13th INTERNATIONAL TOWING TANK CONFERENCE 1972

SUBJECT: RESISTANCE

by Dipl.-Ing. F. Mewis
(Institut für Schiffbau Rostock
Schiffbau-Versuchsanstalt Berlin/Potsdam)

Investigation of the Flow Conditions in the Bow Wave of a Full Cargo Vessel with and without a Bulbous Bow

General

Reductions exceeding that proportion of the total resistance caused by the wave resistance have been achieved on full cargo vessels by means of bulbous bows. In order to be able to explain this phenomenon it is necessary to find a new component belonging to the wave resistance but which has been ignored in the course of previous considerations. By measuring the total pressure loss in the cross-sectional planes behind and beside the ship, Taniguchi and Baba [1] discovered a new resistance component caused by the eddying of the water mass at the bow of the ship. Sharma [2] designated this component as "wave breaking resistance".

This paper presents the results of total pressure measurements in the bow wave of a full cargo vessel with and without a bulbous bow. The aim of the investigation is to show the influence of a bulb on the total pressure loss in the bow wave outside of the friction boundary layer.

Introduction

In order to prove that the area with the total pressure loss in the bow wave of a full cargo vessel is affected by a bulbous bow, measurements of the total pressure

were carried out in a number of cross-sectional planes
in the bow wave and beside the model and the flow around
the fore-body of a model of a full cargo vessel both with
and without a bulbous bow was observed.

Model

The model which was investigated had the following prin-
ciple dimensions:

	Without bulb	With bulb
L_{PP}' $[m]$	6.00	
L_{PP}/B	6.00	
B/T	2.76	
C_M	0.994	
C_B	0.798	0.802
LCB $[\%]$	-1.61	+1.85

The frames are moderately V-shaped.
The bulbous bow selected was determined as the best of
three different bulbs investigated during previous re-
sistance tests. The bulbous bow is faired into the lines
of the model with a normal bow. The frame area at the
forward perpendicular is 9.5 % of the area of the mid-
ship section, the length forwards of the forward per-
pendicular being 3 % of L_{PP}.

Resistance tests

In fully loaded condition as investigated in this paper,
increased resistance was measured in the case of the
model with a bulbous bow in the lower Froude number range
($F_n < 0.15$). In the case of larger Froude numbers
($F_n > 0.15$) it was found that the reduction in resistance
grew as the speed increased. At $F_n = 0.20$, the reduction
in the total resistance coefficient C_T' is 6 %. The
effect of the bulbous bow is still more favou

the ballast condition. A considerable reduction in the
resistance was found for Froude numbers of above 0.17,
these reaching a maximum of 21 % of the total resistan-
ce coefficient at $F_n = 0.22$.

Measurement of the total pressure

The measurements of the total pressure were taken in the
flow beside the model in six cross-sectional planes in
way of the forebody and in the plane of the midship sec-
tion at a Froude number of $F_n = 0.20$ (speed of model
v' = 1.534 m/s), the model being tested in fully loaded
condition both with and without a bulbous bow. Fig. 1
shows the arrangement of the measurement planes. The are-
as of reduced total pressure shown in Fig. 2 were each
obtained from about 200 measuring points.

The delayed layer was found to be thinner than was, at
first, expected. Both the magnitude and the absolute va-
lue of the area of total pressure loss in the back-wave,
on the surface of which numerous eddies could be dis-
cerned, immediately before the stem is smaller in the
case of the model with a bulbous bow than in the model
without a bulbous bow. The depth of the region with pres-
sure loss is reduced by about one half in all of the pla-
nes investigated beside the model by the bulbous bow
(Fig. 2).

In the transverse plane of the midship section, the re-
gion of the total pressure loss is forced outwards in
both model versions by the boundary layers, which are of
approximately equal thickness. In the case of the model
without a bulb, the region of the total pressure loss
was to be found in a definite form, whereas this region
was reduced to a thin layer in the case of the model
with a bulbous bow.

