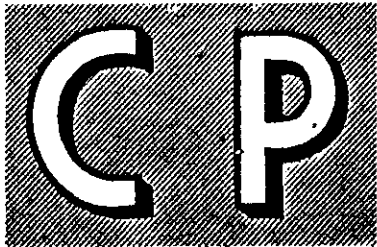


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CHIEF OF PERSONNEL BRANCH
DEFENCE RESEARCH BOARD, CANADA

THE EMPLOYMENT AND PROGRESS OF
DEFENCE SCIENTIFIC SERVICE OFFICERS (U)

by

N.W. Morton



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RESTRICTED

02 DEFENCE RESEARCH BOARD (C.R.)

DEPARTMENT OF NATIONAL DEFENCE
CANADA

020 CHIEF OF PERSONNEL BRANCH

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DEFENCE SCIENTIFIC SERVICE OFFICERS

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17 N.W. Morton

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THE EMPLOYMENT AND PROGRESS OF DEFENCE SCIENTIFIC SERVICE OFFICERS

by

N.W. Morton

INTRODUCTION

1. PURPOSE

The purpose of this report is to present information concerning the employment of Defence Scientific Service Officers (DSSOs), who constitute most of the professional staff of the Defence Research Board. The information was acquired over a period of four months by analysis of personnel records. Its usefulness appears to lie in the extent to which it answers natural questions concerning the sources of the Board's professional staff, changes in its composition, and the progress of its members in rank and salary. A good deal of the information has not been available previously, at least in systematic form.

2. SCOPE

This report, although fairly complete in its reference to scientists and engineers employed by DRB since its inception in 1947, does not attempt to provide an official statistical record as such. The intent was rather to ask a series of questions about this scientific population, and then to determine how far the data that could be extracted would help to answer them. The questions and answers were limited in scope by the number of work hours available (i.e. about 500 man-hours) and also by the records maintained over 18 years, which vary somewhat in their content. For certain purposes it was not profitable to cast back more than a year or two, while for others it was feasible to return almost to the beginning. The study was made on the basis of sub-groups, such as DSSOs taken on strength prior to 1956 and still on strength on 31 December 1965. Sometimes the sub-groups have been combined.

3. DIVISIONS OF THE REPORT

The data and analyses reported are dealt with under two main headings: employment and progress. The first heading concerns initial appointment of DSSOs and termination of employment, together with resulting changes in composition of the employed group. The second refers to information about progress of DSSOs in rank as a result of promotions, and includes an attempt to form a composite picture of such progress.

EMPLOYMENT4. EMPLOYMENT, 1956-65

The population of DSSOs increased during the ten-year period 1956-65 by some 10 per cent to a total of about 570. Nearly all this increase took place in the first half of the period. During the second half, when special restrictions on strength were imposed by the Treasury Board, intake dropped to the point of just balancing losses. In the whole of the period 512 were recruited and there were 454 separations. Of those terminating employment in 1956-65, 218 were recruited within the same period (i.e. about 43 per cent of those recruited). The percentage age distributions for those recruited and separating were as follows:

<u>Age Group (years)</u>	<u>Recruited 1956-65</u>	<u>Recruited and Separating 1956-65</u>	<u>Recruited before 1956 Separating 1956-65</u>	<u>Total Separating 1956-65</u>
46+	3.5%	2.3%	16.1%	9.3%
41 - 45	5.2	4.1	13.4	8.8
36 - 40	8.1	14.7	27.2	21.0
31 - 35	16.0	17.0	25.4	21.3
26 - 30	33.4	42.6	17.4	29.9
21 - 25	33.8	19.3	0.5	9.7
Median Age	27.9 years	29.1 years	36.7 years	32.9 years

5. EMPLOYMENT AND AGING

Fourteen DSSOs were pensioned during 1956-65 at a median age of 62.5 years; 10 died at a median age of 42 years; the remainder of 430 left for other employment. The average age of DSSOs increased; at the beginning the median was about 35 years, while by the end of the period the median was just under 40. The number of DSSOs who were 25 or more years from attainment of the bachelor's degree more than doubled. On the basis of a projection made in 1963 it is estimated that this increase in average age may continue until 1975, when stabilization will take place at a median of about 43 years.

6. RETIREMENT RATE

As noted, there were only 14 retirements to pension in this 10-year period. Clearly, however, if a typical working life is, say, 35 years, it might be expected that in a group of nearly 600 there would be at least 15 retirements a year. An examination of the age distribution of the existing population of DSSOs indicates that if retirement takes place between 60 and 65 years, the average retirement rate for the next 10 years will probably be five times that for the past 10 years, and subsequently will increase further.

An implication suggested by such increase in the rate of retirement is that in order to maintain total strength it will be necessary either to augment the rate of recruitment or to reduce the number of separations that now take place for reasons other than age or death.

7. EMPLOYMENT AND GRADE LEVELS

The percentage distributions by grades for those recruited and separating were:

Grade	Recruited 1956-65	Recruited and Separating 1956-65	Recruited before 1956 Separating 1956-65	Total Separating 1956-65
5+	2.3%	4.1%	26.0%	15.2%
4	12.0	13.4	30.5	22.0
3	37.4	45.2	39.0	42.1
2	48.3	37.3	4.5	20.7
Median*	2.5	2.8	3.7	3.2

8. AGE AND GRADES

Associated with the increase between 1956 and 1965 of four or five years in the average age was an upward shift in the average grade level, as follows:

Grade	1956	1961	1965
6+	7%	9%	10%
5	12	17	22
4	25	33	35
3	38	34	29
2	18	7	4
	100	100	100

In ten years time the largest grade level moved from Grade 3 to Grade 4. The percentage of Grade 5 nearly doubled, while that of Grade 2 diminished almost to the point of disappearance. This decrease in Grade 2 coincided with increases in starting salaries, especially between 1957 and 1961, which outpaced changes in salary scales.

9. SOURCES OF DSSOs

The previous places of training or employment of the 512 DSSOs recruited in 1956-65, classified by highest degree held, were:

	Bachelor	Master	Doctor	Other	Total
<u>Government Agency</u>					
Canadian	30	13	19	2	64
UK	9	3	5	0	17
Other Commonwealth	0	0	5	0	5
	<u>39</u>	<u>16</u>	<u>29</u>	<u>2</u>	<u>86</u>
<u>College, University</u>					
Canadian	75	101	59	0	235
UK	5	8	24	0	37
Other Commonwealth	0	0	2	0	2
USA	2	14	13	0	29
	<u>82</u>	<u>123</u>	<u>98</u>	<u>0</u>	<u>303</u>
<u>Private Employer</u>					
Canadian	49	9	10	0	68
UK	9	3	4	0	16
USA	0	1	2	0	3
	<u>58</u>	<u>13</u>	<u>16</u>	<u>0</u>	<u>87</u>
DRB Reclassification	16	5	0	3	24
Other	2	4	6	0	12
	<u>18</u>	<u>9</u>	<u>6</u>	<u>3</u>	<u>36</u>
Total	<u>197</u>	<u>161</u>	<u>149</u>	<u>5</u>	<u>512</u>

Nearly 60 per cent came from universities, mostly Canadian. Government and private employment, again mostly Canadian, each account for another 15 to 20 per cent.

* Note that for the purpose of computing a median, the grade number has been taken as representing the middle of the grade. Thus the borderline between DSSO 3 and DSSO 4 has been treated as 3.5.

The corresponding distribution by country of origin was:

	<u>Bachelor</u>	<u>Master</u>	<u>Doctor</u>	<u>Other</u>	<u>Total</u>
<u>Canada</u>					
French-speaking	32	15	12	0	59
English-speaking	109	128	97	2	336
	<u>141</u>	<u>143</u>	<u>109</u>	<u>2</u>	<u>395</u>
Great Britain	49	15	24	3	91
Commonwealth	5	2	13	0	20
Other	2	1	3	0	6
Total	<u>197</u>	<u>161</u>	<u>149</u>	<u>5</u>	<u>512</u>

Over three-quarters were Canadian in origin, and of these about 15 per cent were French-speaking.* Most of the remainder came from Great Britain. A smaller percentage of the French-speaking Canadians had postgraduate training compared with other Canadians (46 vs 67 per cent).*

10. SUMMER STUDENTS AS CONTINUING EMPLOYEES

Of the 512 recruits in 1956-65, 115, or about 22 per cent, had been employed as summer students at a DRB research establishment in one or more years prior to full-time employment. Of the total group, at least one-fifth could not have been summer students by virtue of age or origin outside Canada. Excluding these, the percentage of recruits who had been summer students rises to between 25 and 30 per cent. While the exact number of different university students who have been employed over a ten-year period is not known, it is estimated to be of the order of 500 or 600. On this basis, about one-quarter subsequently become full-time scientists in DRB.

DSSOs who had been summer employees appeared to be no more likely than others to remain in DRB. Those least likely to remain held the Bachelor degree only; of those with higher degrees, two-thirds were still in DRB employment at the end of the period.

11. PERCENTAGE OF CANDIDATES RECRUITED

It was not possible with the data immediately available to determine what number of professional candidates were considered for employment or were offered an appointment during the period under review. It appears probable, however, that several thousand were considered and that offers were made to between 1000 and 1500 candidates. It was possible to tabulate the actual offers made in 1964 and 1965, and the number accepted. These were:

* A study kindly made available by the staff of the Royal Commission on Bilingualism and Biculturalism indicates that of students taking first degrees in the natural sciences (including engineering) during the years 1962-65, about 15 per cent were in French-speaking institutions. Of all graduates in the natural sciences in those years from the French-speaking institutions, about 12 per cent were at the Master or Doctorate level, while in English-speaking universities about 16 per cent were at the corresponding levels.

Period of Offer	Offered	Refused	Accepted	Year and Quarter Taken on Strength											
				1964				1965				Later			
				1	2	3	4	1	2	3	4	1	2	3	4
1st Quarter 1964	63	35	28	2	15	9	2								
2nd " "	21	9	12		4	7	1	1							
3rd " "	8	1	7			2	1	1	2	1					
4th " "	9	5	4					4							
Total	101	50	51	2	19	18	4	6	2	1					
1st Quarter 1965	74	52	22					2	9	7	2				2
2nd " "	18	10	8						1	5	2				
3rd " "	17	9	8							4	3				1
4th " "	14	3	11								4				7
Total	123	74	49					2	10	16	11				10

Thus, over the two years, about 45 per cent of offers were accepted (account was not taken of applications that might have been approved but that were withdrawn by the candidate before an offer could be made). The delay time between making an offer and reporting for work was of the order of five months.

