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Comparisons of ICNAF and Westhoff Gauges under Field Conditions

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Abstract

The ICNAF and 1959 model Westhoff gauges have been used in the field to measure meshes of manila netting of various twine and mesh sizes. Differences between mean mesh sizes as obtained by eight different operators using the two gauges were extremely variable and almost always highly significant. This is considered to be due largely to between-operator variability with the ICNAF gauge. The 1959 model Westhoff gauge is considered to be far superior to the ICNAF gauge in producing consistent results under field conditions.

Introduction

The difficulty of obtaining comparable mesh size measurements with wedge-type and direct-pull mesh gauges has been recognized for a number of years. The two types are inherently different in that the load on the mesh is applied indirectly (at right-angles to the direction of measurement) by means of a downward vertical thrust with a wedge-type gauge, and directly by means of a longitudinal pull on the mesh with a direct-pull gauge. Bedford and Beverton (MS, 1956) have shown that with a wedge-type gauge there is no constant relation between applied pressure and resultant longitudinal load on the mesh because of high and variable friction between the mesh and the gauge. On the other hand it should be possible with a direct-pull gauge to apply a fairly constant direct longitudinal load to the mesh being measured, particularly if the gauge is fitted with a pressure limiting device which locks the gauge when a desired pressure is reached.

In recent years a number of controlled mesh measuring experiments have been performed in order to compare results with various models of the two basic types of mesh gauges. It is of interest here to summarize briefly the results for manila twine with the two gauges employed in this study, i.e. the ICNAF (wedge-type) and 1959 model Westhoff (direct-pull) gauges, as well as the Scottish gauge, of which the 1959 model Westhoff is a modification. Basic descriptions of the ICNAF and Scottish gauges may be found in Parrish, Jones and Pope (1956) and von Brandt and Bohl (MS, 1959). The Westhoff gauge is described by Westhoff and Parrish (MS, 1959).

In general, for measurements on manila meshes, it has been found that the ICNAF gauge gives consistently higher readings than either of the other two, as well as a greater bias between operators. Higher measurements with the ICNAF gauge as compared with the Scottish gauge have been reported by Parrish, Jones and Pope (1956), McCracken (MS, 1957), Templeman (MS, 1957), von Brandt and Bohl (MS, 1959), and Sandeman and May (1961). The ICNAF gauge has also been found to measure consistently higher than the 1959 model Westhoff gauge by Sandeman and May (1961) and Bohl and Nomura (MS, 1961). Roessingh (MS, 1961), on the other hand, finds the 1959 model Westhoff to measure consistently higher than the ICNAF, but results with the former were not consistent and are attributed to the fact that the gauge used was the heavy prototype of the 1959 model and was difficult to handle.

Several authors have presented a statistical treatment of their data to illustrate the greater operator variability of the ICNAF gauge as compared with the direct-pull gauges. Their results are summarized in Table 1. Bohl and Nomura (MS, 1961) also conclude that results with the ICNAF gauge are more variable than those with the 1959 model Westhoff because of the greater standard deviation of measurements with the former gauge.

Table 1. Summary of "between-operator" comparisons by various authors using the ICNAF, Scottish, and 1959 model Westhoff gauges.

Source	Mesh Gauge	No. of Comparisons	Significant Differences P = .05	P = .01
Parrish et al (1956)	ICNAF	3	3	
	Scottish	3	0	
McCracken (MS, 1957)	ICNAF	3	2	
	Scottish	3	2	
von Brandt and Bohl (MS, 1959)	ICNAF	6	5	4
	Scottish	6	2	0
Sandeman and May (1961)	ICNAF	45	40	39
	Scottish	45	23	17
	Westhoff	45	14	10

This laboratory has been aware for some time that considerable operator variability existed in mesh measurements made at sea using the ICNAF gauge, and this variability was also found to occur in controlled laboratory experiments (Sandeman and May, 1961). Of three gauges tested in the latter experiments, operator variability was found to be minimal with the 1959 model Westhoff gauge. In most of our mesh selection experiments during 1961, both ICNAF and Westhoff gauges were used at sea to measure the net meshes in order to

(1) test the Westhoff gauge in the field,
(2) compare results with each gauge on a variety of twine and mesh sizes, and
(3) obtain some method of converting measurements made at sea with the ICNAF gauge to those that might be obtained if the Westhoff gauge were used.

Material and Methods

All measurements were made on manila netting, and all were made as soon as possible after completion of a drag so that the nets were always well soaked in sea water. In order to compare results for a variety of twine and mesh sizes, we have examined measurements made on codends, lengthening (extension) pieces and squares of nets of three of our research vessels: the 177-foot A.T.Cameron, the 82-foot Investigator II and the 62-foot Marinus. The variety of gear on which results are based is listed in Table 2. Dry mesh size is the size of stretched dry meshes between knot centres, as ordered from the manufacturer. In the notation for twine size, or runnage, the first number denotes yards per pound of twine, while the second refers to the twine ply.

Table 2. List of twine and mesh sizes of a variety of manila net sections measured at sea.

Twine Size (Runnage)	Dry Mesh Size			
	Double Knit		Single Knit	
	inches	mm	inches	mm
50/4	5 1/8	(130)	4 5/8	(117)
	5 3/4	(146)	5 1/8	(130)
	6 1/4	(159)	5 5/8	(143)
75/4	3 1/4	(83)	3 1/4	(83)
	5	(127)	4 1/2	(114)
	6	(152)	5 1/2	(140)
100/3	--		5	(127)
	--		5 1/2	(140)
125/3	3	(76)	3	(76)
	3 1/4	(83)	3 1/2	(89)
	3 1/2	(89)	4 1/2	(114)
	--		5	(127)
	--		5 3/8	(137)
	--		6	(152)

Measurements by eight operators are included in the results, but, since the measurements were made over a number of vessel cruises, no single operator had the opportunity to measure every piece of netting. Six of the eight operators had a number of years' experience in the use of the ICNAF gauge, whereas none had used the Westhoff gauge prior to 1961.

