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The Long-Run Demand for Educated Labor

by

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In this paper we investigate the long-run elasticity of demand for particular types of educated labor. The elasticity of the long-run demand function for educated labor depends on both the elasticity of substitution between factors in production and the elasticity of supply of substitute factors. For this reason we will need to consider the substitution possibilities between labor of various types (e.g. between college graduates and high school graduates) and between labor and other factors, as well as those labor market adjustment mechanisms which facilitate substitution between labor with different levels of schooling.

The outcome of the investigations contained in this paper will provide a basis for the choice of an appropriate method of choosing the "optimal" set of educational outputs from among the multitude of feasible sets of outputs. If, to take one of the two polar cases, the economy demands labor with various levels of schooling in rigidly fixed proportions, then the desired outputs of the educational system at any future date can be determined solely on the basis of the desired level of production of goods and services in the economy and expected retirement from the existing stock of labor. The function of the educational system in this case is to match the educational attainments of the labor force with the fixed input requirements generated by the economy.

If, however, it is possible to substitute one type of labor for another in production, then the above method breaks down, for it is no longer possible to derive the "demands"

for each type of labor solely from the level of total output. Turning to the alternate polar case, assume that there is such a high degree of substitutability between factors in the economy that the relative marginal products of each type of labor remained constant, regardless of the available amounts of each factor. In this case we could compute the contribution to the present value of the future stream of national income of each type of schooling and choose from the feasible sets of enrollments levels that configuration which yielded the largest total contribution. However, if in this case the marginal product functions for each type of labor are downward sloping, we cannot determine the contribution of each type of education to national income until we know which set of outputs is to be chosen.

The solution to resource allocation problems in education in either polar case presents few computational difficulties. It is clear from the above that intermediate cases are far less simple. Virtually all operational methods of educational planning have relied, at least implicitly, on the first polar case.

3.1 The Elasticity of Demand for Educated Labor

The relation between the amount of a given type of labor available in an economy and its marginal contribution to national income (or social marginal productivity) will be defined as the aggregate demand function for that type of labor. The concept is analogous to the firm's demand function for a factor in that it represents for each amount of the factor the maximum which a national income-maximizing planning agency should be willing to pay in order to acquire one

additional unit.[1/] The shape and position of this aggregate

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[1/] The demand for educated labor should be distinguished clearly from what might be called the individual demand for education, which relates the amount of education desired by an individual to the price of the education and which depends on variables such as the anticipated future returns, monetary and otherwise, to the individual, and his rate of time preference. The demand for education in this latter sense will not be discussed here. In view of the fact that schooling is generally offered either free or at highly subsidized rates, it can be assumed that the private return to education will be sufficiently high to allow government bodies to regulate the amount of schooling undertaken at each level through regulation of available places, supplemented occasionally by relatively minor financial inducements. Deficient demand for education is not regarded as a problem.

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demand function depend on the characteristics of the sectoral production functions, the level and elasticity of demand for the sectoral outputs, and availability of complementary and substitute factors. In order to distinguish between the two extreme cases presented in the previous section we introduce the concept of the elasticity of demand for educated labor, E_i, or the inverse of percentage change in the marginal product of factor i associated with a given percentage change in the amount available.[2/]

[2/]
$$E_i = \frac{dN_i/N_i}{dMP_i/MP_i}$$

The relationship assumed in the above polar cases between the marginal contribution to national income of a given category of labor and the amount of labor available appear in Figure 3.1. The greater is the elasticity of demand, the less

will the marginal productivity of the factor vary with the amount of it available; the more will the situation approach that described as polar case two, where the elasticity of demand is infinite. The contrary situation, case one, implies an elasticity of demand equal to zero.

Following Marshall, we may say that the elasticity of demand for a factor will be greater

a. the greater is the elasticity of substitution between it and other factors in production,

b. the greater is the elasticity of demand for the product or products which it produces,

c. the smaller is the proportion of the factor in the total costs of the enterprises which hire it; and

d. the greater is the elasticity of supply of factors of production which may serve as substitutes for the factor in question.[3/]

[3/] A. Marshall, Principles of Economics, Book V, Ch. 6, pp. 385-386.

For a given sector in the economy, assumed to use only two factors, the elasticity of demand for a given factor can be written as:

$$E_i = -(k_1 n + k_2 s)$$

where k_i = the share of total output paid to the factor i, $i = 1,2$

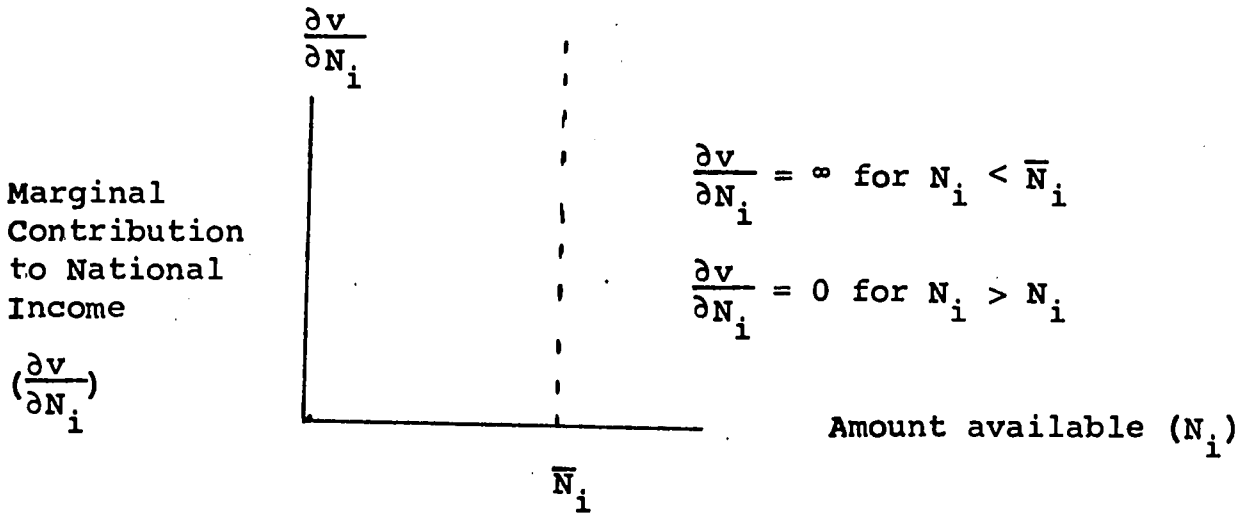
n = the price elasticity of demand for the sector's output

s = the elasticity of substitution in production between the two factors, or

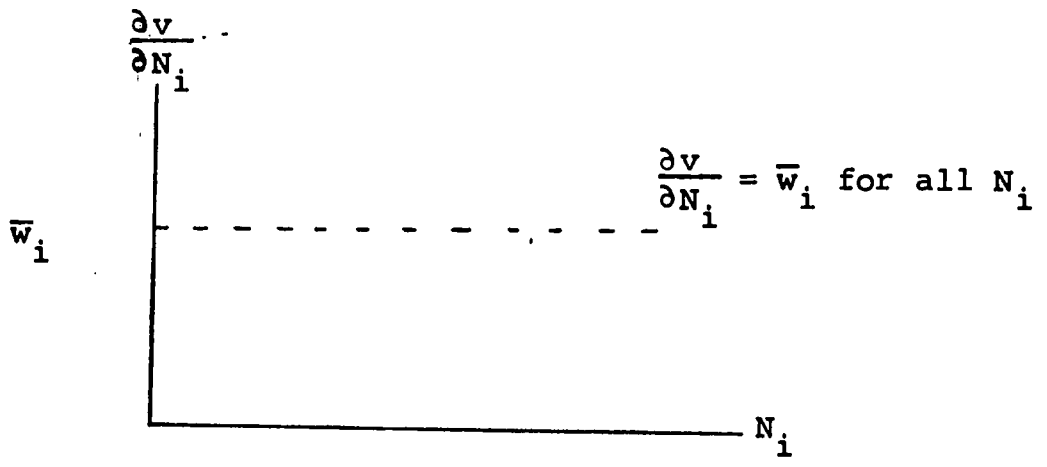
$$\frac{d[\log N_1/N_2]}{d[\log w_2/w_1]}$$, where w_i represents the unit payment to factor i.

It is assumed that the price of factor 2 is constant and that the production function is homogeneous of degree 1. Thus $k_1 + k_2 = 1$.

Polar Case One: Labor Inputs Required in Fixed Proportions



Polar Case Two: Marginal Products Not Dependent on Factor Supplies



(R. G. D. Allen, Mathematical Analysis for Economists, p. 372)

With many factors, the concept of the elasticity of substitution as defined above is inappropriate and must be replaced by some concept of the "partial" elasticity of substitution. Although the formal expression for the elasticity of demand for the factor is thus altered, the economic considerations leading to a high or a low elasticity are not. For a review of some alternative concepts of the partial elasticity of substitution, see R. Solow, Some Recent Developments in the Theory of Production. The Theory and Empirical Analysis of Production, National Bureau of Economic Research Studies in Income and Wealth, Vol. 31, pp. 25-50, 1967. For an expression for the elasticity of demand for a factor in the multi-factor case, see R. G. D. Allen, Mathematical Analysis for Economists, pp. 507-508.

If the aggregate demand function for each type of labor in the economy were highly elastic, then we would expect to find that the relative earnings of different types of labor would be relatively insensitive to differences in the composition of the labor force.[4/] Thus by estimating the relationship between

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[4/] Here, and below, we assume that earnings provide an adequate measure of the marginal productivity of the factor in question.

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relative earnings and relative quantities of different types of labor we may gain some insights about the elasticity of demand for labor educated to various levels.