12. AGE, ACADEMIC DEGREE AND GRADE LEVELS AT ESTABLISHMENTS

Considering only the current (December 1965) population of DSSOs, there are substantial differences among establishments (treating DRB Headquarters, exclusive of ORE, as a single establishment) in the distribution of age, academic degree, and grade levels. These differences are illustrated in Figs. 1 to 3.

It is evident that Headquarters is much the oldest group, and that PNL, DCBRL, and SES tend toward a higher age level than the rest.

There are large differences in the distribution of academic degree levels shown in Fig. 2 as No Degree, Bachelor, Master, and Doctor. Two establishments, DRML and DCBRL, are marked with the highest proportion of DSSOs with postgraduate degrees, particularly the doctorate. Two others, DRTE and SES, tend in the same direction. Headquarters, ORE, and CARDE, on the other hand, have 50 per cent or more DSSOs below the postgraduate level.

Headquarters has the highest average grade level. The differences among the rest are not large, and are probably not significant. This lack of substantial difference, except for Headquarters, is somewhat difficult to account for, in view of the normal positive association of grade level with both age and academic degree level. For example, the staff of CARDE is relatively young (median age is 36 years) and includes only 20 per cent Ph.Ds., while at DCBRL the median age is 41, with nearly 60 per cent Ph.Ds. Yet there is practically no difference in the average grade level, which is just below the middle of DSSO 4 in each case.

13. DESTINATIONS OF SEPARATING DSSOs

Following is a tabulation of the destinations, in terms of employment, of separating DSSOs during the period 1956-65:

	<u>Bachelor</u>	<u>Master</u>	<u>Doctor</u>	<u>Other</u>	<u>Total</u>
<u>Government</u>					
Canada	20	16	23	1	60
USA	1	1	6	0	8
Great Britain	0	1	0	1	2
Other	<u>0</u>	<u>0</u>	<u>1</u>	<u>0</u>	<u>1</u>
	21	18	30	2	71
<u>Private Employer</u>					
Canada	32	14	27	4	77
USA	12	12	20	1	45
Great Britain	1	2	0	0	3
Other	<u>0</u>	<u>1</u>	<u>0</u>	<u>0</u>	<u>1</u>
	45	29	47	5	126
<u>University Staff</u>					
Canada	6	26	61	1	94
USA	0	1	11	0	12
Great Britain	2	1	3	0	6
Other	<u>0</u>	<u>1</u>	<u>4</u>	<u>0</u>	<u>5</u>
	8	29	79	1	117
<u>University Studies</u>					
Canada	16	16	2	1	35
USA	4	7	0	0	11
Great Britain	1	3	0	0	4
Other	<u>2</u>	<u>0</u>	<u>1</u>	<u>0</u>	<u>3</u>
	23	26	3	1	53
Pension	5	3	4	2	14
Death	1	2	6	1	10
Reclassified	2	2	0	1	5
Other	11	7	4	2	24
Not Known	<u>12</u>	<u>7</u>	<u>12</u>	<u>3</u>	<u>34</u>
	31	21	26	9	87
Total	<u>128</u>	<u>123</u>	<u>185</u>	<u>18</u>	<u>454</u>

The largest number left for private employment, closely followed by those going to university teaching. Altogether, between 35 and 40 per cent went to universities either as staff or students. Notable is the number of Ph.Ds. returning to universities: they made up one-sixth of the entire group of separating scientists. About one-sixth of the total were bound for the USA, mostly for industrial employment.

Of the separating DSSOs, 152 had served with DRB for three years or less when they left. Their destinations were as follows:

	<u>Bachelor</u>	<u>Master</u>	<u>Doctor</u>	<u>Other</u>	<u>Total</u>
<u>Government</u>					
Canada	8	6	6	0	20
USA	0	0	1	0	1
Other	<u>0</u>	<u>0</u>	<u>5</u>	<u>0</u>	<u>5</u>
	8	6	12	0	26
<u>Private</u>					
Canada	8	6	7	1	22
USA	2	3	4	1	10
Great Britain	1	1	0	1	3
Other	<u>0</u>	<u>1</u>	<u>0</u>	<u>0</u>	<u>1</u>
	11	11	11	3	36
<u>University Staff</u>					
Canada	2	7	15	0	24
USA	0	1	2	0	3
Great Britain	0	0	2	0	2
Other	<u>0</u>	<u>0</u>	<u>2</u>	<u>0</u>	<u>2</u>
	2	8	21	0	31
<u>University Studies</u>					
Canada	16	11	0	1	28
USA	4	4	0	0	8
Great Britain	0	2	0	0	2
Other	<u>1</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>1</u>
	21	17	0	1	39*
Death	1	0	1	0	2
Other	4	1	0	0	5
Not Known	<u>5</u>	<u>3</u>	<u>5</u>	<u>0</u>	<u>13</u>
	10	4	6	0	20
Total	<u>52</u>	<u>46</u>	<u>50</u>	<u>4</u>	<u>152</u>

Of these 152 DSSOs, a larger proportion than of the entire separating group left to return to university studies; in fact, three-quarters of all leaving for this reason were in this short-service group. It is noticeable also that Ph.Ds. constituted a smaller proportion of the short-service group than of the entirety.

A comparison of recruitments (cf. Section 9) and separations during the period indicates a gain in staff at the Bachelor and Master level and a loss of 36 Ph.Ds. The Ph.Ds. lost were those with longer service: 236 of the DSSOs separating had joined prior to 1956, and of these 117 were Ph.Ds. The numbers exchanged with other agencies of government in Canada were

* 21 in the period 1956-60.

nearly in balance, with some loss in terms of academic levels. More went to private employment than came from it, and in particular DSSOs with postgraduate training were lost in this way. There were returned to the universities, the chief source of DSSOs, nearly 60 per cent of the number drawn from them: the number of Ph.Ds. nearly balances.

14. LOSS OF RECENTLY RECRUITED DSSOs

As stated (Section 4), of 512 DSSOs recruited, 218 were lost within the same period. The percentage loss relative to duration of employment to the end of 1965 is shown by:

	<u>Single Year</u>	<u>Cumulative</u>
Per cent separated in same year recruited	3.5	3.5
next year	13.3	16.8
two years after recruitment	7.8	24.6
three " " "	7.4	32.0
four " " "	2.9	34.9
five " " "	3.7	38.6
six " " "	2.0	40.6
seven " " "	0.6	41.2
eight " " "	0.6	41.8
nine " " "	0.8	42.6

Clearly the high loss is in the first few years: few will leave in the same calendar year as hired, but within four years a third of the group leaves. By the sixth year, some 40 per cent of recruits have left and the remainder continue for a long period of employment.

A graphical presentation of the separation of these 218 DSSOs, classified by duration of employment, together with that of DSSOs recruited before 1956, is shown in Fig. 4.

DSSOs when separating are graded by their establishments on a four-point scale from A to D. Of the 218 recruited and leaving within the 1956-65 period, 26 per cent were graded "A", 55 per cent "B", and 9 per cent "C" or "D". The remainder were ungraded, or the grade was not recorded. Those graded C or D were employed for a median period of just over two years, which is not greatly different from that of the entire separating group. The distribution for DSSOs separating in this period who had been recruited before 1956 was: 27 per cent A, 44 per cent B, 10 per cent C or D, and 20 per cent ungraded or unrecorded. In either series, more are reported as outstandingly good than as poor.

The comparative degree status of DSSOs recruited in 1956-65, divided between those lost and those retained, is:

	<u>Bachelor</u>	<u>Master</u>	<u>Doctor</u>	<u>No Degree</u>	<u>Total</u>
Lost	91	58	68	1	218
Retained	106	103	81	4	294
	197	161	149	5	512

There appears to be a slightly better chance of retaining a Master than a Bachelor or Ph.D.

The relation of retention to loss by stations is shown in the following table:

<u>Station</u>	<u>Retained</u>	<u>Lost</u>	<u>Total</u>	<u>Per cent Retained</u>
DRNL	1	0	1	100
PNL	12	3	15	80
NRE	33	18	51	65
SES	22	14	36	61
ORE	37	25	62	60
HQ	19	13	32	59
DRTE	62	44	106	58
DCBRL	23	17	40	58
CARDE	64	61	125	51
DRML	21	23	44	48
Total	<u>294</u>	<u>218</u>	<u>512</u>	<u>57</u>

The recruitment into a station has been roughly proportionate to its size, with certain exceptions, notably PNL and HQ. The two naval research establishments had the lowest record of turnover, CARDE and DRML the highest.

The same tabulation broken down by degree levels tends to be consistent with total numbers retained and the percentage at various academic degree levels indicated by the previous tables, with the following exceptions: DRML has retained fewer at the higher academic levels, and CARDE at the Ph.D. level; while on the other hand the Shirley Bay establishments retained more of those with postgraduate training, but lost more recruits with only the Bachelor degree.

15. RELATIONS OF ACADEMIC GRADE-POINT AVERAGES

Two questions of interest are: does the quality of DSSOs retained compare favorably with that of the DSSOs who leave, and has there been any change in the quality of recruits within the past ten years? It was not possible to answer these questions readily in terms of the DSSO's productivity or assessed quality as a research worker. However, it was possible to determine something of the individual's formal academic record in a majority of cases. This record was converted into a single index for the undergraduate period, and where applicable, for the postgraduate period as well, simply by assigning the weights 4, 3, 2, 1 to first-, second-, third-class, and pass marks, and then obtaining a mean, weighted accordingly. Such grade-point averages were available for 303 DSSOs at the undergraduate level, and for 145 DSSOs with both undergraduate and postgraduate records.

Before use of such grade-point averages as a measure of quality, it was desirable to determine whether they exhibited characteristics that would suggest their usefulness or credibility for this purpose. Two features were examined: relation with the degree level finally attained, and consistency between undergraduate and postgraduate levels.

The following distributions of undergraduate grade-point averages were found with those for Bachelor, Master and Doctor degrees:

<u>Weighted Means</u>	<u>Bachelor</u>	<u>Master</u>	<u>Doctor</u>	<u>Total</u>
3.6 - 4.0	18	21	21	60
3.1 - 3.5	38	52	34	124
2.6 - 3.0	30	35	18	83
2.1 - 2.5	18	11	3	32
1.6 - 2.0	3	0	1	4
	<u>107</u>	<u>119</u>	<u>77</u>	<u>303</u>
Mean	3.0	3.1	3.2	3.1
σ	0.5	0.4	0.5	0.5

An analysis of variance indicates that the differences by degree levels are significant at the 1 per cent level of confidence.

