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SHIP MAINTENANCE AND REPAIR COST VERSUS AGE

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FOREWORD

This paper on ship repair costs was originally written in Japanese by Prof. F. Hiramoto of the Department of Naval Architecture, University of Tokyo. At my request, Prof. Hiramoto's colleague Dr. T. Koyama translated it into English, and it is his translation (with my editing) that appears here. The topic is one about which little has been written and we are grateful to our friends at the University of Tokyo for making this important paper available to us.

June 21, 1972 Harry Benford

INTRODUCTION

Merchant ships must pass periodic inspections to meet the requirements of classification societies and national safety laws. Repairs and renewals naturally follow related periodic activities. Major classification society surveys occur every four years. The extent of such surveys vary with the ship's age. Intermediate, relatively superficial surveys are made more or less annually and routine shipyard M & R is carried out on the same basis. Consequently, there is a periodicity in the extent and cost of M & R in addition to the increasing trend related to the ship's age.

Before proceeding, four things should be explained: (1) M & R cost as defined here specifically excludes work done by the ship's crew. (2) Dry dock charges <u>are</u> included. (3) Major conversions are excluded. (4) Lost income during time out of service is also excluded.

In analyzing M & R costs, we can restrict the data to the same type of ships or to the same owner. Alternatively, we may consider the problems in a statistical way without such restrictions. We use the latter approach here.

The Japanese Ship Owners Association publishes every year the statistics of the ships' M & R costs (Annual Report of Shipping) according to the data from its members. The statistics of the cost by age group are most useful in obtaining the general characteristics of M & R cost according to the age of ships as well as fiscal years (from April 1 to March 31, in Japan). The intent of this paper is to present the findings of our analysis of the aforementioned data, and to propose some conclusions that may be useful to the profession.

1. HULL M & R COSTS

In the cases of planning of budget and analysis of the balance sheet for hull M & R costs, we consider each of the major parameters that normally appear in the statistics. These include, for example, the ship's price (building cost or book value), gross tonnage, and deadweight. For machinery M & R costs, we consider the output of the main engines or number of cylinders. This of course leaves much to be desired. Special protective coatings may have been applied in order to reduce M & R costs. Such an investment will clearly increase intitial cost but decrease M & R cost. Nor is ship size an ideal parameter; M & R costs are not directly proportional to the gross tonnage or deadweight. M & R costs per ton decrease according to the ship's size.

In the case of the hull, most of the M & R cost (painting, hull structure or outfitting) depends more on the surface area (shell or deck) of ships than the capacity (GT or DW). So, we might better consider costs on a basis of $GT^{2/3}$ or $DW^{2/3}$. Table 1 summarizes statistics of M & R costs in thousands of yen per $(DW)^{2/3}$, broken down by age group, type of ship, and fiscal year. Hull M & R costs depend mainly on the corrosion or damage of steel. So, it should increase in constant rate with age. Figs. 1.1 to 1.3 are plots on semi-log coordinates for each of the fiscal years shown in Table 1. Lines in these figures have the same slope throughout three years, indicating an annual increase of about 6 percent compounded.

2. MACHINERY M & R COSTS

There are several parameters against which we could compare machinery M & R costs. Unfortunately, the available statistics do not include the horsepower or other likely parameters. So, we will again use $DW^{2/3}$. In the cases of trampers and tankers (middle- or small-sized liners of old age also), $DW^{2/3}$ is not too bad. The service speed of those ships does not vary widely and DWT and SHP are therefore related. Table 2 shows the results of the machinery analysis.

The characteristics of machinery M & R costs differ from those of the hull. Engine repairs require replacement of parts. Consequently, the characteristic is more additive than accumulative. We can see the linear relation to age in Figs. 2.1 to 2.3. Lines in those figures are the same for three years. Though the machinery M & R cost increases with fiscal years, it is not as obvious as with hull M & R costs.

3. TOTAL COST ANALYSIS

Our statistics do not show a breakdown between hull and machinery costs before 1966. We can, however, analyze total M & R costs going back to 1963. Table 3 shows our analysis and the results are illustrated in Figures 3.1 to 3.3. Again, we have used $DW^{2/3}$ as our basis.

Fig. 3.1 shows the variation of the M & R cost index ($¥1000/DW^{2/3}$) for liners on the bases of ship's age and fiscal years. Curves in this figure show the average tendency of the three-dimensional surface. As may be seen, M & R cost increases almost lineally due to ship's age. The increasing tendency according to fiscal years originates from 1966.

Fig. 3.2 shows the trend for trampers. The increasing tendency of M & R cost is less evident with respect to ship's age. This could be due to the difference of shipowner's policy for liners and trampers. The increasing tendency with fiscal years is the same as with liners.

Fig. 3.3 is for tankers. Though the increasing tendency due to ship's age is linear, the variation due to fiscal year is different from those for liners and trampers. The M & R cost increased in 1963-1965, decreased in 1965-1967 and increased again from 1968. This trend seems to be caused by additional investments intended to decrease annual costs of M & R (cost and time). These improvements included better coatings and maintenance-free equipment.

If the variation of the 1966-1968 cost is exponential for the hull and linear for the machinery (Figs. 1.1 to 2.3), the total cost should have intermediate characteristics. The shape of Figs. 3.1 to 3.3 might be seen as a contradiction to this. However, it is impossible to determine whether it is a straight line or a gently curved line. Our data are scattered and our range is small. We believe, nevertheless, that we have demonstrated the existence of definite trends and shown a rational method of analysis.

4. EFFECT ON ECONOMIC LIFE

The foregoing analyses indicate that total M & R costs may easily double in the first ten to twelve years of a ship's life. How much impact will this have on economic life of ships? The question is not easily answered, but we suspect the influence may not be as great as one might at first suppose. One must realize that the data are uncorrected for inflation and that much of the apparent upward cost trend is therefore illusory. Be that as it may, ship economists must not overlook these trends when assessing optimal ship life or ship maintenance policies.

