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ABSTRACT

The study indicates that jobs in astronomy have become severely limited in the last few years, with a near balance between supply and demand of astronomers. The following issues are assessed in this study: the current supply of astronomers in the United States, and its change as a function of time; the background and make-up of astronomers in the United States; how recent recipients of Ph.D. degrees in astronomy or astrophysics obtained their first professional position; current level of unemployment among United States astronomers, and how it compares with rumors about the situation; nature of the first professional position of recent degree holders; the degree of satisfaction of such persons with their current employment; and conclusions and recommendations drawn from the above considerations. Conclusions indicate that a major cause of the very limited employment opportunities in astronomy has been the migration into this field by scientists from other disciplines, especially physics, where the job opportunities are worse. (PR)

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# MANPOWER AND EMPLOYMENT IN AMERICAN ASTRONOMY

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## 1. INTRODUCTION

Ironically, the topic regarding astronomers that has been the most carefully scrutinized at the highest levels has not been their education, but their number. Until recently these studies generally concluded that there was a shortage of astronomers in the United States, and that the shortage was expected to continue into the 1970's[1,2]; e.g. as recently as 1969 the U.S. Department of Labor[3] stated that

> Employment opportunities for astronomers with the Ph.D. degree are expected to be excellent through the 1970's. Well-qualified persons with only bachelor's or master's degrees in astronomy also will have good employment prospects...

Today, however, the general concensus about astronomy, like for other sciences, is that an acute manpower problem exists and shows no signs of subsiding.[4,5]

This paper attempts to assess the following questions:

(a) What is the current supply of astronomers in the

U.S., and how has it been changing as a function of time, especially in comparison with other fields?

(b) What is the background and make-up today of astronomers in the U.S.?

(c) How have recent recipients of Ph.D. degrees in Astronomy or Astrophysics obtained their first professional position?

(d) In fact, what is the current level of unemployment among U.S. Astronomers, and how does it compare with rumors about the situation?

(e) What is the nature of the first professional position of such recent degree holders?

(f) How satisfied are such persons with their current employment?

(j) What conclusions and recommendations can be drawn from the above considerations?

Since manpower and unemployment are extraordinarily controversial and significant topics, it might be appropriate to note a few matters that this paper does not treat:

(a) International migration of scientists. It might be noted, nevertheless, that job shortages in astronomy exist elsewhere, although not always so acutely; cf., Roeder and Kronberg.[6]

(b) Longitudinal study of migrations into and out of the field. Such an ambitious analysis is being made at the American Institute of Physics (A.I.P.) for physics, including astronomy.

(c) Projections. Although fascinating, projections are almost impossible to make accurately; nevertheless, they are being constructed for science in general.[7-10] To make accurate predictions for astronomy would require a detailed analysis of current and projected manpower needs and funding allocations, all of which are speculative.

## 2. SOURCES OF DATA

Most data sources for manpower in American Astronomy have been discussed by Berendzen.[11] In this study, three sources were used:

(a) The National Register of Scientific and Technical Personnel of the National Science Foundation (NSF). The Register,[12] which is compiled biennially, collects information on the supply, utilization, and characteristics of scientists in the United States. NSF sends a questionnaire to members of U.S. professional scientific organizations. Typically the response rate for holders of Ph.D.'s is about 80 to 95%. Unfortunately, comparisons among the Register's data for various epochs are problematical, because NSF has made changes in its definitions of scientific fields and professional standing.

This study includes unpublished data from the Register that were provided by NSF, analyzed by computers at the A.I.P., and studied at Boston University.

(b) Information on enrollment for advanced degrees[13] and earned degrees awarded[14] from the U.S. Office of Education (Department of HEW). Since H.E.W. collects these data annually from hundreds of graduate institutions, the information is not always consistent or complete, although it is nearly so.

(c) A questionnaire sent to recipients of Ph.D. degrees in astronomy or astrophysics at U.S. institutions between 1967 and 1970. This form was sent in spring 1971 under the auspices of the Statistics Panel of the Astronomy Survey Committee of the National Academy of Sciences.

Eighty-two percent of the persons polled returned their forms, which is a substantial response rate considering the length and complexity of the questionnaire. Efforts were made to insure that all appropriate persons received questionnaires by having the forms forwarded to them by their graduate institutions. No sampling bias was detected for the respondents either in their graduate institutions or in their year of award of Ph.D. It is possible that persons who received their degrees in astronomy but have since left the field would not have received the form or would not have responded to it. There was no indication in the replies, however, that this biased situation had occurred. The high response rate plus lack of detectable

bias seem to indicate that the sample in this study is representative of recent recipients of astronomy doctorates in the U.S.

## 3. MANPOWER

### 3.1 The Increasing Population

One of the most perplexing problems in analyzing manpower in astronomy is to define who astronomers are. Astronomy's hybrid, multifaceted nature makes it difficult to distinguish uniquely from its sister disciplines of physics, geophysics, engineering, and the like. Two modern areas of research are especially problematic in this regard: space-and-planetary physics and relativistic astrophysics.

After carefully analyzing the manpower data in the National Register, the authors of this paper believe that the best estimates of the current manpower pool in American astronomy are shown in Figure 1.

Figure 1

Both the total number of full-time-equivalent (FTE) persons employed in astronomy and the number with Ph.D.'s who are working in astronomy, irrespective of the field of their degree, have approximately tripled during the past decade.

One measure of the recent rapid growth of astronomy is the increase in the rate of awarding of doctorates in the field. Figure 2 shows that from 1920 until 1960 the annual rate of

Figure 2

growth of the number of astronomy doctorates was only about 4%, compared with a rate in other sciences of 7%. Beginning in about 1960, with the advent of the space era and the rise of modern astrophysics, astronomy's annual growth rate jumped to roughly 15 to 20%. Thus for the past decade astronomy has been expanding exceptionally fast, but over the broader time scale of the last fifty years, the recent surge has only brought the field into approximate equilibrium with the average in other sciences. Clearly, however, the recent expansion in astronomy could not be maintained indefinitely without draining proto-scientists from other fields and necessitation a realignment of the nation's priorities in science.

Not surprisingly, the number of departments that have awarded graduate degrees in astronomy have also risen during the past decade. Figure 3 shows that while the number of institutions granting Ph.D.'s in the field remained nearly constant through the 1950's, it nearly tripled during the 1960's.

Figure 3

There is evidence, nevertheless, that the proliferation of astronomy degrees may have begun to subside, as is indicated in Figure 4. (No reliable data are available for 1968-69).

Figure 4

Apparently the relative influx into graduate programs in the field has begun to taper. If so, obviously the rate of pro-

duction of graduate degrees in astronomy will lessen. But that effect alone will not cause a decline in the rate of production of astronomers, because of the enormous influz into astronomy from other fields.

3.2 Influx From Physics

The Register data indicate that approximately 700 new Ph.D. holders have entered astronomy during the last decade. According to HEW[14] reports, approximately half that number of Ph.D. degrees were awarded by U.S. astronomy departments during the same period. Close examination of the Register data eliminates the possibility that massive immigration of foreign astronomers could have caused this discrepancy. A significant portion of the influx into astronomy must have been caused by a transfer of persons from other degree fields.

The Register data support this conclusion. Whereas in the early 1960's less than a quarter of the Ph.D. holders employed in astronomy held their doctorates in physics, by 1970 the portion had risen to nearly half. During the 1960's, the percentage of doctorates working in astronomy who have Ph.D.'s in fields other than astronomy or physics has remained roughly constant at about 7%. Thus today over half of the Ph.D.'s employed in American astronomy hold doctorates in fields other than astronomy; among American astronomers approximately as many hold their Ph.D.'s in physics as in astronomy.

Such shifts in the graduate preparation of proto-astronomers have dramatic implications. From an educational standpoint, the early 1970's will mark a turning point in the development of modern American astronomy. In the mid-1960's, about 40% of the U.S. astronomers had obtained their undergraduate preparation in physics and 25% had obtained it in astronomy; on the other hand, a great majority of them held Ph.D.'s in astronomy.[16] Today the proportions from graduate programs in physics and in astronomy are nearly equal. And if the trend continues, henceforth the mojority of American astronomers will hold all of their degrees in physics.