The operators were instructed to use the ICNAF gauges at a pressure of 12 lbs (5.4 kg), and the Westhoff gauges were adjusted to lock at the same pressure. Initially, some difficulty was experienced in attaining this pressure with the Westhoff gauges as originally supplied. New (heavier) springs were eventually inserted in the Westhoff gauges to make an adjustment to 12 lbs pressure more easily attainable. The gauges were periodically oiled and checked at sea to ensure that they were registering correct pressure.

The various nets used in any particular selection experiment were generally measured after the first, second and fifth drags with each net, and every fifth drag thereafter. All measurements after any particular drag were made by one operator, using each of the gauges on a different row of meshes. The sequence of measurement began at the fourth mesh of the codend, anywhere from 8 to 15 meshes away from the lateral lacings (selvage), and continued forward in the same row to the headrope. Every consecutive mesh was measured in the codend, and every third mesh in the lengthening piece and square. The measurer was assisted by a second person who straightened out the net as the measuring proceeded and held it at waist level above the deck.

Since the data for this study have been collected entirely at sea, analysis of gauge and operator variation is complicated by the introduction of several factors which would not be present in controlled laboratory experiments. These may be enumerated as follows:

(1) Since some of the data were collected during 24-hour selection experiments with operators on one schedule and use of nets on another, and since measurements were made on a number of cruises of three different vessels, it was impossible to have each operator measure any one net section an equal number of times, or even to obtain measurements by any one operator for the whole variety of gear.

(2) Due to the loss and wearing-out of gear, particular net sections or entire nets were often replaced during and between cruises, thus making direct comparisons of a number of measurements invalid.

(3) Variable changes in mesh size associated with size of catch probably occurred over the experiments, especially if a cruise was begun with new gear.

(4) The same row of meshes was seldom measured by any two operators. This probably would not affect the analysis since it can be reasonably assumed that any particular row is a normal sample of the net section, i.e. that no significant differences occur between rows of the same piece of netting, at least in the central part from which the measurements were obtained.

Because of the foregoing, direct comparisons of average mesh size measurements for the examination of operator and gauge variation are not possible. In fact there is no meaningful way of comparing operator variation for any particular gauge, since, for the same or different operators, variations in mesh size measurement may be due either to operator variability or to actual differences in mesh size caused by fishing or by insertion of new twine. However, it should be possible to obtain meaningful comparisons between gauges for each operator by examining the order of difference obtained between measurements with each gauge. For any particular net section it is necessary only to assume that any actual changes in mesh size due to fishing or insertion of new twine will be recorded by both guages, and, since such mesh size changes would undoubtedly be small, the order of difference obtained should be similar. Also, of course, it must be assumed that an operator's method of using the gauge remains constant, i.e. that the within operator variability with each gauge is negligible.

Results

Differences in mesh size as measured with the ICNAF and Westhoff gauges have been average for each operator and are listed in Table 3 separately for each twine size, knit and dry mesh size. The average difference obtained by all operators for each type of netting is also shown. Numbers in parentheses refer to the number of times the particular type of netting was measured. Differences between the two gauges as used by all the operators have been analysed by means of paired comparisons tests, and t-values are shown. Several points are apparent:

(1) Measurements made with the ICNAF gauge are consistently higher than those with the Westhoff gauge, and the differences found are almost invariably highly significant.

(2) A good deal of variability exists between operators with regard to the order of differences obtained. It is apparent that these are not always random differences for any particular type of netting, as, in general, particular operators tend to obtain a consistent relative order of differences as compared with those of the other operators. In particular the differences obtained by operators A and B are almost always smaller than those obtained by any of the other operators, while the differences obtained by operator F are almost always greater.

(3) The differences obtained by each operator when measuring double knit twine are generally greater than those for single knit twine of similar mesh size.

Average mesh sizes obtained by each operator in measurements with each gauge on the various types of netting cannot be directly compared because of the nature of the data. However, some indication of variability between operators for each gauge may be obtained by plotting results with one gauge against those for the other, as in Figures 1 to 7. The resultant plots generally consist of several groups of points since each kind of twine is usually represented by net sections of different mesh sizes. A straight line trend is evident in each of the plots, indicating that changes in mesh size as recorded by one of the gauges tend to be proportional to the changes recorded by the other. The scatter of the points within each group gives an indication of the variability of results with each gauge as handled by the different operators. The horizontal scatter of points within each group generally tends to be greater than the vertical scatter, indicating greater variability between operators using the ICNAF gauge for measurements of any particular net section. It may be noted that the plots of results for operator F never appear to be distributed randomly within any group, but tend to be on the extreme right of the horizontal axis of any group. This is caused by the fact that this operator's measurements with the ICNAF gauge were consistently very high, and as a result, relatively large differences between his ICNAF and Westhoff averages were obtained. It must be concluded that pressures applied by this operator using the ICNAF gauge were appreciably higher than the intended 12 lbs (5.4 kg).

It is useful to be able to convert measurements made in the field by a particular gauge to measurements that would likely result had another gauge been used. In order to accomplish this, straight lines have been fitted by the method of least squares to the data of Figures 1 to 7 (excluding the results of operator F). Such lines could be fitted to the plots for each operator separately, if adequate data were available, to provide a more exact means of converting measurements. The regressions given here are those of Westhoff gauge means on ICNAF gauge means, and provide a method of converting ICNAF gauge results in terms of the Westhoff gauge. Since the correlation coefficient is obviously not unity for any of the plots of Figures 1 to 7, these regression equations theoretically should not be used to convert Westhoff gauge measurements to those that might be obtained with the ICNAF gauge. For this purpose it would be necessary to compute another regression, using Westhoff gauge values as the independent variable, though the value of this procedure would depend on the nature of the data and the practical use of such conversions. Errors would certainly be small near the regression means.