The relation between grade-point averages at the undergraduate and graduate levels is exhibited in the following table:

UNDERGRADUATE						
	<u>1.6-2.0</u>	<u>2.1-2.5</u>	<u>2.6-3.0</u>	<u>3.1-3.5</u>	<u>3.6-4.0</u>	<u>Total</u>
	0	4	11	36	19	70
	0	6	19	20	9	54
GRADUATE	0	3	7	6	1	17
	0	0	2	1	0	3
	1	0	0	0	0	1
Total	<u>1</u>	<u>13</u>	<u>39</u>	<u>63</u>	<u>29</u>	<u>145</u>

This relation may also be expressed as a product-moment correlation of +.4.

The foregoing associations suggest that the computed undergraduate grade-point average has some significance, since they are consistent with the expectation that those students proceeding to graduate study would represent a positively selected group and further that the postgraduate academic record would be in some degree predictable from the undergraduate record. On the basis of this apparent consistency, or credibility, the undergraduate grade-point averages were then used to compare (a) those DSSOs retained from 1956-65 recruitment with those lost, and (b) those recruited in 1956-60 with those recruited in 1961-65.

Comparison of 184 DSSOs retained with 119 DSSOs lost yields in each group a mean grade-point average of 3.1 with a standard deviation of 0.4. Comparison of 152 DSSOs recruited in 1956-60 with 151 recruited in 1961-65 shows means of 3.1 and 3.2, respectively, with a standard deviation of 0.5 in each case. This difference is not statistically significant at any acceptable level of confidence.

16. SEASONAL VARIATION IN EMPLOYMENT

It is of some interest, in connection with the management of the total personnel establishment for DSSOs, to know if any seasonal pattern is to be found in the employment of DSSOs. Between 1956 and 1960 there was a substantial net gain in DSSOs, as annual intake averaged over 60 and losses were fewer than 50, while in 1961-65 the total intake numbered over 200, about equalling the losses. Since intake and loss nearly balanced in the latter period, it was used for the analysis of seasonal variation. The analysis yielded the following data, which are also presented graphically in Fig.5.

Monthly Change of DSSO Strength (average of 1961 -- 1965)

Month	<u>Jan.</u>	<u>Feb.</u>	<u>Mar.</u>	<u>Apr.</u>	<u>May</u>	<u>June</u>	<u>July</u>	<u>Aug.</u>	<u>Sept.</u>	<u>Oct.</u>	<u>Nov.</u>	<u>Dec.</u>
Intake	2	2	1	5	6	4	4	2	5	6	3	2
Loss	1	2	4	3	3	3	4	5	9	3	3	1
Net change in strength	1	1	-2	0	3	4	4	1	-3	0	0	1

Nearly half the intake occurs from April to July, with a marked drop in August and an upward surge in the fall. November to March are low months, like August. Over 40 per cent of losses take place in July, August, and September; few DSSOs leave during the winter. The interaction of the two patterns results in a maximum strength in the summer, with minimum in late winter and early fall. It should be noted that none of this results in a total average variation at any time of more than one or two per cent of the DSSO strength.

PROGRESS

17. RELATION OF SALARY TO EXPERIENCE

In studies of salary progress conducted elsewhere, it has been the practice to relate salary either to age or the number of years from the primary degree. As most persons obtaining a bachelor degree do so between the ages of 20 and 25, these two correlates of salary are themselves closely associated. In the present instance, years from bachelor degree was used. The simplest approach to the matter is to correlate the values involved for a current population, and this has been done for DSSOs as of 1 April 1966, treating separately three mutually exclusive sub-groups of bachelor, master, and doctor graduates. When a line representing whatever association exists is plotted, this may be taken by inference to show how the average individual would progress over a period of years. It should be noted, however, that this is only an inference, because the data are not based on an actual historical account of anybody's advancement.

18. The number of years from the bachelor degree for the present DSSO population ranges from zero to over 40 years. When salary is plotted against these, it is apparent that while a straight line will describe the relation quite well as a first approximation, the variability of salary increases with diminishing numbers of cases in the upper age range (over 50), and there tends to be a levelling-off of average salary. Another way of expressing this is that while a number of individuals continue progress on a straight-line basis, or nearly so, the progress of others diminishes markedly after a certain stage. This is particularly true for the Bachelor and Master degree groups, and less true for the Doctor group.

19. For each degree group the linear regression equations were computed, and a straight line bisecting the two regression lines was drawn. This line is shown for the several groups in Figs. 6 to 10. The computations were made separately for each degree group for the periods of 15, 20, 25, 30, and unlimited years from the Bachelor degree. Naturally, in view of what has been mentioned concerning the form of scatter of the data, the best fit by a straight line is achieved for the least number of years. However, the correlation coefficient drops less rapidly than might be expected as the age range is extended, partly because the line of best fit rotates clockwise on the point of origin to accommodate the data.

20. VARIATION BETWEEN ACADEMIC DEGREE GROUPS

It is apparent that the Doctor line is always above the other lines, and tends to diverge from them, and that the Master and Bachelor lines do not distinctly differ, since first one will be higher, then the other, and sometimes they cross. The increasing divergences of the Doctor line from the others as the time-span is extended results from the fact that in the later years there are more highly paid Ph.Ds. Of the DSSO 7 class and higher, 62 per cent held the doctorate; DSSO 6, 34 per cent; DSSO 5, 44 per cent; DSSO 4, 29 per cent; and DSSO 3, 19 per cent. The shifting of the Bachelor-Master lines relative to each other results from variations, in successive five-year periods, of the extent to which salaries fall off in the one group or the other.

21. It may be questioned whether the differences (or the lack of difference) shown would support sufficiently the incentive to acquire a postgraduate degree. It has been indicated earlier that it appears to be the better student who goes further up the academic ladder, and obviously in doing so he sacrifices a certain amount of his immediate earning capacity. It does not seem likely that the Master graduate with a degree will at any given subsequent time in his employment with DRB have gained any financial advantage from the degree: indeed, he may even have lost. For the Ph.D. degree, it may be assumed that four years is usually required, and that had the student alternatively engaged in DRB employment he would have earned during this period some \$25,000 to \$30,000. Using the 25-year data of Fig. 8 (i.e. 21 years of Ph.D. employment) he would over that period recoup about \$19,000 to add to whatever income he had as a postgraduate student. By that time he would be 45 or 50 years of age.

22. U.S. DATA

By way of comparison, a recent U.S. Department of Defense report (MAN 65-1, September 1965) indicates that in their internal laboratories an average differential is maintained (increasing with time) between Bachelors and Masters of \$500 to \$2,000, and between Bachelors and Ph.Ds. of \$2,000 to \$4,000. At the same time this U.S. report comments that in industry there is a tendency to pay a premium for highly qualified research people in their earlier years, when a scientist is most productive as an innovator, and to pay less later on; while in government organizations seniority appears to be more important.

23. DIRECT ASSESSMENT OF CUMULATIVE EARNINGS

It has already been remarked (Sec. 17) that any observations such as the immediately foregoing are based on inference. It is not easy to verify them by an inspection of salary histories, because any employment history within DRB is limited to about 18 years (1947-1965), salary scales have changed frequently, and educational and employment histories do not follow a single, simple pattern. However, it was found possible to isolate a group of 100 cases (out of about 570) in the three degree groups, subject to the following constraints:

- Recruited between 1947 and 1960 and still on strength at 31 December 1965.
- Bachelor degree awarded not later than 1956.
- Final degree awarded within two years of date of recruitment.
- Not over two years from bachelor to master degree.
- Not over five years from bachelor degree to doctor.

The salary records, including the evidence of income during the postgraduate student period from scholarships, summer or part-time earnings, Department of Veterans Affairs support in the case of veterans, etc., were examined for these 100 DSSOs, of whom 45 held the bachelor degree only, 24 the master degree, and 31 the Ph.D. or D.Sc. The data, showing the cumulative income from the bachelor degree for the three degree groups against year of bachelor graduation, are plotted in Fig. 11. Each entry represents the mean cumulative income of from one to 11 DSSOs — typically two or three.

24. These data, while admittedly based on quite small numbers of records, tend to bear out the proposition advanced earlier that no financial advantage exists in the master degree. In fact, in 8 of 10 year-groups the mean cumulative earnings of the bachelors are higher. For those holding the doctorate, the data suggest that over the period extending roughly from the tenth to the fifteenth year after the Bachelor degree (that is, while the typical individual is in his middle thirties), the cumulative earnings, year by year, are the same as for DSSOs without the doctorate. There is some indication that subsequently those with the doctorate may start to pull ahead. For a few years after the acquisition of the doctorate, the cumulative earnings are almost sure to be less than for the non-doctorate graduate because, even with a differential of \$2000 or \$3000 in starting rates, the low income of the postgraduate student puts him at an initial financial disadvantage. For the 31 Ph.Ds. or D.Sc.s. examined in this group, the mean number of years of university residence required for this degree was 3.6 (range of 2 to 5 years), and in this period the mean estimated income was under \$2000 per annum (typically, during the early 1950s). Over the same years a DSSO with a bachelor degree would have earned from \$4000 to \$5000 per annum. Thus, neglecting expenditures for fees, books, etc., there would have been an initial deficit in cumulative earnings of the order of \$10,000 to be made up. This is apparently accomplished within five or six years after employment.

25. COMPARISON OF INDIRECT AND DIRECT FINDINGS

There is, then, no serious discrepancy between the inferential and the direct findings on the financial status of those DSSOs with the master degree relative to the bachelor. However, the data for those with the doctorate are somewhat in conflict, since the one set (inferential) suggest that about 20 years of employment may be required before some net financial advantage is gained, while the other (direct findings) suggest a figure nearer 10 or 12 years.

26. GRADE PROGRESSION

The foregoing correlations of salary with years from the bachelor degree are based on a cross-sectional analysis as of the end of 1965. A more direct approach to the same question would be to examine increases in salary on an historical basis for DSSOs employed by DRB. This involves the difficulty that salary scales have changed substantially over the years. The difficulty may be overcome by reference to grades, which have not altered greatly since 1951. The only substantial change in grade structure has been the downward extension in 1953 of DSSO 2, and to a lesser extent of DSSO 3 and 4.

