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THE UNIVERSITY OF MICHIGAN
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Final Report

FEASIBILITY OF FITTING HINGED OR TELESCOPING MASTS TO SAILING YACHTS USING THE ATLANTIC INTRACOASTAL WATERWAY

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INTRODUCTION

The Department of Naval Architecture and Marine Engineering of The University of Michigan has been asked by the District Engineer, United States Army Engineer District, Jacksonville Corps of Engineers, to make a brief study of the feasibility of fitting hinged or telescoping spars on tall-masted sailing yachts. Proposals have been made to reduce the minimum fixed bridge clearance over the Atlantic Intracoastal Waterway from 80 feet above mean high water to some lower height. An appreciable number of tall-masted sailboats which presently use the waterway would experience difficulties if the height requirements for new bridges were reduced. It has been suggested that the masts of such boats could be hinged, made telescoping, or unstepped to allow passage under new lower bridges.

There are many facets to this problem involving such matters as cost of bridges, location of bridges, total numbers of yachts of different sizes using the waterway, and other factors which are beyond the scope of this report. This report has been restricted insofar as practicable to discussion of the technical problems associated with fitting hinged or telescoping masts to sailing craft or with the unstepping of masts for transit of the waterway.

The suggestion that masts be made collapsible or unstepped for transit under low bridges over the waterway has been the subject of considerable argument, much of it exaggerated. It is hoped that this report can serve to put the question into proper perspective.

In testimony given at the public hearing on bridge clearances held in Jacksonville, Florida, on April 8, 1958, hinged masts were described as simple, cheap, and easily operated by some people and as impossible from the engineering standpoint by others. The cost of providing such a mast was estimated by one expert at $250 (European shipyard costs), while another stated that the cost would be so fantastic that the cost of the mast could equal the cost of the boat. It was also stated that it cost $18,000 to hinge a radar mast on a certain yacht. Further conflicting testimony concerning the difficulty of unstepping masts for passage through the waterway can be found in the minutes of this hearing.

It is the considered opinion, based on study of the testimony of the public hearings and the limited available literature on the subject, of the staff of this Department that no simple affirmative or negative answer can be given to this question. Much will depend on the type of boat involved and the circumstances of its use of the waterway. For purposes of this report, sailing yachts are divided according to their primary function as follows: 1) racing, and 2) cruising. It is of course difficult to make a clear distinction between racing and cruising yachts. Racing yachts are here defined as those vessels designed and

used for competitive sailing. Cruising yachts are defined as those vessels primarily intended for pleasure cruises and in which the utmost speed is not generally sought.

Yachts are also categorized according to their normal usage of the waterway:

1) Passage between northern cities and Florida:
   a) every year;
   b) only infrequently.

2) Passage between regular mooring and open sea via the waterway or its branches.

3) Entry into the waterway for refuge from hurricanes.

Consideration must also be given as to whether the problem is associated with present craft or ones which are to be built in the future. The material from which the mast is constructed is also an important factor.

RACING YACHTS

Many racing yachts are relatively large, expensive craft. These craft are carefully built with light weight and efficient masts and rigging. Rigging is designed so that fine tuning of the masts can be accomplished and sail can be handled relatively easily and quickly. Much engineering goes into the design of the rigging which, in general, is fairly complicated involving a multiplicity of spreaders, shrouds, and stays. Figures 1a through 1d show several examples of rigging arrangements for these craft. It can be clearly seen that a great deal of careful adjustment would be necessary to install such a mast properly.

Nearly all modern boats of this type have carefully designed masts which are hollow wood or aluminum to provide strength with a minimum weight. The masts are fitted with sail track either attached to the after side of the mast or recessed inside. The track is a continuous metal strip upon which the sail slides travel from the boom to the head of the mast. The track must be straight and uninterrupted so that the slides will not jam when raising or lowering sail. Typical mast details are shown in Fig. 2. In most cases these masts extend through the deck to a step on the keel structure. A sketch of a typical step arrangement is shown in Fig. 3. Masts complete with rigging for the larger boats may weigh up to 2,000 pounds.

Consider first the possibility of providing a telescoping top portion for one of these masts. Such an arrangement would be inherently infeasible in wooden spars, whether solid or hollow in construction. If the mast is built of aluminum of hollow construction, it is conceivable that a telescoping section could be de-

signed; however, the requirement that the sail track be straight and continuous, the complication of spreaders and stays, the the undoubtedly greater weight makes this an extremely unsatisfactory proposition for a racing yacht.

A second possibility is that of hinging an upper portion of a tall mast. In the case of masts of wood construction, it is unlikely that a satisfactory hinge and locking device could be developed that would not impair mast strength, add excessive topside weight, cost a great deal, and require yard facilities to rig and unrig it safely. If the hinged portion is to be of appreciable length and weight, it would be extremely difficult to handle with the boat's crew. Temporary stays might also be necessary. Furthermore, the question of continuity of sail track would arise. It is believed that this scheme would not be practicable for any of the yacht types.

The third possibility, that of hinging the mast from the bottom in a tabernacle such as is provided on some European boats and shown in Fig. 4, has disadvantages that would preclude its use on racing yachts, although it might be adaptable to single-masted cruising craft. It should be pointed out that the types of craft in Europe so fitted are generally not in a class with the refined racing yachts. The literature shows photographs and sketches of tabernacles used on some craft, but most of these are older gaff rigged boats which have shorter masts than modern rigs. Some of the disadvantages of such an arrangement are listed below:

1) Added weight and bulk of tabernacle.
2) Added weight and bulk of mast.
3) Rearrangement of supports in cabin below.
4) Gear expensive and difficult to maintain.
5) Nuisance of overhanging spar at stern.
6) Some danger to mast and crew.

