′	10′	3, 100	4, 100	5, 600	6, 100	7, 000	8, 000	10, 100	12, 000	13, 200
8′	8′	4, 100	5, 100	5, 800	7, 000	8, 300	9, 400	10, 400	11, 500	12, 000
6′	8′	2, 400	3, 200	4, 300	4, 700	6, 500	7, 400	8, 200	9, 000	9, 500
6′	6′	1, 700	2, 200	3, 000	3, 200	4, 600	5, 400	6, 000	6, 600	7, 000

Using a pair of brakes 11.73 feet wide and 14 feet deep set normal to the direction of the vessel, the speed being 18 knots, the speed will be reduced to 15.2 knots in 500 feet, to 11.6 knots in 1,000 feet, to 7.15 knots in 2,000 feet without the assistance of the propellers in backing.

Assuming the weight of the vessel at 17,230 tons, the striking blow at
18 knots equals 247,300 foot-second tons.
15.2 knots equals 176,300 foot-second tons.
11.6 knots equals 102,700 foot-second tons.
7.15 knots equals 39,000 foot-second tons.

Using the element of time, the speed will be reduced in
50 seconds to 11.1 knots.
100 seconds to 7.35 knots.
150 seconds to 5.85 knots.
200 seconds to 4.70 knots.

The experiments conducted on the U. S. S. Indiana showed very little. The vessel was entirely unsuitable, owing to the fact that there is not a straight line in any part of her hull and the brake had to be fitted on by means of a molded frame. There were no accurate means of determining the total instantaneous indicated horse-power nor the exact speed.

When the subject was revised, the model tank was considered by far the most accurate method of determining the data to be used in designating a brake. To satisfy the ideas of many concerned, various forms of the brake were considered, principally with the idea of controlling the brake by power so as to open and close at will, the vessel going at full speed.

Scheme 1.—Long hydraulic cylinders installed athwartship on a stiffened bulkhead to work connecting rods attached to the brakes. This involved an additional weight of about 190 tons, including 33 tons of contained water.

Scheme 2.—In order to reduce weights, especially that of contained water, a toggle joint arrangement was studied to reduce the power required and to reduce the peak load when the brakes were to be started in. This involved a stress of 340,000 pounds on each of three principal connecting rods and 320,000 pounds on each of three lesser members.

Scheme 3.—Rack and pinion arrangement, allowing very little contained water. The diameter of the vertical shaft working the pinions and the width of the gear needed rendered this scheme out of consideration.

Scheme 4.—Same as Scheme 3, but with the idea of pushing the brake out to 35° to assist the rudder. This required too much machinery to develop the power necessary, about 500 estimated horse-power for a pair of brakes 9 by 13 feet.

Many other schemes were studied out, but the weights and power required made any and all of them impracticable.

The final conclusion reached—that the simplest form of brake designed to be set in the side of a vessel, to be released instantly by the officer on the bridge by throwing a lever and open by the pressure of the water without further thought; to be supplied with only enough power and mechanism to haul in the brake when the vessel was stopped or going astern and lock it fast for future use—was the only practical solution of the question.

With these points in view, a type design was made for the Canadian Pacific S. S. Empress of Asia, practical, strong and simple, for emergency use only. The officer on the bridge has but to pull a lever and the brake will open and exert its resistance. When the danger is past, it requires but the attention of one man on each side to haul in and secure the brake.

With this done, the technicist closes his work and the financier and promoter begins to write his story.

DISCUSSION.

THE CHAIRMAN:—This interesting paper by Captain Smith is now open for discussion.

MR. CLAY L. JENNISON, *Junior*:—As I am a Junior Member and have only recently been elected, I do not know that I shall be allowed the floor. In some recent tests in the model basin in Washington, which I conducted for Mr. Hyde, of Tacoma, Washington, I found the results—although they were rather elementary compared with what Captain Smith has offered—compared very favorably with his results. In tests on the midship section we fitted a series of brakes in place of one or two. We found that the results obtained were very unfavorable, but on results from brakes fitted well forward, so that they obtained a good flow of water, we received an increase of resistance of about 300 per cent. That seems almost abnormal, but the curves show it at 13 knots.

Recently Mr. Hyde has had tested some brakes made up of sections of the bilge keel; the sections were about 6 feet long by about 2 feet in section. These showed a resistance increase of about 155 per cent. From these results and the ones we obtained previously, Mr. Hyde has decided to go ahead with some work on his own plans, and I think in the near future a vessel on the west coast will be fitted with brakes, either the bow brake or bilge keel brake. Perhaps at an early date Mr. Hyde will be able to submit to the members of the Society some data on the bilge keel brake.