Table 1 Hull part repair cost (₩ 1000/$DW^{2/3}$)

fiscal year	ship's age (year) / type of ships	0 - 4			4 - 8			8 - 12			12 - 16			16 -		
		No. of ships	average age	repair cost	No. of ships	average age	repair cost	No. of ships	average age	repair cost	No. of ships	average age	repair cost	No.of ships	average age	repair cost
1966	liner	19	2.08	10.42	63	6.05	14.38	87	9.8	16.24	*112	14.8	24.02			
	tramper	11	2.6	8.36	64	6.08	12.02	73	9.64	14.77	* 36	18.84	19.52			
	tanker	39	2.1	7.09	61	5.6	13.09	27	9.2	16.28	9	15.3	23.42			
1967	liner	30	1.87	11.13	51	6.40	14.96	85	10.10	18.30	83	14.35	23.12	47	17.58	28.33
	tramper	21	2.64	9.76	45	6.11	14.60	79	10.15	17.92	20	14.13	18.66	21	21.58	19.65
	tanker	36	2.70	11.01	46	5.82	11.85	33	9.98	18.65	2	14.75	22.60			
1968	liner	46	2.21	14.0	38	6.82	15.5	106	10.31	19.9	75	13.97	25.8	73	17.68	30.9
	tramper	35	2.86	10.3	29	5.82	18.8	44	10.10	19.2	18	13.23	21.4	17	18.66	26.0
	tanker	42	2.78	9.3	41	5.76	12.8	29	10.06	18.9	4	12.46	20.8			
1969	liner	45	2.71	12.8	31	6.12	20.1	75	10.17	22.0	89	13.46	27.5	87	17.87	28.2
	tramper	54	2.50	11.2	39	6.26	18.2	58	9.65	21.0	51	12.95	25.8	20	18.61	21.9
	tanker	45	2.48	12.9	54	5.58	15.6	41	9.86	22.6	17	12.99	24.9			

* : 12 years or more

Table 2 Engin part repair cost (₩ 1000/$DW^{2/3}$)

fiscal year	ship's age (year) / type of ships	0 - 4			4 - 8			8 - 12			12 - 16			16 -		
		No. of ships	average age	repair cost	No. of ships	average age	repair cost	No. of ships	average age	repair cost	No. of ships	average age	repair cost	No. of ships	average age	repair cost
1966	liner	19	2.08	9.31	63	6.05	16.04	87	9.8	18.98	*112	15.8	24.78			
	tramper	4	2.7	7.50	41	6.1	14.62	57	9.6	14.15	*30	17.4	17.45			
	tanker	31	2.0	6.63	37	5.5	11.81	19	9.2	19.65	5	12.9	21.90			
1967	liner	30	1.87	10.57	51	6.40	17.62	85	10.10	20.13	83	14.35	24.58	47	17.58	25.10
	tramper	16	2.40	7.86	23	6.09	17.52	52	10.28	15.58	17	14.20	16.72	17	20.93	18.57
	tanker	25	2.69	8.62	30	5.74	11.66	23	9.67	17.56	1	14.7	22.6			
1968	liner	46	2.21	12.8	38	6.82	18.0	106	10.31	20.7	75	13.97	25.4	73	17.68	27.6
	tramper	35	2.86	9.6	29	5.82	20.2	44	10.10	15.8	18	13.23	22.0	17	18.66	22.7
	tanker	42	2.78	9.7	41	5.76	14.3	29	10.06	20.0	4	12.46	20.8			
1969	liner	45	2.71	12.1	31	6.12	20.1	75	10.17	23.1	89	13.46	22.6	87	17.87	25.7
	tramper	54	2.50	11.8	39	6.26	22.7	58	9.65	21.3	51	12.95	21.4	20	18.61	22.7
	tanker	45	2.48	13.4	54	5.58	20.0	41	9.86	23.4	17	12.99	27.6			