A more sophisticated approach could doubtlessly be developed in the case of hollow metal masts, but this would involve special castings and machined parts. Such a refinement might eliminate most of the objection to additional weight and bulk and possible loss in speed, but would be excessively expensive and somewhat heavy. It appears extremely unlikely that racing-yacht owners would accept such a solution. The only probable exception might be the owner who lives along the waterway and must regularly pass under low bridges. An owner wishing to travel between New York and Florida would more likely either unstep the mast and carry it on deck, or spurn the waterway and sail outside. Yachts sailing along the coast find the most dangerous portion of the voyage to be rounding Cape Hatteras and Cape Fear. If clearances are reduced in some parts of the waterway, the stretch between Chesapeake Bay and the northern border of Georgia might be the most critical.

A fourth possible solution to this problem in the case of yachts transiting the waterway would be to unstep the mast, carry it on deck, and step it again upon completion of transit. This is not inordinately difficult; however, crane

facilities will be required in almost all cases. If the demand should develop, it seems probable that sufficient facilities at either end of the waterway would be provided if these are not now available. The cost of such an operation should not be unreasonable if it becomes a routine operation for large numbers of craft. Figure 5 is a plot of mast heights against length-over-all for a number of representative yachts. Although exceptions to the average curves can undoubtedly be found, it is believed to indicate general practice. On this basis it is seen that if masts were stowed on deck while in passage, projections of the masts beyond the bow and stern of the boat would be of the order of 5 to 10 feet. Normally masts would have to be stowed on centerline in special supports above the deck so as not to interfere with steering and handling of the boat. These special supports will be somewhat unwieldy and require stowing ashore when not in use. This arrangement is feasible and used frequently by boats going through the New York State Barge Canal. The nuisance of navigating the waterway with a mast overhanging the ends of the vessel depends perhaps on the skill of the crew. Handling of small craft normally requires some skill and experience, and even with overhanging masts should not be difficult for an experienced crew. Figure 3 shows a typical arrangement with the mast stowed on deck.

If low bridges block access to protected harbors, the racing yacht which seeks sanctuary from hurricanes is in trouble. Collapsible masts are impractical for reasons previously discussed. Unshipping of masts is manifestly out of the question under the circumstances which generally exist when yachtsman suddenly learn of an impending hurricane. While a discussion of bridges is outside the scope of this study, it does appear that bascule or swinging-type bridges are necessary where waterway feeders are to be crossed by bridges of less than 80-foot clearance.

It has been pointed out here that racing yachts fitted with hinged masts in tabernacles would suffer some loss in speed because of added weight and bulk. However, it is possible that the various racing associations might be willing to recognize this in assigning handicaps.

CRUISING YACHTS

In regard to cruising sloops, it is believed that hinged masts in tabernacles would be reasonably feasible in most cases. The extra cost of such an installation should not add more than a few percent to the cost of a new yacht, and it should be neither difficult nor costly to effect the alteration of an existing craft. It has been testified that 70-foot English sailing barges employing only two men can lower masts and sails and raise them again to allow passage under bridges without losing headway. Given more time and a modicum of equipment, it seems probable that two or three men could raise or lower a properly designed hinged mast without any particular danger to themselves or to the mast. However, hinged masts, if turned down to a horizontal position would present

an overhang nuisance generally worse than in the case of unstepped masts. Cruising yachts with schooner, yawl, or ketch rigs would offer particularly stubborn problems in connection with the arrangement of hinged masts. In general, hinged masts must be considered as impractical for multimast craft.

Retractable telescoping masts are not feasible because of the practical difficulties which would be encountered in fitting the sail track. Masts which are only slightly over the minimum bridge clearance might conceivably be arranged with removable upper sections which could be unstepped with the aid of a crane. For larger masts, however, the multiplicity of stays and other attachments would make such an operation difficult and undesirable.

CONCLUSIONS

1. As regards racing yachts, hinging or telescoping of masts appears to be infeasible at this time. A general reduction of fixed bridge clearances over the waterway and its sea entrances would jeopardize the safety of tall-masted craft which presently depend upon the waterway as a sanctuary from storms. The problem would not be as serious in the case of racing yachts utilizing the waterway for safe passage between Florida and cities in the North. Such vessels could be expected to have their masts unstepped and carried on deck if lowered bridge clearances made this necessary. It is recognized that unstepping and stepping masts entails appreciable additional costs to the owners each season and is undesirable and inconvenient.

2. Hinged masts would, in most cases, be practical in single-masted cruising yachts whether existing or contemplated. Appreciable costs will be involved at the outset and some complication of rigging in connection with handling the mast will be involved. In the case of the largest craft, boat-yard help may be needed.

3. Telescoping masts are considered impractical in any application.

4. A search of the available literature in such collections as the Library of Congress, Mariners' Museum (Warwick, Va.), and the Library of The University of Michigan has failed to uncover any designs for hinging masts other than the old-fashioned tabernacle arrangement.

In short, it can be said that provision for lowering of masts in sailing yachts involves appreciable additional first cost and seasonal or operating costs, and is inconvenient and undesirable. It cannot be claimed, however, that to accomplish such provision is unreasonably difficult for vessels transiting the waterway.