27. On the assumption that entry into a new grade might be used as a measure of progress, the records for all DSSOs employed during a 15-year period were examined to determine the number of years since bachelor graduation at which such promotion took place. This yields the following tabulation of median number of years for DSSO 3 to 7, subdivided by those with bachelor, master, and doctor degrees, and by the time periods 1951-55, 1956-60, and 1961-65. Medians were not computed for fewer than 15 cases.

GRADE		1951-55			1956-60			1961-65		
		B	M	D	B	M	D	B	M	D
DSSO 3	No.	68	44	37	70	37	3	30	50	1
	Md.	4.7	5.3	5.4	4.2	4.5	-	3.4	3.5	-
DSSO 4	No.	25	21	58	38	32	70	27	27	32
	Md.	11.3	12.1	10.7	8.8	9.8	9.3	11.2	12.2	10.5
DSSO 5	No.	17	8	22	7	15	27	25	18	46
	Md.	14.4	-	15.0	-	18.0	12.8	14.2	15.0	15.2
DSSO 6	No.	7	-	5	1	8	9	6	3	8
	Md.	-	-	-	-	-	-	-	-	-
DSSO 7	No.	-	-	6	3	-	5	1	2	4
	Md.	-	-	-	-	-	-	-	-	-

The only regular change between successive five-year periods appears to have been a decrease from about five to three and a half years as the typical length of time required to enter DSSO 3. This is explicable in part by the downward extension of DSSO 3 in 1953. Although there were too few cases in DSSO 6 and 7 to permit medians to be computed for each sub-group, there was nothing in the data to suggest systematic differences for the three time periods, except that promotions to DSSO 6 were made earlier in 1951-55 than in 1956-65.

28. Combination of the foregoing data for the three time periods yields the following table:

GRADE		Bachelor	Master	Doctor	All
DSSO 3	Number	168	131	41	340
	75th Percentile	-	-	-	6.0
	Median	4.3	4.2	5.3	4.4
	25th Percentile	-	-	-	3.4
DSSO 4	Number	90	80	160	330
	75th Percentile	-	-	-	12.5
	Median	10.4	10.9	9.7	10.2
	25th Percentile	-	-	-	8.2
DSSO 5	Number	49	41	95	185
	75th Percentile	-	-	-	18.2
	Median	14.2	16.1	15.1	14.8
	25th Percentile	-	-	-	12.6

DSSO 6	Number	14	11	22	47
	75th Percentile	-	-	-	23.1
	Median	20.5	21.2	18.5	20.0
	25th Percentile	-	-	-	16.1
DSSO 7	Number	6	2	14	22
	75th Percentile	-	-	-	24.0
	Median	-	-	-	21.7
	25th Percentile	-	-	-	19.0

It appears that there is no substantial and regular difference in progress rates for the three degree groups. From DSSO 3 to 6 the trend for the entire group might be generalized in terms of a "Rule of Five Years" — i.e. those who are promoted through successive grades are promoted every five years. The interquartile range lies typically from 15 to 25 per cent on either side of the median.

29. PROMOTION HISTORY OF HIGHER-LEVEL DSSOs

The above-mentioned "rule" of course neglects the fact that the actual history of those reaching the higher grades may have been different at the lower grades. If each of the senior grades is considered separately, the following data emerge:

Time (in Years) after Bachelor Degree to Reach Highest Grade yet Attained

	<u>DSSO 5</u>		<u>DSSO 6</u>		<u>DSSO 7</u>	
	No.	Median	No.	Median	No.	Median
DSSO 7	-	-	-	-	22	21.7
DSSO 6	-	-	24	20.0	20	17.5
DSSO 5	143	14.5	21	15.0	16	14.3
DSSO 4	112	9.5	17	10.0	9	11.0
DSSO 3	42	5.8	-	-	-	-

The only difference that appears between this and the preceding table is the fact that those reaching DSSO 7 attain DSSO 6 sooner than others. They do not, however, attain earlier grades any sooner.

30. COMPARISON WITH UNIVERSITY STAFFS

These progress rates for DSSOs may be compared with those shown in the report of the Pay Research Bureau of the Civil Service Commission, February 1965, on "The Trend of Rates of Pay for University Teachers, 1963-64 to 1964-65". That report furnishes the median number of years from the bachelor degree for university staff by rank for the standard PRB sample for 1964-65. These are 10, 16, and 25 years for assistant, associate, and full professors. Treating a DSSO 3 as an assistant professor, a DSSO 4 as an associate, and a DSSO 5 as a full professor, the corresponding DRB medians for the end of 1965 are 7.5, 14.5, and 18.5 years. The DRB data are most like those for the engineering faculties of the western universities, which show medians of 8.5, 13.5, and 20 years.

31. COMPARISON WITH INSTITUTIONAL STANDARDS

A further comparison may be made with the standards quoted in the same report for the Canadian Service Colleges and the National Research Council. These include:

- four years' relevant experience after first degree (together, in the case of the NRC, with a master degree, and in the case of the Colleges, a doctor) for entry into the equivalent of DSSO 3;
- eight years' experience after first degree (or in the case of the NRC, Ph.D. plus four to six years' research experience) for entry into the equivalent of DSSO 4;
- and twelve years of experience (or in NRC, 10 to 15 years' experience beyond Ph.D.) for entry into the equivalent of DSSO 5.

The DRB experience appears to be roughly consistent with these standards.

32. CONCLUSIONS REGARDING GRADE PROGRESS

The main conclusions from this portion of the analysis appear to be:

- (a) There is a numerical regularity in the number of years since bachelor degree at which a grade level is attained. This involves a multiple of about five years. There is appreciable variation around these median values;
- (b) There is no strong indication of differing rates of progress for those at different academic degree levels;
- (c) Only at the DSSO 7 level is there evidence that earlier progress for those attaining that level has been accelerated;
- (d) The grade progress of DSSOs appears to compare favorably with progress in the larger Canadian universities and to be roughly compatible with the published standards of the Canadian Services Colleges and the National Research Council.

33. GRADE DISTRIBUTION RELATIVE TO YEARS FROM GRADUATION

The data presented up to this point suggest the average salary level to be expected with increasing years of experience, and the average number of years required to attain a given grade level, together with the variation surrounding the latter. In conducting this study it was hoped to determine also the probability that a DSSO commencing at a lower point in the scale would achieve a higher grade in a given length of time. This was approached by tabulating the recruitment, promotion, and separation history of all DSSOs other than those employed only in 1947-1950 (for which period complete data were not available). These tabulations were then combined on the basis of the number of years from the bachelor degree that each DSSO was employed when the change of status took place. The resulting data, showing the total numbers of DSSOs in each grade relative to years from bachelor graduation, are given in Table 1, and the same data are expressed as percentage at each grade level in Table 2.

TABLE 1. Total Numbers of DSSOs in Each Grade Relative to Years from Bachelor Graduation

Years from Bachelor Degree	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42						
DSSO 1	23	32	15	7	2	1	4	2	1	1	1	1	14	11	9	6	2	4	4	4	1	1	1																									
2	91	171	230	186	129	82	57	37	22	18	11	10	14	11	9	6	2	4	4	4	1	1	1																									
3	1	3	19	116	233	302	319	318	279	206	182	137	98	79	62	49	39	39	36	27	26	23	22	16	13	12	12	8	5	4	3	3	2	1	1	5	4	5	5	5	3	2	2	2	2	2	2	
4		2	1	2	3	10	26	65	90	129	167	197	193	183	170	145	110	80	69	59	53	47	43	43	37	33	30	25	22	20	18	14	11	7	6	6	4	4	2	2	1	2	2	1				
5			1	1	1	1		3	7	9	15	24	43	65	78	84	87	84	67	69	65	64	53	46	39	38	31	28	26	19	18	15	14	13	8	9	6	4	4	3	3	2	2	2	2	2		
6											1	3	3	4	5	9	13	17	19	17	20	25	25	28	26	19	18	18	16	17	14	13	8	9	6	4	4	3	3	2	2	2	2	2	2	2		
7												1	1	1	1	1	2	3	5	12	15	21	18	16	20	21	17	15	13	13	11	11	10	10	11	10	10	8	4	2	1	1	1	1	1	1		
TOTAL	115	208	266	312	368	396	406	425	399	363	377	372	352	343	325	294	253	227	200	188	184	183	163	150	136	125	110	96	85	76	66	59	48	44	38	33	26	18	12	8	7	6	6	6				

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TABLE 2. Percentage of DSSOs at Each Grade Level Relative to Years from Bachelor Graduation

Years from Bachelor Degree	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42					
DSSO 1	20	16	6	2	1	*	1	*	*	*	*	*	*	*	*	*	*	*	*	*	1	1	1																								
2	79	82	86	60	35	21	14	9	5	5	3	3	4	3	3	2	1	2		14	13	13	11	9	10	11	8	6	5	5	8	8	11	13	15	12	11	16	25	29	33						
3	1	1	7	37	63	76	78	75	70	57	48	37	28	23	19	17	16	18	18	14	14	13	13	11	9	10	11	8	6	5	5	8	8	11	13	15	12	11	16	25	29	33					
4		1	*	1	1	3	7	15	23	35	44	53	55	53	52	49	43	35	34	31	29	25	26	28	27	26	27	26	26	26	27	24	23	16	16	18	15	11	16	12							
5			*	*	*	*		1	2	3	4	6	12	19	24	29	34	37	33	37	35	35	33	30	29	30	28	29	31	25	27	25	29	30	26	24	27	39	25	25	28	17					
6											*	1	1	1	2	3	5	7	9	9	11	14	15	19	19	15	16	19	19	23	21	22	17	20	16	12	15	17	25	25	29	33					
7												*	1	1	1	*	1	1	2	7	8	11	11	11	15	17	16	16	15	17	17	19	21	23	29	31	31	22	17	13	14	17					

* Less than 1/2 of one per cent.

The same percentage data, to the end of the 36th year, are shown in graphical form in Fig. 12.

34. It appears valid to place on this tabulation the interpretation that at a given number of years from the bachelor degree there is a probability of a DSSO having attained a grade level indicated by the percentages shown for that year. The usefulness of this information is possibly twofold:

- (a) Recent thinking about grade structure and careers for research scientists in the public service tends to relate promotions to the proportion who may in the course of their lifetime expect to reach a given grade level.
- (b) It may be of value in projecting personnel establishment requirements some years ahead on the basis of expected aging of the DSSO population (cf. remarks in Section 5 and 8).

