HYDRODYNAMIC RESISTANCE TESTS ON A SCUBA DIVER

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Abstract

Drag measurements were taken for a diver wearing various standard free swimming and scuba dress while being towed in the Naval Academy 120 foot ship model towing tank. Resistance curves are plotted for simulated swim speeds and five diver dress configurations. It was found that there was as much as a fourfold increase in diver drag for the fully equipped diver.

1. Introduction

Divers outfitted in scuba dress must overcome the resistance of the water as they propel themselves forward by kicking while wearing swim fins. As part of an analysis of the efficiencies of swim fins being conducted by the authors, it was first necessary to determine the resistance of diver swimming at various speeds wearing various diving configurations. Swim speeds of 0.0 to 0.8 ft/sec would require light exertion; 0.8 to 1.5 ft/sec moderate exertion; and speeds greater than 1.5 ft/sec heavy exertion for the fully equipped diver. For this reason, test were conducted for swim speeds varying from 0.4 to 1.5 ft/sec. (note: 1 ft/sec = .59 knot).

The resistance of the variously configured divers were obtained by towing our instrumented diver through the Naval Academy's 120 foot ship model towing tank.

2. Procedure

Two sets of experiments were conducted. Volunteer divers were towed in the ship model force is measured. There is no "cross-talk" with any moment forces from the towing rig arm.

3. Test results

Tests were conducted by first towing the test rig at various speeds to establish its drag. The rig was then towed with the diver aboard. Five dress configurations were tested as shown in Table 1. Each configuration was tested at 6 velocities from 0.4 to 1.5 feet per second. Figure 5 shows drag curves for the second series of tests. A comparison with figure 2 shows the importance of a diver maintaining body position, particularly if a powered device is used to propel a diver.

Diver drag is made up of two parts: frictional resistance which is a function the wetted surface area of the diver, and eddy resistance created as water flows around the diver and his equipment. It is theoretically possible to separate the total resistance into the two parts. Frictional resistance is a function of Reynold's number, and the diver typically swims at velocities which are in the transition range between laminar and turbulent flow.

4. Conclusions

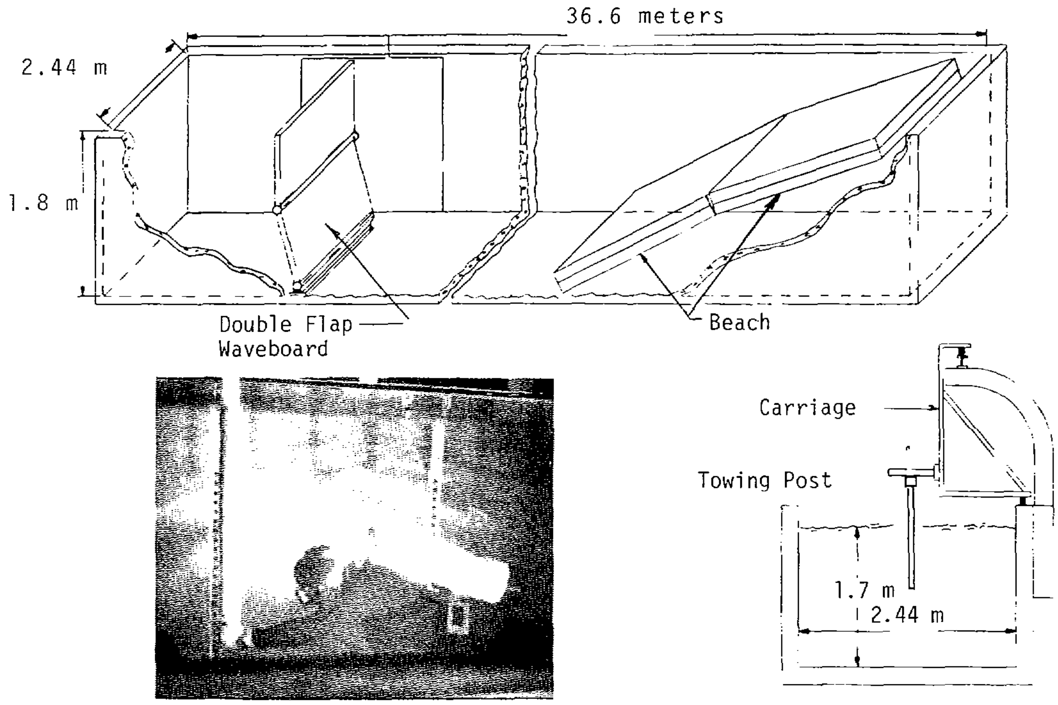
For swim speeds of less than 0.5 ft/sec there is little variation in the drag for the various diver configurations. As the swim speed approached 1.5 ft/sec the differences in the drag become very significant. Eddy resistance is much larger than the frictional component, suggesting that significant drag reduction is possible by streamlining the equipment. Further tests to evaluate the effectiveness of streamlining equipment are scheduled for this year.