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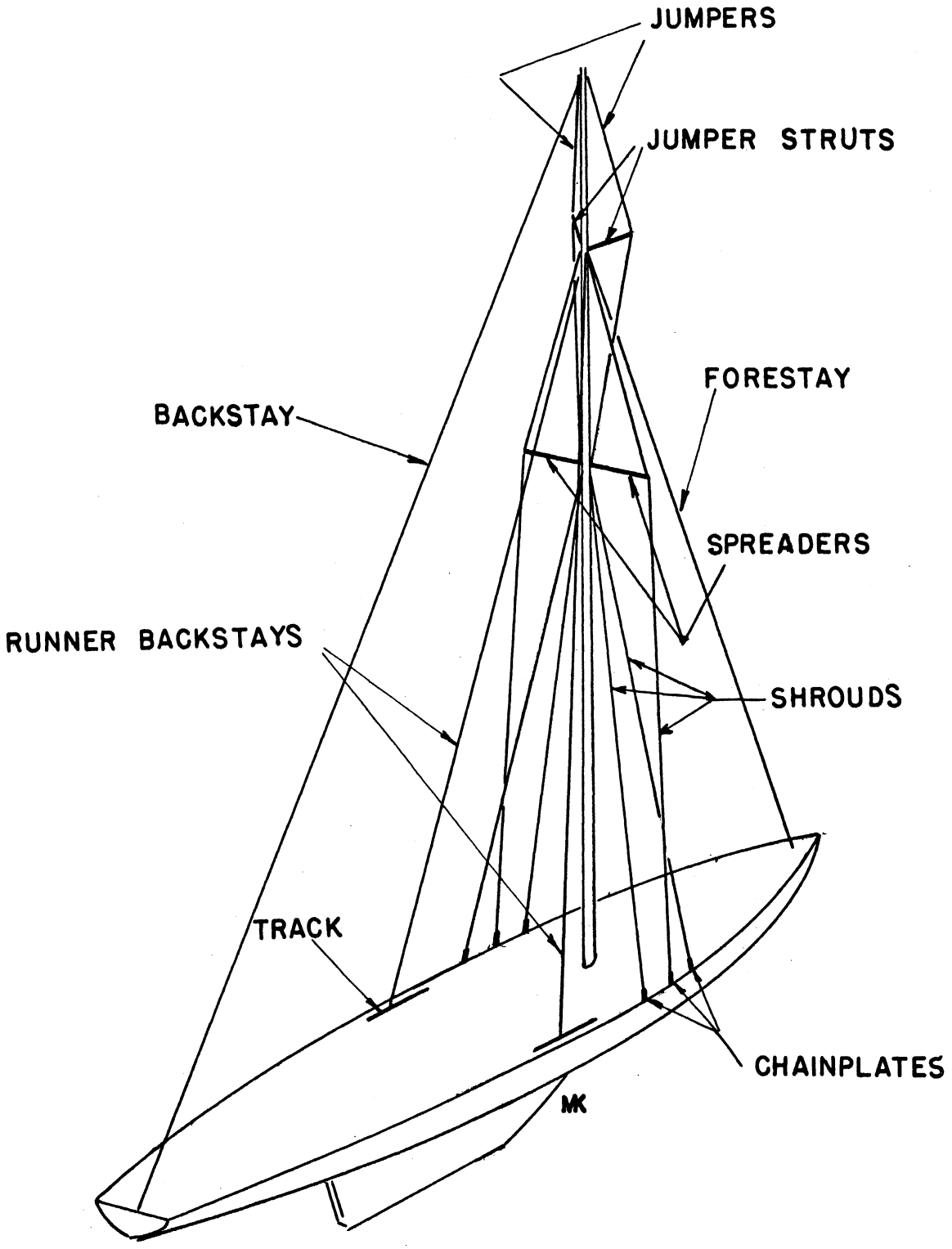
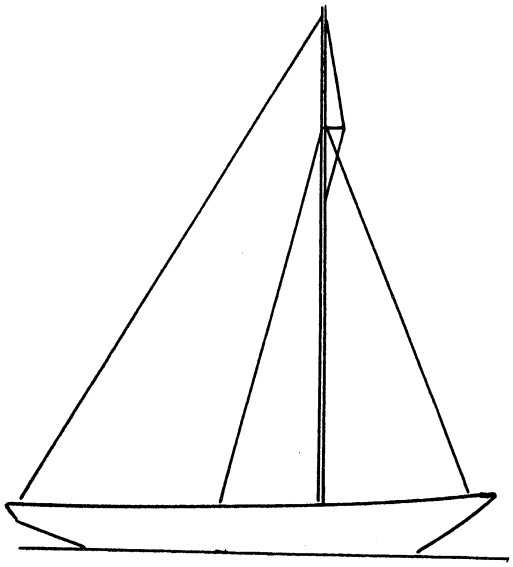
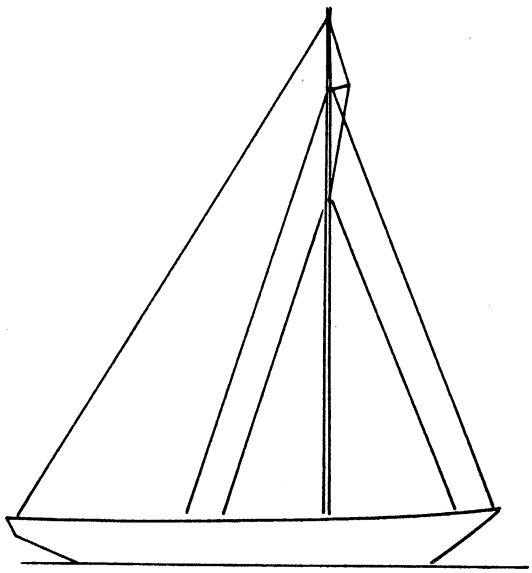