We have chosen ten economies, both developed and underdeveloped, on which we have data on both the mean earnings and quantities of labor classified by years of schooling. In each economy the labor force is separated into those with less than 12 years of school and those having completed 12 years or more of school. Mean earnings are a weighted average of the earnings of the various subcategories of labor within the two major categories defined above. For example, high school graduates

and university graduates both fall under the highly educated category. The mean earnings of the category is thus a weighted average of the earnings of high school graduates and those of college graduates, the weights referring to the relative quantities of each type of labor.[5/] The basic data appear in Table 3.1.

[5/] Weights based on both the United States and the Indian labor force were used. The choice of weights made very little difference in the estimates. See below.

The relationship between relative earnings and relative quantities of labor is illustrated in Figure 3.2, in which relative earnings is plotted against relative quantities on a double log scale.

We would like to estimate the elasticity of substitution between L_1 (less than 12 years) and L_2 (12 years or more) which we define as:

$$\sigma = - \frac{d(L_1/L_2)/(L_1/L_2)}{d(w_1/w_2)/(w_1/w_2)} = - \frac{d \log (L_1/L_2)}{d \log (w_1/w_2)}$$

Before estimating σ, we must reinterpret the elasticity of substitution concept. As conventionally defined, the elasticity of substitution is a static concept, and refers to only two factors in a given production process. We are considering here a case with many factors of production, only two of which are being observed explicitly. Moreover, the context here is more aptly described as "historical" rather than static; other things are not equal. Specifically, the capital stock per worker and the sectoral composition of output varies greatly among the countries in our sample. Lastly, our data refer not to a single production process, but to economy-wide aggregates.

Table 3.1: Relative Supply and Remuneration of Educated and Uneducated Labor.

Country	$\frac{L_1}{L_2}$	$\frac{w_1}{w_2}$ U.S. Weights	$\frac{w_1}{w_2}$ Indian Weights
Belgium	5.134	0.390	0.325
Canada	3.098	0.669	0.626
Chile	13.554	0.342	0.275
France	6.142	0.522	0.427
Great Britain	9.102	0.520	0.508
Greece	7.432	0.852	0.801
India	35.489	0.472	0.326
Mexico	36.735	0.354	0.224
Netherlands	8.259	0.549	0.480
U.S. 1960	1.228	0.703	0.584
U.S. 1939	2.612	0.562	0.436
U.S. 1949	1.675	0.577	0.428
U.S. 1956	1.202	0.524	0.442
U.S. 1958	1.091	0.547	0.416
U.S. 1963	0.924	0.610	0.442

Source: See Appendix.

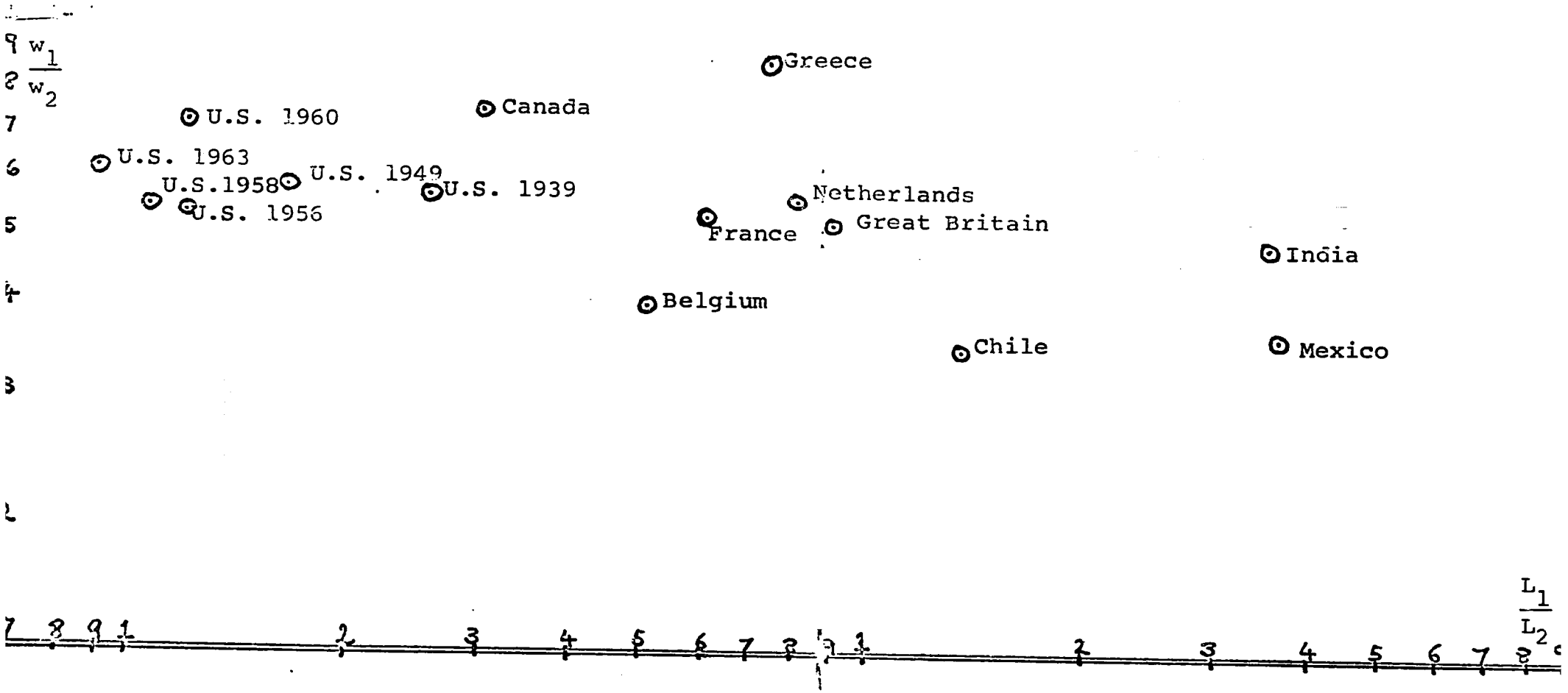


Figure 3.2: Plot of W_1/w_2 Against L_1/L_2 Using Double Logarithmic Scale

Source: w_1/w_2 are from column 3 of Table 3.1
L_1/L_2 are from column 2 of Table 3.1

Thus our estimated elasticity will reflect the combined effects of:

a. the partial elasticity of substitution in production between L_1 and L_2,

b. the degree of complementarity or substitutability between each of the two types of labor and excluded factors of production, particularly capital,

c. differences in the composition of final demand.

It is this "historical" concept of the elasticity rather than the static one, which is relevant to the process of planning. What we would like to know is the changes in relative marginal products of factors as the composition of the labor force becomes progressively better educated. The educational transformation of a labor force is a historical process in which other factors are not held constant, and which is ordinarily accompanied by substantial changes in the composition of final output. Thus the elasticity estimated from our international cross-section of countries at various stages of development is in fact the appropriate quantity.

The relationship estimated on the basis of the data in Table 3.1 is

$$\log \frac{w_1}{w_2} = \underset{(.09)}{-.49} - \underset{(.05)}{.10} \log \frac{L_1}{L_2}$$

$$R_c^2 = .134$$

The figures in parentheses are the standard errors.

The estimated elasticity of substitution[6/] is $\hat{\sigma} = -\frac{1}{\hat{b}} = 10$.

6/ $\hat{\sigma} = -\frac{1}{\hat{b}} = \frac{d(\log L_1/L_2)}{d(\log w_1/w_2)}$

The estimate implies that, when considered as part of the historical process of growth, and 10 per cent change in the ratio of labor quantities is associated with a 1 per cent change in the relative earnings.[7/]

[7/] This equation was estimated using the earnings weighted by relative quantities in the United States labor force. The elasticity estimate based on Indian weights is 8.1.

Because we intend to apply these results to problems of educational development within a given country over time, we should investigate the possibility that the high elasticity apparent from the association estimates is not representative of actual historical development of any given economy. Thus we estimate equations separately for the 6 United States observations between 1939 and 1963, and for the international cross-section (10 observations, including the United States in 1960). The results are as follows:

For the United States (1939-1963):

$$\log \frac{w_1}{w_2} = - \underset{(.06)}{.55} - \underset{(.14)}{.009} \log \frac{L_1}{L_2} \qquad R_c^2 = .498$$

For the international cross-section:

$$\log \frac{w_1}{w_2} = - \underset{(.19)}{.30} - \underset{(.08)}{.177} \log \frac{L_1}{L_2} \qquad R_c^2 = .195.$$

United States labor force weights were used in both estimates. Although the significance levels in the United States estimates are low, the results are not inconsistent with the hypothesis that the actual historical elasticity in a given country is at least as high as the elasticity estimated from the time

series.[/]

[/] The above findings may provide a partial explanation for the fact that the rates of return on additional years of schooling appear to be roughly similar between countries with very different relative factor supply conditions. See Marcelo Selowsky, "Education and Economic Growth: Some International Comparisons," unpublished Ph.D. Dissertation, University of Chicago, December, 1967 and Martin Carnoy, "Rates of Return to Schooling in Latin America," The Journal of Human Resources, Vol. II, No. 3, Summer 1967, pp. 359-374.

In the remainder of this paper I will investigate some of the sources of this very high degree of labor substitutability.

3.2 Substitution in Production

The production of any commodity requires the combination of particular skills embodied in the labor force with other inputs such as raw materials, intermediate goods, and plant and equipment. The possibility of substitution in production between labor with different years of schooling arises, first, because labor skills are not required to be used in fixed proportions; there is some substitutability between skills. Secondly, there may also be some range of choice in the level of education associated with each skill; years of schooling, on-the-job training, and experience are partial substitutes in the formation of most skills. Some amount of both types of substitution are possible in most cases.