Further, I would like to ask Captain Smith a question. In his paper he says that some brakes were made for the Empress of Asia. I would ask if these have been placed on the vessel, or if they are going to be placed on the vessel?

CAPTAIN SMITH:—I will answer the question by saying that no brakes have been built or installed, to my knowledge, on any vessel. They have simply been designed.

THE CHAIRMAN:—Is there any further discussion on this paper? Doubtless Mr. Hyde will be willing to bring to our notice the results of such further work as may be done in this connection. I trust it will be ready for our next meeting. I am sure you will allow the Chair to extend on your behalf a vote of thanks to Captain Smith for giving us this most interesting paper, and also to authorize the Chair to extend a vote of thanks to Mr. Etter for the paper read by Professor Owen—both valuable contributions to the literature of their respective subjects.

The next paper to be presented is No. 12, "The Maintenance of the Fleet," by Capt. A. P. Niblack, U. S. N., Vice-President.

CAPTAIN NIBLACK:—Under the Navy regulations I was required to submit this paper to the Department to be censored, and one of the conditions under which it is permitted to be read here is that it shall be read verbatim as written, and not interspersed with any remarks. The Society wished me to make an abstract of the paper, to be read here, and thus save you the infliction of the whole paper. I have made the abstracts as requested, but under the conditions just set forth it is necessary that I shall read the whole thing. Therefore, I will read it without alteration of any kind.

To illustrate paper on "Results of Model Tank Experiments to Determine the Action of a Ship Brake," by Captain William Strother Smith, U. S. N., Member.

SECTION A-B

LOOKING FORWARD

SECTION A-C

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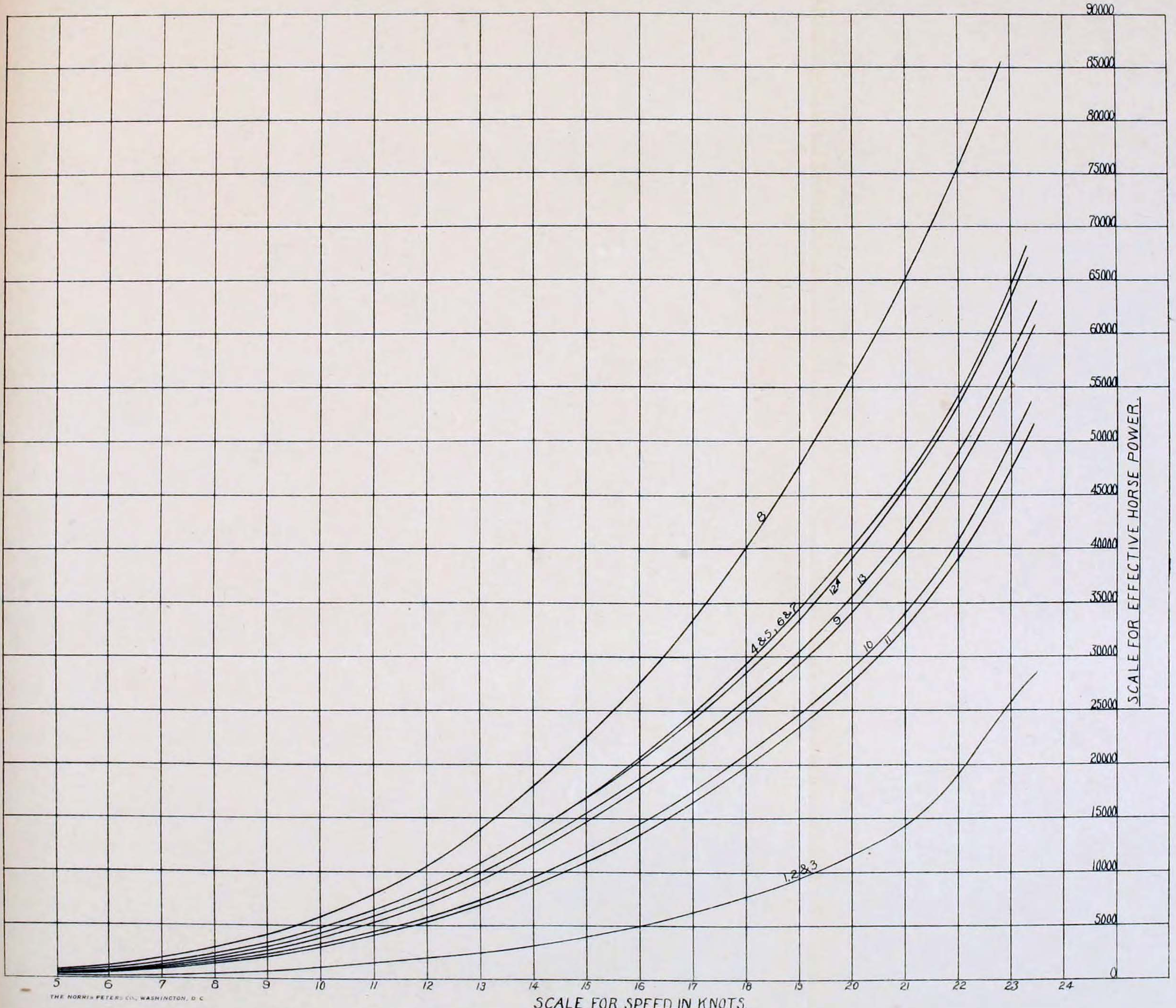