BASIC STANDING RIGGING OF A SLOOP

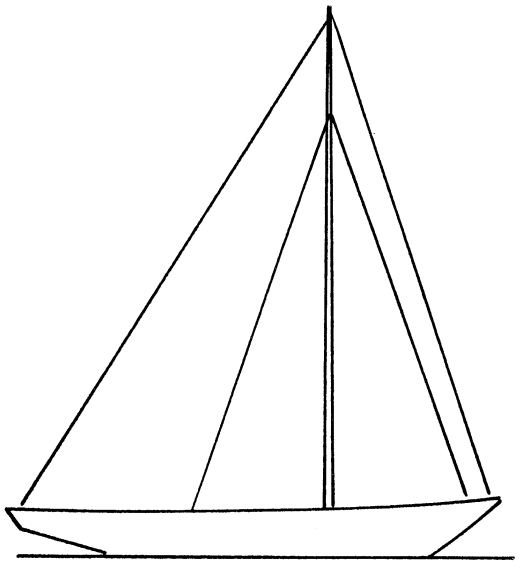
FIG. 1a



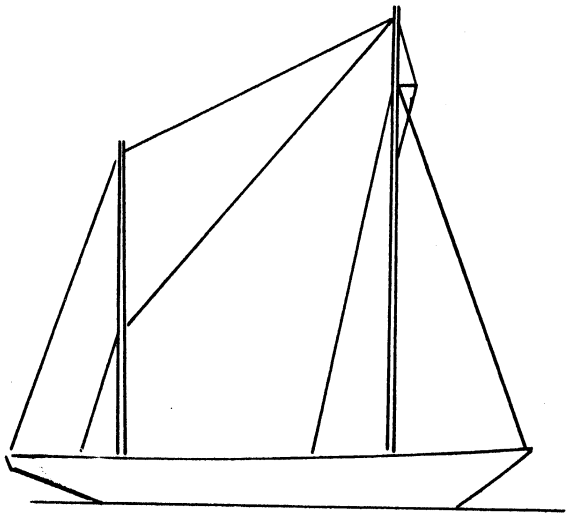
STAY ARRANGEMENT FOR SLOOP



STAY ARRANGEMENT FOR CUTTER



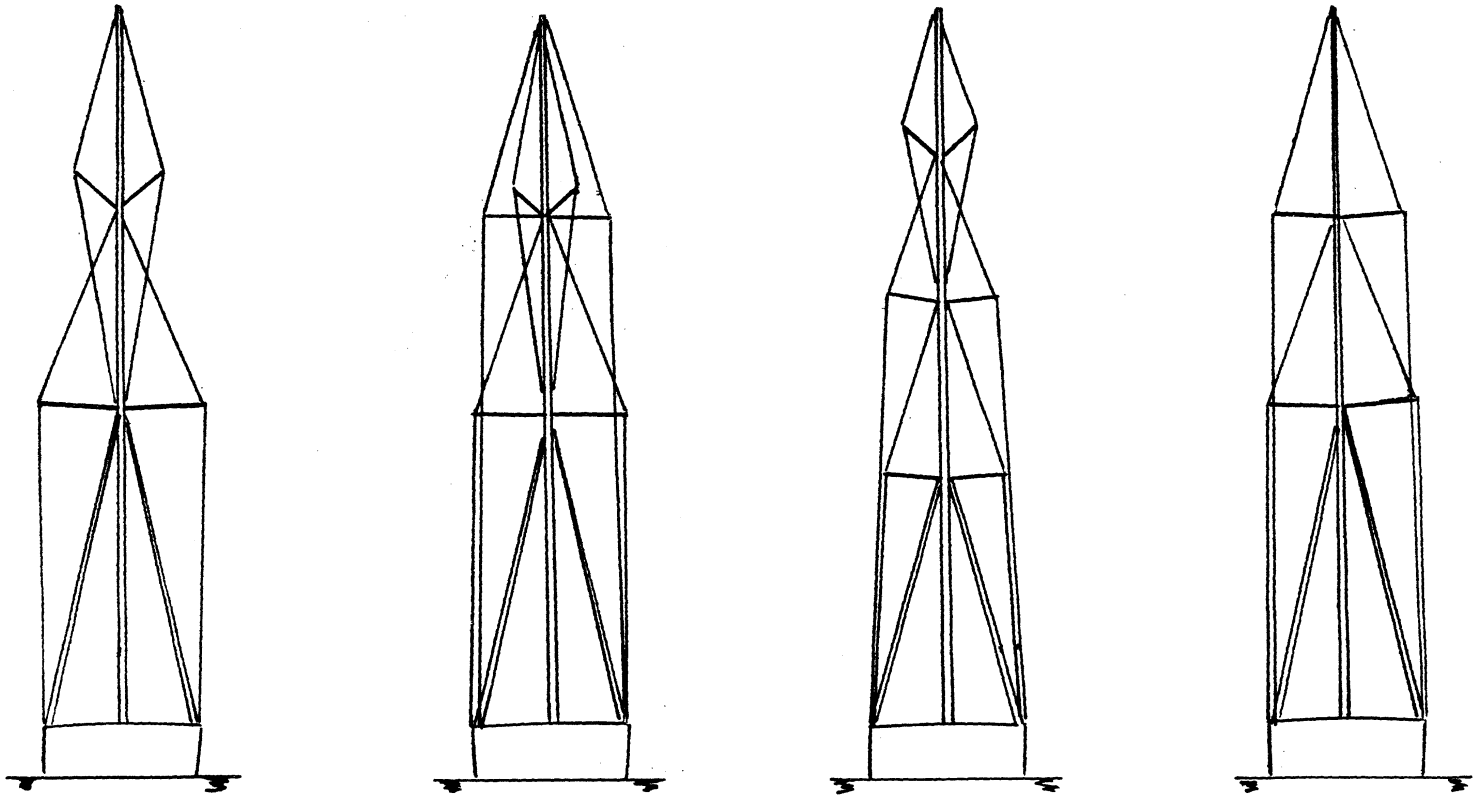
MASTHEAD CUTTER



MK

KETCH WITH MASTS STAYED TOGETHER

FIG. 1b



A BASIC SHROUD ARRANGEMENT FOR SLOOPS

B IMPROVED VERSION OF "A"

C SHROUD ARRANGEMENT FOR TALLER MASTS

D SHROUD PLAN FOR MASTHEAD RIG

FIG. Ic

COMPARISON OF GAFF AND BERMUDA RIGGED SLOOPS WITH EQUAL SAIL AREAS

(NOTE DIFFERENCE IN MAST HEIGHT)