* : 12 yearsor more

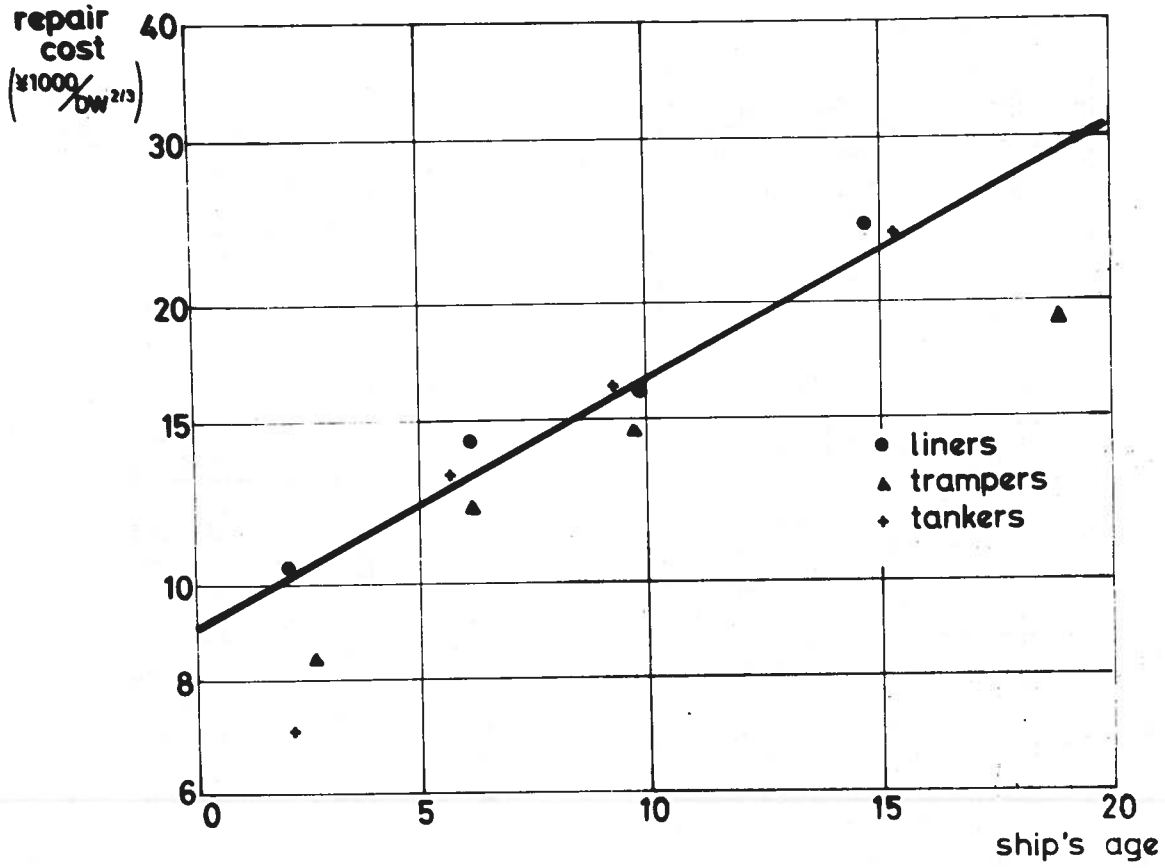

FIG. 1.1 Hull part (1966 f. year)

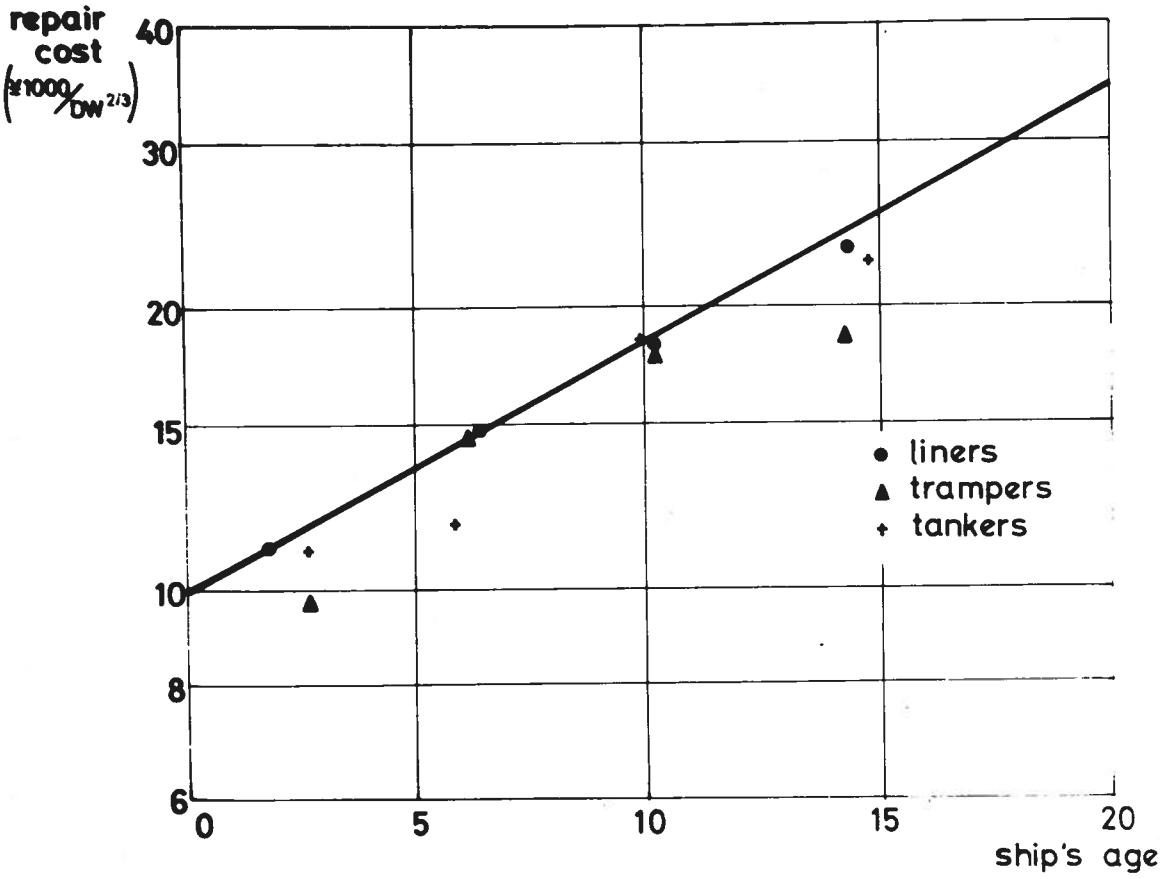

FIG. 1.2 HUll part (1967 f. year)