We will consider first the fact that a given skill may be possessed by labor of differing educational attainments. We would like an estimate of the degree of substitutability in the formation of skills between formal education and other characteristics of workers. The most important substitute for formal education in most jobs is clearly work experience. The degree of substitutability between job experience and formal education undoubtedly varies from skill to skill. However, for a number of skills the data suggest that the relationship is highly elastic. From the work of Strumilin, for example, we have data on the skill levels of metal-working operatives in St. Petersburg in 1919 classified by years of experience and years of schooling. Skill levels are converted to a cardinal scale, using pre-1917 wage scales. These data are presented in Figure 3.3 in the form of iso-skill lines. Experience and schooling appear to be good substitutes. Experienced, less well educated workers can readily be substituted in production for better educated, but less experienced, individuals. While one should be circumspect in generalizing this somewhat esoteric case, it is necessary to note that United States census data on earnings, age and years of schooling for 1959-60 suggest a similar degree of substitutability between schooling and experience.

Of course the existence of this high degree of substitution in skill formation does not necessarily imply that each occupation will in fact be filled by workers of widely varying educational levels. The level of schooling of the work force performing a given skill is in general the result of an economic choice, and is not technologically determined by the nature of the job itself. Presumably employers bear in mind the added cost of filling an occupational opening with a more educated

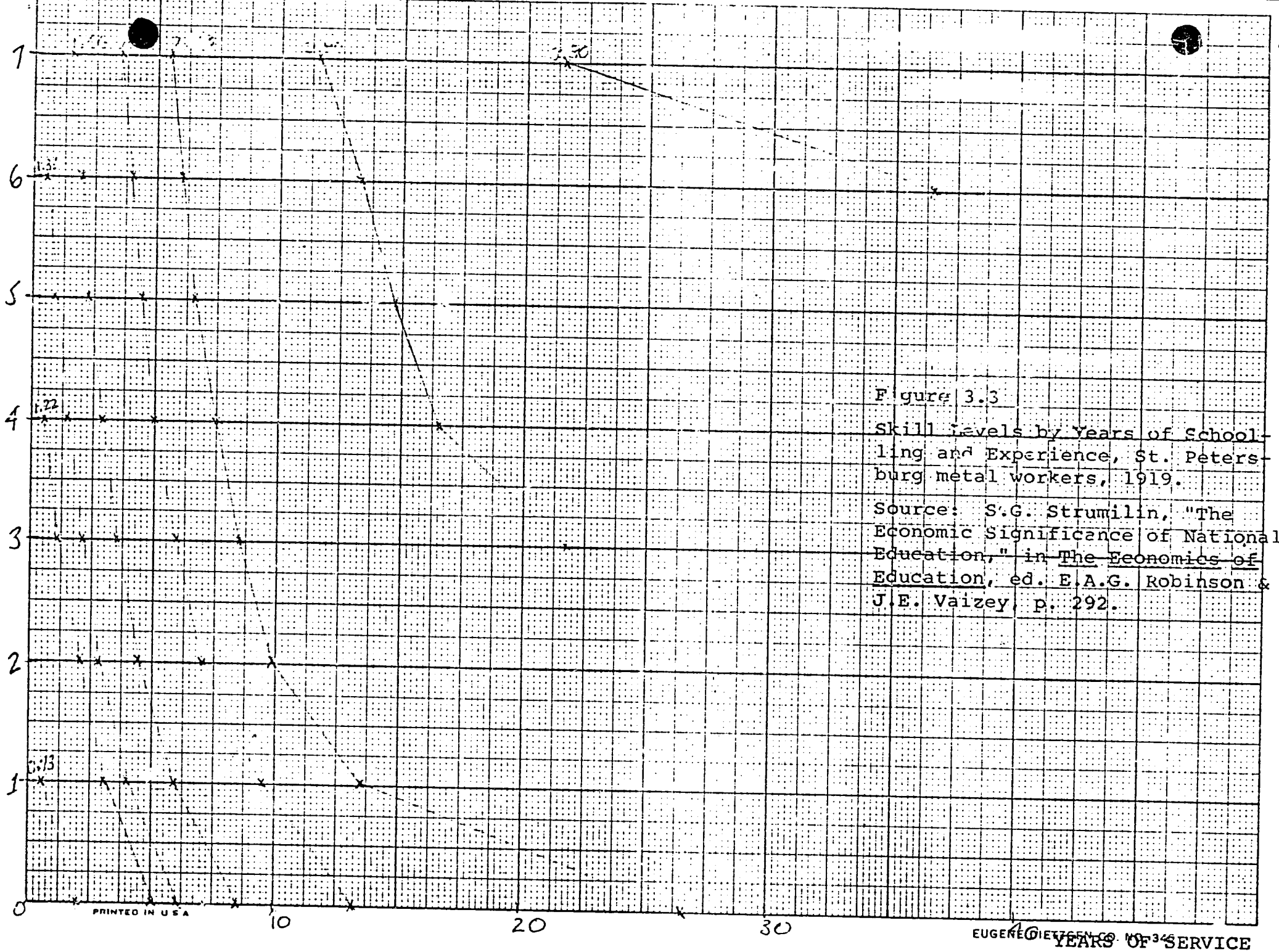


Figure 3.3

Skill levels by Years of Schooling and Experience, St. Petersburg metal workers, 1919.

Source: S.G. Strumilin, "The Economic Significance of National Education," in The Economics of Education, ed. E.A.G. Robinson & J.E. Vaizey, p. 292.

worker and the difference in the worker's productivity associated with his additional education. Thus, given differences in both production and factor supply functions, we would expect to find some differences between firms and between countries in the educational level of workers in a given occupation. When this is the case, we have evidence of the absence of a uniquely determined technological relationship between formal schooling and skill formation. The converse is not true, for where we find a fairly uniform educational attainment in a given job, this may be the result of a conscious choice by employers from a wide variety of possible educational backgrounds for the job.[8/]

[8/] Of course if the productivity relationships and the cost of hiring more educated workers is the same within a given country, we would expect to observe a unique relationship between job titles and educational attainments. This unique relationship would, of course, be the result of each firm's optimization process and would not reflect an underlying technologically-determined relation.

We now investigate whether persons in a given occupation in different countries are characterized by similar educational attainments. In order to make use of available data we must assume that particular skills are well represented by occupational titles, such as sales workers or metal workers.[9/]

[9/] Naturally the level of skill will vary with any occupational category.

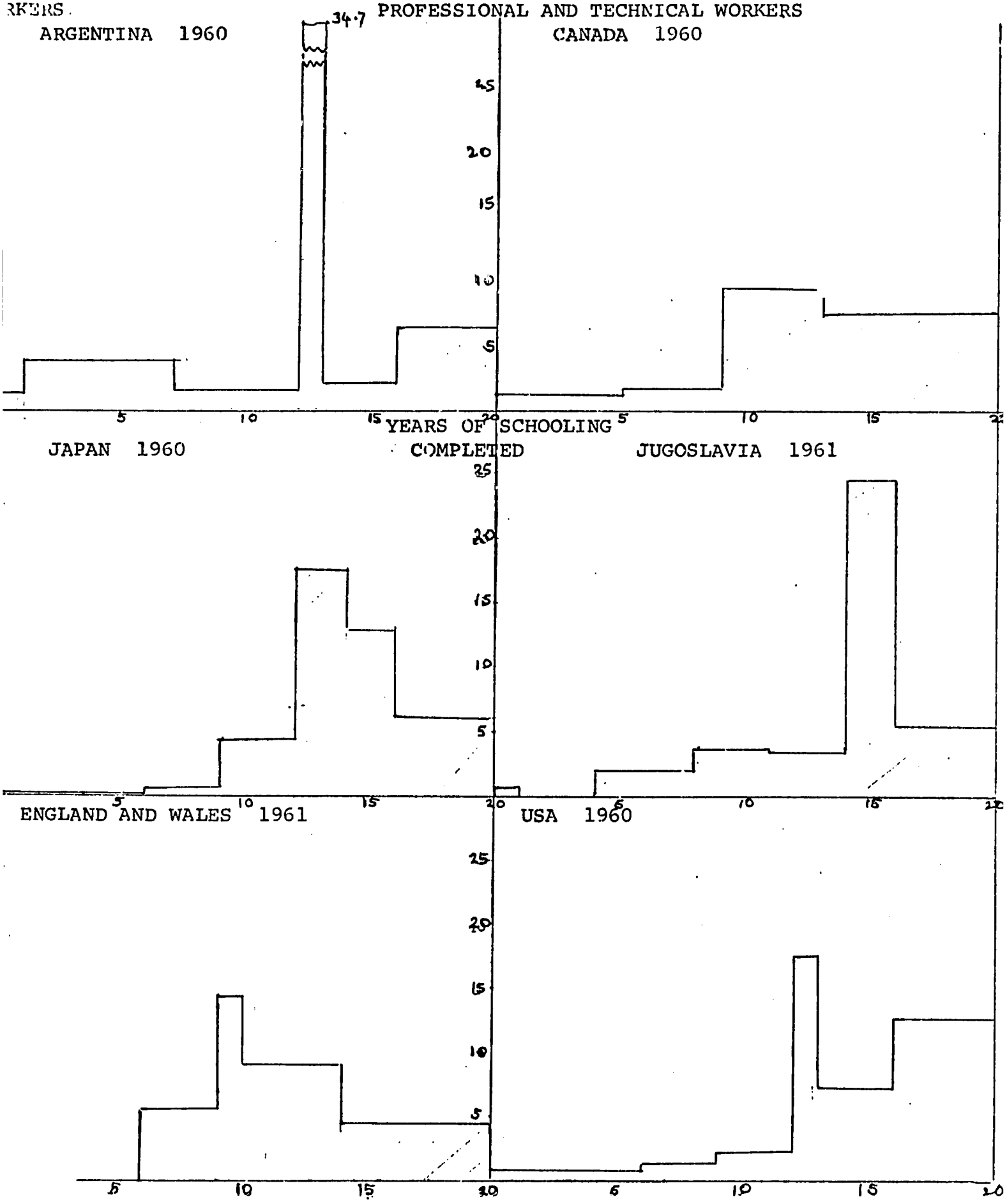
Some occupations, of course, have a unique educational requirement; doctors and lawyers (in some countries) are probably the best examples.[10/] At the other end of the spectrum we might expect that there is no unique educational requirement for being a sales worker or a manager.