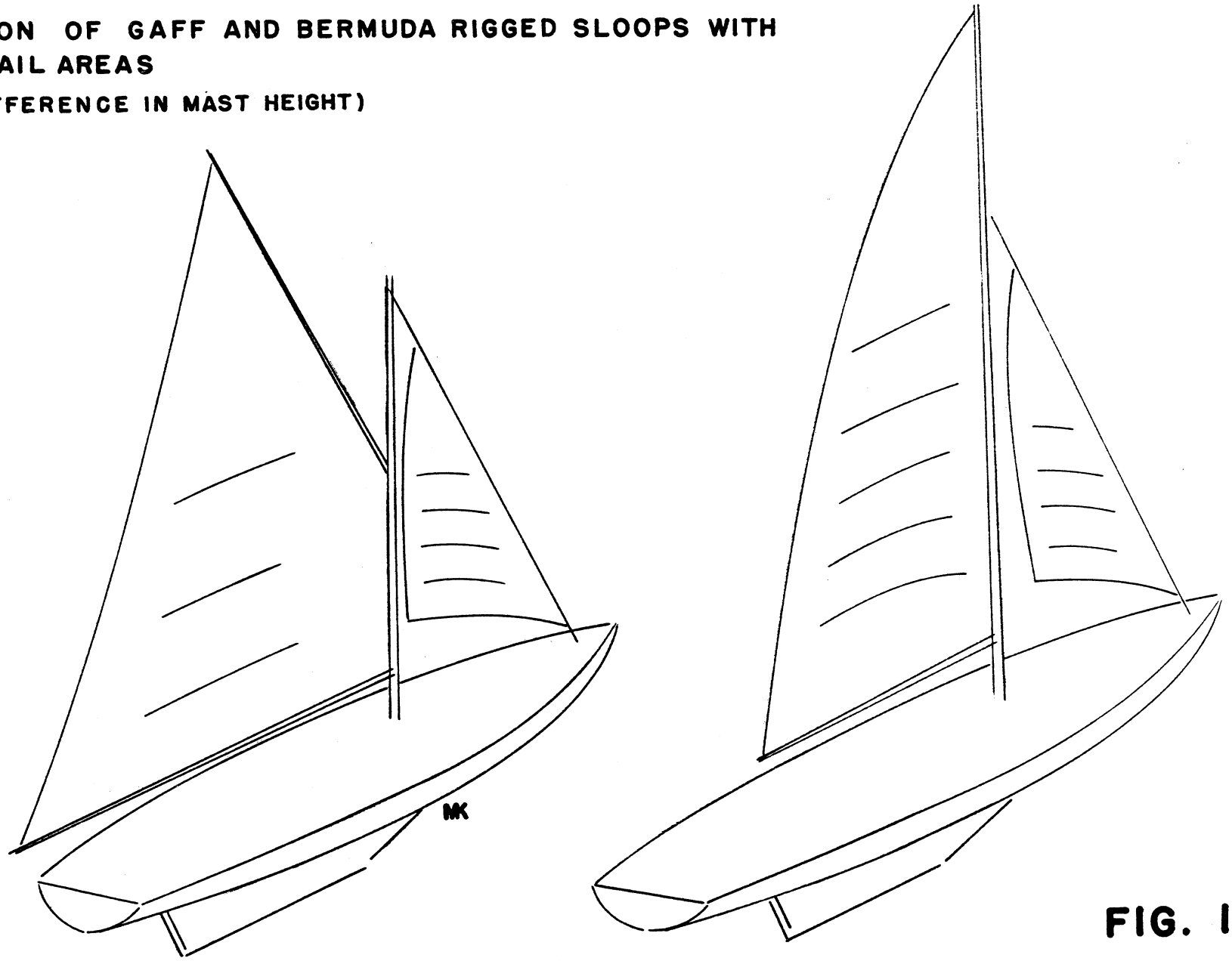
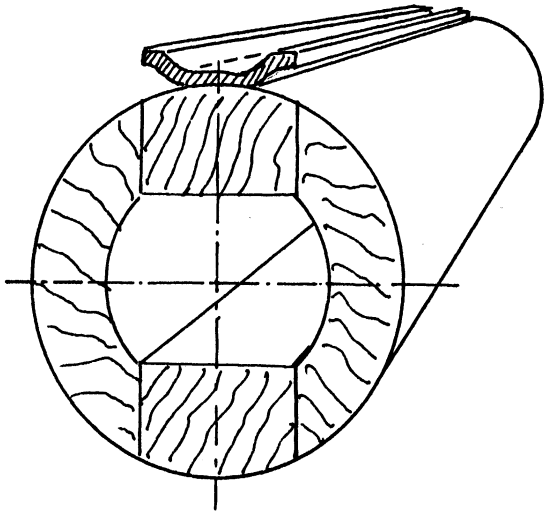
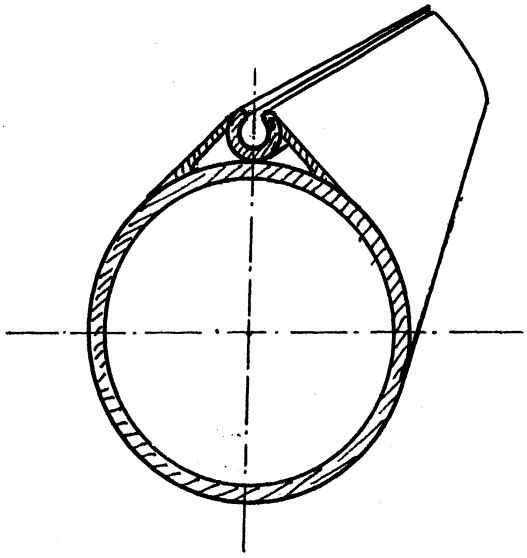