Observation of the flow in the bow wave

The reduction in resistance obtained by means of the bul-
bous bow could not, when comparing the wave systems ge-
nerated by the model with and without a bulb, be ex-
plained by favourable interference between the wave sys-
tems generated by the bulb and the ships hull. There are,
however, differences in the external appearance of the
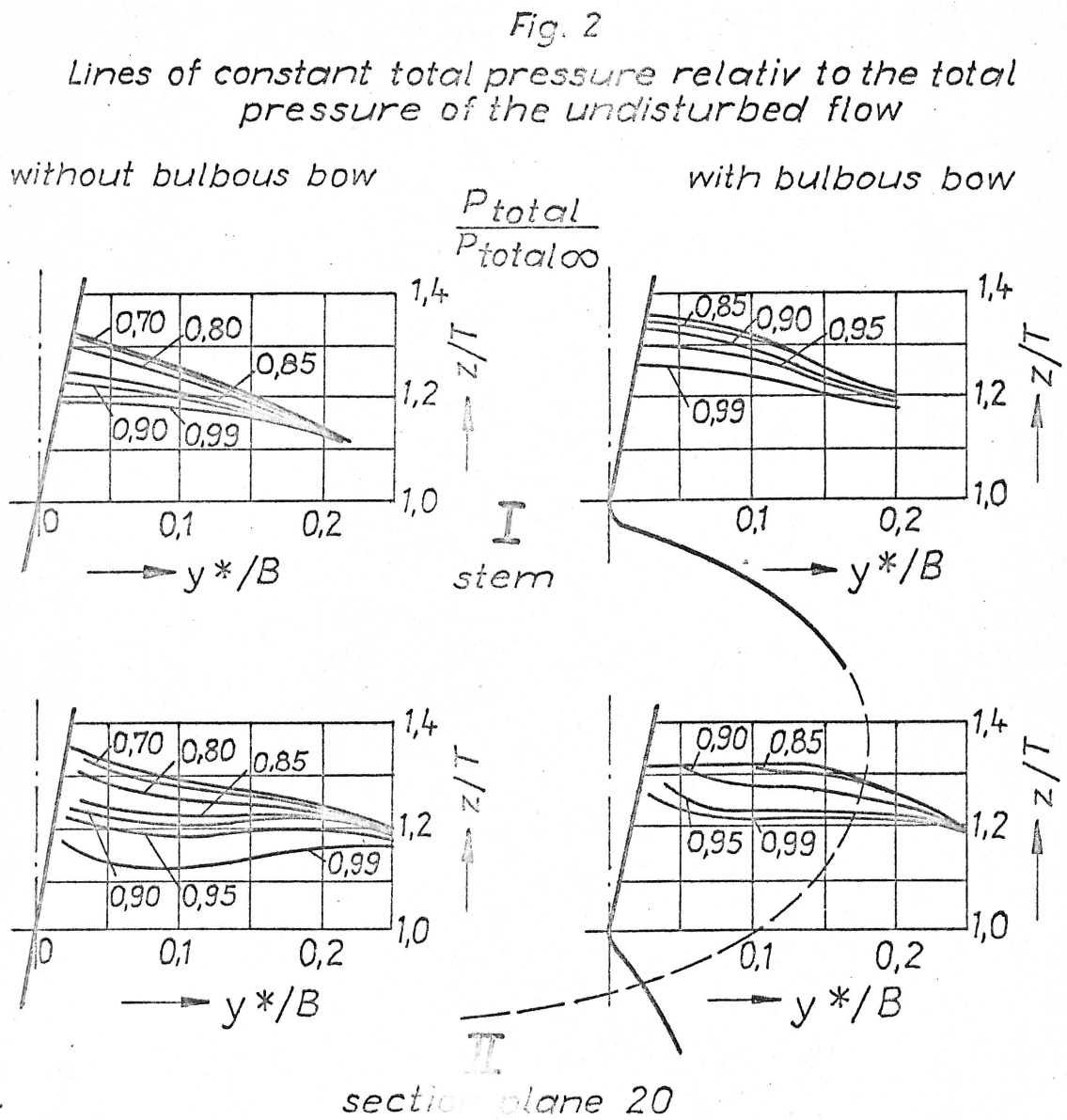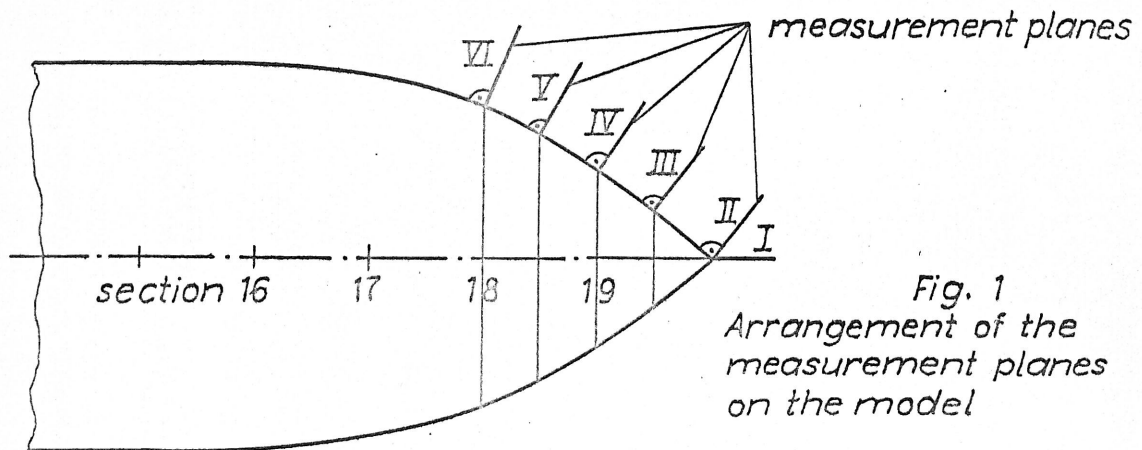bow wave. The eddying part of the back-wave is reduced
by the bulbous bow.