Of course, at many graduate institutions the programs in physics and in astronomy are virtually identical; clearly astronomy has become astrophysics. But the shift in the preparation of future astronomers has important educational implications:

(a) To meet the needs and interests of all physics graduate students, physics departments should have on their faculties persons who are knowledgeable in astronomy.

(b) To influence the graduate education of future astronomers, efforts should be placed at least as much in departments of physics as in departments of astronomy.

(c) To influence manpower and employment in astronomy, efforts should be placed at least as much in departments of

physics as in departments of astronomy.

## 4. EMPLOYMENT

### 4.1 The Search for Employment

Because of concern over a shortage of jobs for well-prepared astronomers, a study was made of the issue in spring 1971 for the Astronomy Survey Committee of the National Academy of Sciences. Since the persons most directly affected by a job shortage are usually those who are at the beginning of their career, it was decided to survey recent redipients of Ph.D.'s in astronomy or astrophysics from U.S. institutions.

(Ideally the survey would have included Ph.D. recipients in physics, but this was not attempted because the physics population is too large to reach efficiently and the findings for that group would virtually defy analysis. If they did not find employment in astronomy, what precisely would that mean? If astronomy Ph.D.'s failed to find jobs in their own field, the conclusions would be less vague.)

Figure 5 shows findings from the survey. Although virtually all of the persons in the sample had found employment, apparently the difficulties in doing so has gotten progressively worse during the past four years. The portion receiving more than one job offer decreased from two-thirds for the 1967 graduates to roughly one-third for the 1970 graduates. Since some of the graduates might have received more job offers in

Figure 5

they had not accepted an early one (perhaps out of fear of not receiving others), the data here reflect the lower limits of the potential job market. On the other hand, each year a higher percentage of the graduates sent out larger numbers of applications, yet an increasing fraction of those sending multiple letters received only one job offer. The percentage sending more than three letters rose from twenty-four for the 1967 graduates to fifty-two for the 1970 graduates; in only three years the fraction more than doubled.

During the same period, the way that the first job was found has also changed, as is shown in Figure 6. The influence

Figure 6

of faculty referral on job placement declined for the 1968 and 1969 classes compared with the 1967 class; concomitantly, the effects of previous employment and personal soliciting rose in influence. These changes further demonstrate the tightening of the market.

It should be noted, however, that the situation for the 1970 graduates began to return more towards the situation for the 1967 graduates. This reversal may indicate either a slightly improving market or a more job-wise faculty.

Interestingly, comparison of numerous variables in this study against the relative ranking of "Effectiveness of Doctoral Programs" by the American Council of Education (ACE '67) shows that

the only significant difference among the institutions in terms of employment of their graduates arose in the way by which they

Figure 7

secured their first job. Figure 7 substantiates what might be expected intuitively--that graduates from the highest-ranked graduate programs were greatly aided in their job securement by their faculty, while those from the lowest-ranked programs had to rely more upon their own efforts.

(In Figure 7 only institution listed by the ACE were included. Thus the ranking of "lowest" is the bottom group of the twenty-three institutions that achieved an effectiveness score of at least 0.8 on the ACE's scale for astronomy.)

4.2 Unemployment

According to data from the 1970 National Register,[22] unemployment was not a major problem among astronomers as a whole. Of the non-students in the field, 1.5% were unemployed and seeking employment, a figure that is identical to the average for all scientists listed in the Register. For Ph.D.'s in astronomy the percentage was 0.8, compared with the Register average of 0.9.

It should be emphasized, however, that the job market is constantly tightening. For the class of 1970 in astronomy, the numbers of jobs and of applicants were about equal, which suggests an extremely tight market; moreover, the recent trend indicates that the situation today must be worse, and unless conditions change, will be even more severe next year.

A follow-up survey by the NSF[18] in spring 1971 showed that unemployment among all scientists had risen since 1970 from 1.5% to 2.6%, and for Ph.D.'s from 0.9% to 1.4%; however, for physicists it had risen to 3.9%. Specifically, that survey found that the age group under thirty had the highest

unemployment, and that more than half of the nation's unemployed scientists were in either chemistry or physics.

The findings in this study for recent Ph.D.'s in astronomy indicate that even the ones under age 30 had a comparatively small problem with unemployment. Less than 1% of them were unemployed and an additional group of under 1% were under-employed, in the sense that they could only obtain part-time work; however, half of this total 2% with employment problems had restricted their employment search to specific geographic locations.

In contrast, a report of the Physics Economic Concerns Committee, headed by Professor Lee Grodzins[19] at MIT, found for recent recipients of Ph.D.'s in physics the unemployment and under-employment levels to be about 4% and 2.5%, respectively.

### 4.3 Field of Employment

Even though 99% of the recent Ph.D.'s in astronomy are employed, not all of them found positions in astronomy. Twenty-four percent had looked for a position in other fields, usually physics, computer technology, or "teaching"; but only 9% of those employed today actually had taken a non-astronomical job, which is a natural migration rate in science.[20] The ones who had searched outside of astronomy reported that they had done so primarily because of job scarcity in astronomy or because of their greater interest in another field. Half of the 9% who are employed in other fields had made the change by choice, and a third

of the 9% said that they had sought but had been unable to find a position in astronomy. These statistics, like those in section 4.2, indicate that the current demand for astronomers is essentially equal to the supply, but not in excess of it.

The situation for young physics Ph.D.'s is strikingly worse: about 30% of those who sought employment in traditional sectors of physics in this country failed to secure such jobs.[19]

The percentage of astronomy Ph.D.'s seeking employment outside the field is an indicator of the fear of job scarcity in astronomy. While 13% of the 1967 graduates looked outside astronomy, 40% of the class of 1970 did so.

(Moreover, many of the graduates did not seek regular employment immediately after receiving their doctorates; instead 31% obtained post-doctoral appointments. Only a tenth of these appointments were for less than one year, and no increase in a "holding pattern," or short-term tiding-over period prior to employment was evident.[4,21] Each year from 1967 to 1970 approximately the same fraction of the graduates who applied for post-doctoral fellowships received them -- about 2/3. But during that period the fraction who applied for such appointments rose.)

## 4.4 Nature of the Employment

In 1970, according to the National Register,[22] about 50% of all astronomers were employed by educational institutions, 20% by the government, 10% by non-governmental research centers, and

10% by industry. For Ph.D.'s working in the field, the pattern was different, with 65% being employed by educational institutions.

Table 1

The employers and principal work activities of the recent astronomy doctorates in this study are shown in Table 1. In terms of FTE percentages, the main types of employment were, in decreasing order: research on-campus at educational institutions, teaching on-campus at educational institutions, research at government facilities, and research off-campus at educational institutions. Those four endeavors account for over 3/4 of the total working time of the recent astronomy doctorates.

Note that even though 4/7's of them are employed on-campus at educational institutions, the new Ph.D.'s devote over twice as much of their working time to research than to teaching.

The nature of the employment of the new Ph.D.'s has changed drastically during the past few years, as is shown in Figures 8 and 9. Employment at on-campus educational institutions plummeted from 80% for the 1967 graduates to 37% for the 1970 graduates.

Figure 8

Figure 9

And naturally there was a simultaneous rise in the relative levels of employment in non-academic positions.

As could be expected, the nature of the work activities also shifted; cf. Figure 9. The principal work activities of the 1967 graduates in their first job were divided approximately: research and development, 48%; teaching, 41%. In contrast, the principal activities of the 1970 graduates were: research and development, 81%; teaching, 13%.

This shift may have arisen because traditional teaching positions have now become saturated, a situation forecast years ago by Cartter[23] and recently reiterated by him.[9] Or perhaps the recent graduating classes have preferred new forms of employment. Considering the lack of job choice today, and the apparent slowing of the expansion of astronomy departments, the first hypothesis is more likely.

The shift in employment patterns may also have been one of the reasons, besides actual job scarcity, that recent graduates have found it necessary to send increasingly large numbers of job applications. From their knowledge of past employment patterns, they likely have sought jobs at the traditional employer of astronomy doctorates, namely educational institutions. But apparently that market is nearly filled, at least in comparison with non-academic employers.

### 4.5 Employment Satisfaction

Even though virtually all of the recent doctorates obtained employment, it is possible (indeed, widely believed) that many of them are severely dissatisfied with their jobs, having accepted

the only positions they could find. It is rumored that graduates today are often forced to accept positions that will not allow adequate time for research, and that what research time they do have available can not be spent as they would like.