FIG. 1d

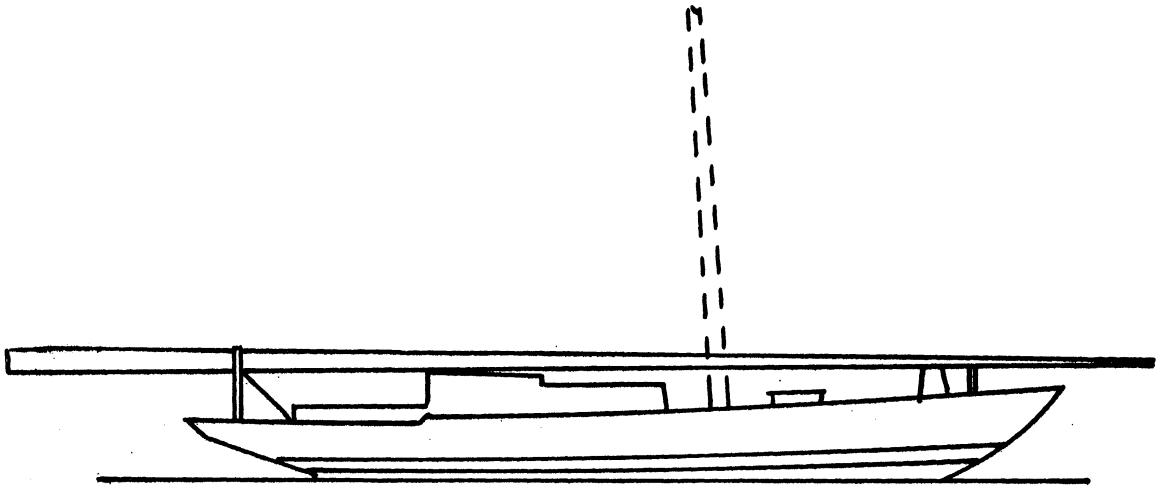


SECTION OF HOLLOW WOODEN MAST WITH SAILTRACK

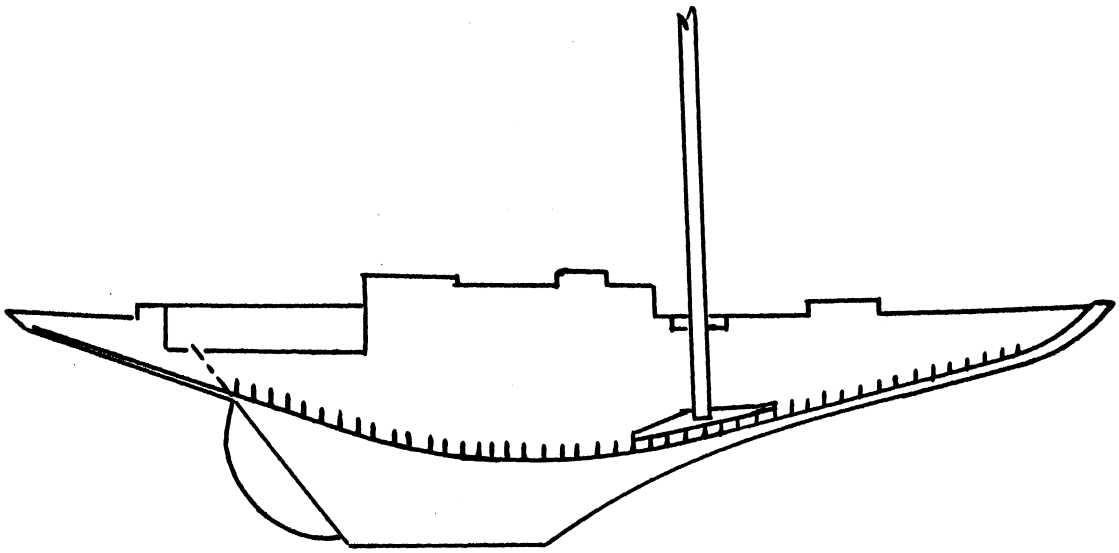


SECTION OF LIGHT ALLOY MAST WITH RECESSED SAILTRACK

FIG. 2

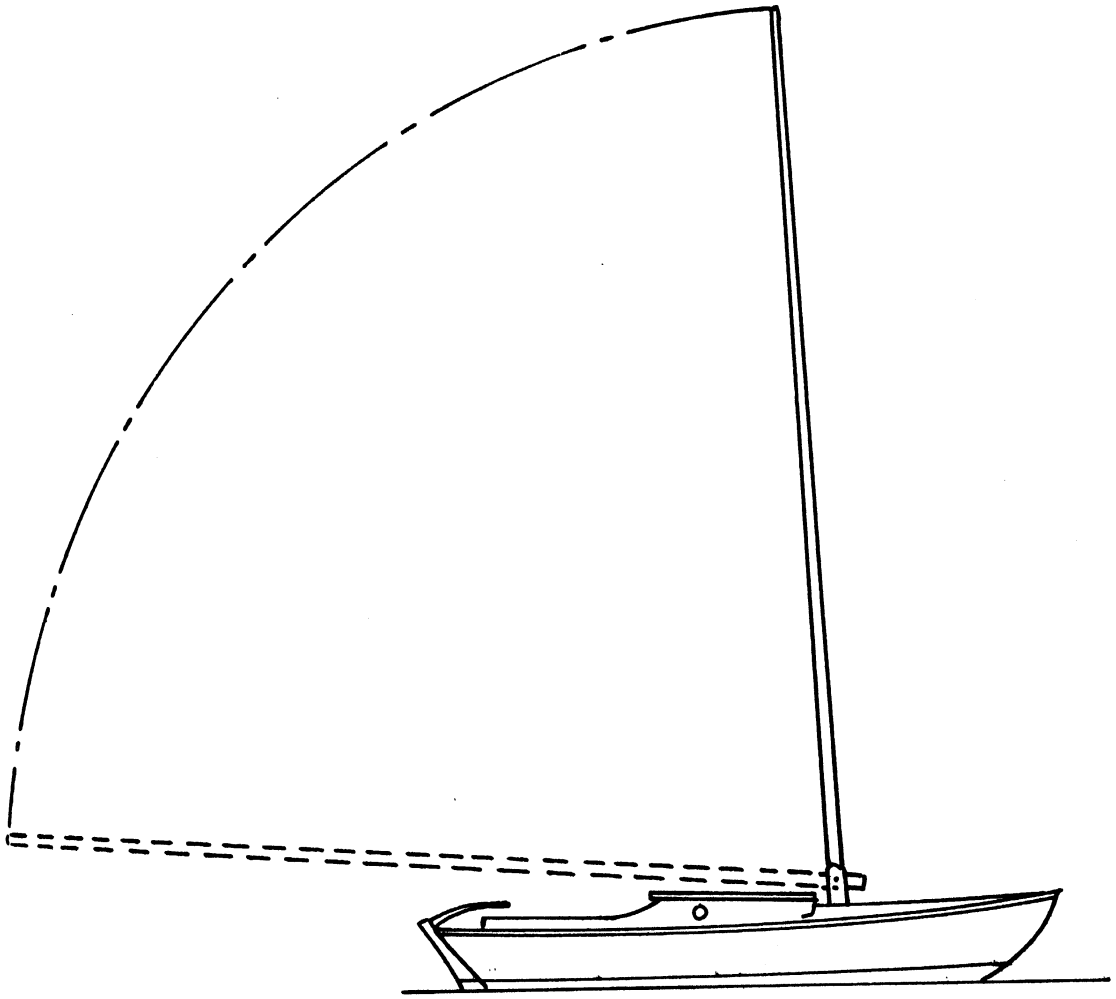


50' CUTTER CARRYING MAST ON DECK