Table 1

Diver configurations

Test	1	2	3	4	5
Trunks	X	X	X	X	X
Wet Suit & Weight Belt		X	X	X	X
Mask, Snorke, Fins			X	X	X
Single Tank				X	
Twin Tanks					X

Figure 1 120 Foot Towing Tank



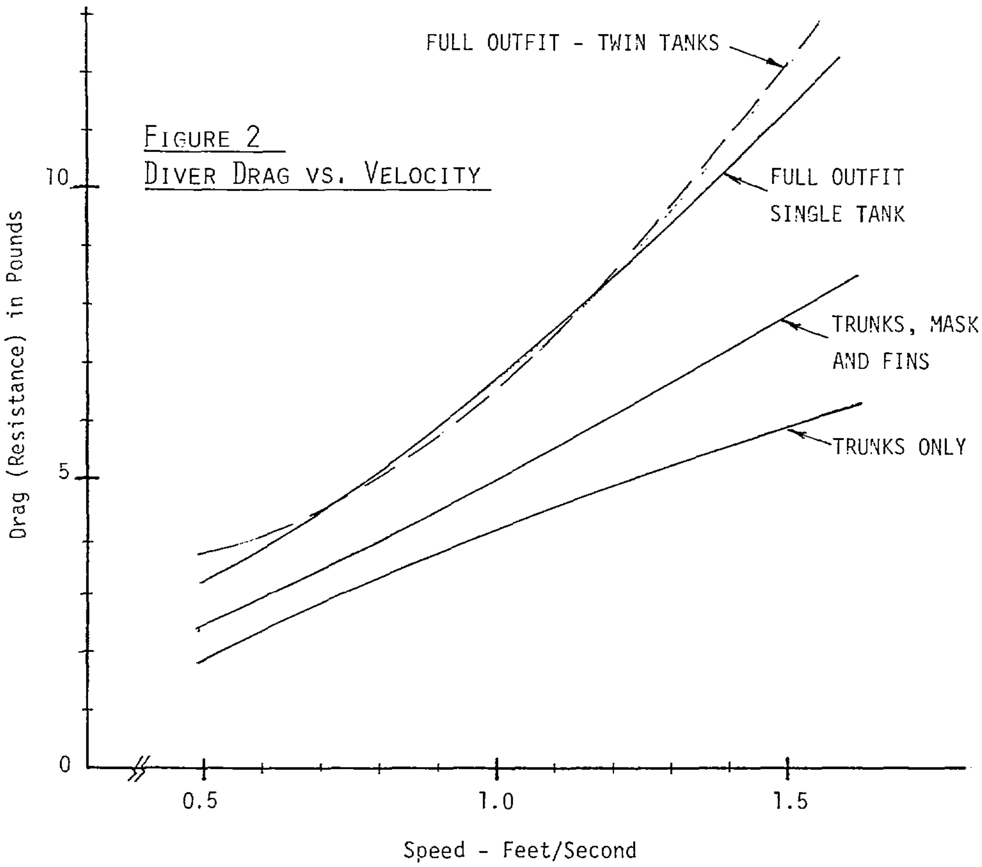


Figure 2
Diver Drag vs. Velocity

FIGURE 3

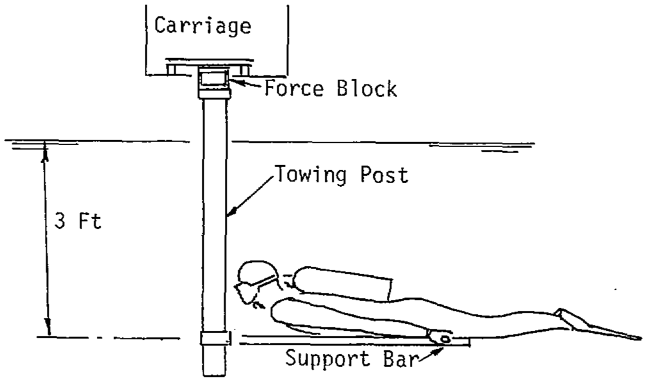


FIGURE 4

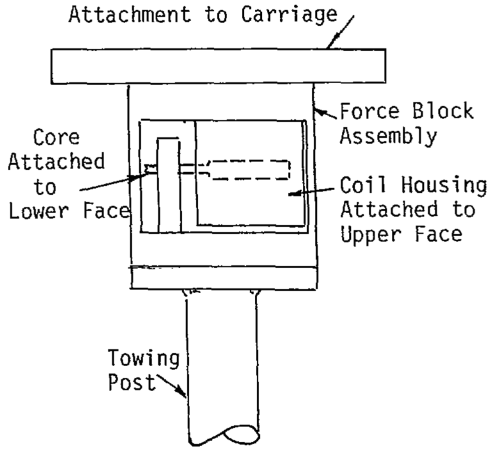


FIGURE 5

DIVER DRAG VS. VELOCITY