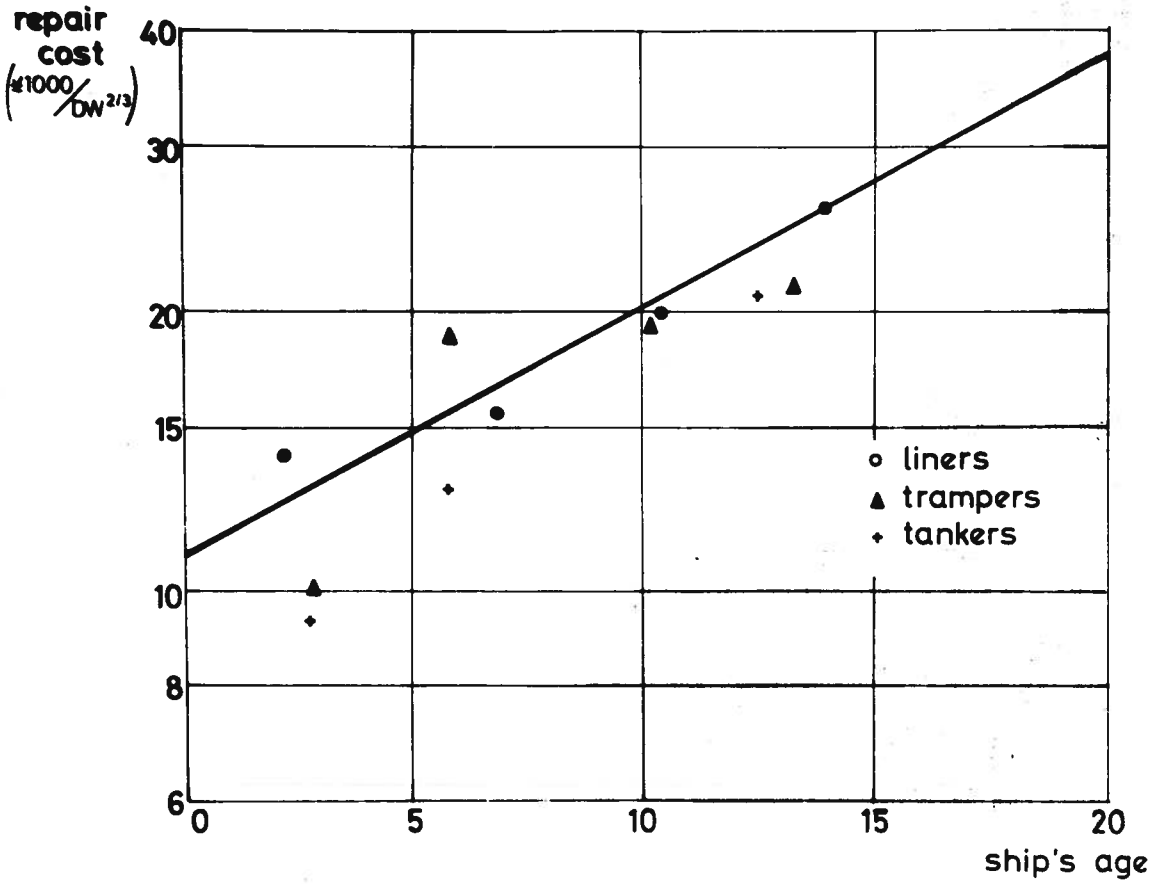

FIG. 1.3 Hull part (1968 f. year)

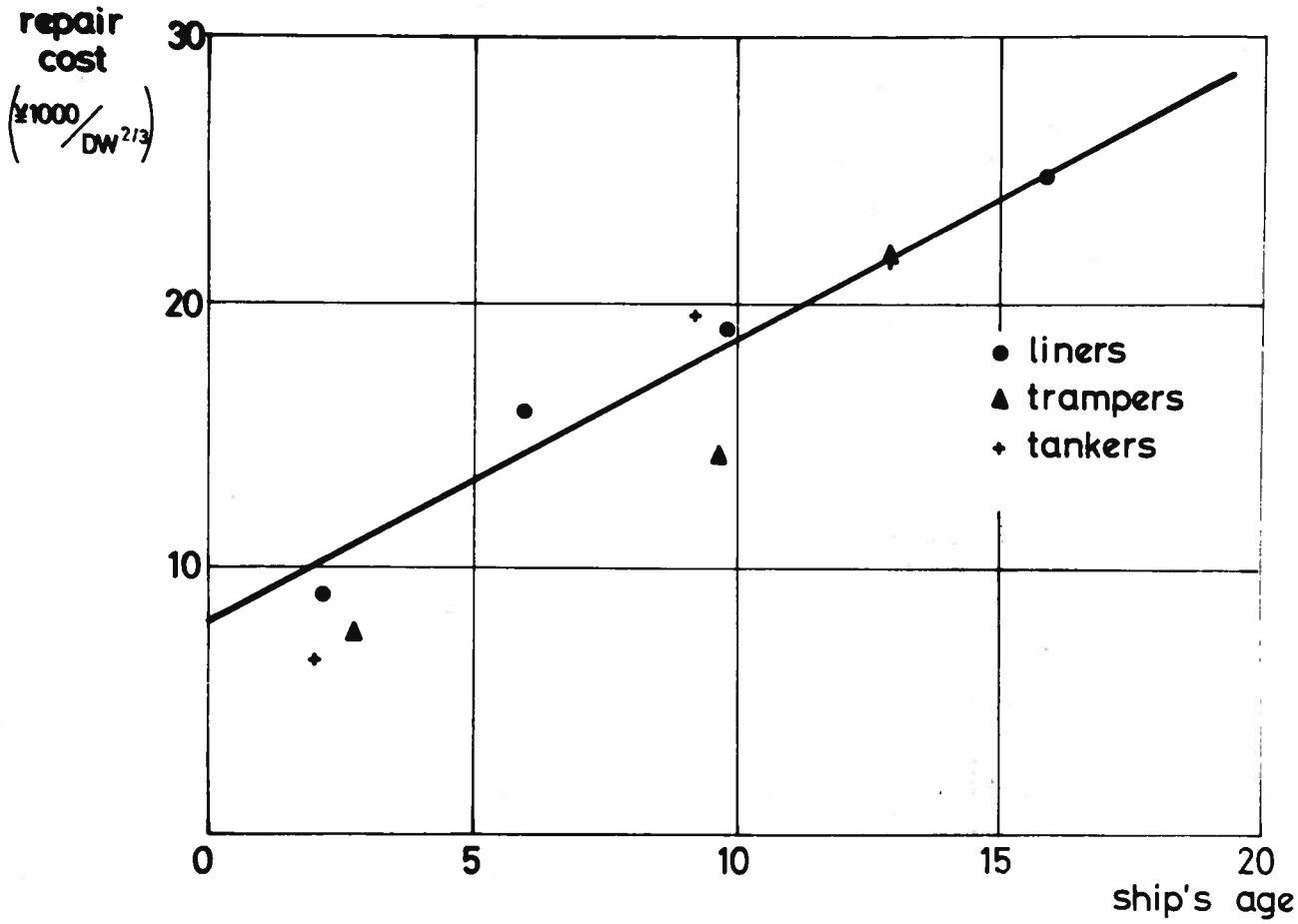

FIG. 2.1 Engine part (1966 f.year)