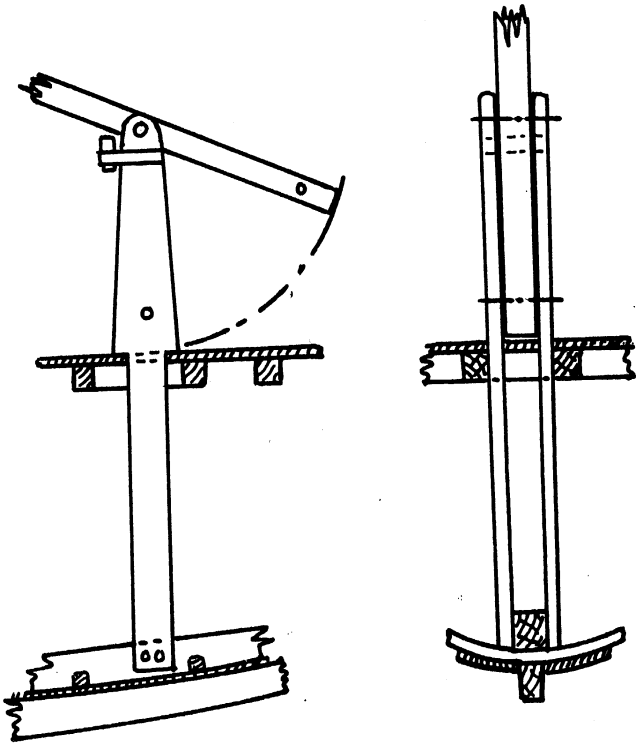


INSTALLATION OF STEPPED MAST

FIG. 3



21' CRUSING SLOOP WITH MAST TABERNACLE



MAST TABERNACLE
FOR SMALL BOATS

FIG. 4

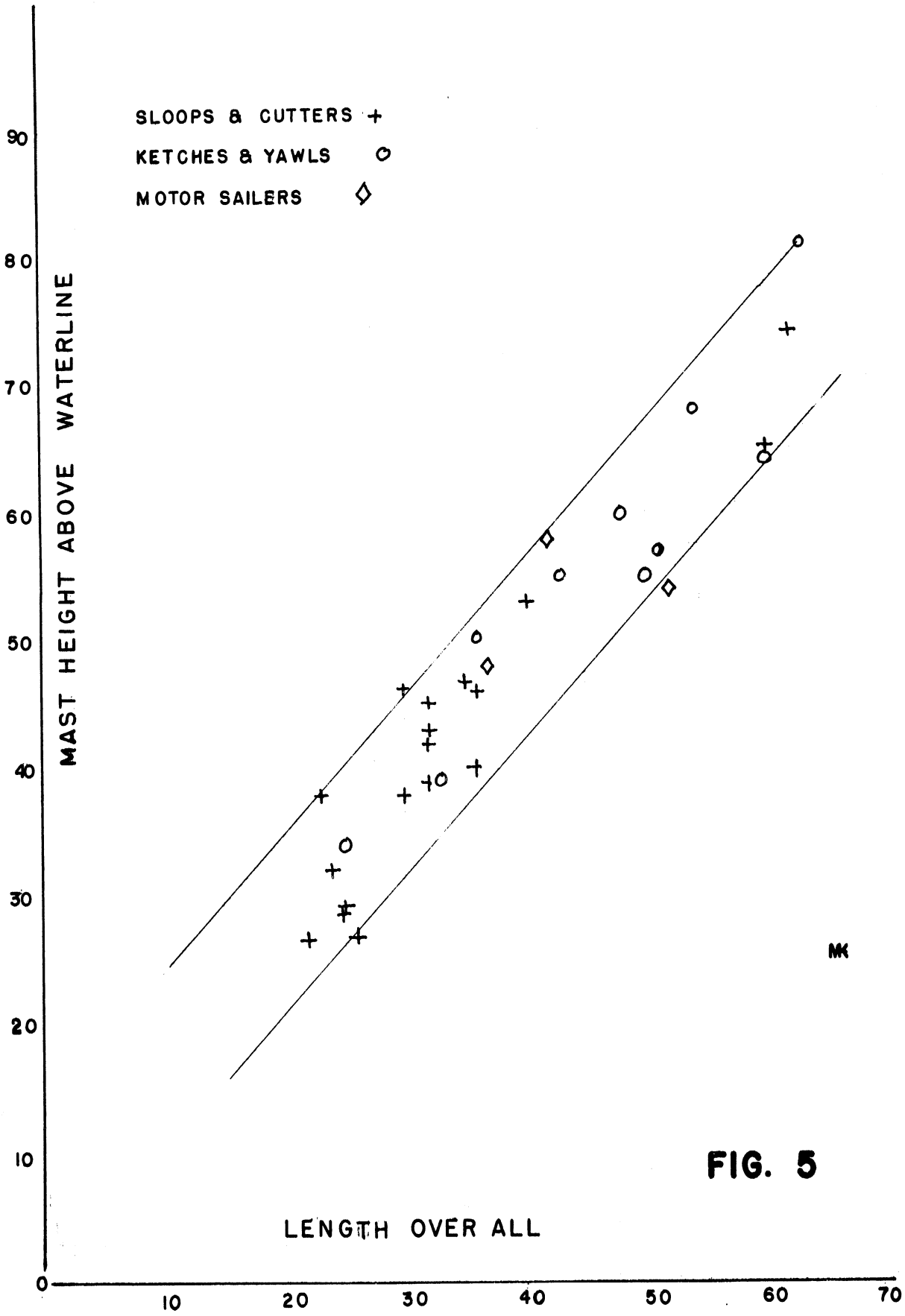

SLOOPS & CUTTERS +
KETCHES & YAWLS O
MOTOR SAILERS ◇