GENERAL CONCLUSIONS

35. Without attempting to summarize the detail of this report, there appears to be one conclusion arising from each of its two main sections which is worthy of some special emphasis.

The first conclusion, on employment, is that it would be worthwhile to examine in more detail the circumstances leading to the loss of a high number of DSSOs, most of them of acceptable quality, early in their employment with DRB. Although this experience is not thought to be different from that of other comparable employers, it is a wasteful situation. The first year or two of a DSSO's employment involves little more than his getting started in a program, while a few more years might result in a reasonable amount of achievement. In addition, rapid early turnover must be compensated by corresponding replacement through recruitment. In the near future, this recruiting effort may be more appropriately directed toward replacement of the increased number of DSSOs who will be retiring to pension.

The second conclusion is that the policy of progression for those with postgraduate training should be reviewed. The chief purpose of such training is presumably to enhance the individual's capability for independent, creative research. There appears to be no financial incentive for this at the master degree level. It does appear to exist for the Ph.D., but financial reward is deferred for some time and does not become significant until the scientist reaches his forties; by this time the major part of the scientific innovation of which he is capable may lie behind him. DRB has so far been able to employ a higher percentage of DSSOs with postgraduate degrees, although in the past 10 years it lost three or four more Ph. Ds. annually than it acquired (cf. Sections 9 and 13), and partially in consequence has undertaken a vigorous scholarship program to counterbalance these losses. If this high proportion of staff with postgraduate training is actually required, it is for consideration whether a salary policy should be applied to pay substantially more to the active and productive independent research worker earlier in his career, and possibly no more later on unless an unusual degree of creativeness is maintained or enhancement of his salary then is justified on the basis of other and different values, such as staff duties or management responsibility.

January 6, 1967.

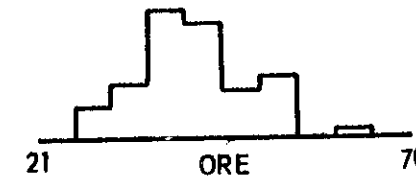
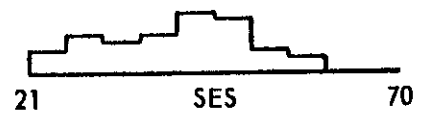
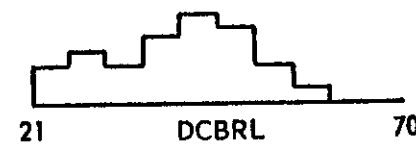
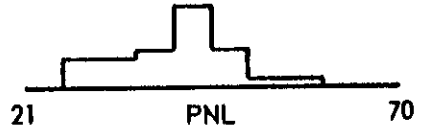
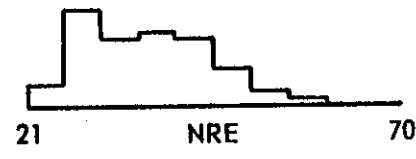
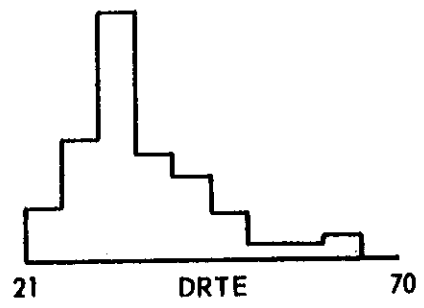
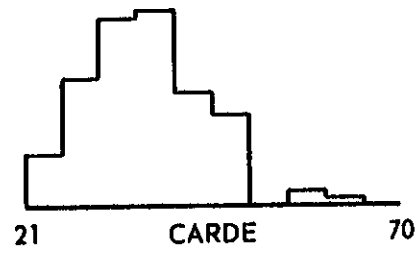
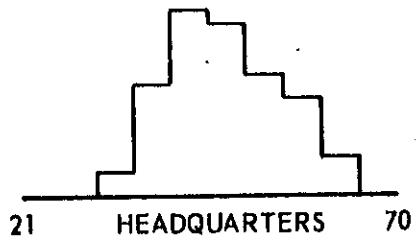


Fig. 1. Age distribution of DSSOs, by Establishments December 1965.

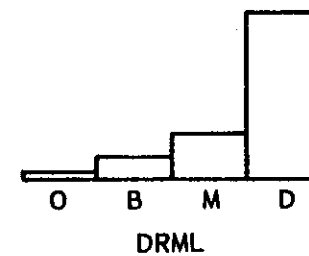
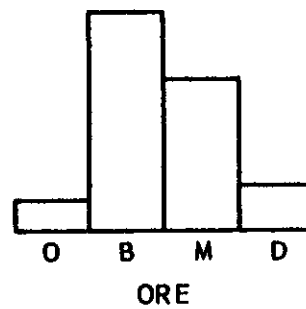
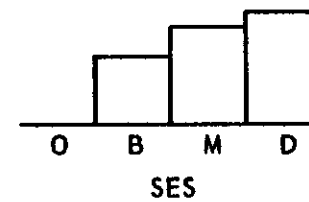
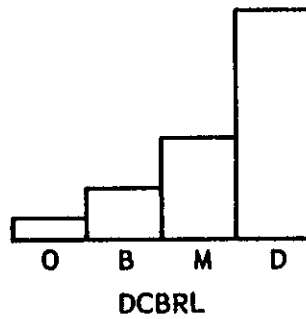
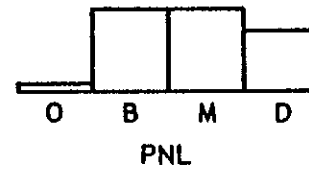
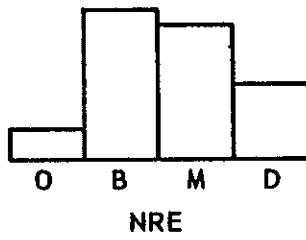
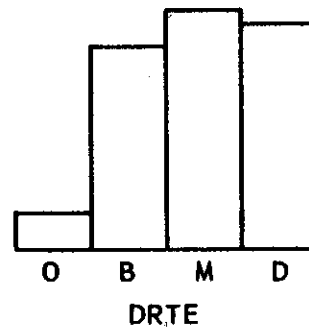
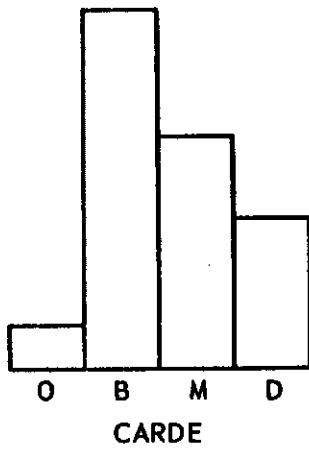
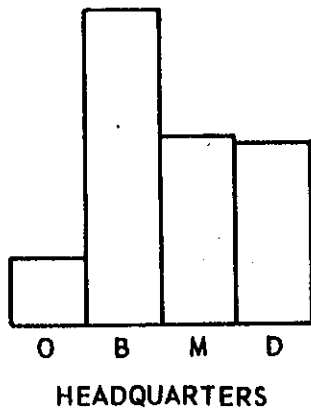


Fig. 2. Highest Academic Degrees of DSSOs, by Establishments December 1965.

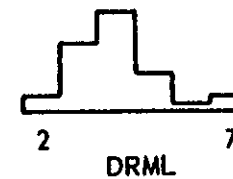
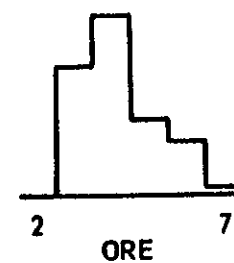
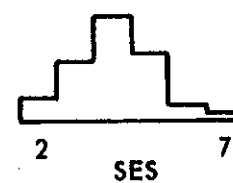
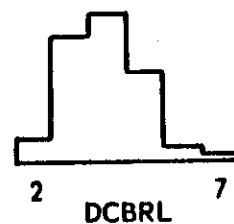
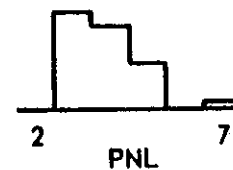
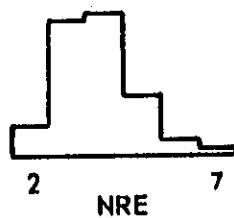
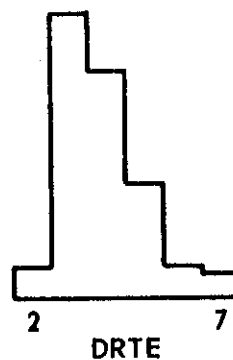
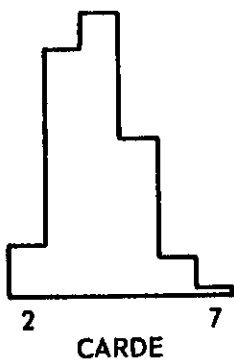
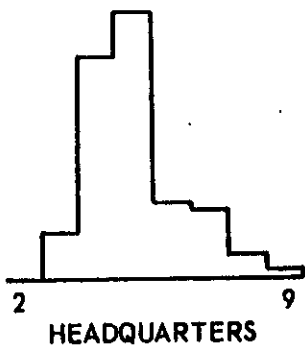


Fig. 3. Grade distribution of DSSOs, by Establishments December 1965.