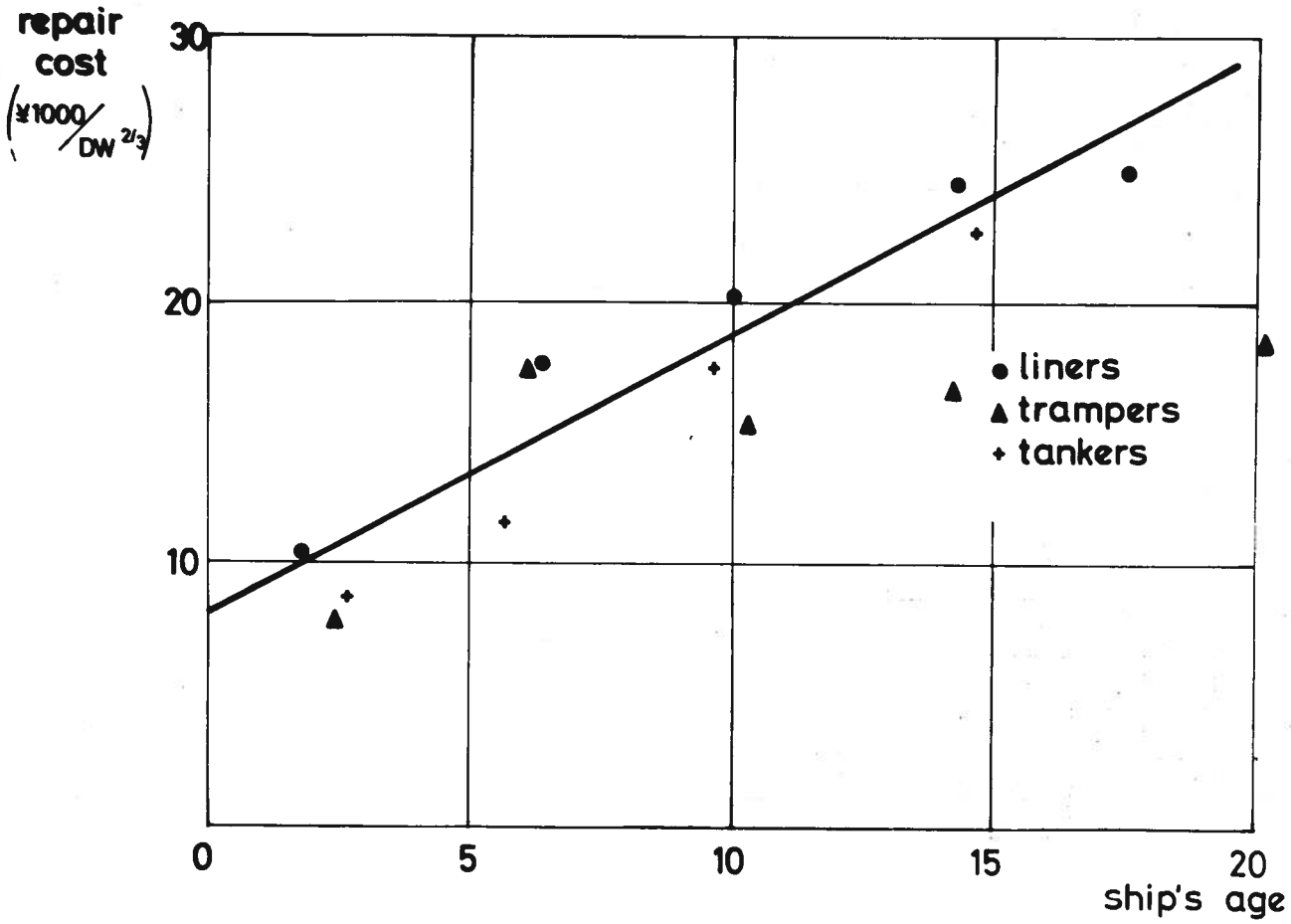

FIG.2.2 Engine part (1967 f.year)