MAST HEIGHT ABOVE WATERLINE
LENGTH OVER ALL
0
10
20
30
40
50
60
70
80
90
10
20
30
40
50
60
70
MK

FIG. 5

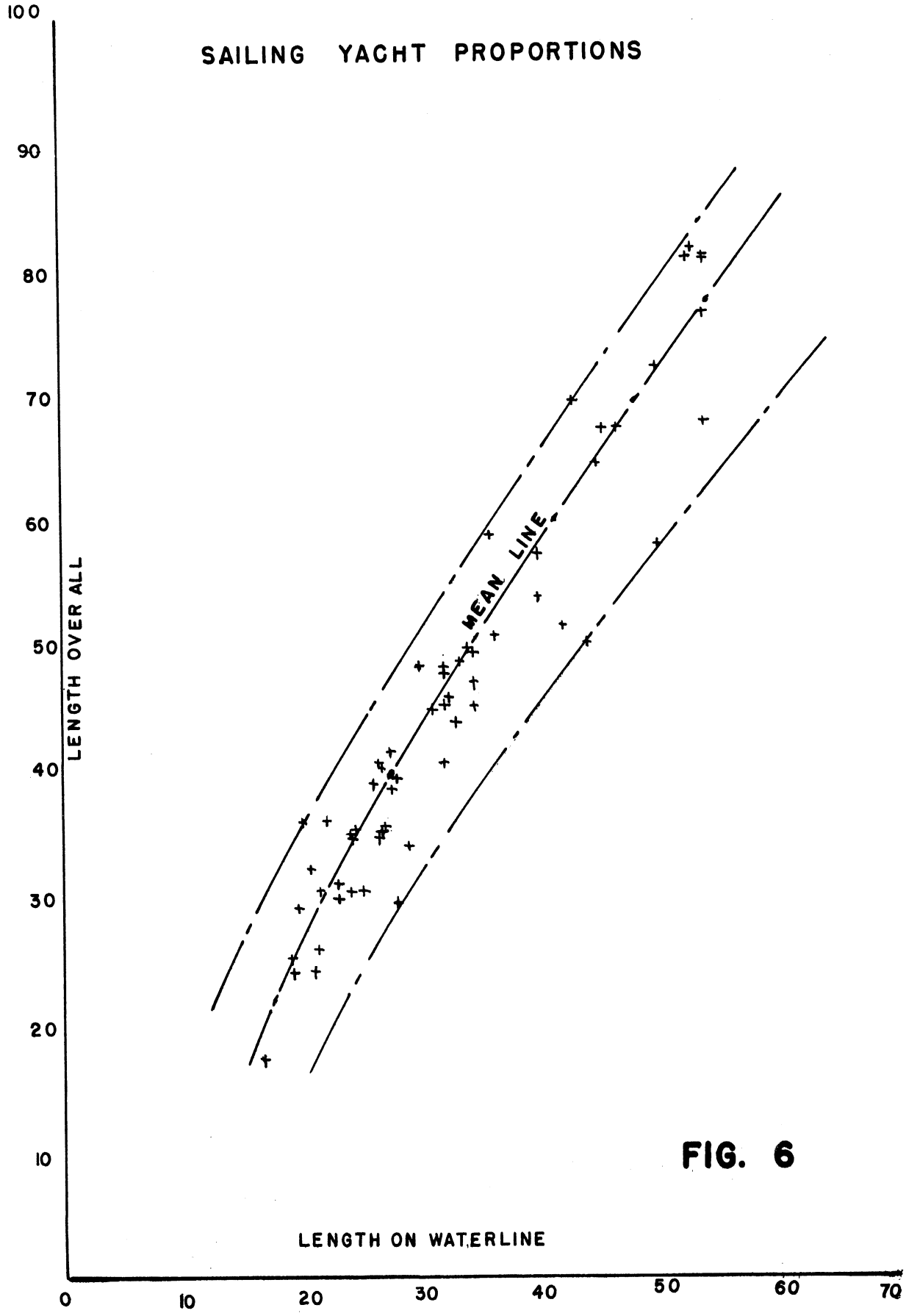

SAILING YACHT PROPORTIONS
100
90
80
70
60
50
40
30
20
10
LENGTH OVER ALL
MEAN LINE
0
10
20
30
40
50
60
70
LENGTH ON WATERLINE

FIG. 6