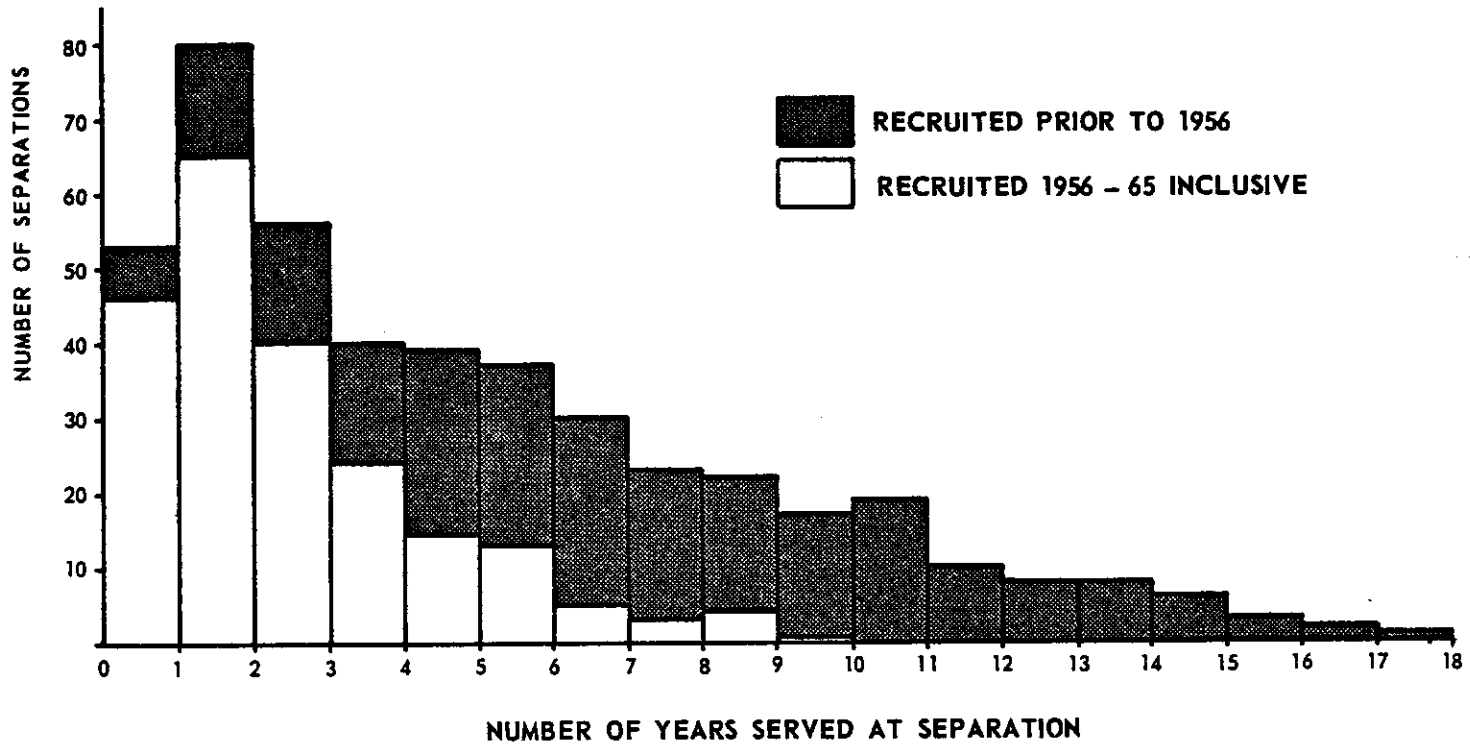


Fig. 4. Duration of employment of DSSOs who left from 1956-65 inclusive.

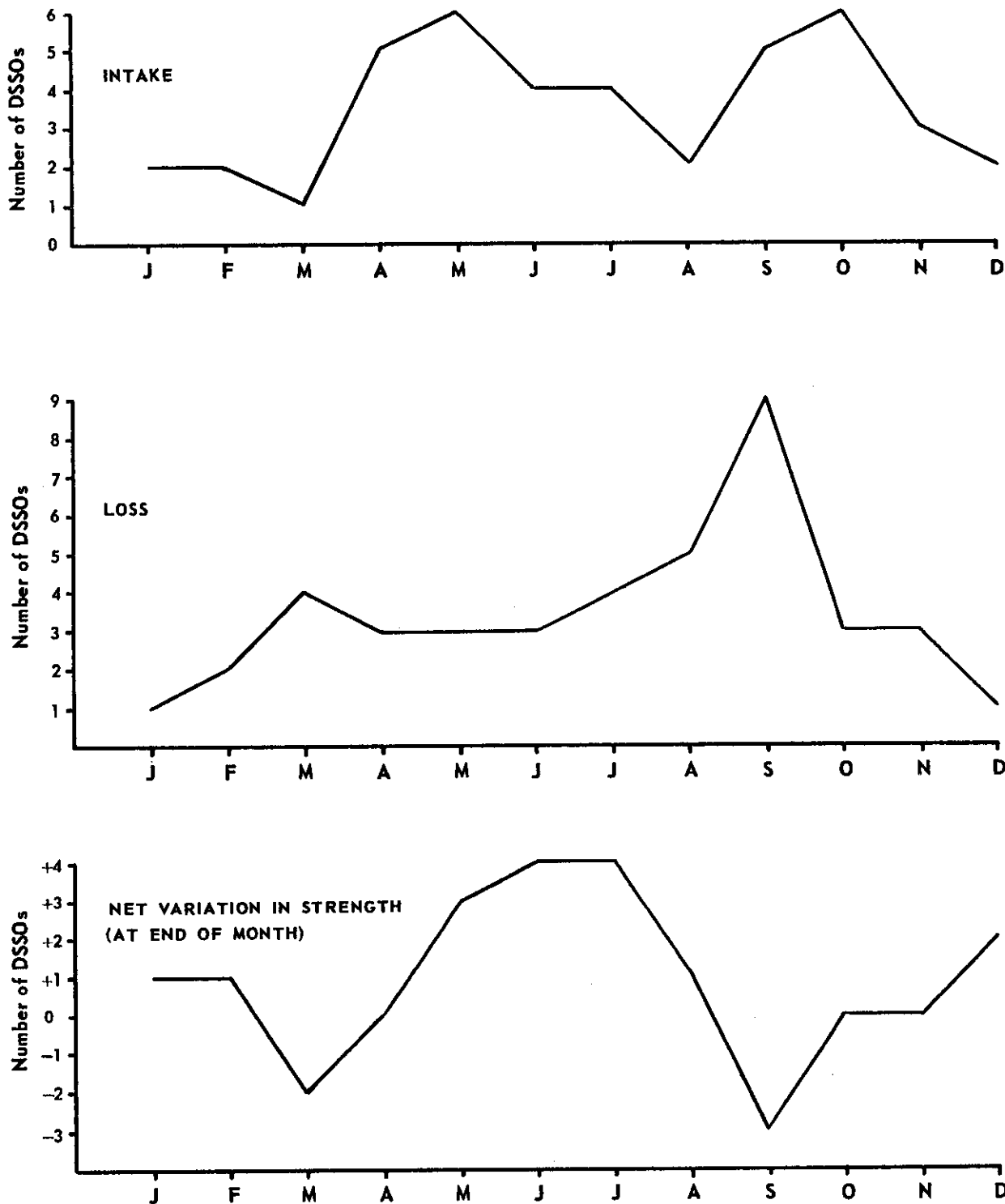


Fig. 5. Average monthly change of DSSO strength (average of experience from 1961-65).

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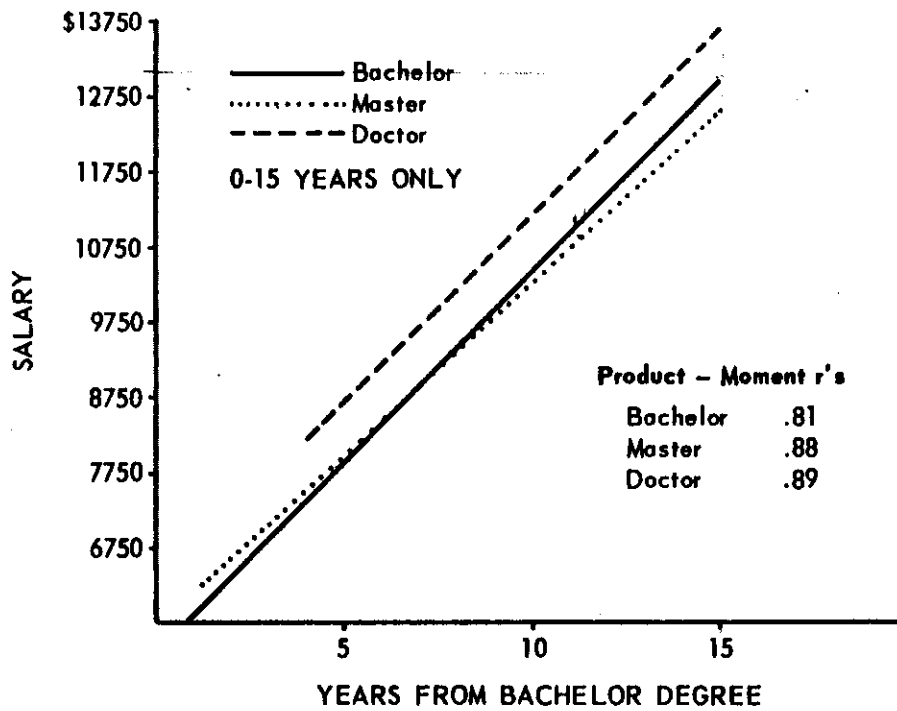


Fig. 6. Relation of salary to years from Bachelor Degree (line bisecting regression lines) for DSSOs on 1 April, 1966.

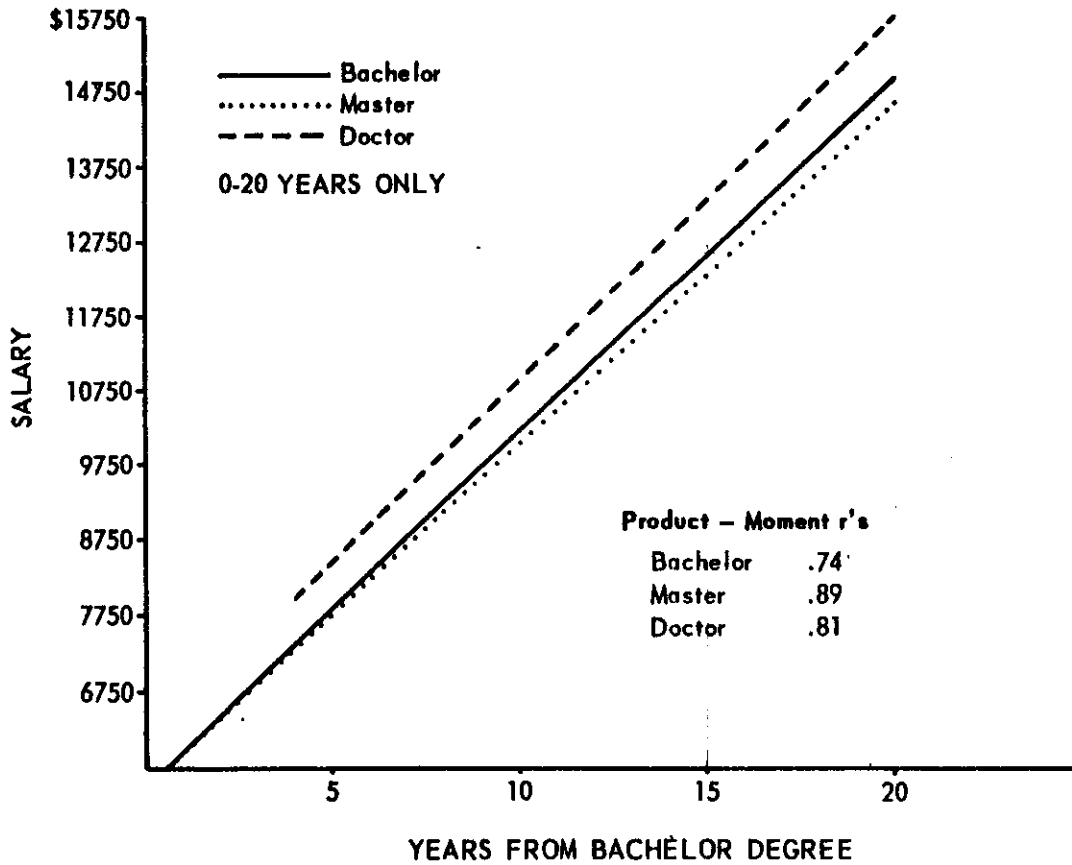


Fig. 7. Relation of salary to years from Bachelor Degree (line bisecting regression lines) for DSSOs on 1 April, 1966