Discussion and Conclusions

The differences found between mean mesh sizes of any particular piece of netting as measured with each of the gauges can largely be explained in terms of the pressures at which the gauges were used. Notwithstanding the fact that both gauges were intended to be used at pressures of approximately 12 lbs (5.4 kg), it was found to be very difficult to obtain this pressure with the Westhoff gauges as originally supplied, and new springs had to be inserted in order to accomplish this. Thus, for much of the data for the Westhoff gauge, 12 lbs pressure was probably the maximum, and a range of 9 to 11 lbs (4.1 to 5.0 kg) is more likely. On the other hand it is thought that the ICNAF gauge was often used at pressures considerably in excess of 12 lbs, and that 12 lbs is a minimum value for this gauge, probably being consistently approached only by operators A and B. These apparent differences in pressures applied with the two gauges may possibly explain why greater differences in mesh size measurement were obtained for double than for single knit twine. Differential stretching of double and single knit meshes might not have been as great at the pressures applied with the ICNAF gauge as they were at the lower Westhoff gauge pressures. Thus, for single twine, the Westhoff gauge might tend to stretch the meshes in relatively high proportion to the stretch by the ICNAF gauge, but in relatively lower proportion for double twine. The wide variation in applied

Table 3. Average amounts in inches by which ICNAF gauge measurements exceeded Westhoff gauge measurements for each operator separately, and for all operators combined for each type of netting measured. t-values from paired comparisons tests are also shown. Two asterisks (**) indicate significance at the 1% level; a single asterisk indicates significance at the 5% level.

Twine size (Runnage)	Knit	Dry Mesh Size (inches)	A	B	C	D	E	F	G	H	Mean	t
50/4	Single	4 5/8	.151(3)	.075(1)	.099(1)	.387(5)	.444(2)	.830(2)	--	--	.365(14)	5.39**
		5 1/8	.161(4)	.145(1)	.225(1)	.528(3)	.399(3)	.714(2)	--	--	.371(14)	5.17**
		5 5/8	.118(3)	.197(2)	.328(2)	.487(3)	.341(3)	.553(1)	--	--	.318(14)	5.77**
	Double	5 1/8	.197(3)	.255(1)	.371(1)	.462(5)	.437(2)	.853(2)	--	--	.435(14)	6.92**
		5 3/4	.320(4)	.401(1)	.224(1)	.513(3)	.568(3)	.854(2)	--	--	.490(14)	7.94**
		6 1/4	.275(3)	.303(2)	.335(2)	.454(3)	.451(3)	.615(1)	--	--	.391(14)	9.14**
75/4	Single	3 1/4	.075(4)	.095(2)	.183(2)	.247(5)	.135(2)	.290(1)	--	--	.166(16)	7.10**
		4 1/2	--	--	--	--	--	.649(6)	--	--	.649(6)	16.85**
		5 1/2	--	.218(3)	--	--	--	.608(6)	--	--	.478(9)	6.32**
	Double	3 1/4	.174(4)	.184(2)	.213(2)	.333(5)	.244(2)	.304(1)	--	--	.248(16)	11.97**
		5	--	--	--	--	--	.618(6)	--	--	.618(6)	9.30**
		6	--	.364(3)	--	--	--	.659(6)	--	--	.561(9)	8.47**
100/3	Single	5	.120(6)	.146(1)	.255(4)	.356(3)	.259(3)	.654(4)	--	--	.299(21)	6.36**
		5 1/2	.044(2)	.058(1)	.229(3)	--	.230(1)	.703(1)	--	--	.216(8)	2.85*
125/3	Single	3	--	--	.220(15)	.045(9)	--	.484(6)	.150(32)	.187(12)	.185(74)	11.82**
		3 1/2	--	.231(4)	--	--	--	--	--	--	.231(4)	6.66**
		4 1/2	--	--	.294(5)	--	--	--	.270(6)	--	.278(11)	7.22**
		5	--	.124(1)	--	--	--	.453(4)	--	--	.390(5)	4.68**
		5 3/8	--	.134(1)	--	--	--	.377(3)	--	--	.316(4)	4.75*
		6	--	--	.245(11)	.031(3)	--	--	.276(16)	.080(4)	.211(34)	10.31**
	Double	3	--	--	--	--	--	.465(6)	--	--	.465(6)	6.00**
		3 1/4	--	--	.287(15)	.062(9)	--	--	.190(32)	.209(14)	.198(7)	17.13**
		3 1/2	--	.254(4)	--	--	--	--	--	--	.254(4)	12.83**

pressures with the ICNAF gauge must be due largely to careless use of the gauge by at least some of the operators, but may also be a reflection of a criticism put forth by von Brandt and Bohl (MS, 1959) in that when measuring quickly, a too high initial pressure as the gauge is being inserted in the mesh often cannot be avoided.

It is considered that the wide variations in differences in mesh measurement as found in the present study between ICNAF and Westhoff gauges were due largely to variable results with the ICNAF gauge. The extreme variability of this gauge as compared with the Westhoff has previously been demonstrated by Sandeman and May (1961) in controlled laboratory experiments in which most of the operators involved in this study took part. The ICNAF gauge can be very easily misused, especially under the relatively uncomfortable conditions often prevailing at sea. Inherent faults in the gauge which contribute to its misuse have been described by Bedford and Beverton (MS, 1956) and von Brandt and Bohl (MS, 1959) and are briefly summarized here:

(1) Insertion of the wedge into the mesh until a desired pressure is reached does not take place smoothly or continuously. The high and variable friction between mesh and wedge results in a variable relation between downward thrust and resultant longitudinal load.