The thickness of the eddying layer in the back-wave was
measured by means of a thread probe and optical observa-
tions were carried out in the back-wave in the direction
of flow. The most important result of these observations
is the fact that the externally visible area of eddies
in the back-wave is only a turbulently eddying layer on
the exposed surface and that the thickness of this layer
decreases rapidly as it flows to the rear. Both the hori-
zontal extent and the thickness of this layer are reduced
by the bulbous bow. The thickness of the layer in which
the presence of eddies was proved by the thread probes
is less than the depth of the region of total pressure
loss obtained from the pressure measurements.

Summary of the results

The results presented here show that the flow conditions
in the back-wave of a full ship are influenced by a
bulbous bow. It could be proved that a region of total
pressure loss resulting from the back-wave is present
in the bow wave and in the midship section plane and
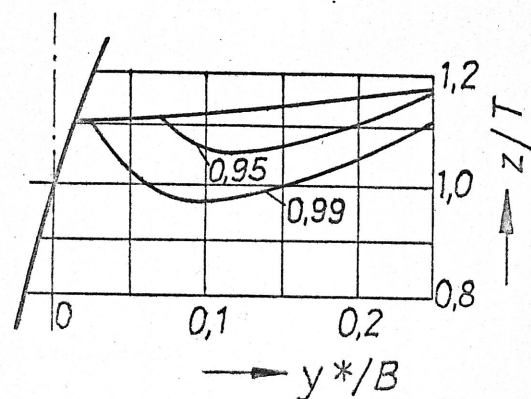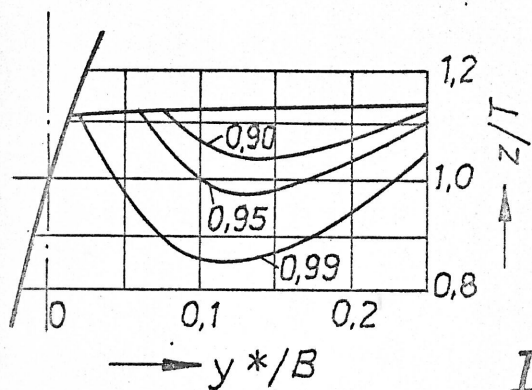that the size of this region can be reduced by means of
a bulbous bow.