10/ It should be noted that the unique relationship here derives not so much from the nature of the work and the crucial importance of the education in the performance of the job, as in job entry restrictions imposed by professional organizations and enforced by the state. It would not be an exaggeration to say that we define a doctor as one who has successfully completed medical school and the associated internship; the occupational title and the educational requirement are synonymous.

We find that persons in a given occupational group tend to have a wide variety of educational attainments and that the educational characteristics of occupation differ considerably from country to country. Figures 3.4 and 3.5 present data on the distribution of workers in two major occupational groups in six countries for which comparable occupational definitions and educational data are available. Professional and technical workers and clerical workers were chosen as the two major groups most likely to exhibit distinct educational "requirements." The remaining major groups, manual workers, sales workers, administrators and managers, and other workers, display a dispersion of educational backgrounds which is, in most cases, greater than that for the two categories shown here. It is possible, of course, that the considerable dispersion of educational attainments within occupational groups and the considerable differences in mean attainments between countries is explained by an insufficiently narrow definition of the occupation. Figures 3.6 and 3.7, which present similar data for subgroups within the professional and technical workers and the clerical workers categories suggest that this is only partly the case: some narrowing of the dispersion appears, but the general picture conveyed

FIG. 3.4

PROFESSIONAL AND TECHNICAL WORKERS



OF
ORKERS

FIG 3.5 CLERICAL WORKERS

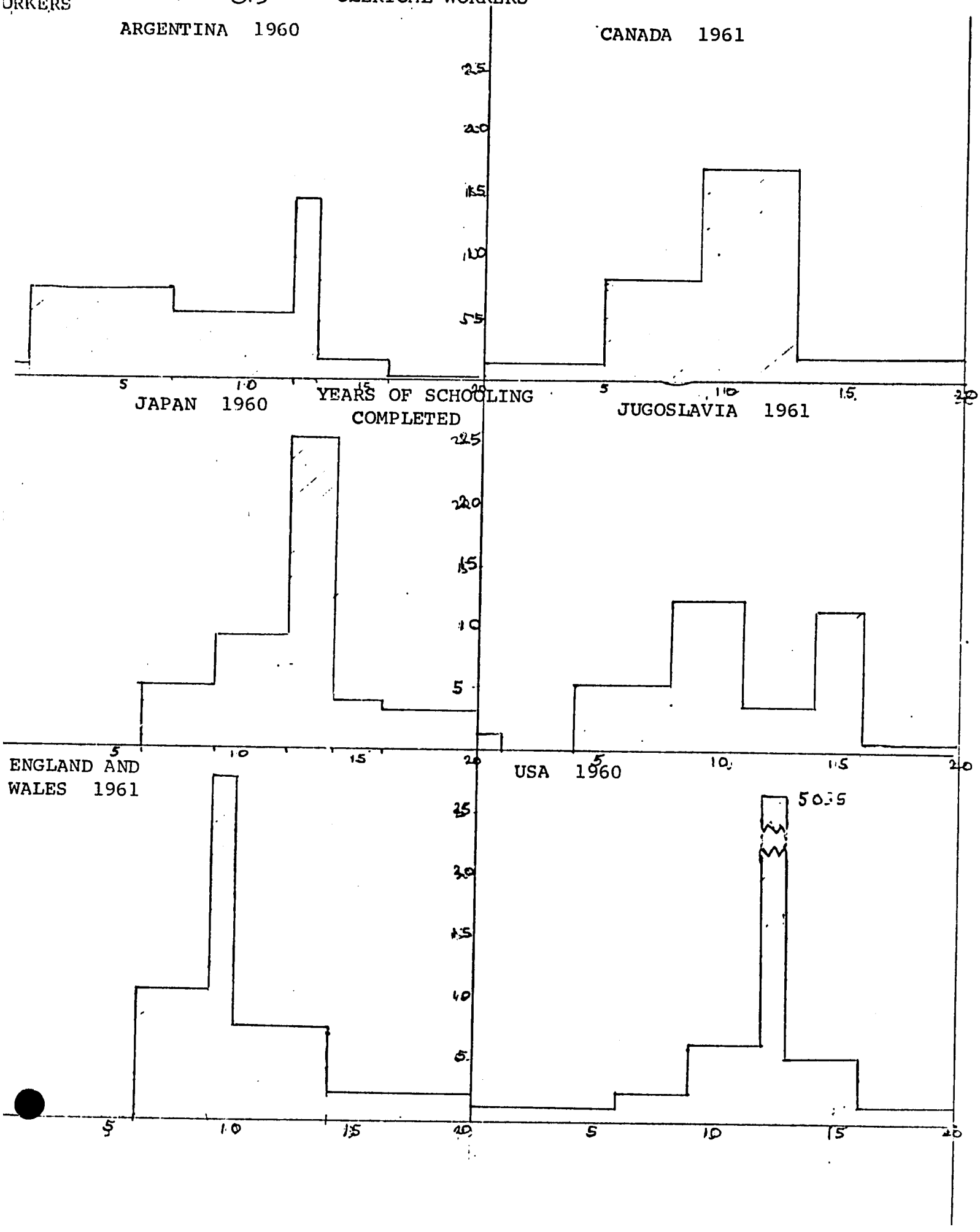
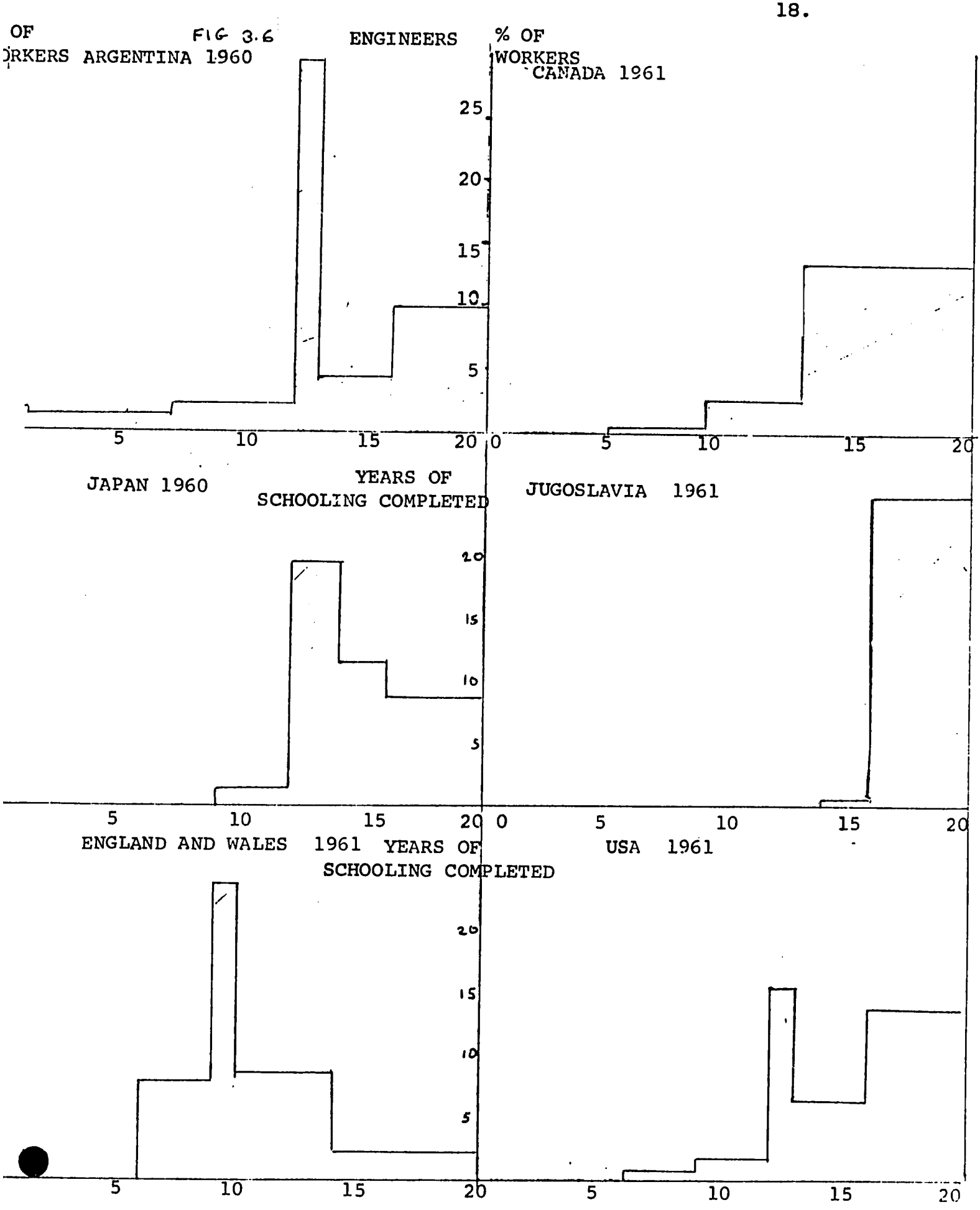