(2) It is difficult to watch the pressure scale on the handle and the measuring scale on the wedge at the same time. Thus the wedge may not enter the mesh perpendicularly, but rather at some other angle to the direction of measurement. Attempting to straighten the gauge may result in the application to the mesh of greater loads than intended.

(3) When working quickly, the initial pressure as the gauge is being inserted into the mesh may be too high.

(4) Results vary according to the time during which the thrust is applied.

Another fault may be added. Friction between the fixed and movable parts of the gauge handle, especially if this area is not well lubricated and if the operator does not apply a force exactly perpendicular to the mesh, may cause higher loads than intended to be applied to attain a pressure reading of 12 lbs.

Most of these faults are not present in the 1959 model Westhoff gauge, and although this gauge has a few inherent faults of its own, the authors consider it to be far superior to the ICNAF gauge as regards its capability of producing consistent results when used by different operators in the field. The 1961 model of the same gauge as described by Westhoff (MS, 1961) may be even better in this respect. In spite of the faults of the ICNAF gauge as described, and the variable results produced by it, Sandeman and May (MS, 1962) have found that if the ICNAF and 1959 model Westhoff gauges are carefully calibrated and carefully used, no significant differences between mesh measurements by each gauge are found over a range of pressures and with a variety of manila netting. However, it does seem impractical to attempt to use the ICNAF gauge with such precision under field conditions. Not only is great care in handling required, but the measurements when such care is exercised take considerably longer to obtain.

Operator variability in measurement of meshes presents a very serious problem in comparison of selection factors (since average mesh size is one of the variables on which selection factor depends) and must be minimized if meaningful comparisons are to be made.

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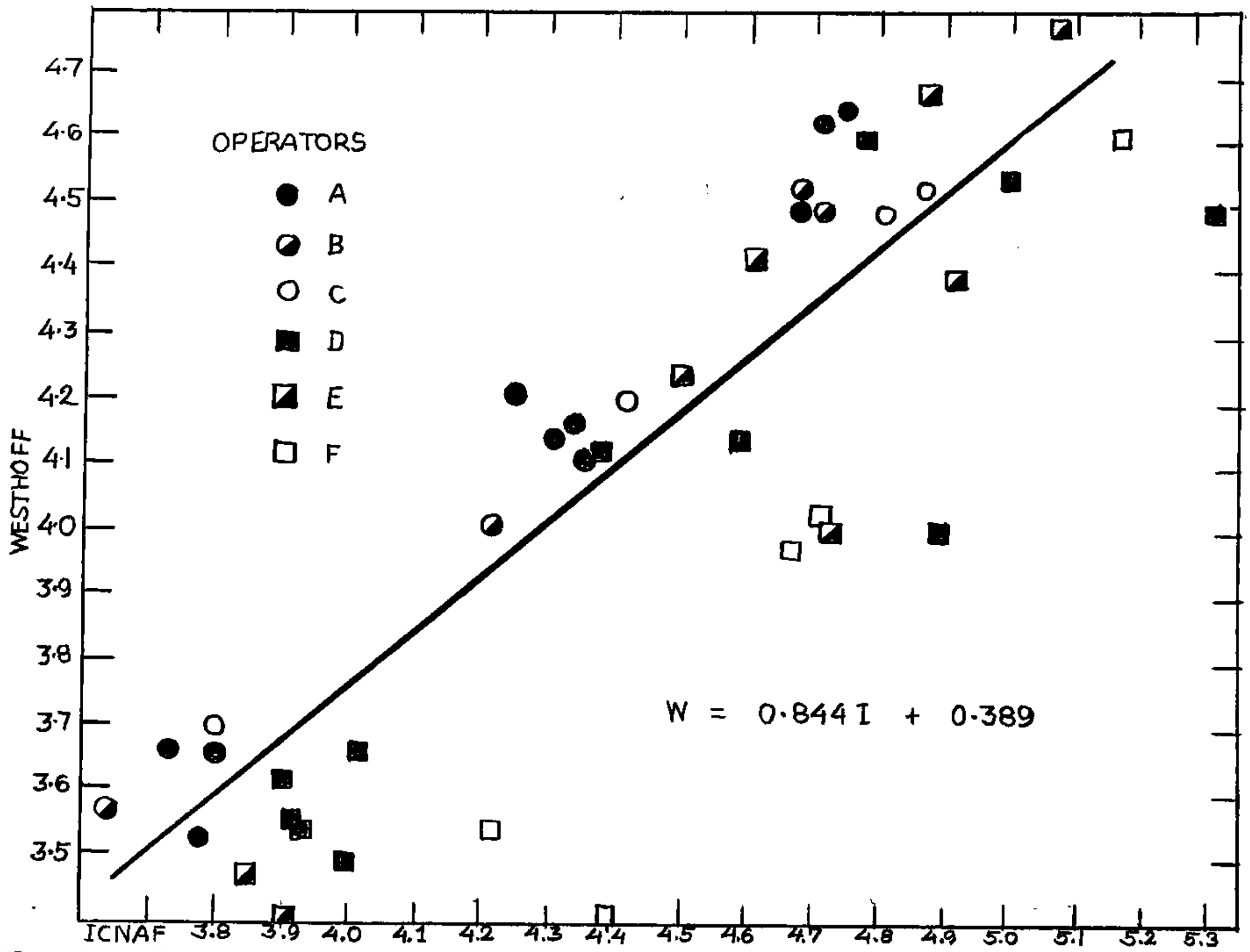

Fig.1. Straight line regression fitted to plots of Westhoff versus ICNAF mean mesh sizes for 50/4 single manila twine.