References

/1/ Taniguchi, K. and Baba, K.: A new Component of
Viscous Resistance Measured by Wake Survey.
Proceedings 12th ITTC, Rome 1969

/2/ Sharma, S. C.: On the Wavebreaking Resistance of
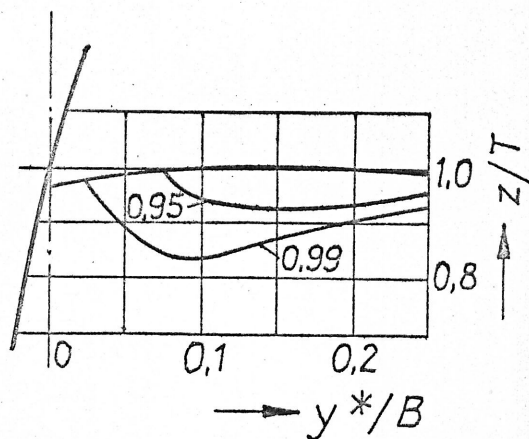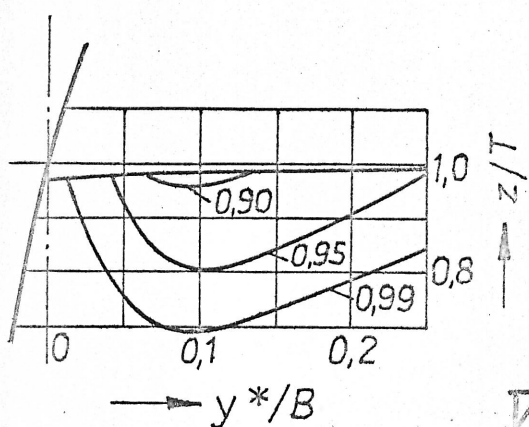Full Hull Forms.
Contribution to the 12th ITTC, Rome 1969

Fig. 1
Arrangement of the
measurement planes
on the model

Fig. 2

Lines of constant total pressure relativ to the total
pressure of the undisturbed flow

without bulbous bow

with bulbous bow

$\dfrac{P_{total}}{P_{total\infty}}$

I

stem

II

section plane 20
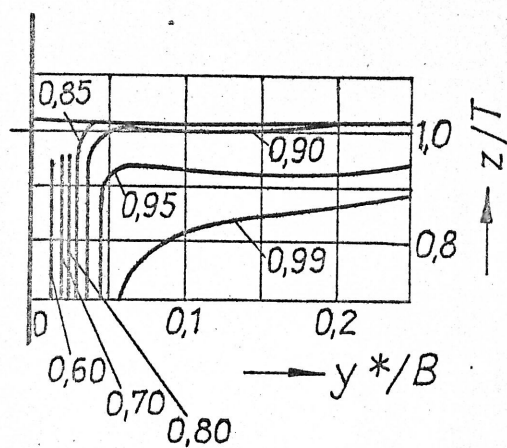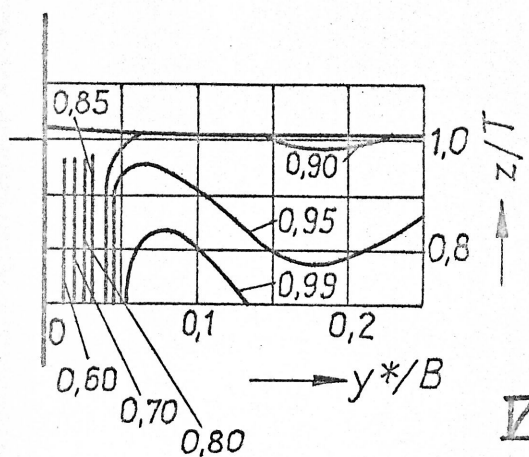
without bulbous bow   with bulbous bow

section plane 19

section plane 18

section plane 10