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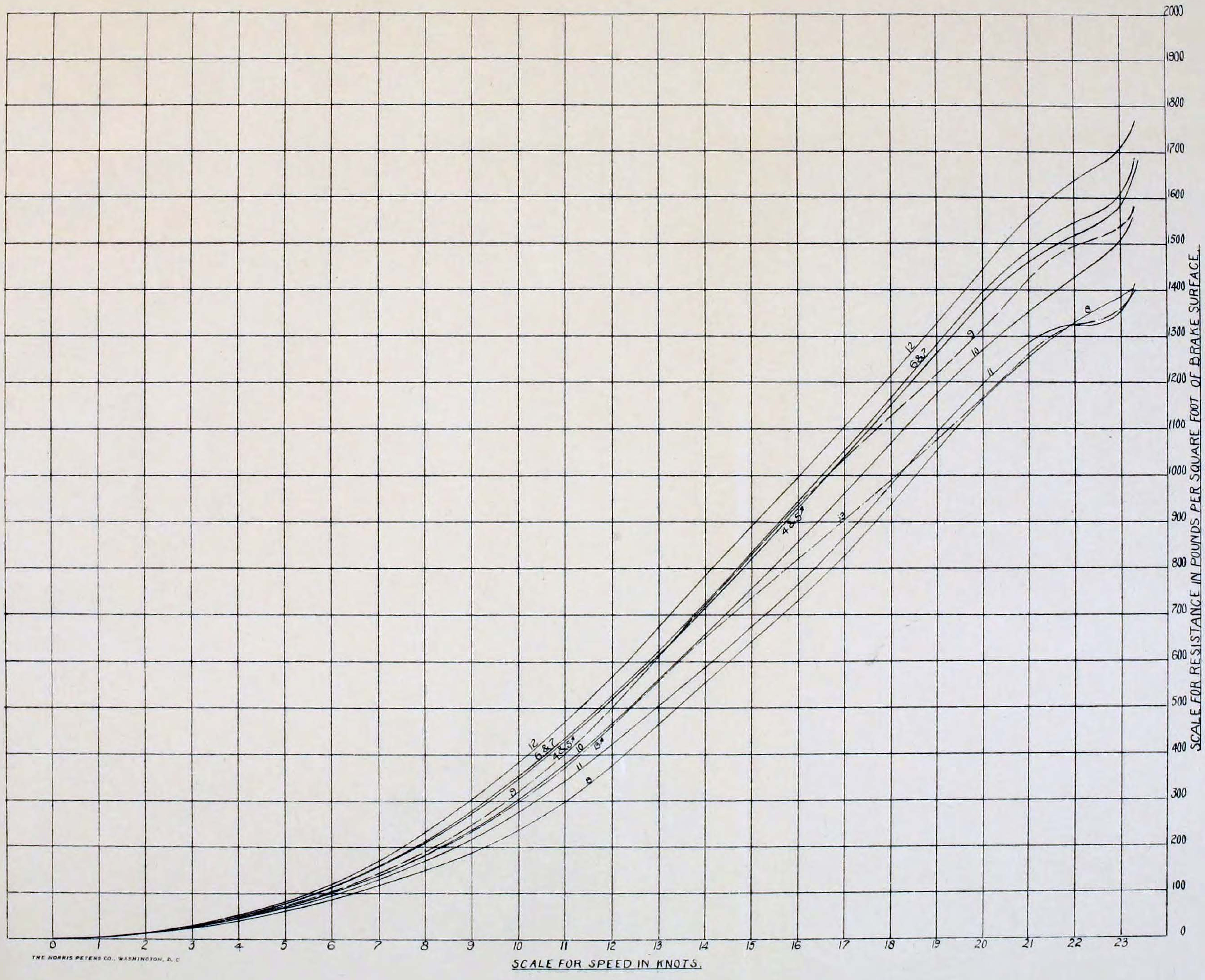