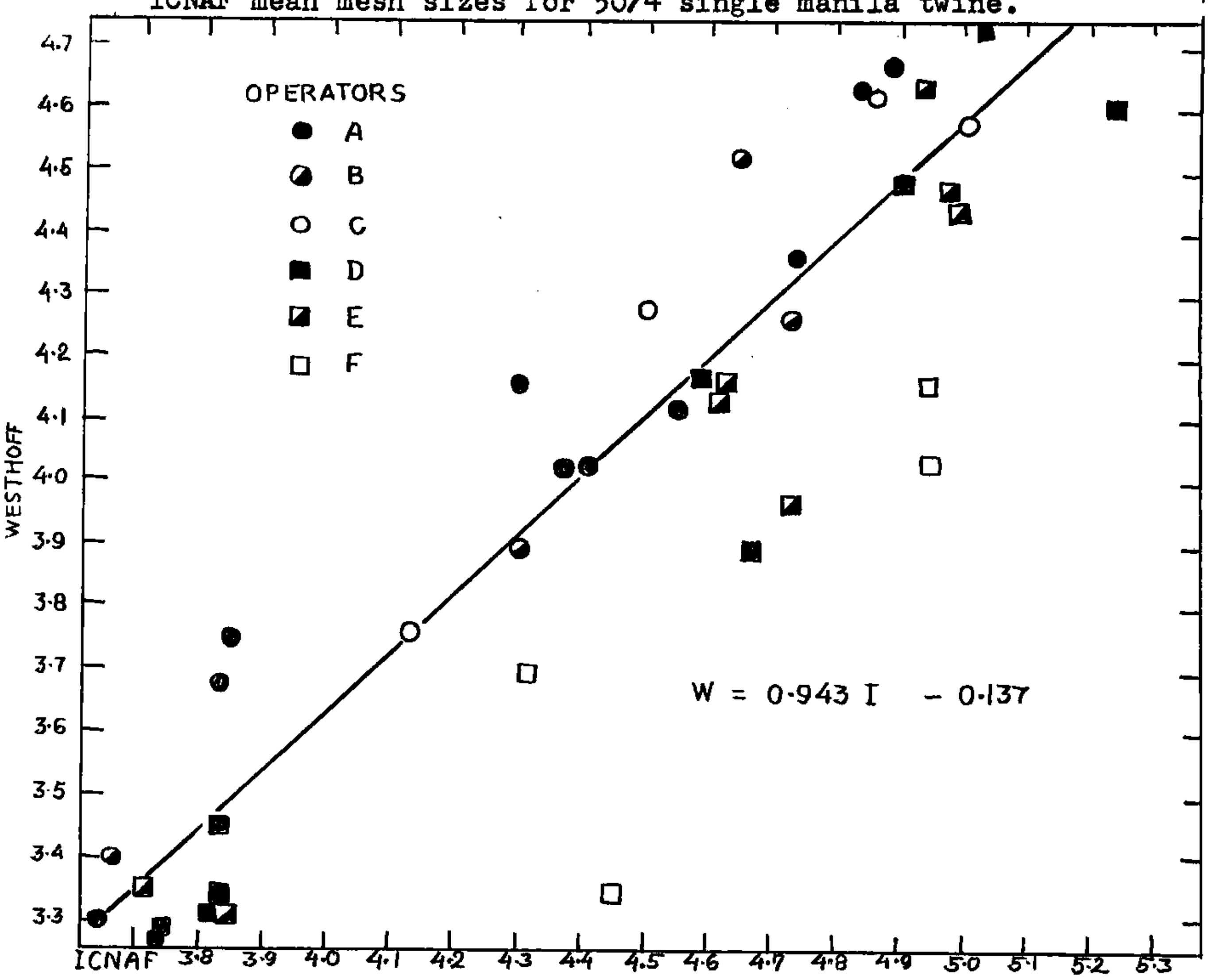

Fig.2. Straight line regression fitted to plots of Westhoff versus ICNAF mean mesh sizes for 50/4 double manila twine.