FIG 3.6


OF
ORKERS ARGENTINA 1960
ENGINEERS
% OF
WORKERS
CANADA 1961
25
20
15
10
5
5
10
15
20
0
5
10
15
20
JAPAN 1960
YEARS OF
SCHOOLING COMPLETED
JUGOSLAVIA 1961
20
15
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20
0
5
10
15
20
ENGLAND AND WALES 1961
YEARS OF
SCHOOLING COMPLETED
USA 1961
20
15
10
5
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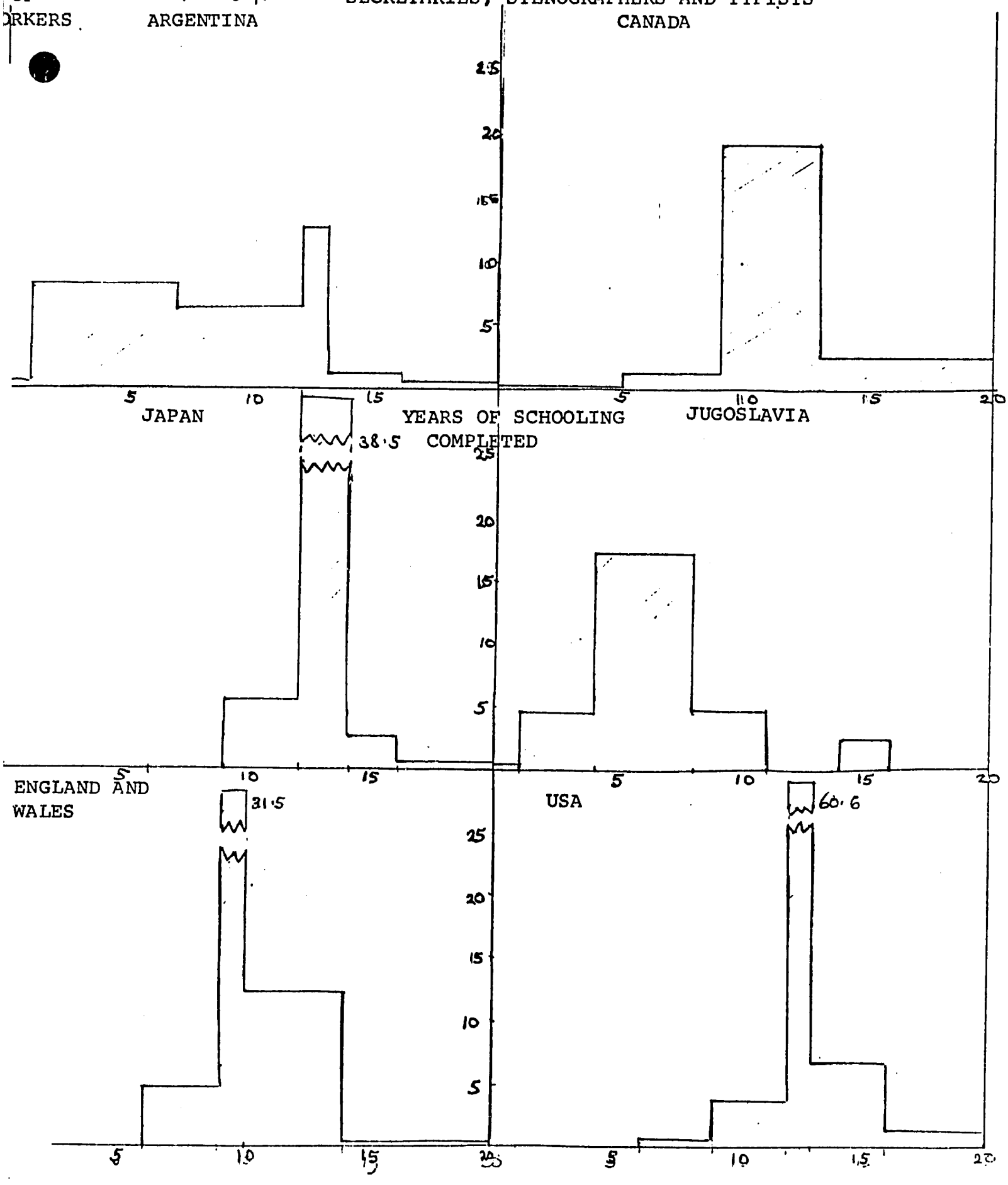
20

OF
ORKERS

FIG 3.7. SECRETARIES, STENOGRAPHERS AND TYPISTS



is not qualitatively different.[11/]

[11/] Additional evidence on the wide dispersion of educational attainments within an occupation relating to India, the Congo, and several European countries can be found in H. Parnes "The Relation of Occupation to Educational Qualification," in OECD, Planning Education for Economic and Social Development, Paris, 1962, p. 152, and in C. A. Anderson, "Patterns and Variability in the Diffusion of Schooling" in C. A. Anderson and M. J. Bowman, Education and Economic Development, pp. 321, 322.

While the above data are illuminating, the best information on this subject concerns the United States. Moreover, because of the existence of earnings data associated with occupation and level of education, we are able to test an additional implication of the existence of a unique educational requirement for the performance of each job. This is that if workers have less than the "required" amount of schooling employers find them worth virtually nothing, and consequently pay them very little (or do not hire them at all), and further, that years of education above the "required" amount may or may not impair one's earnings, but do not enhance them. Thus we can say that the distribution of workers and salaries implied by the existence of rigid educational requirements for each job resembles Figure 3.8.A, rather than 3.8.B.[12/]

[12/] This approach was suggested to me by M. Blaug et al., "The Utilization of Educated Manpower in Industry," Ch. 5, p. 3.

Figures 3.9-3.12 represent the distribution of male workers and the level of annual earnings for the United States in 1960 by occupation.