Although 62% of the recent doctorates in this study said that their research was restricted in some way, their most prevalent complaint was a "lack of assistants," followed by a shortage of computer facilities. Teaching and administrative demands were listed as relatively minor interferences. Similarly, lack of available observing time was not a major problem, except for a few astronomers who used optical telescopes.

(Unfortunately, no similar study is available from "better" times; if one were, it could calibrate these replies. No one knows what percentage of Ph.D.'s are dissatisfied even under excellent working conditions.)

And the astronomers' ideal and present distributions of time and research were remarkably homogeneous, as Table 2 demonstrates. Among the respondents who spent more than half their time in research, almost 95% were able to devote at least 3/4 of their re-

Table 2

search time exactly as they would like; in fact, only 7% of the total research time of the entire set of recent astronomy doctorates was spent in sub-fields that the individuals ideally would not pursue.

This study also attempted to assess employment disappointments by asking the respondents specifically for their complaints. Surprisingly perhaps, the most frequently mentioned problem was not too much teaching, stated by only 10% of the sample, but "lack of intellectual stimulation," mentioned by 25%. Another 25% of the sample reported no disappointments. Other frequently mentioned problems were "isolation" and the lack of miscellaneous support, such as assistants, travel funds, and secretaries.

Another rumor holds that many young astronomers are forced to choose between teaching at remote, undesirable sites or taking mundane jobs, below their technical competency. In fact, this study found that they have not (at least in appreciable numbers) been forced into the latter situation, even though that has happened in physics; nevertheless, the rumored geographic effect has occurred in astronomy, albeit not so severely as some believe.

Figure 10

Comparison of the upper map in Figure 10 with the lower one shows that there were not enough jobs in the Southwest to meet the demand, and some astronomers had to accept employment in the South and Mid-west, contrary to their preference. But on the whole, the situation could not be described as bleak, for half of the persons in the study with a preference had obtained a job in the state of their first choice and three-fourths of them secured a position in one of their first three states of preference.

Even though securement in one of the top choice states does not insure that the site was desirable, only 18% mentioned any disappointment with their location, and often not for professional reasons.

## 5. CONCLUSIONS AND COMMENTS

Starting in about 1960, manpower in American astronomy began to increase at a phenomenally large rate. From the perspective of the last fifty years, the surge during the past decade has only brought astronomy's over-all rate of growth roughly into line with that of other sciences. But the magnitude of its recent expansion, especially when compared with its funding, has in the last few years almost exactly brought the supply of astronomers into balance with the demand. That situation is dramatically different from what obtained in astronomy in the early 1960's, the era of the employees' market. And, of course, if the recent trend should continue, the supply would substantially exceed the demand.

How critical is the job problem in astronomy? The answer can only be given in relative terms. This study shows that the availability of jobs in the field today is severely limited compared with five years ago, but it is not so limited in astronomy as it is in many other sciences. And undoubtedly one of the major factors that has exacerbated the job problem in astronomy has been the migration into the field of scientists from other disciplines, especially physics, where the job situation is even more difficult. Even though the nation as a whole has been in a recession, astronomy has survived comparatively well.

Overall, employment levels in American astronomy are high, and despite anecdotal stories to the contrary, most of the recent astronomy doctorates seem fairly satisfied with their jobs. On the other hand, many of them have had to seek employment outside the traditional academic environment and away from their ideal geographic location; moreover, even then job securement has often been difficult. And the situation seems to be rapidly worsening.

How could the job market in astronomy be improved? As in any problem of supply and demand, there are two related remedies: decrease the supply or increase the demand. The latter alternative implies increased funding for astronomy,[24] particularly on a per capita basis. Since that nettlesome issue is outside the scope of this paper, it will not be discussed here.

But what about decreasing the supply; i.e., reducing the number of astronomers? Two-thirds of the Ph.D.'s in this study said that relative to funding, there are too many astronomers in the U. S. today, and over 80% of them recommended having graduate astronomy departments train fewer people. In manpower parlance, that tactic implies "negative recruiting."

The authors of this paper believe that it would be prudent if the recent proliferation of graduate programs in astronomy would cease, and if the size of existing departments would hold constant or slightly decrease. (Such recommendations are frequently made today about the output of doctorates in most fields.[25,26]) Extreme measures of negative recruiting might have catastrophic effects for the future, however, as has been cautioned by NSF.[27]

In this regard, a well-known senior astronomer recently remarked to one of the authors that he was glad no one had enforced negative recruitment in his graduate years, which came during the Depression of the 1930's. Considering the number of remarkably productive astronomers from that era, his observation seems highly sage. (Numerous alternatives have been discussed in the literature.[9,16,28])

While a tightening of graduate astronomy departments would help to taper the supply, by itself it would be inadequate; indeed, it would not be aimed at the heart of the problem. Since over half of the future astronomers in the U. S. will receive doctorates in physics rather than astronomy, the curtailment of physics departments would be more effective. Furthermore, considering the relatively tight job market in physics, the recent massive influx of physicists into astronomy may have been caused not only by the enormous latent interest of the field but also by superior job opportunities in it. Whatever the current manpower problem may be in astronomy, it has been caused more by departments of physics than of astronomy.

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## CAPTIONS FOR FIGURES

Figure 1. NUMBER OF PERSONS EMPLOYED IN ASTRONOMY, 1960-1970: TOTAL AND PH.D.'S

Source: Ref. 12

Figure 2. NUMBER OF PH.D.'S AWARDED IN THE UNITED STATES IN ASTRONOMY, IN PHYSICS, AND IN ALL PHYSICAL SCIENCES (INCLUDING ENGINEERING), BY ACADEMIC YEAR; 1920-1969.

Sources: 1920-1958, Ref. 15
1959-1969, Ref. 14

Figure 3. NUMBER OF INSTITUTIONS IN THE UNITED STATES AWARDING AT LEAST ONE GRADUATE DEGREE IN ASTRONOMY/ASTROPHYSICS, BY INTERVALS OF TWO ACADEMIC YEARS; 1948-1969.

Source: Ref. 14

Figure 4. PERCENTAGE OF ALL GRADUATE STUDENTS IN THE FIELD WHO ARE FIRST YEAR STUDENTS, FOR ASTRONOMY AND FOR PHYSICS, BY ACADEMIC YEAR.

Source: Ref. 13

Figure 5. SECUREMENT OF FIRST POST-DOCTORAL EMPLOYMENT (OTHER THAN FELLOWSHIP) BY RECENT RECIPIENTS OF PH.D.'S IN ASTRONOMY: SUCCESS AT OBTAINING JOB VS. YEAR OF AWARD OF PH.D.

Figure 6. SECUREMENT OF FIRST POST-DOCTORAL EMPLOYMENT (OTHER THAN FELLOWSHIP) BY RECENT RECIPIENTS OF PH.D.'S IN ASTRONOMY: HOW JOB WAS OBTAINED VS. YEAR OF AWARD OF PH.D.

Figure 7. SECUREMENT OF FIRST POST-DOCTORAL EMPLOYMENT (OTHER THAN FELLOWSHIP) BY RECENT RECIPIENTS OF PH.D.'S IN ASTRONOMY: HOW JOB WAS OBTAINED VS. THE "EFFECTIVENESS" OF THE DOCTORAL PROGRAM AT THEIR GRADUATE INSTITUTION.