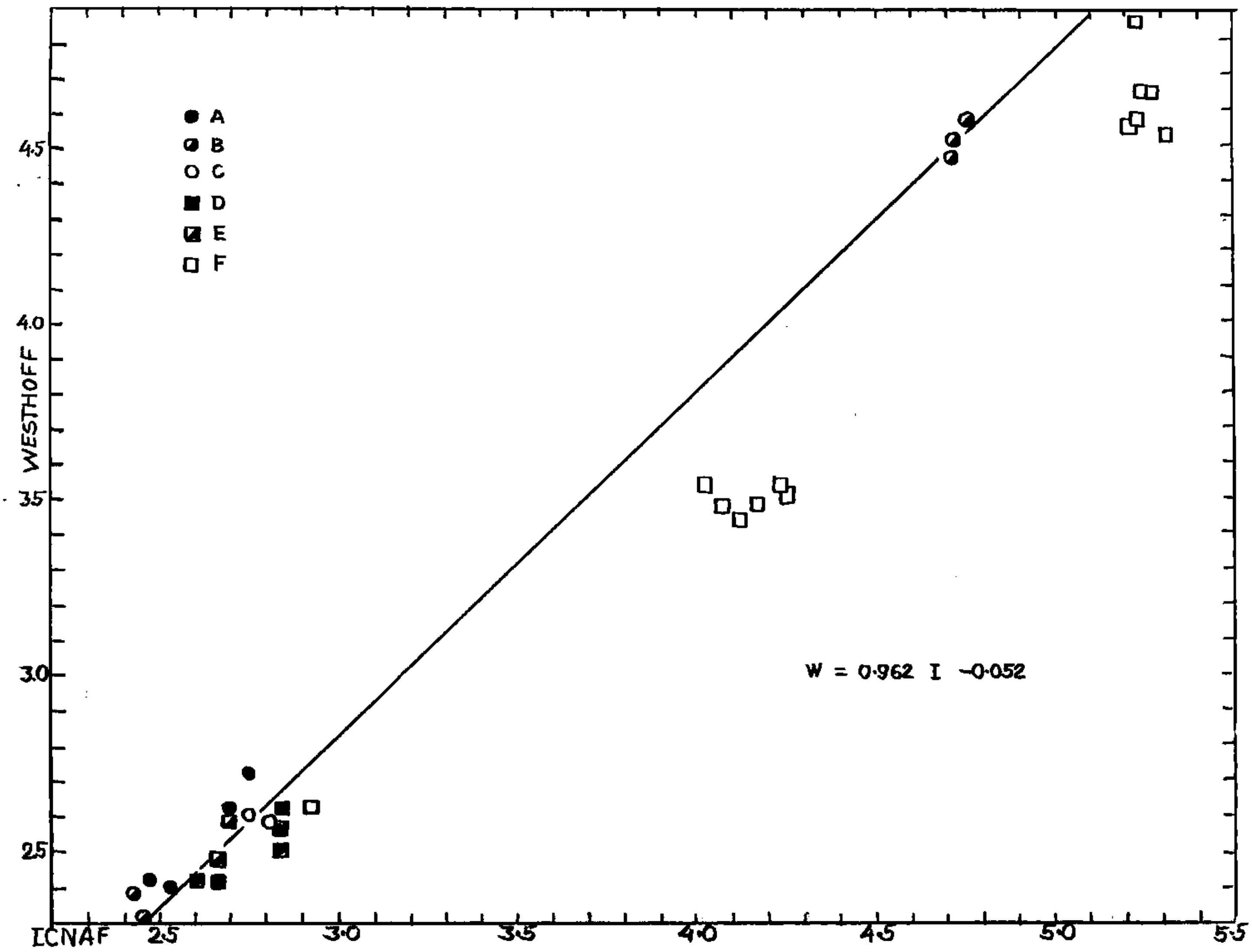

Fig.3. Straight line regression fitted to plots of Westhoff versus ICNAF mean mesh sizes for 75/4 single manila twine.

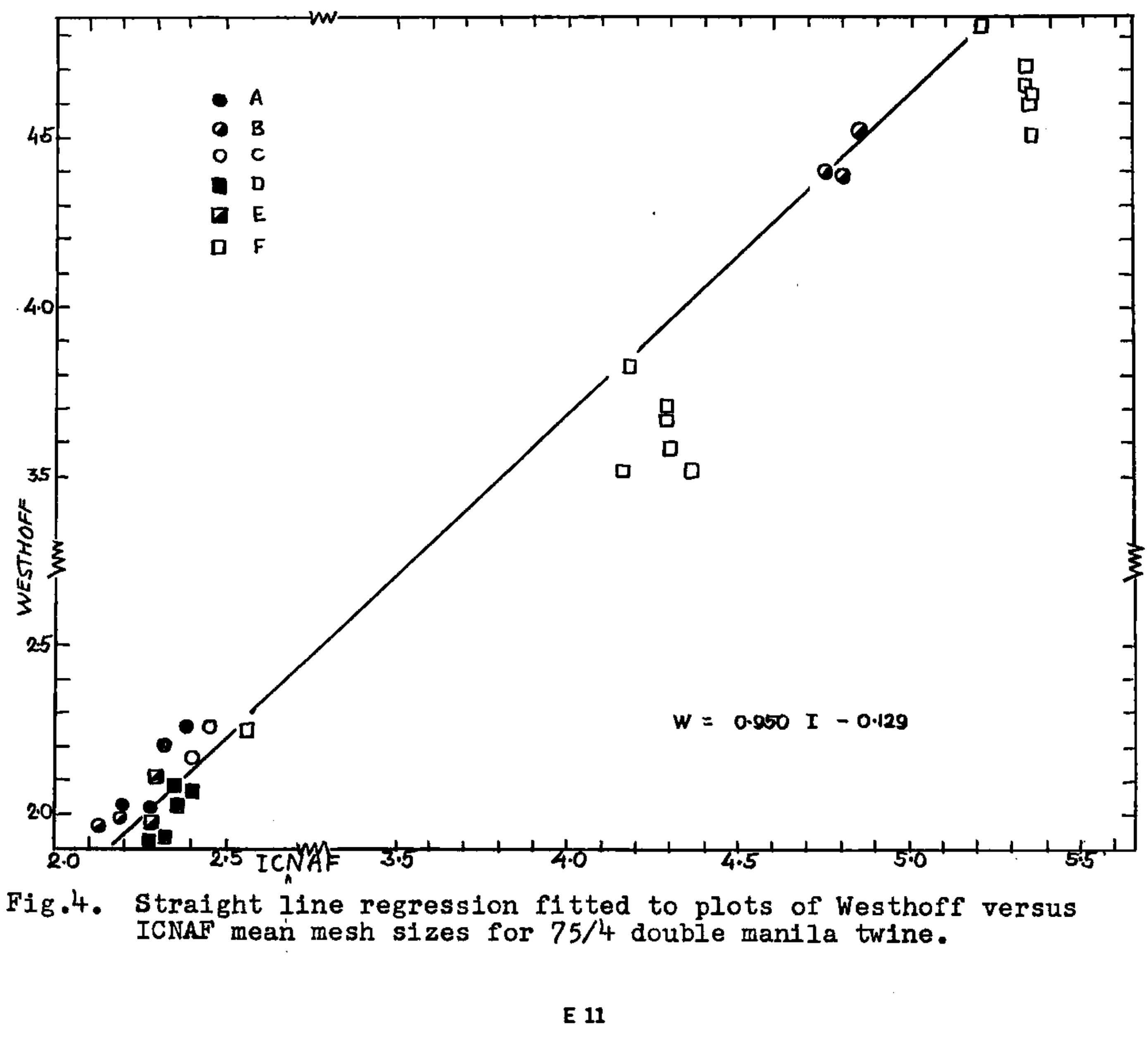

Fig.4. Straight line regression fitted to plots of Westhoff versus ICNAF mean mesh sizes for 75/4 double manila twine.