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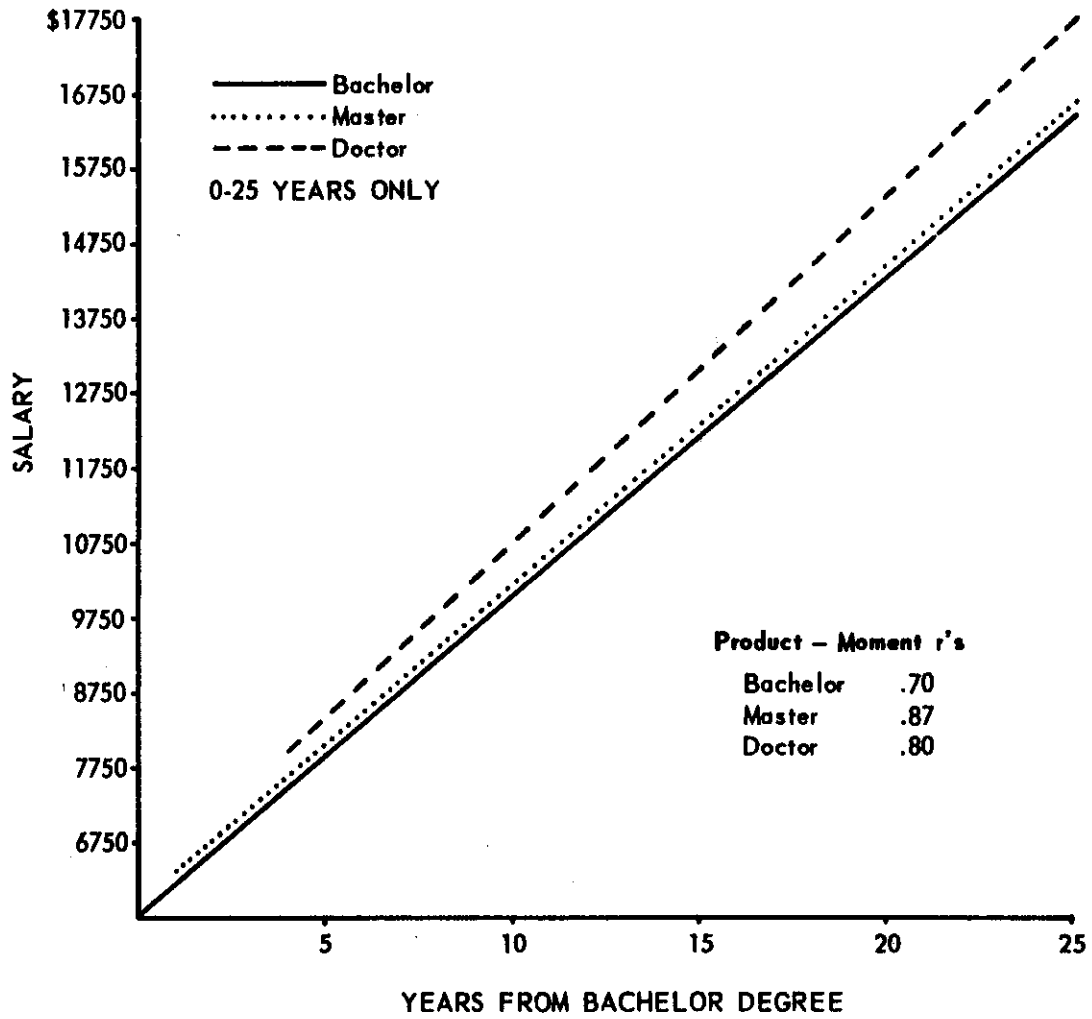


Fig. 8. Relation of salary to years from Bachelor Degree (line bisecting regression lines) for DSSOs on 1 April, 1966.

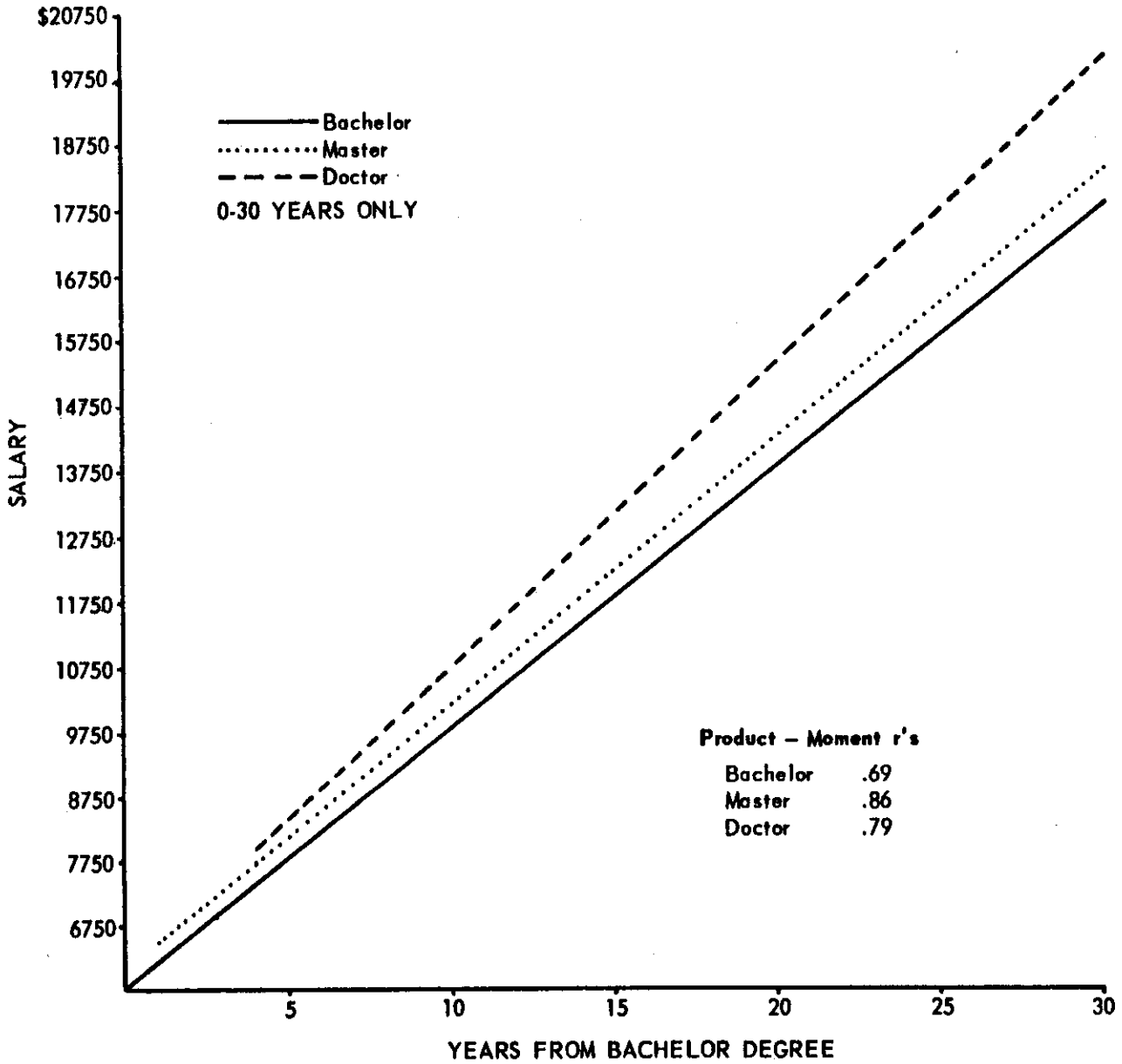


Fig. 9. Relation of salary to years from Bachelor Degree (line bisecting regression lines) for DSSOs on 1 April, 1966.