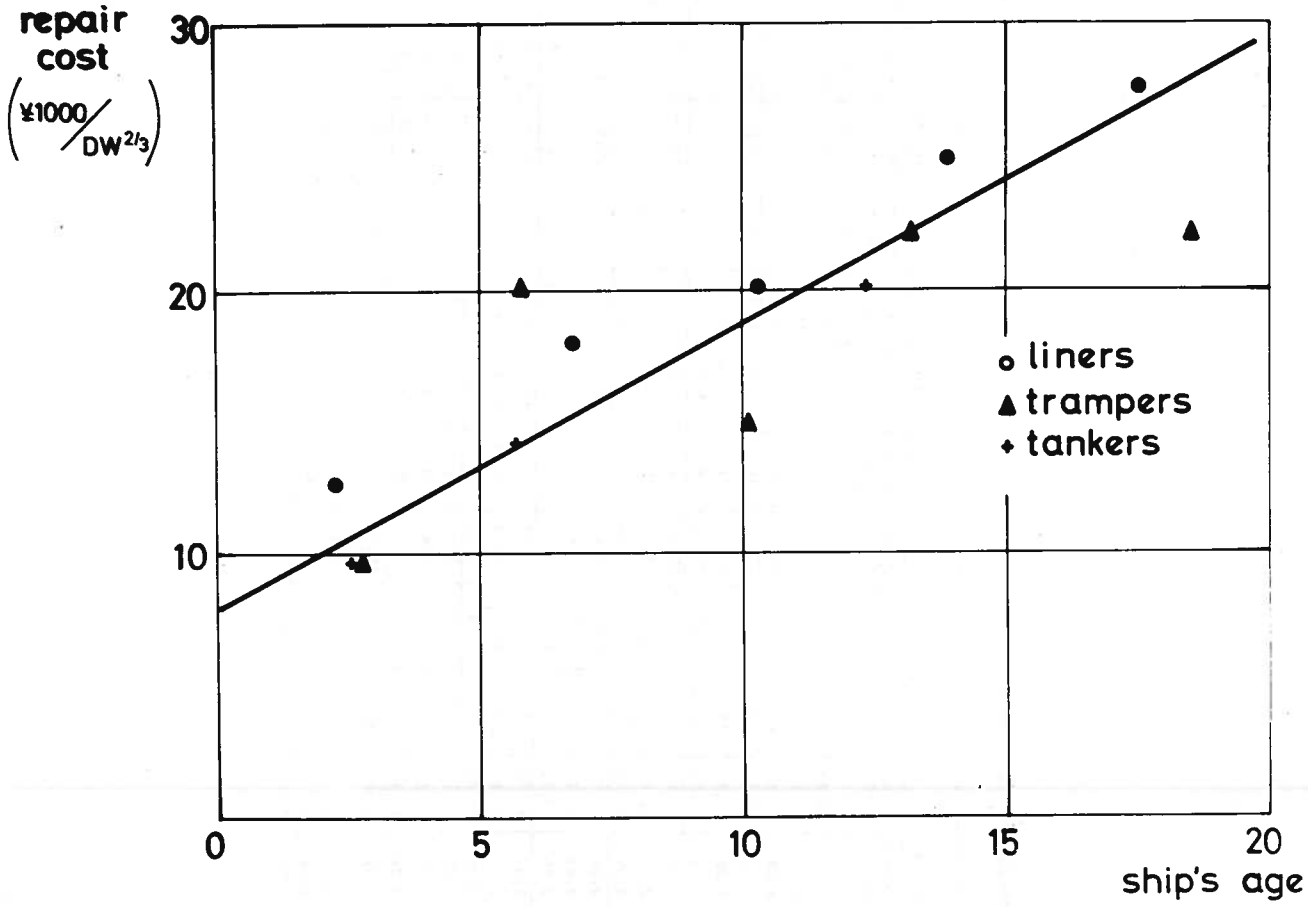

FIG.2.3 Engine part (1968 f.year)

Table 3 Total repair cost (¥ 1000 $DW^{2/3}$)

fiscal year	ship's age (year) / type of ships	0 - 4			4 - 8			8 - 12			12 -16			16 -		
		No. of ships	average age	repair cost	No. of ships	average age	repair cost	No. of ships	average age	repair cost	No. of ships	average age	repair cost	No. of ships	average age	repair cost
1963	liner	35	2.43	19.29	67	6.15	27.09	66	10.14	36.72	38	13.01	42.70			
	tramper	36	2.30	17.55	86	5.98	28.07	20	9.88	29.73				83	19.03	33.50
	tanker	30	2.48	20.09	40	5.81	24.80	16	10.35	31.54				12	19.28	24.73
1964	liner	28	2.98	19.86	74	6.39	26.53	71	9.93	34.30	75	13.25	41.19			
	tramper	39	2.78	21.74	99	6.11	26.97	29	9.21	28.22				78	18.14	35.27
	tanker	44	2.74	19.74	54	6.05	27.55	19	9.54	38.70				13	19.80	38.25
1965	liner	20	2.76	19.91	70	6.12	32.55	76	9.61	39.97	113	14.65	43.88			
	tramper	31	2.69	21.20	72	6.23	28.62	70	8.90	32.44				59	18.27	34.06
	tanker	21	2.39	20.70	58	5.65	28.16	24	9.18	39.09				13	17.06	53.63
1966	liner	19	2.08	19.73	63	6.05	30.42	87	9.8	35.22	112	15.8	48.80			
	tramper	4	2.63	16.26	41	6.09	26.08	71	9.59	30.81				34	18.67	35.55
	tanker	31	2.06	13.77	37	5.56	25.21	19	9.2	35.34	5	14.44	45.75			
1967	liner	30	1.87	21.70	51	6.40	32.58	85	10.10	38.43	83	14.35	47.70	47	17.58	53.43
	tramper	16	2.54	17.88	23	6.10	31.18	52	10.20	33.98	20	14.12	35.44	19	21.78	36.91
	tanker	25	2.70	20.06	30	5.79	23.55	23	9.85	36.40	1	14.73	45.20			
1968	liner	46	2.21	26.8	38	6.82	33.5	106	10.31	40.6	75	13.97	51.2	73	17.68	58.5
	tramper	35	2.86	19.9	29	5.81	38.4	41	10.06	34.9	18	13.23	43.4	17	18.66	48.7
	tanker	42	2.78	19.0	41	5.76	27.1	29	10.06	38.9	4	12.46	41.6			
1969	liner	45	2.71	24.9	31	6.12	40.2	75	10.17	45.1	89	13.46	50.1	87	17.87	53.8
	tramper	54	2.50	23.1	39	6.26	40.9	58	9.65	42.3	51	12.95	47.2	20	18.61	44.6
	tanker	45	2.48	26.3	54	5.58	35.6	41	9.86	46.0	17	12.99	52.5			