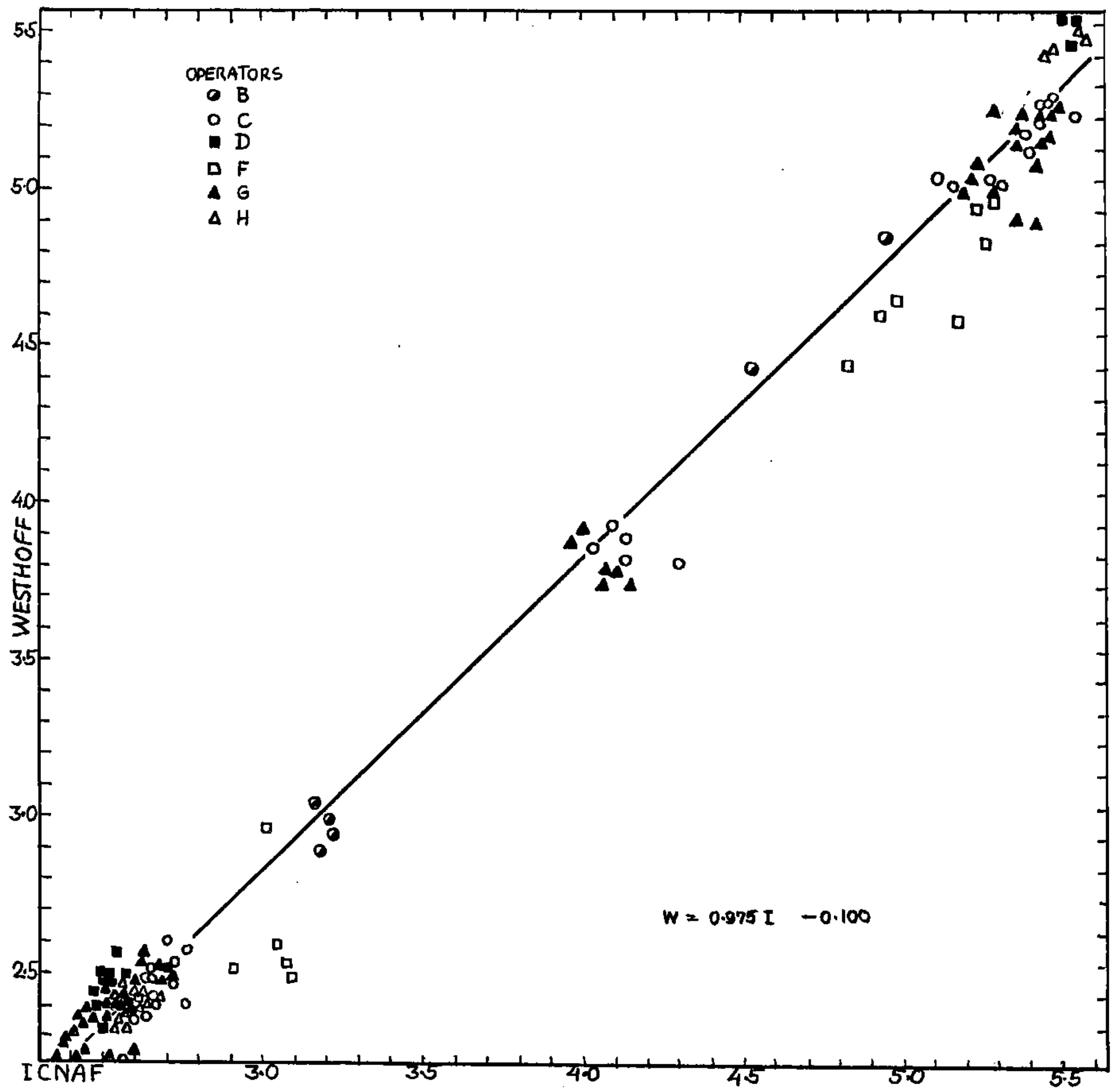

Fig.5. Straight line regression fitted to plots of Westhoff versus ICNAF mean mesh sizes for 125/3 single manila twine.