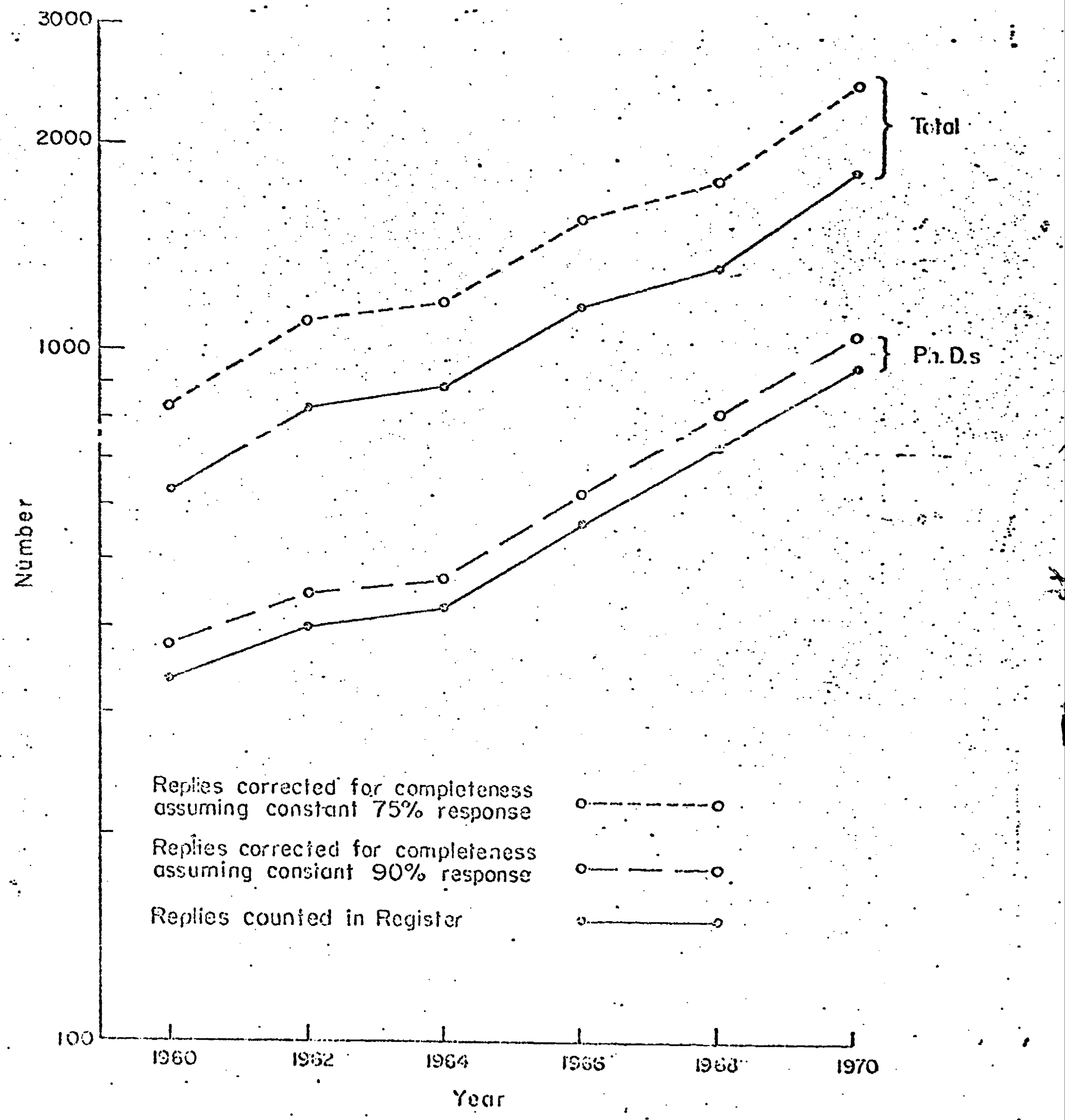
Figure 8. EMPLOYMENT OF RECENT RECIPIENTS OF PH.D.'S IN ASTRONOMY: PERCENTAGE FTE EMPLOYERS VS. YEAR OF AWARD OF PH.D.

Figure 9. EMPLOYMENT OF RECENT RECIPIENTS OF PH.D.'S IN ASTRONOMY: PERCENTAGE FTE EMPLOYMENT ACTIVITY VS. YEAR OF AWARD OF PH.D.

## CAPTIONS FOR TABLES

Table 1. DISTRIBUTION OF PERCENTAGES OF ACTUAL WORKING TIME FOR RECIPIENTS OF PH.D.'S IN ASTRONOMY FROM U.S. INSTITUTIONS, 1967-70 (Total Sum)