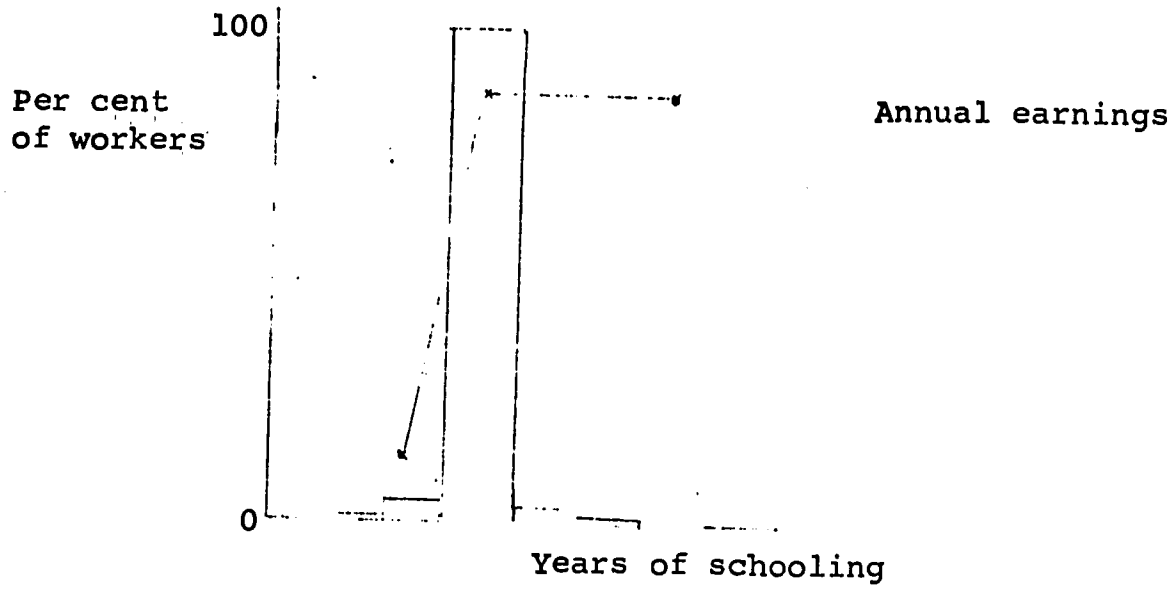


Figure 3.8.A

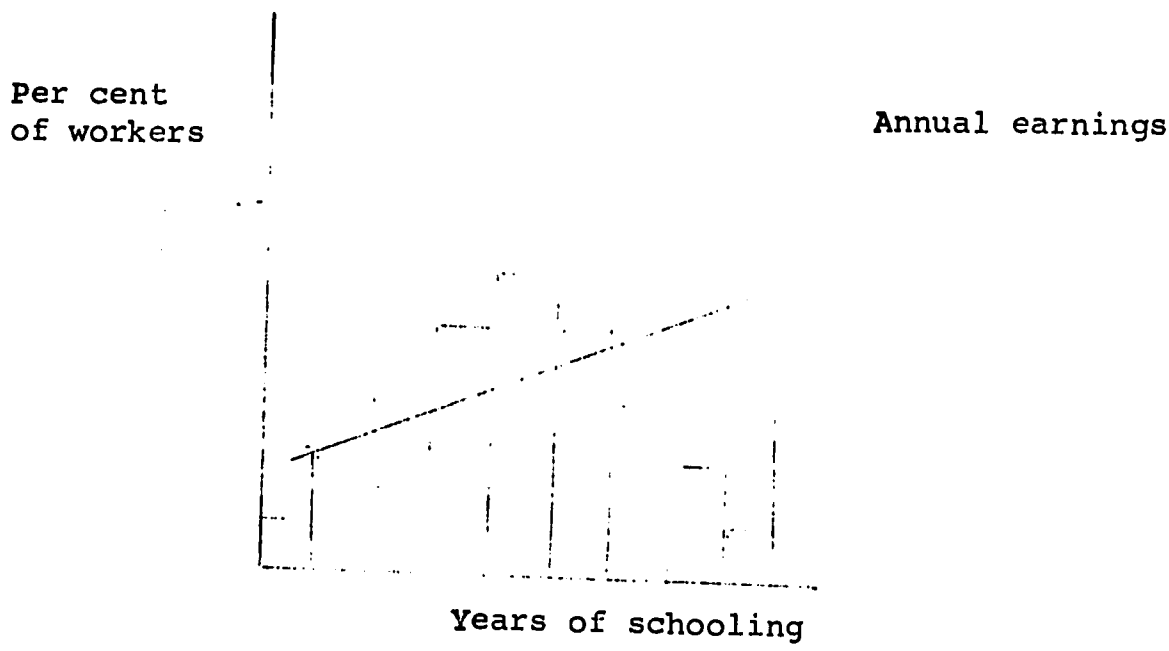


Figure 3.8.B

FIG 3.9

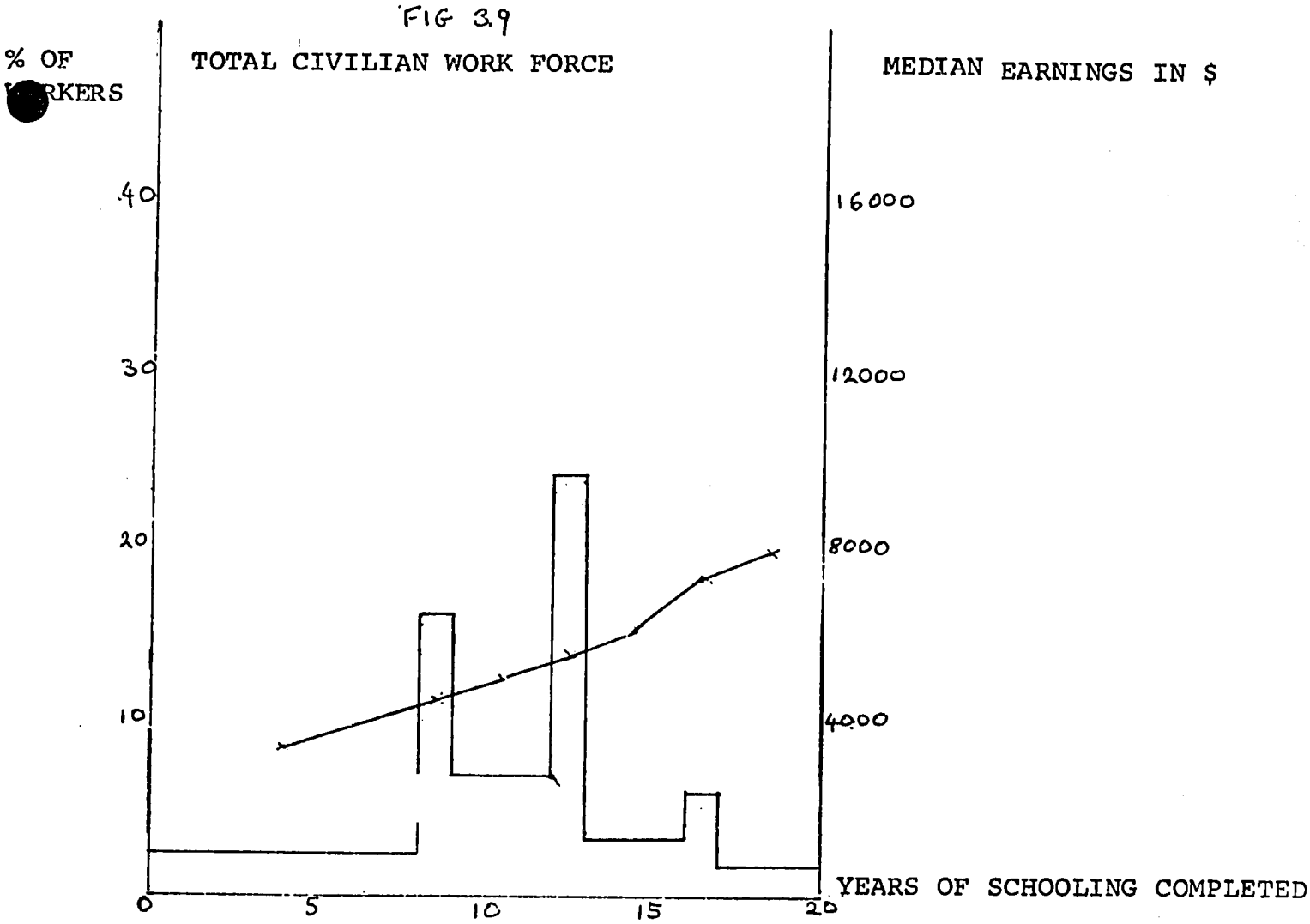
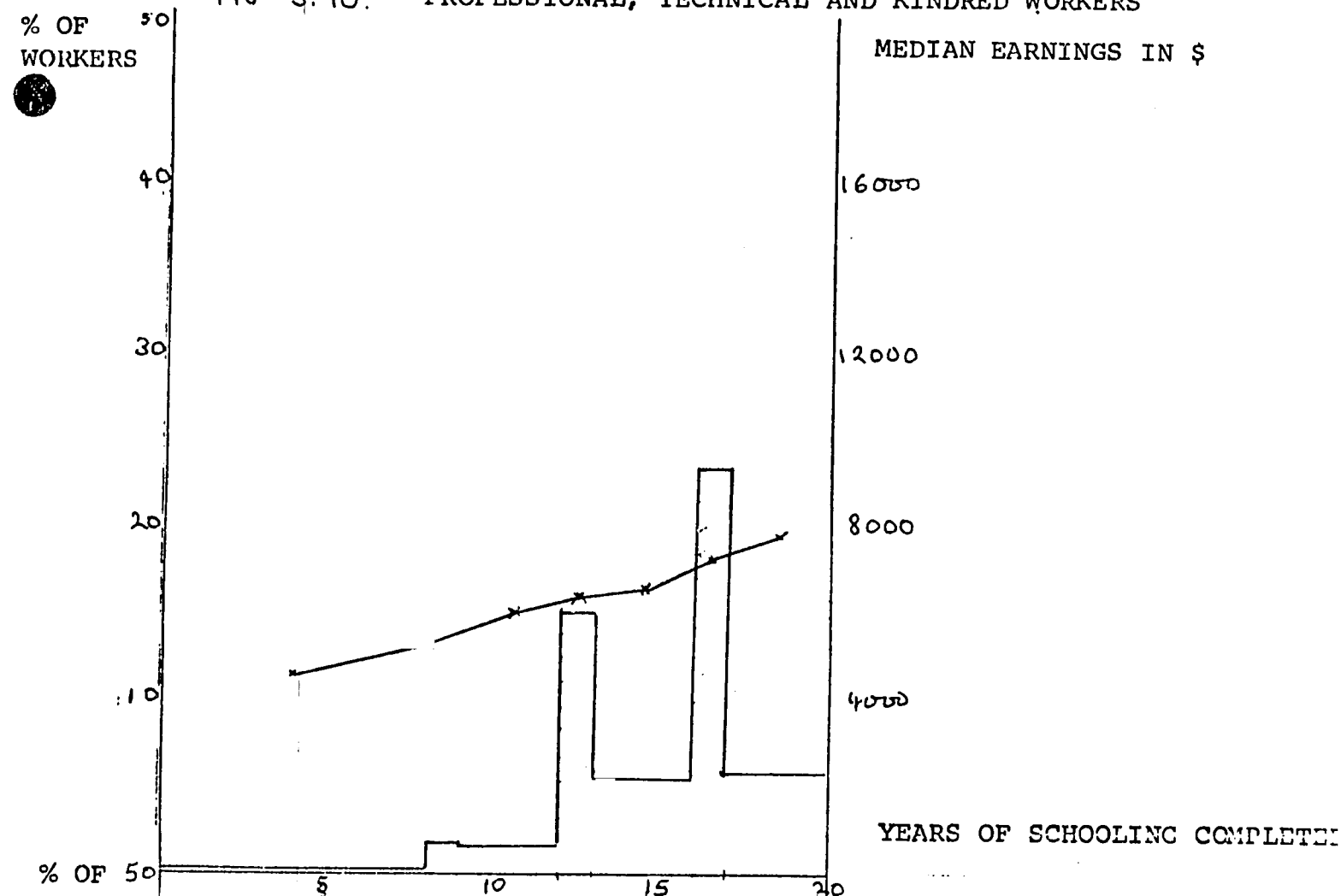
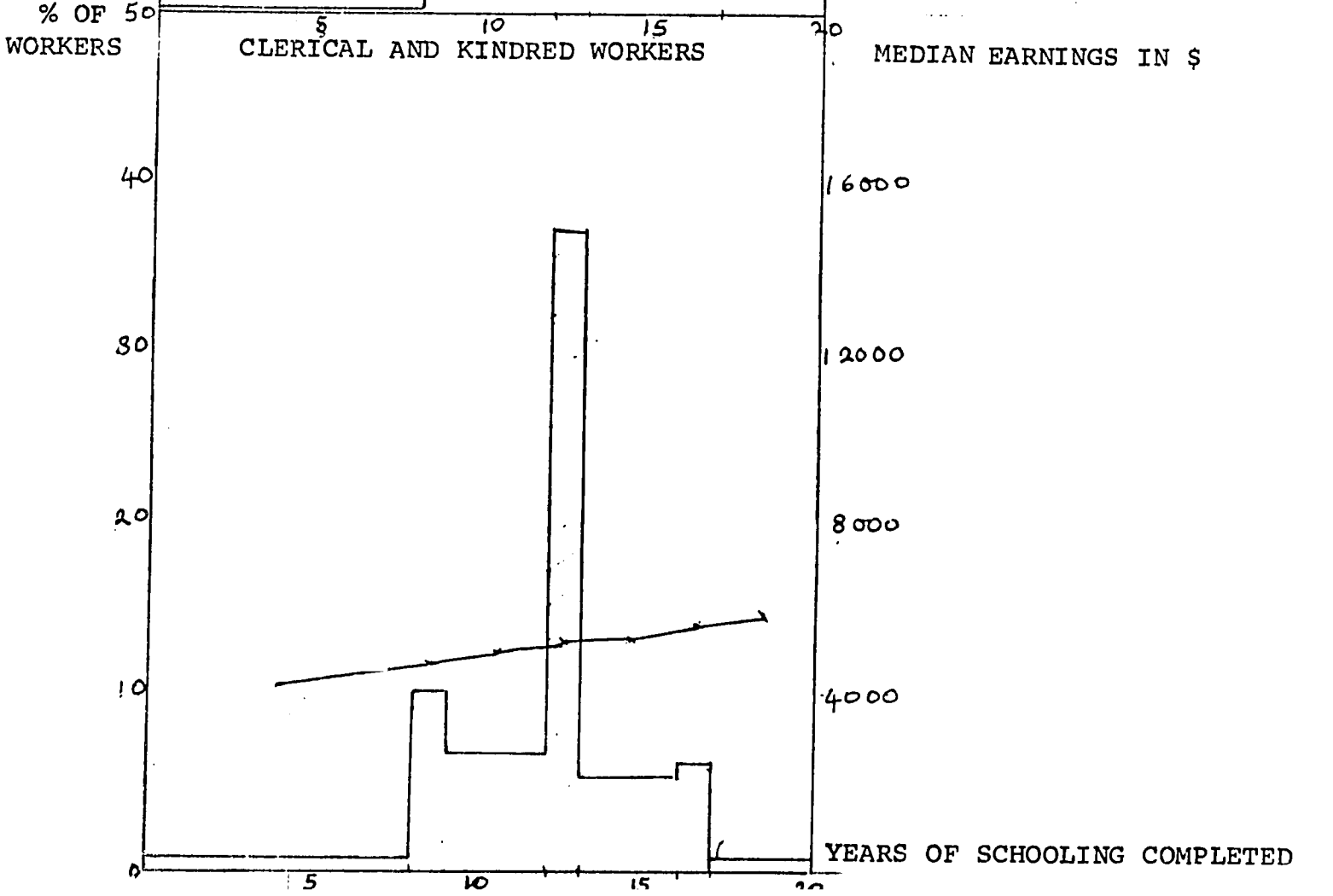