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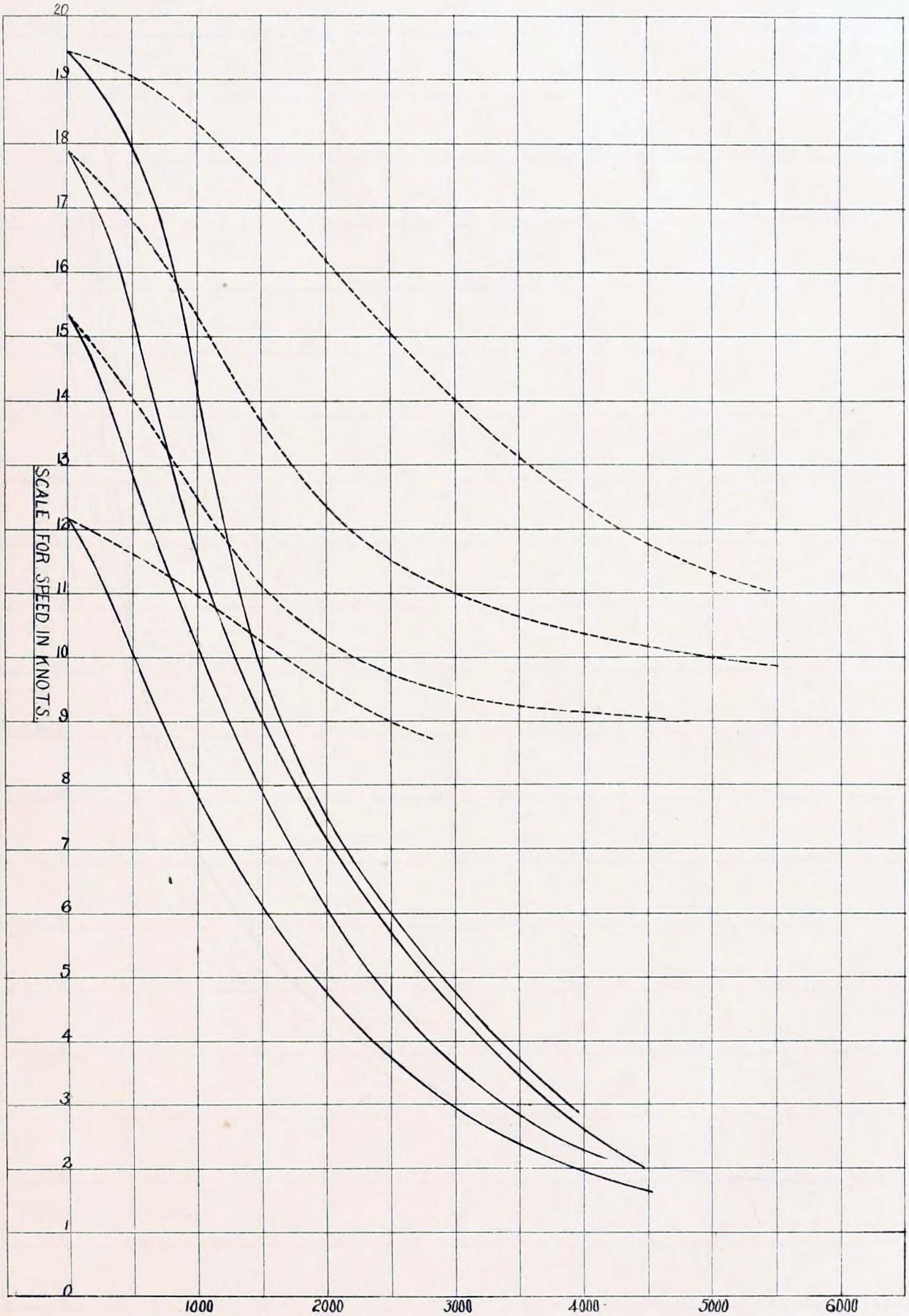

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