Table 2. DISTRIBUTION OF TIME IN RESEARCH FOR RECIPIENTS OF PH.D.'S IN ASTRONOMY IN THE U.S., 1967-1970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Ph. D.s
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Replies counted in Register
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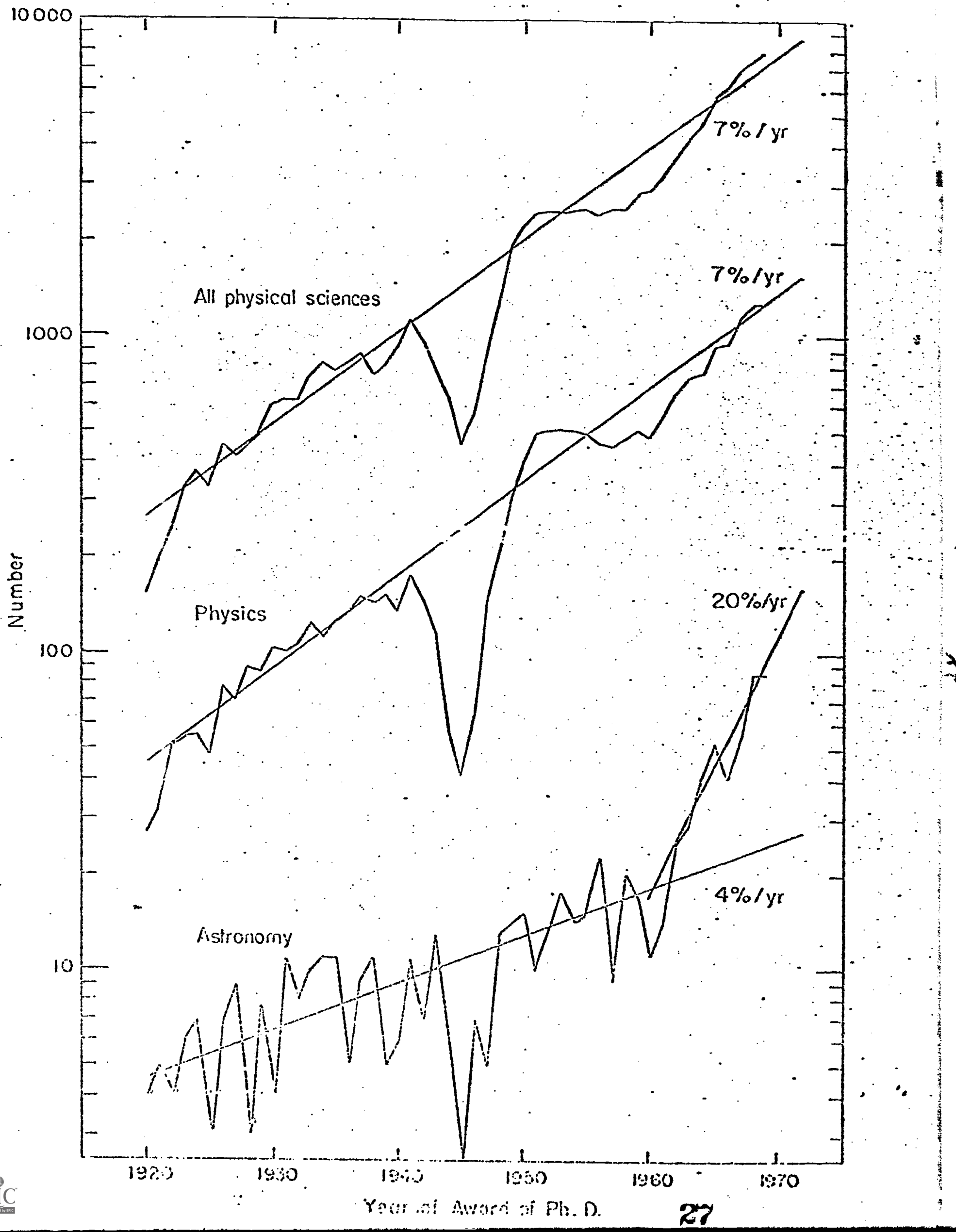
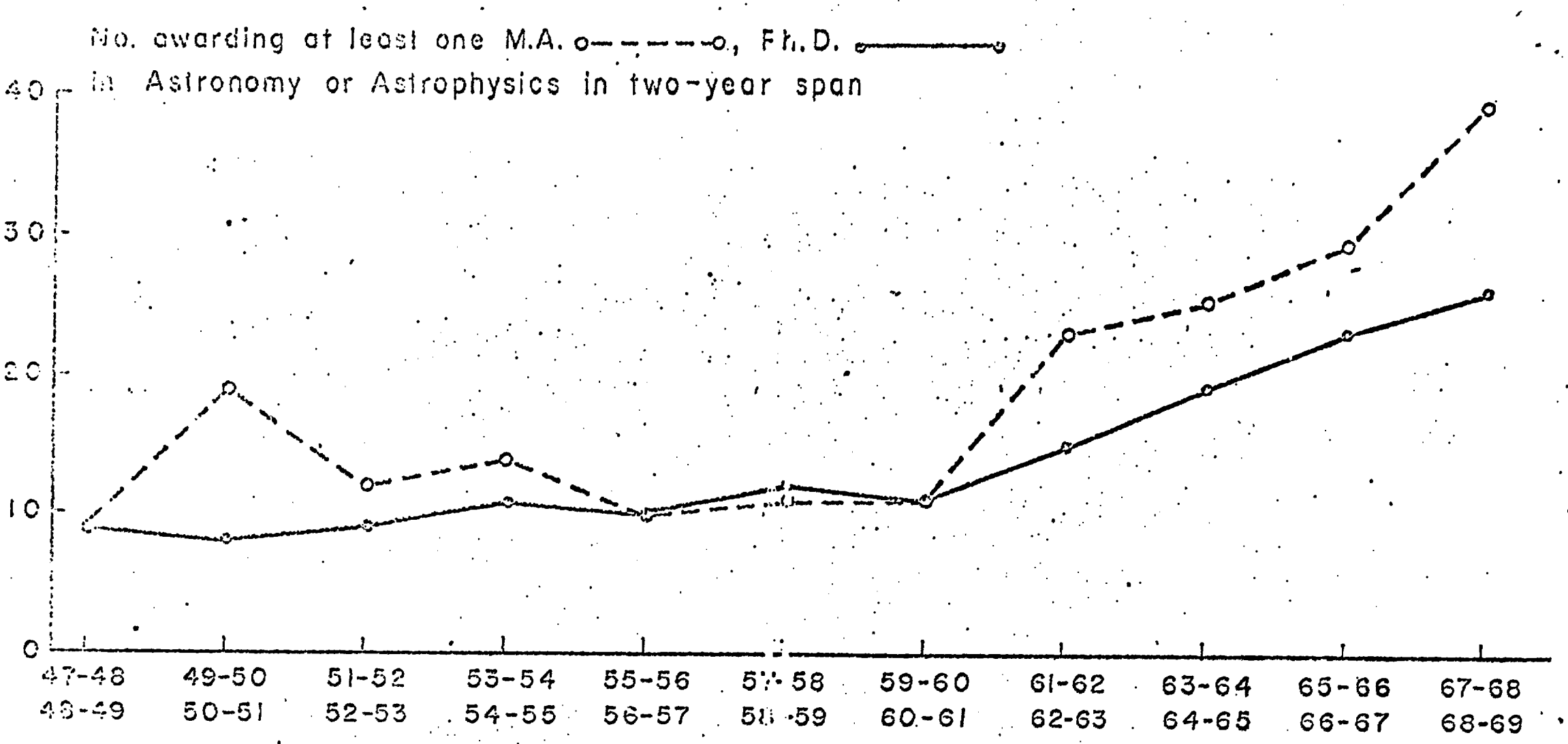
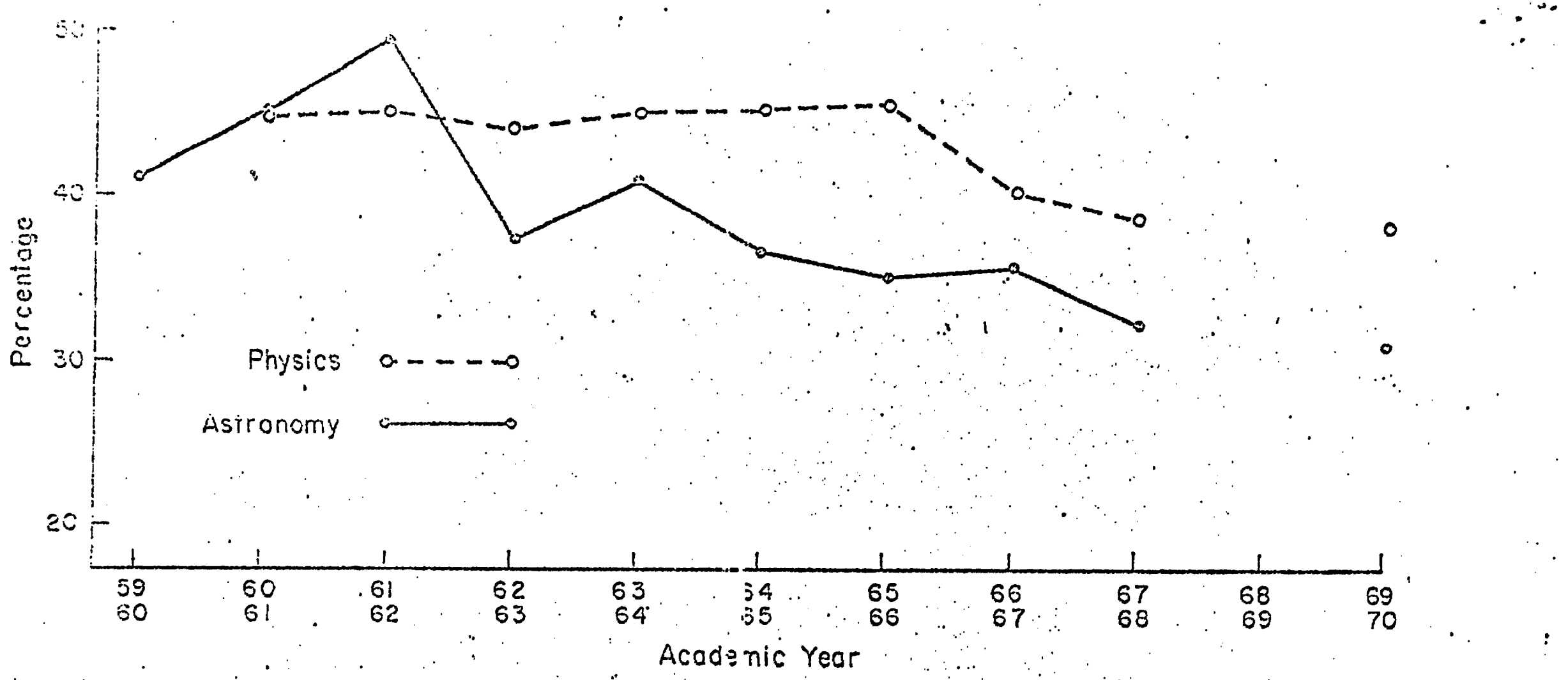
Year


10 000
1000
100
10
Number
All physical sciences
7%/yr
7%/yr
Physics
20%/yr
Astronomy
4%/yr
1920
1930
1940
1950
1960
1970
Year of Award of Ph. D.


No. awarding at least one M.A. o—-—-—o, Ph.D. ———o
in Astronomy or Astrophysics in two-year span
Number
40
30
20
10
0
47-48
48-49
49-50
50-51
51-52
52-53
53-54
54-55
55-56
56-57
57-58
58-59
59-60
60-61
61-62
62-63
63-64
64-65
65-66
66-67
67-68
68-69
Span of Two Academic Years


Percentage
50
40
30
20
Physics
Astronomy
59 60
60 61
61 62
62 63
63 64
64 65
65 66
66 67
67 68
68 69
69 70
Academic Year