% OF
RKERS
TOTAL CIVILIAN WORK FORCE
MEDIAN EARNINGS IN $
40
30
20
10
16000
12000
8000
4000
0
5
10
15
20
YEARS OF SCHOOLING COMPLETED

FIG 3.10. PROFESSIONAL, TECHNICAL AND KINDRED WORKERS

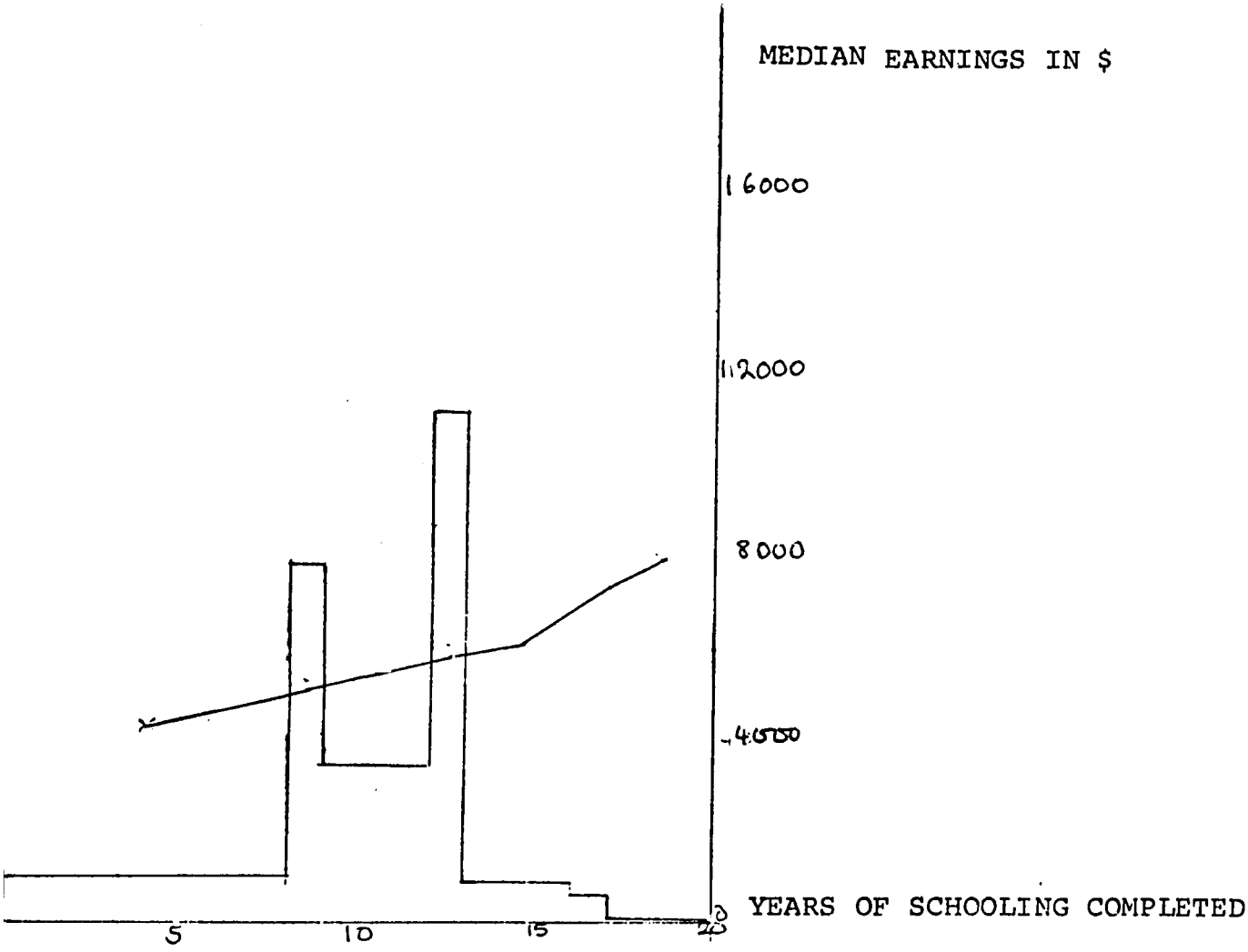


CLERICAL AND KINDRED WORKERS



OF WORKERS

FIG 3.11. CRAFTSMEN, FOREMEN AND KINDRED WORKERS



OPERATIVES AND KINDRED WORKERS

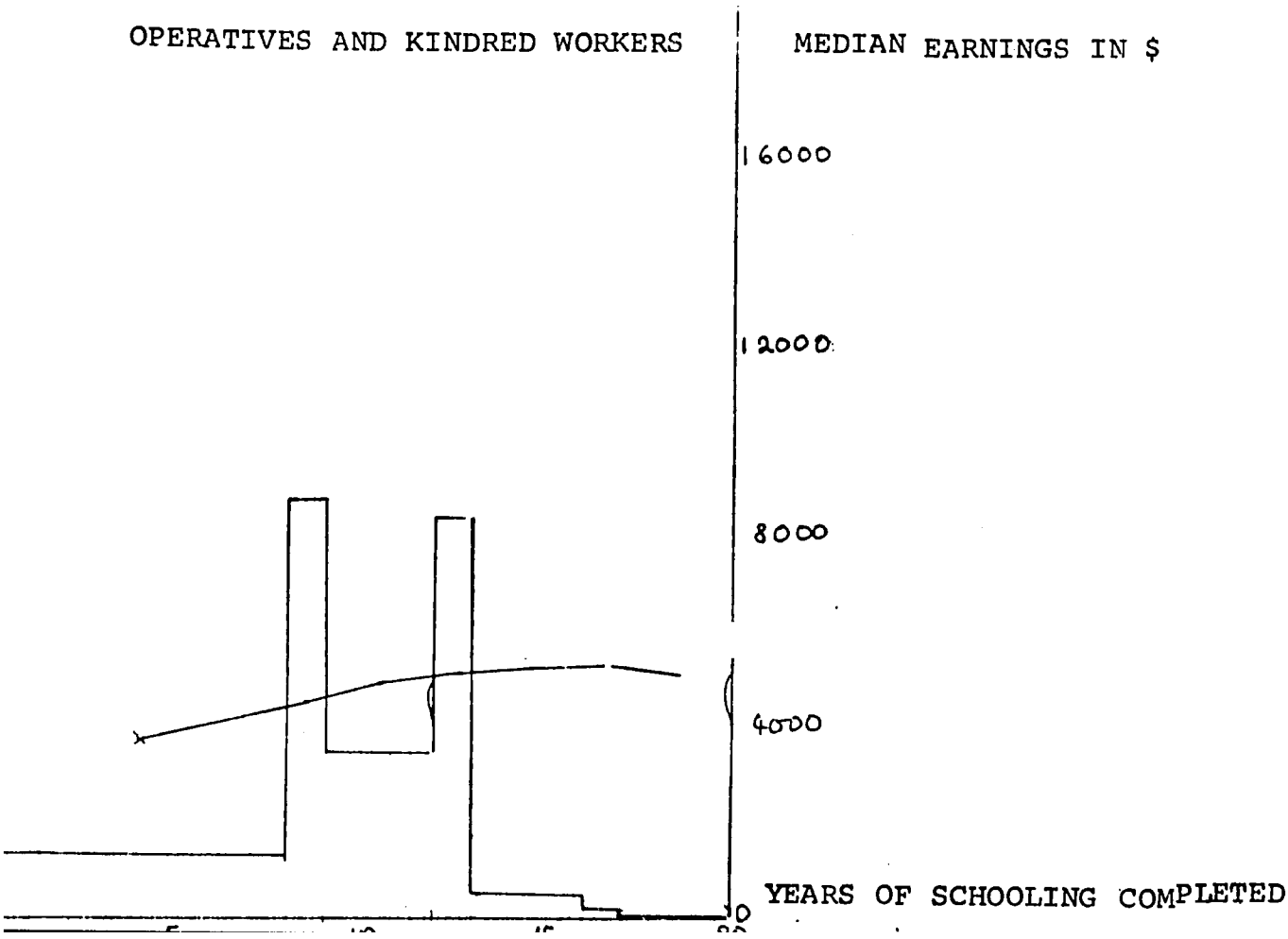
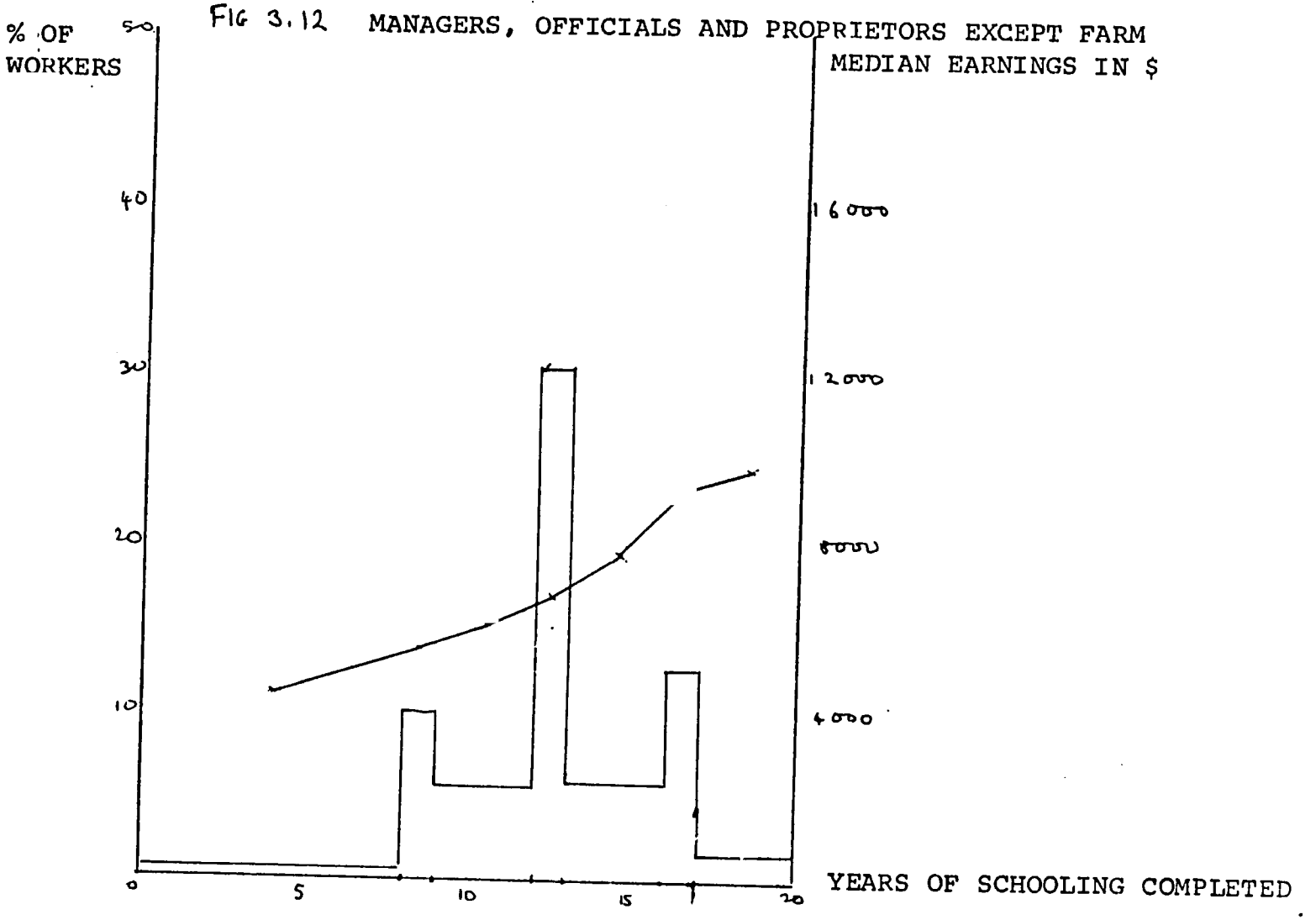


FIG 3.12 MANAGERS, OFFICIALS AND PROPRIETORS EXCEPT FARM



A number of comments about these figures should be made. First, it might be thought illegitimate to include workers of all ages, as this group does not reflect contemporary hiring policies, and moreover because of the association of low educational attainment with a long work experience and seniority, the steepness of the earnings curve in the aggregate data is underestimated. For this reason the analogous data for males 18-24 years old are presented in Figures 3.13-15.[13/] The

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[13/] For some occupations there were too few observations in this category to be recorded in the census report.