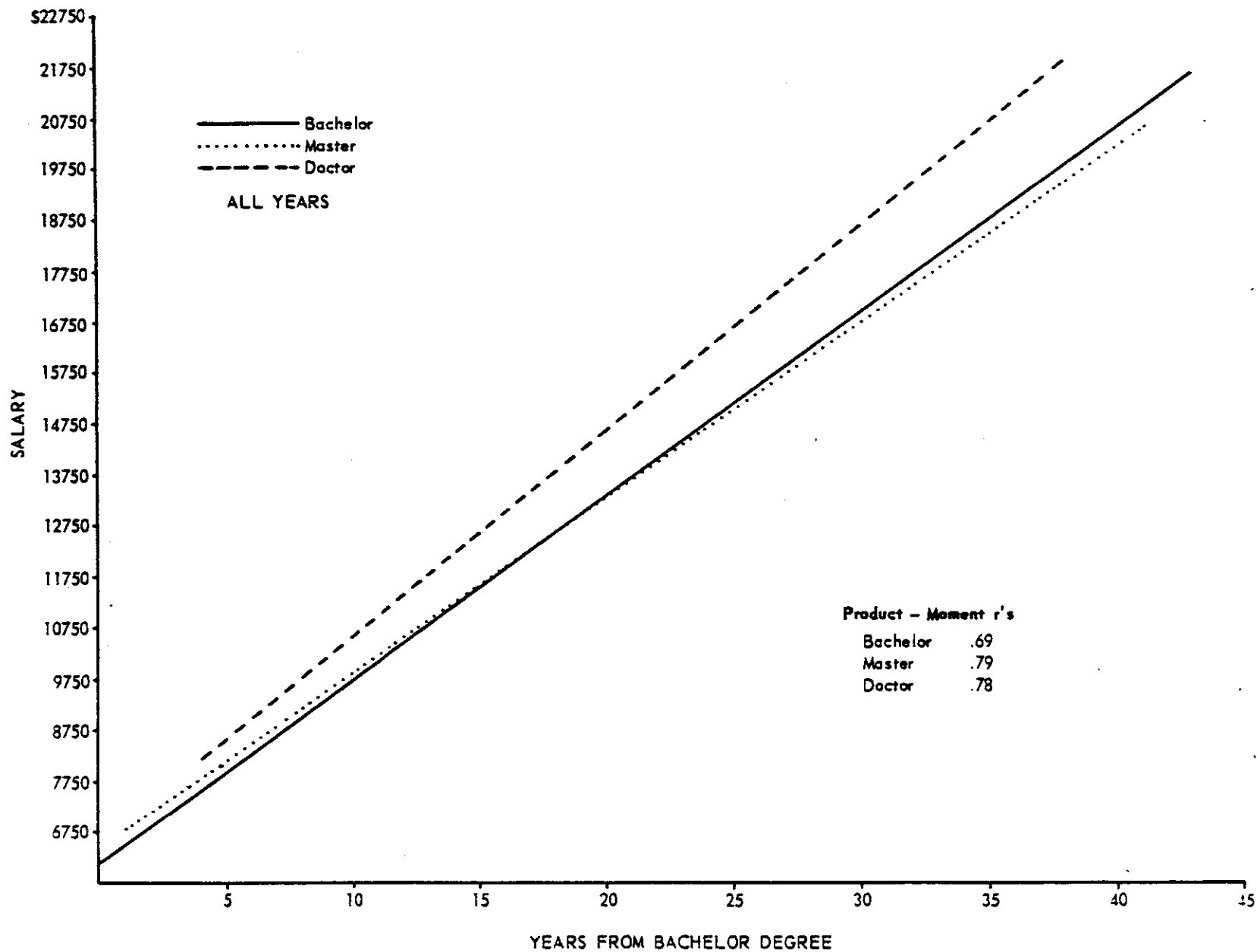


Fig. 10. Relation of salary to years from Bachelor Degree (line bisecting regression lines) for DSSOs on 1 April, 1966.

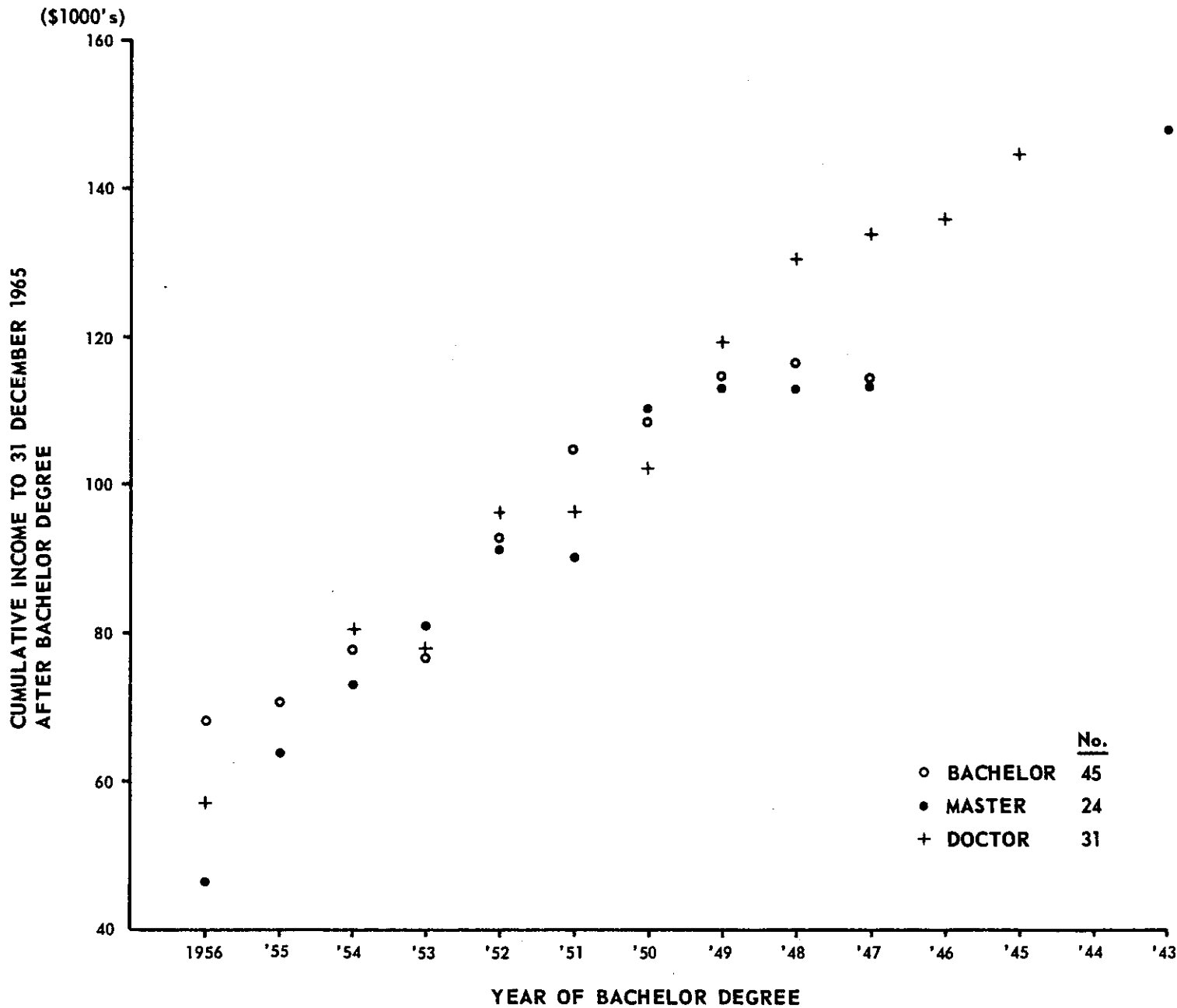


Fig. 11. Cumulative Earnings from Bachelor Degree for Graduates with Bachelor, Master or Doctor Degrees.

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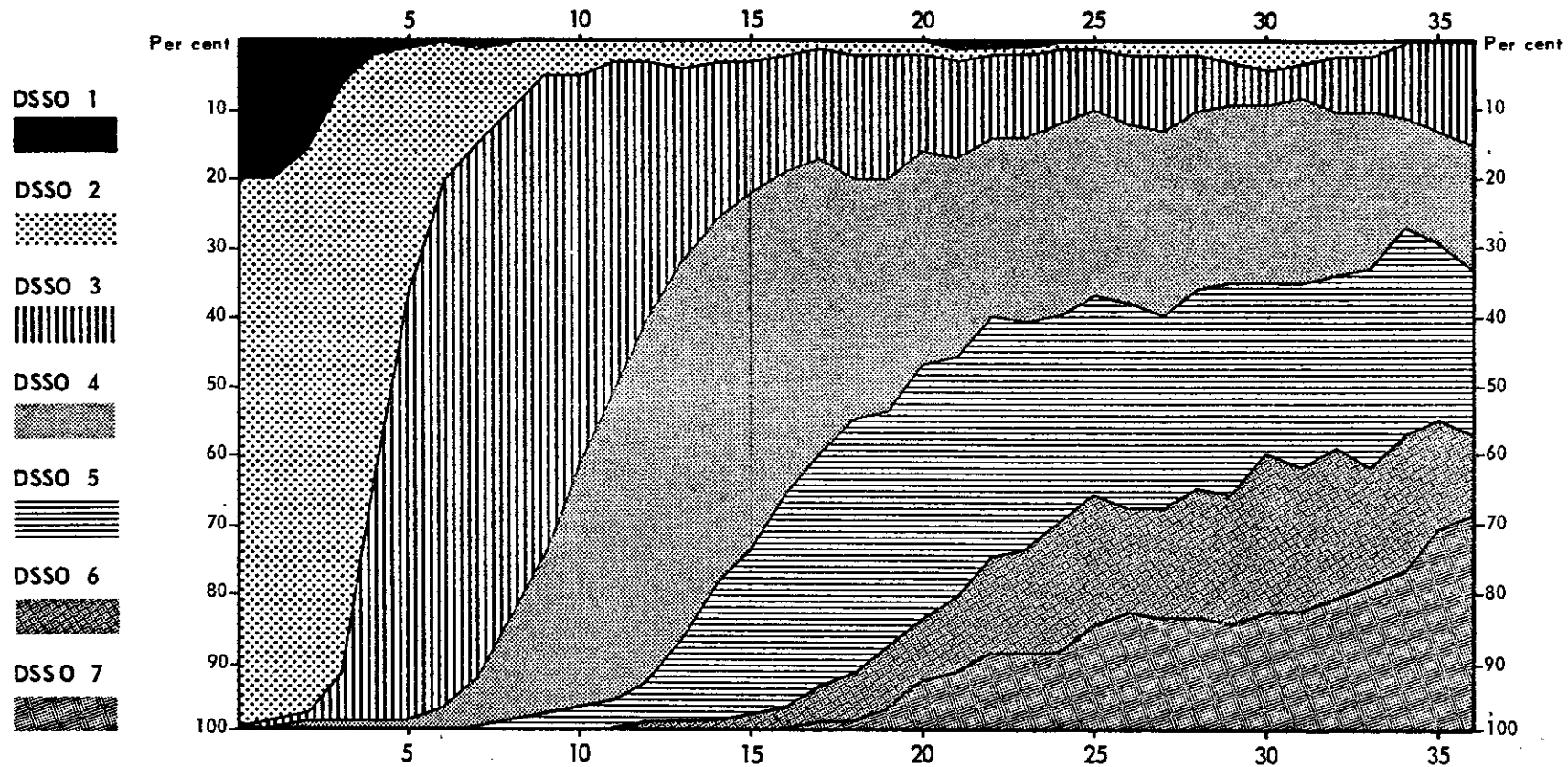


Fig. 12. Percentage of DSSOs at each Grade Level Relative to Years from Bachelor Graduation.

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