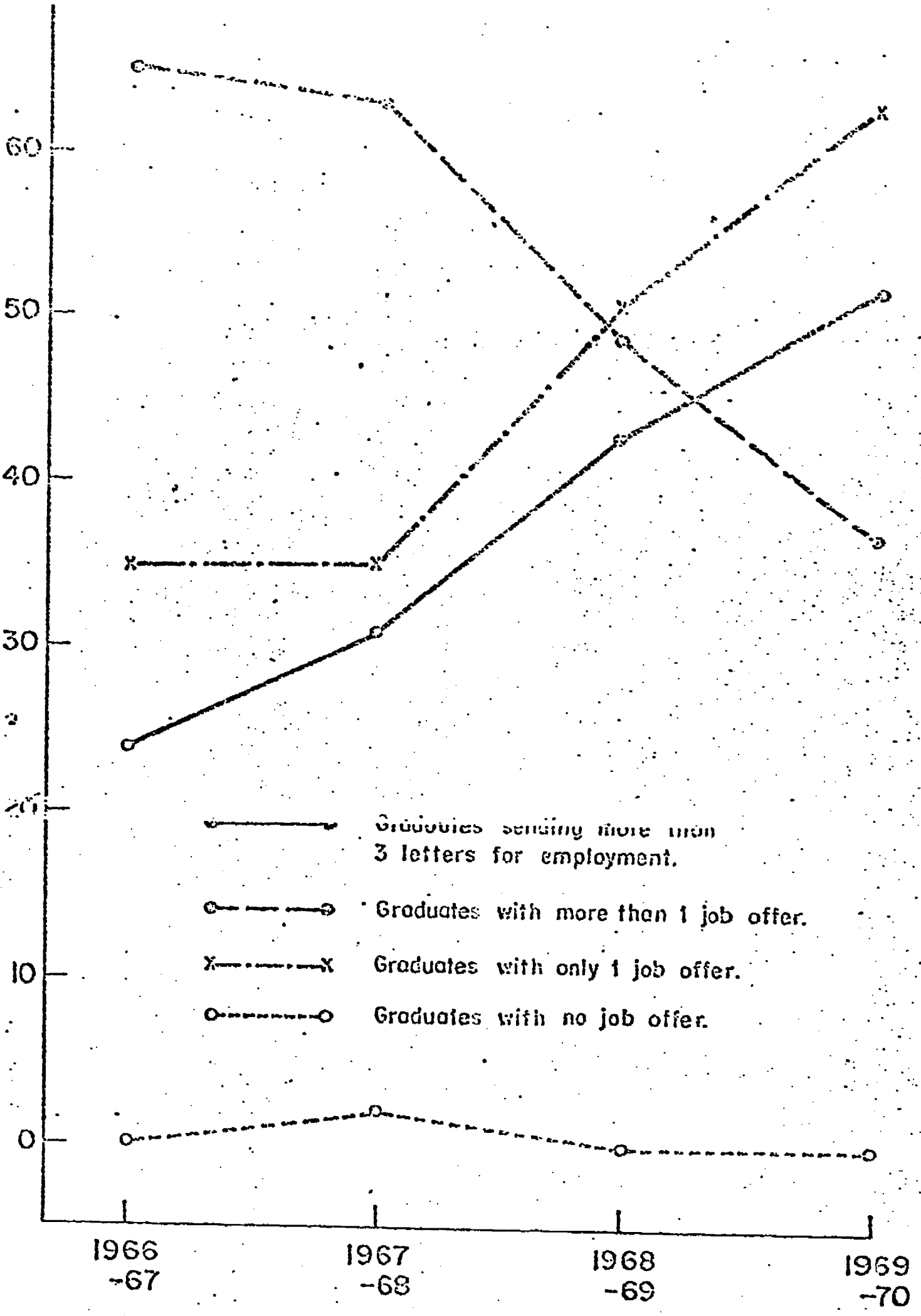
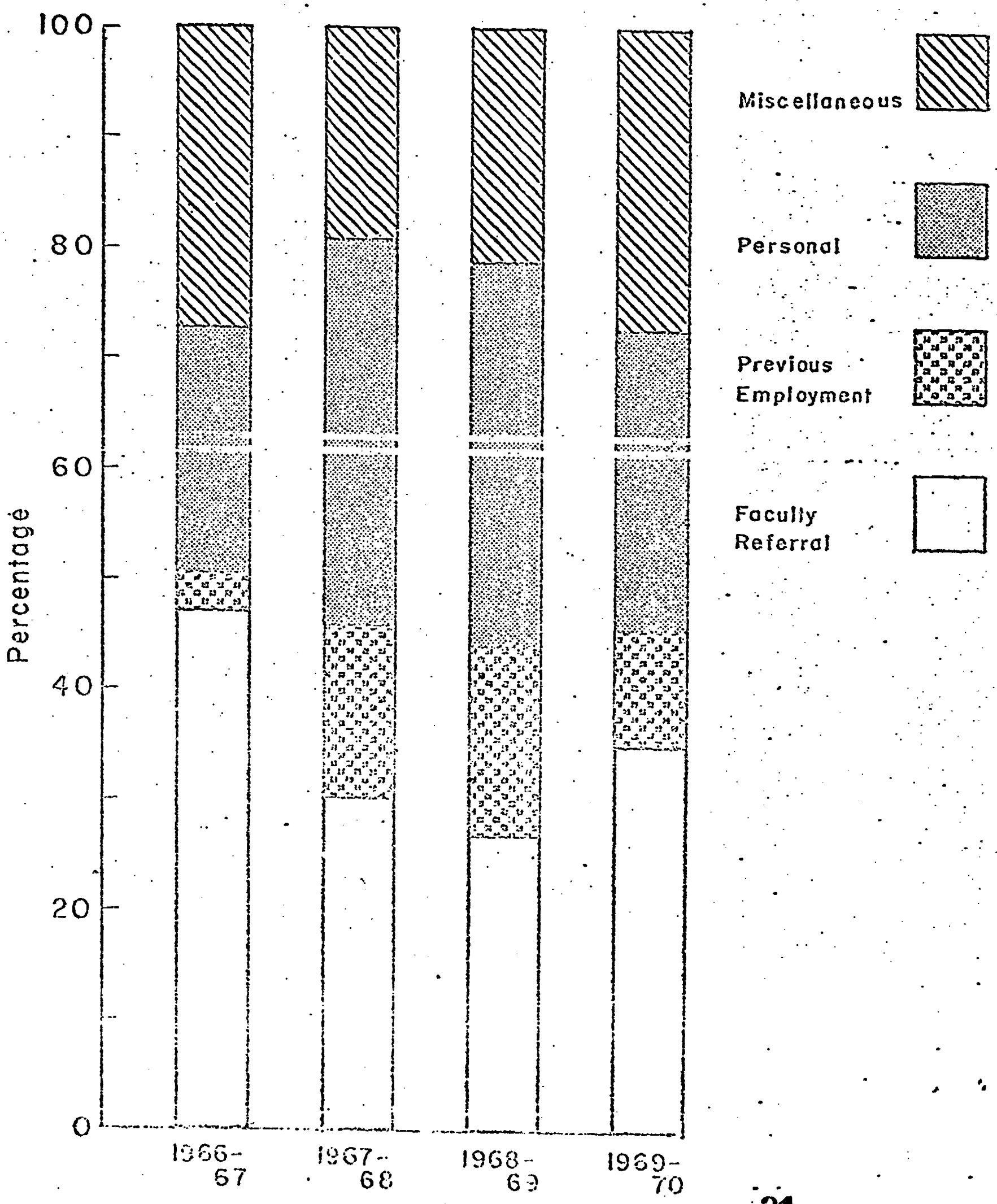
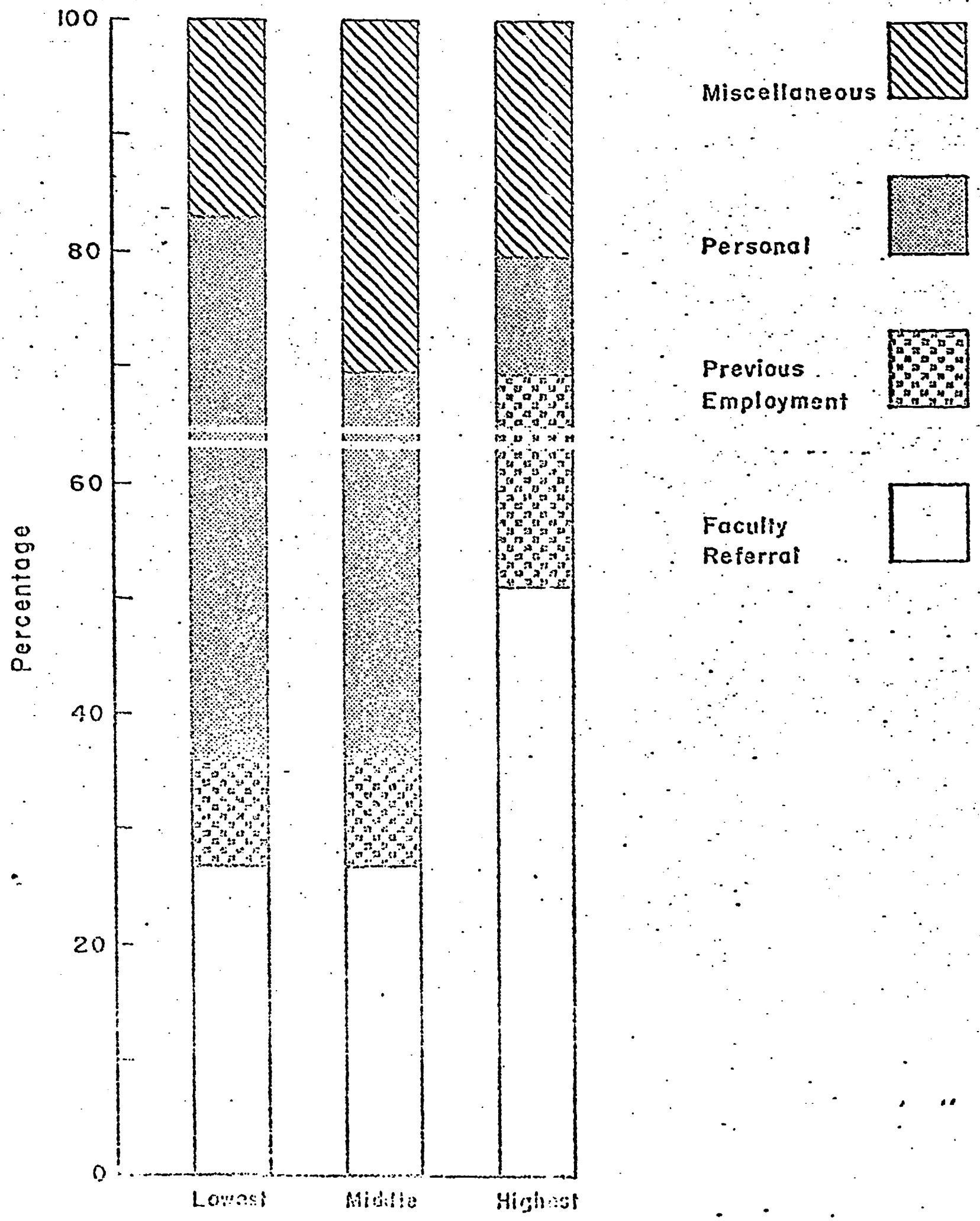