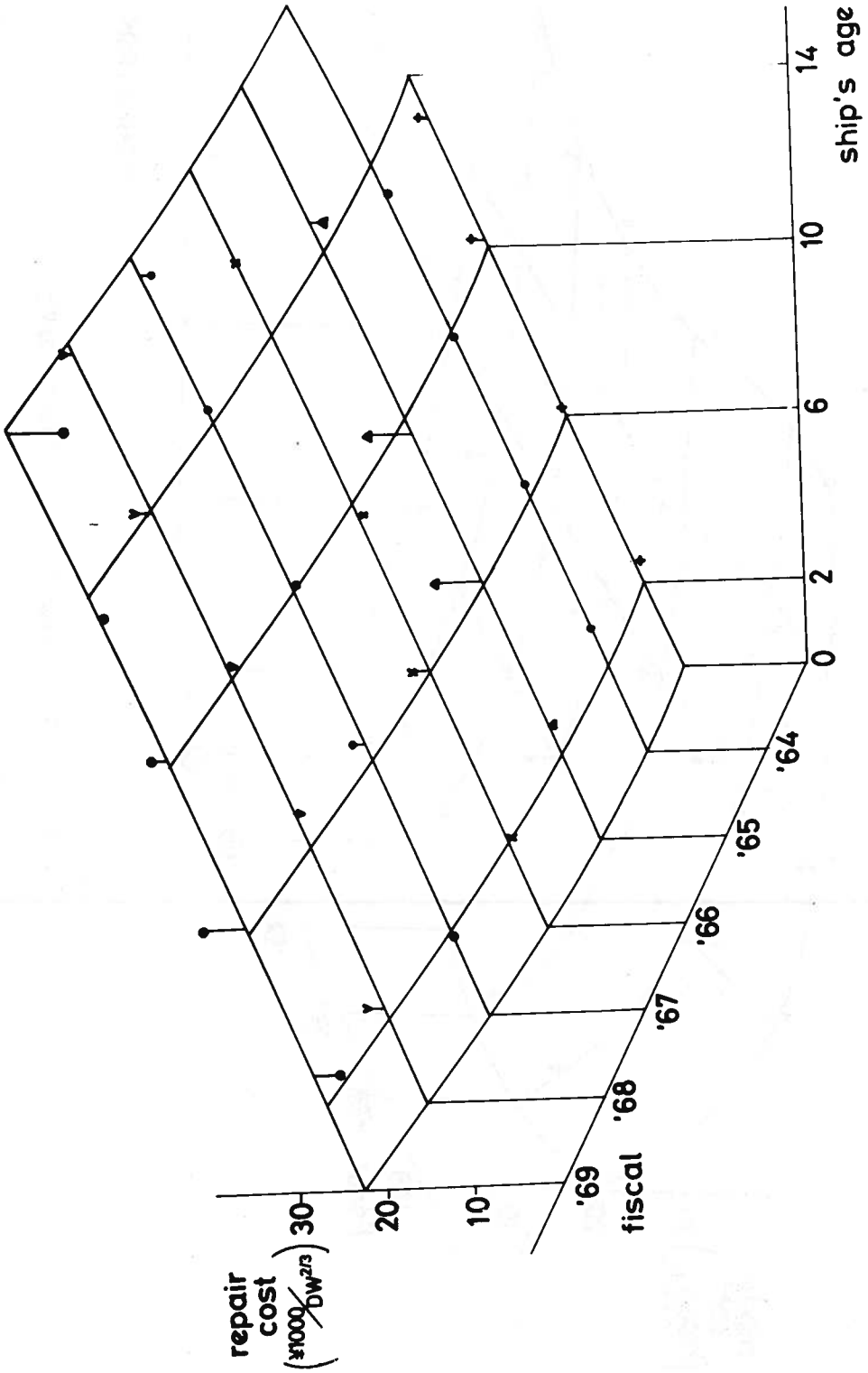

FIG. 3.1 Total repair cost. liners

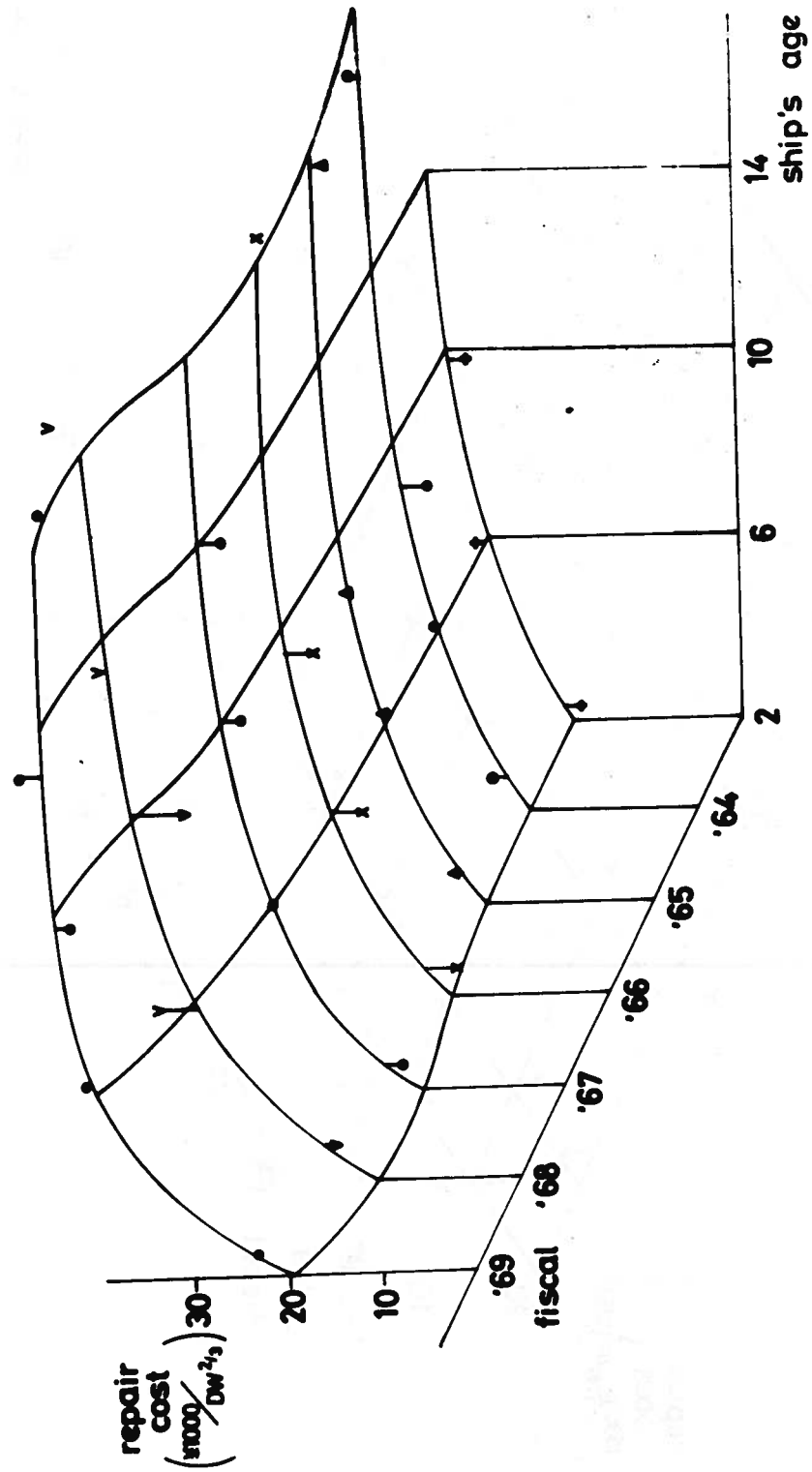