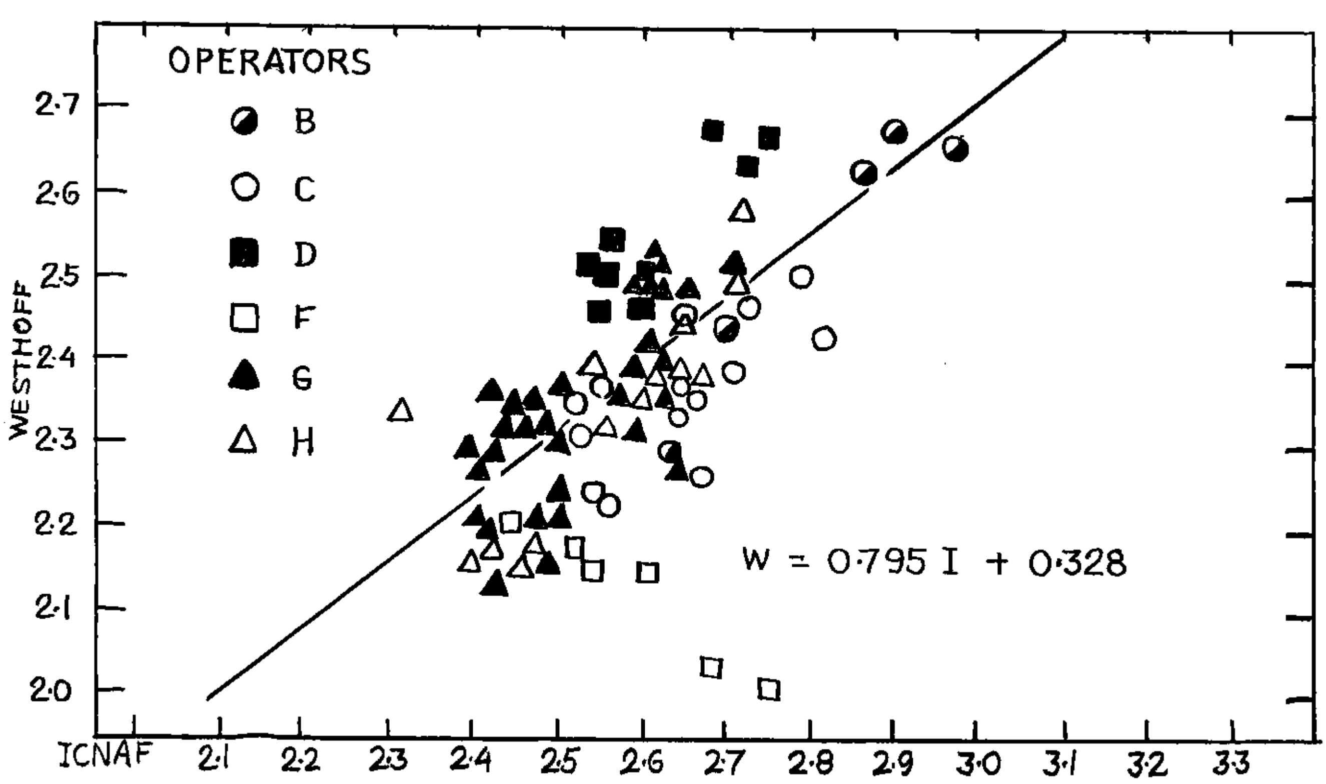

Fig.6. Straight line regression fitted to plots of Westhoff versus ICNAF mean mesh sizes for 125/3 double manila twine.

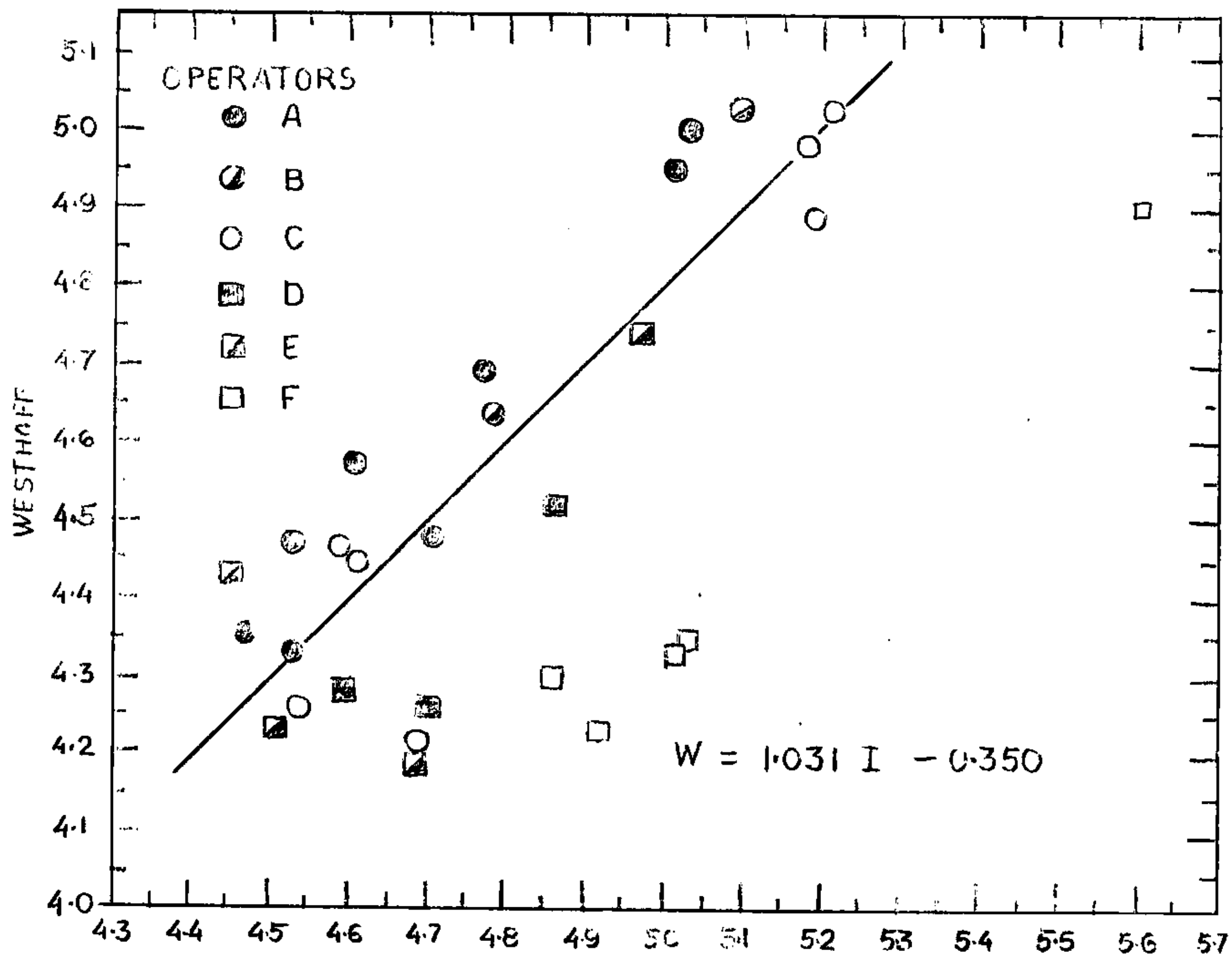

Fig.7. Straight line regression fitted to plots of Westhoff versus ICNAF mean mesh sizes for 100/3 single manila twine.