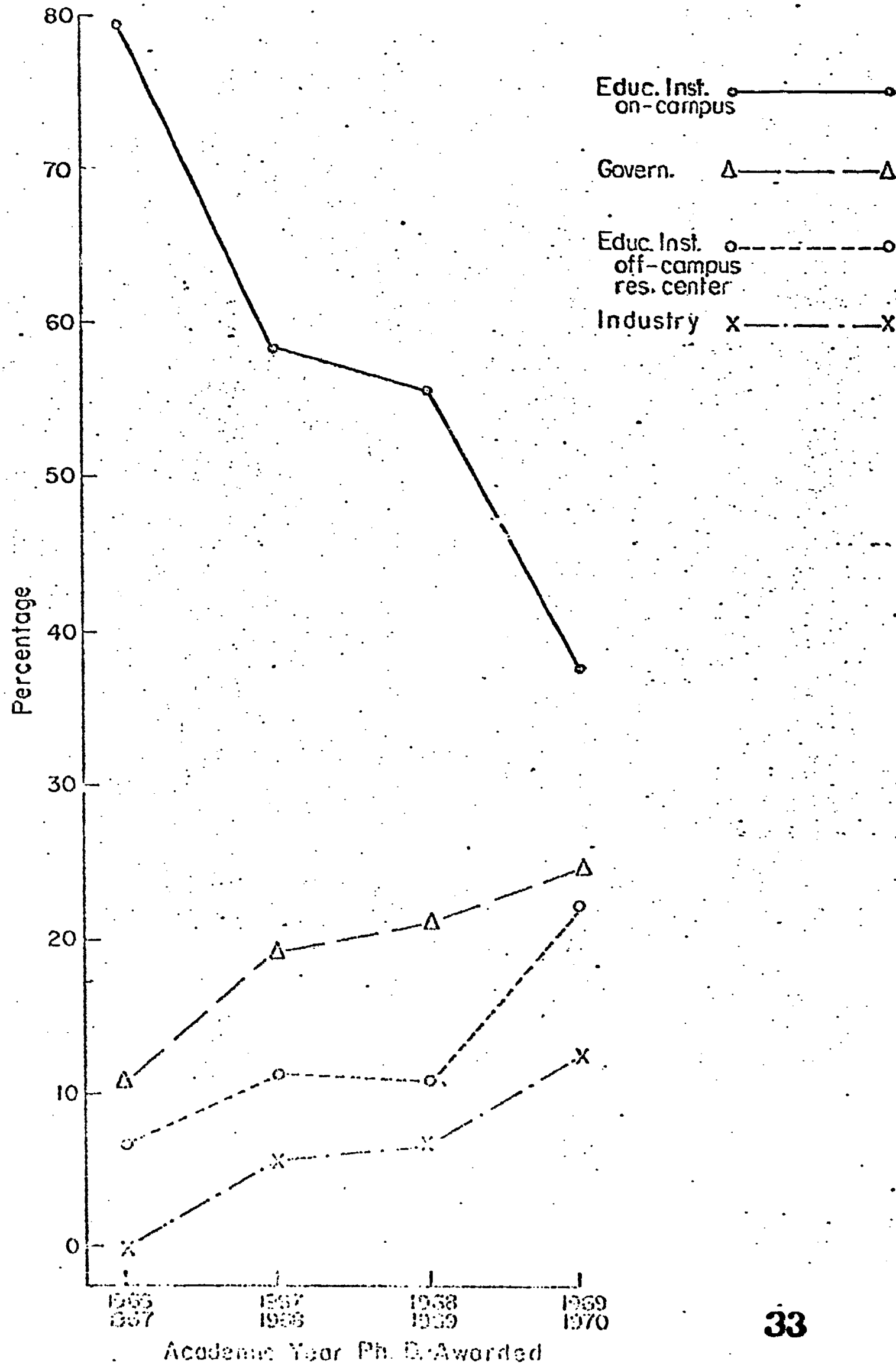
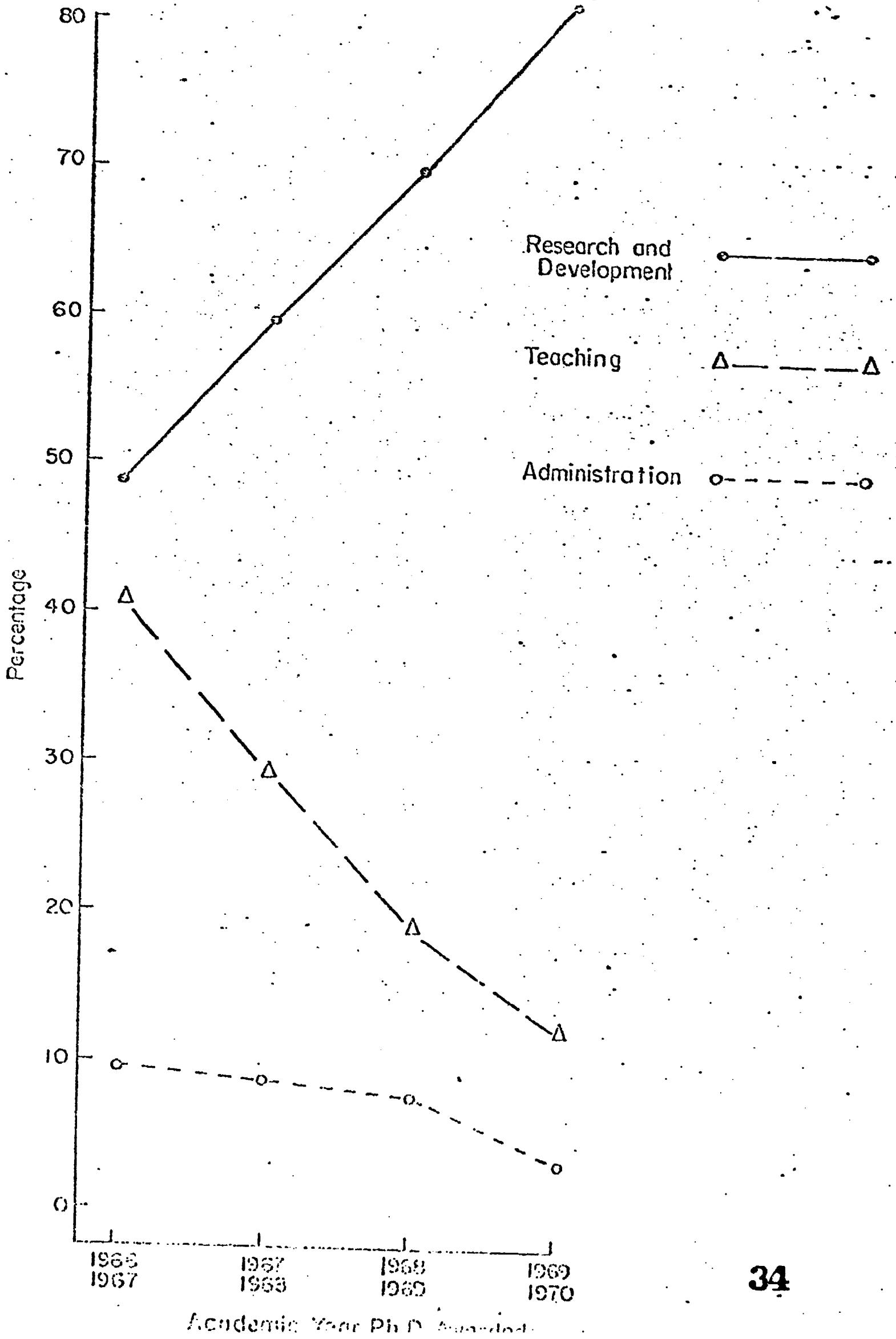