FIG. 3.2 Total repair cost, trampers

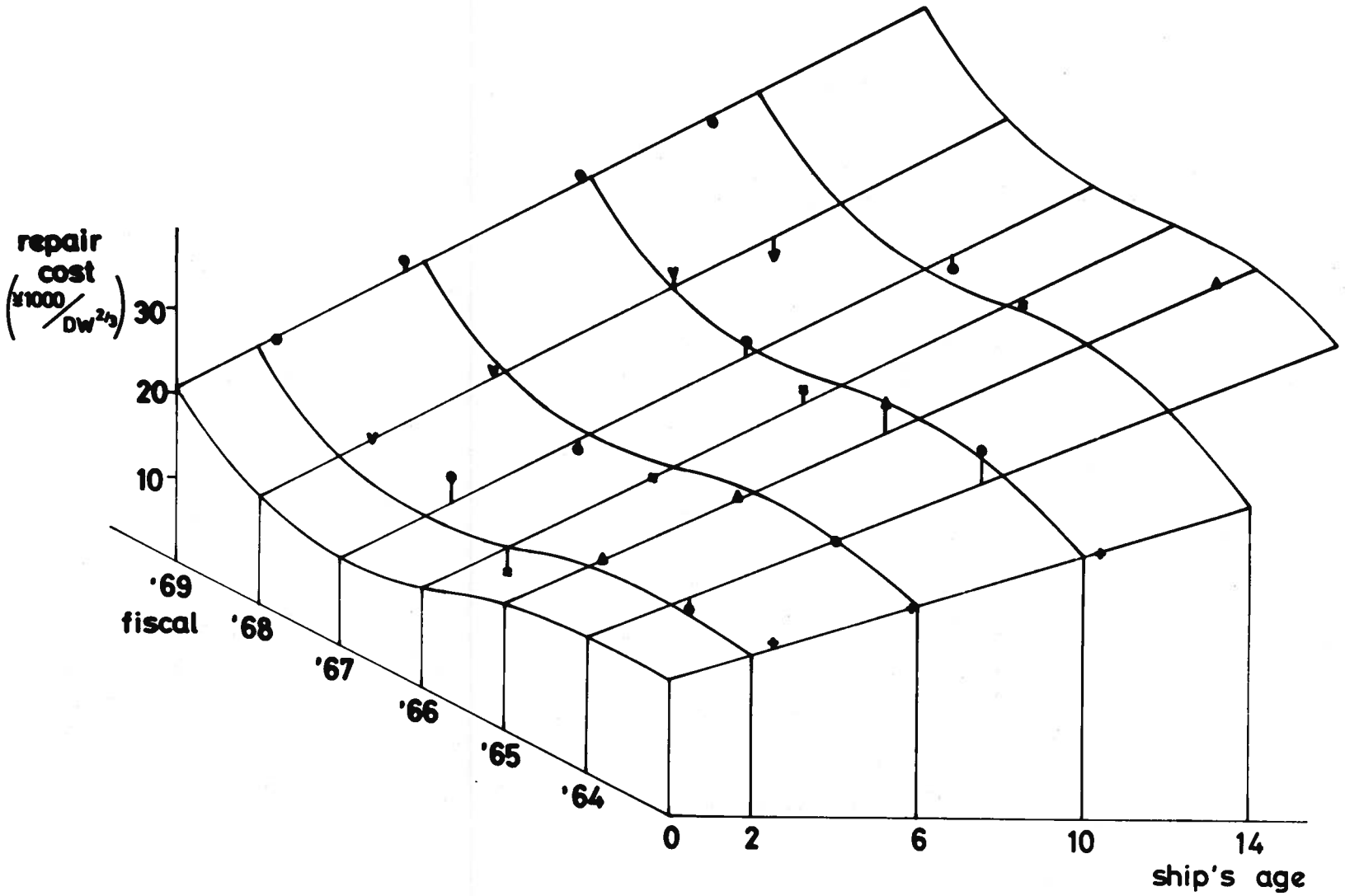

FIG. 3.3 Total repair cost, tankers