60
50
40
30
20
10
0
Percentage
Graduates sending more than 3 letters for employment.
Graduates with more than 1 job offer.
Graduates with only 1 job offer.
Graduates with no job offer.
1966 -67
1967 -68
1968 -69
1969 -70
Academic Year of Award of PhD

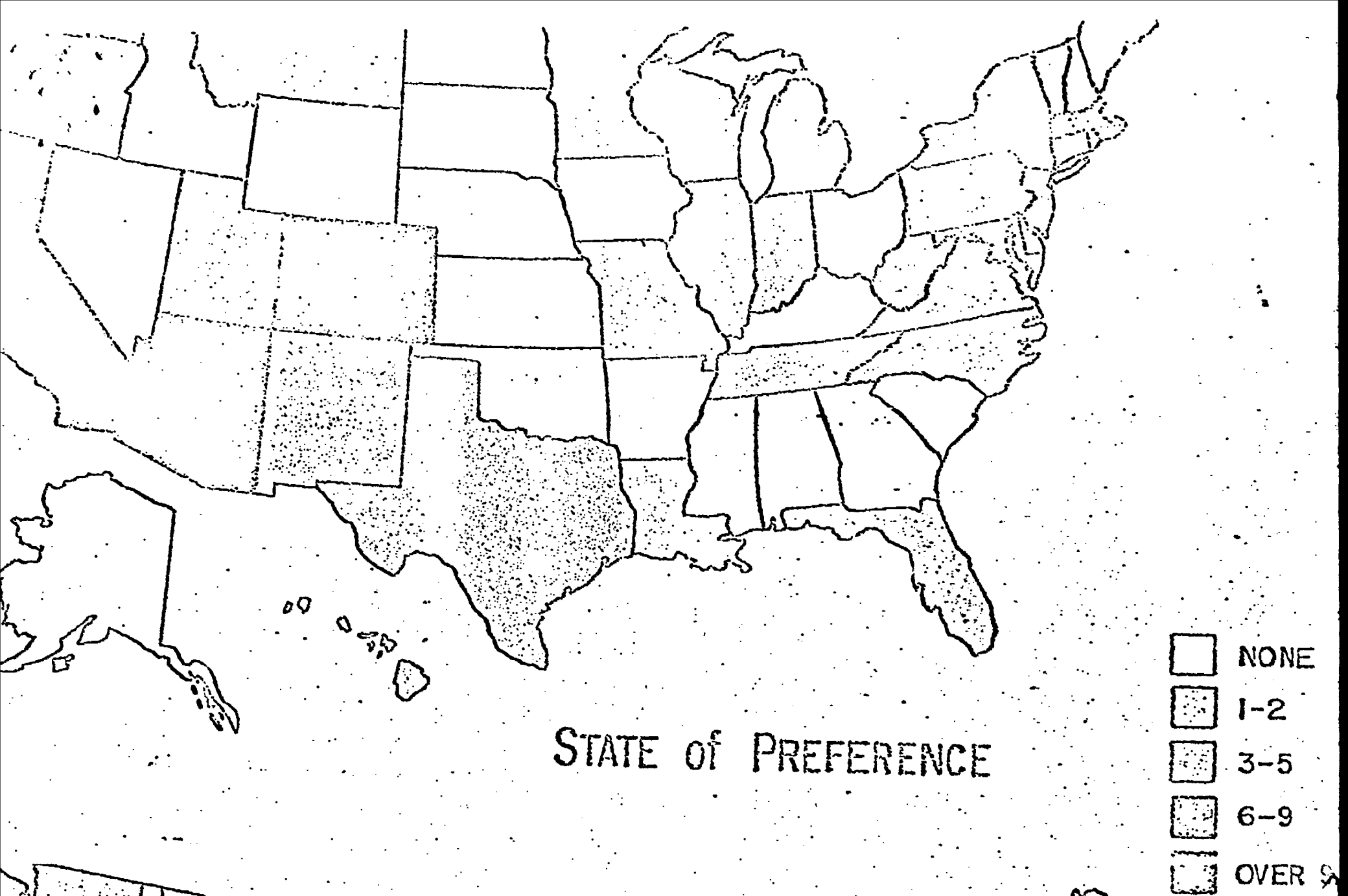
Fig. 5 [illegible]


100
80
60
40
20
0
Percentage
1966-67
1967-68
1968-69
1969-70
Academic Year of Award of Degree
Miscellaneous
Personal
Previous Employment
Faculty Referral


100
80
60
40
20
0
Percentage
Lowest
Middle
Highest
Ranking by "Effectiveness of Doctoral Program"
Miscellaneous
Personal
Previous Employment
Faculty Referral


80
70
60
50
40
30
20
10
0
Percentage
Educ. Inst. on-campus
Govern.
Educ. Inst. off-campus res. center
Industry
1966 1967
1967 1968
1968 1969
1969 1970
Academic Year Ph. D. Awarded


80
70
60
50
40
30
20
10
0
Percentage
Research and Development
Teaching
Administration
1966 1967
1967 1968
1968 1969
1969 1970
Academic Year Ph.D. Awarded




STATE of PREFERENCE

STATE of EMPLOYMENT

# DISTRIBUTION OF PERCENTAGES OF ACTUAL WORKING TIME FOR RECIPIENTS OF PH.D.'S IN ASTRONOMY FROM U.S. INSTITUTIONS, 1967-70

(TOTAL SUM)

| ACTIVITY | EMPLOYER | | | | ROW SUMS |
|---|---|---|---|---|---|
| | EDUC. INST. ON-CAMPUS | GOVERN. | EDUC. INST. OFF-CAMPUS | INDUSTRY | |
| RESEARCH | 27 | 16 | 10 | 5 | 58 |
| TEACHING | 24 | 1 | 1 | 0 | 26 |
| DESIGN AND DEVELOPMENT | 3 | 1 | 2 | 2 | 8 |
| ADMINISTRATION | 3 | 3 | 1 | 1 | 8 |
| COLUMN SUMS | 57 | 21 | 14 | 8 | 100 |

# DISTRIBUTION OF TIME IN RESEARCH

## FOR RECIPIENTS OF PH.D.'s IN ASTRONOMY IN THE U.S., 1967-1970

| Subfield of Astronomy | Distribution of Time | | |
|---|---|---|---|
| | Thesis | Present | Ideal |
| Theoretical Astrophysics | 38% | 28% | 33% |
| Observ., Ground-based, Optical | 31 | 28 | 31 |
| Observ., Ground-based, Radio | 6 | 9 | 7 |
| Observ., Space-Based, All | 6 | 8 | 9 |
| Instrument Development | 5 | 8 | 6 |
| Celes. Mech. & Astrometry | 8 | 8 | 8 |
| Other | 6 | 11 | 6 |
| Total | 100% | 100% | 100% |