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graphs for the younger age group convey roughly the same picture except for a slightly less dispersed distribution of workers by educational level and, in some cases, a slightly more marked upward kink in the earnings curve at some level of schooling.

Second, those occupations representing the broad occupational categories could be expected to give the appearance of considerably more educational substitutability than would be the case if the occupations were defined more narrowly. For this reason similar information on some of the narrow occupational categories is presented in Figures 3.16-18. These figures indicate somewhat less substitutability, as expected, yet the overall picture conveyed is still one of a rather weak relationship between education and occupation.

The data presented here were not selected in any systematic way, although they appear to be representative of most of the other occupational categories in the U.S. Census. Although we have found no distributions of earnings and workers within an occupation which correspond to that implied by the existence of a schooling requirement for an occupation, the data will not support any strong conclusions on the degree of substitutability

FIG 3.13

PROFESSIONAL AND TECHNICAL WORKERS AGE 18-24

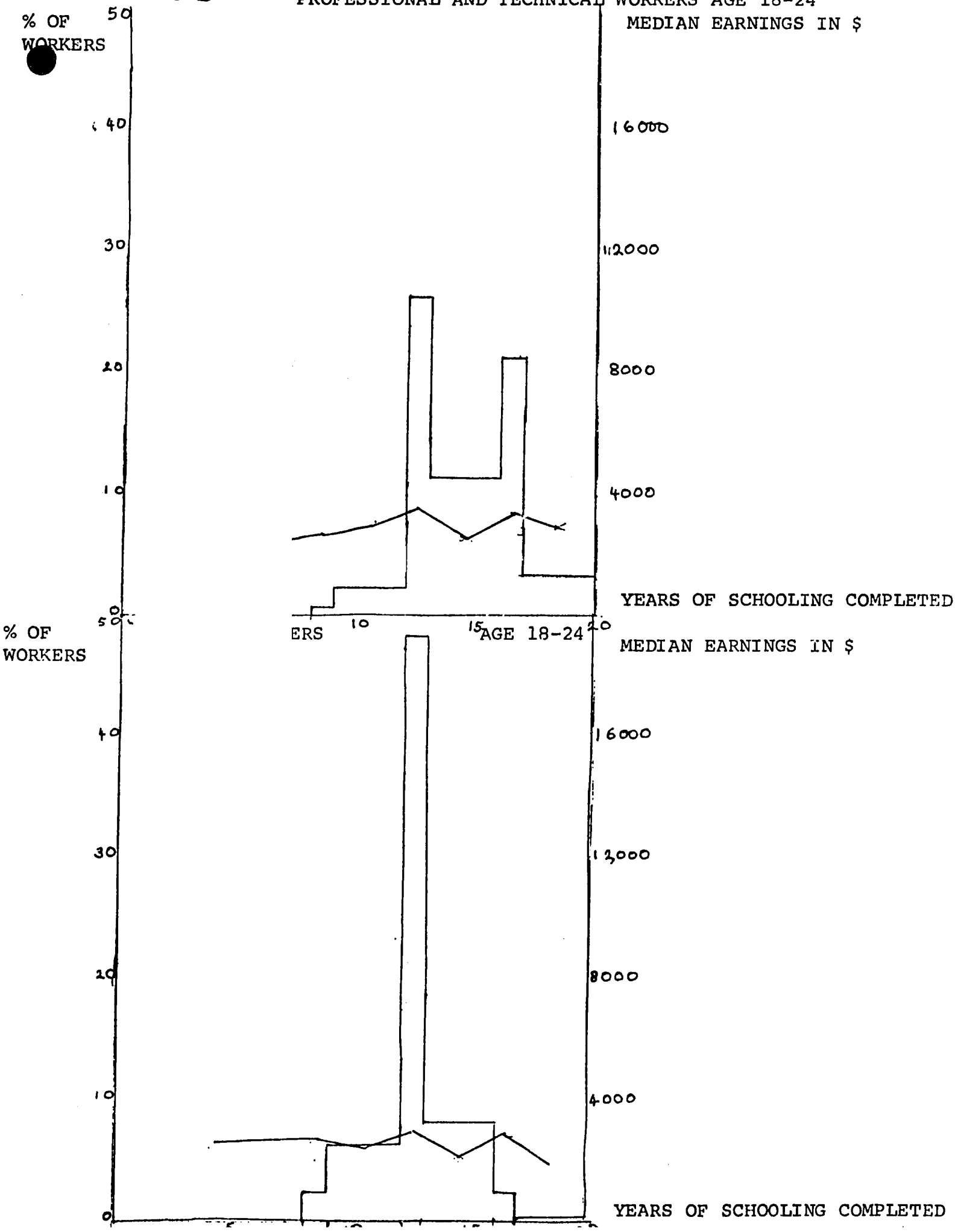
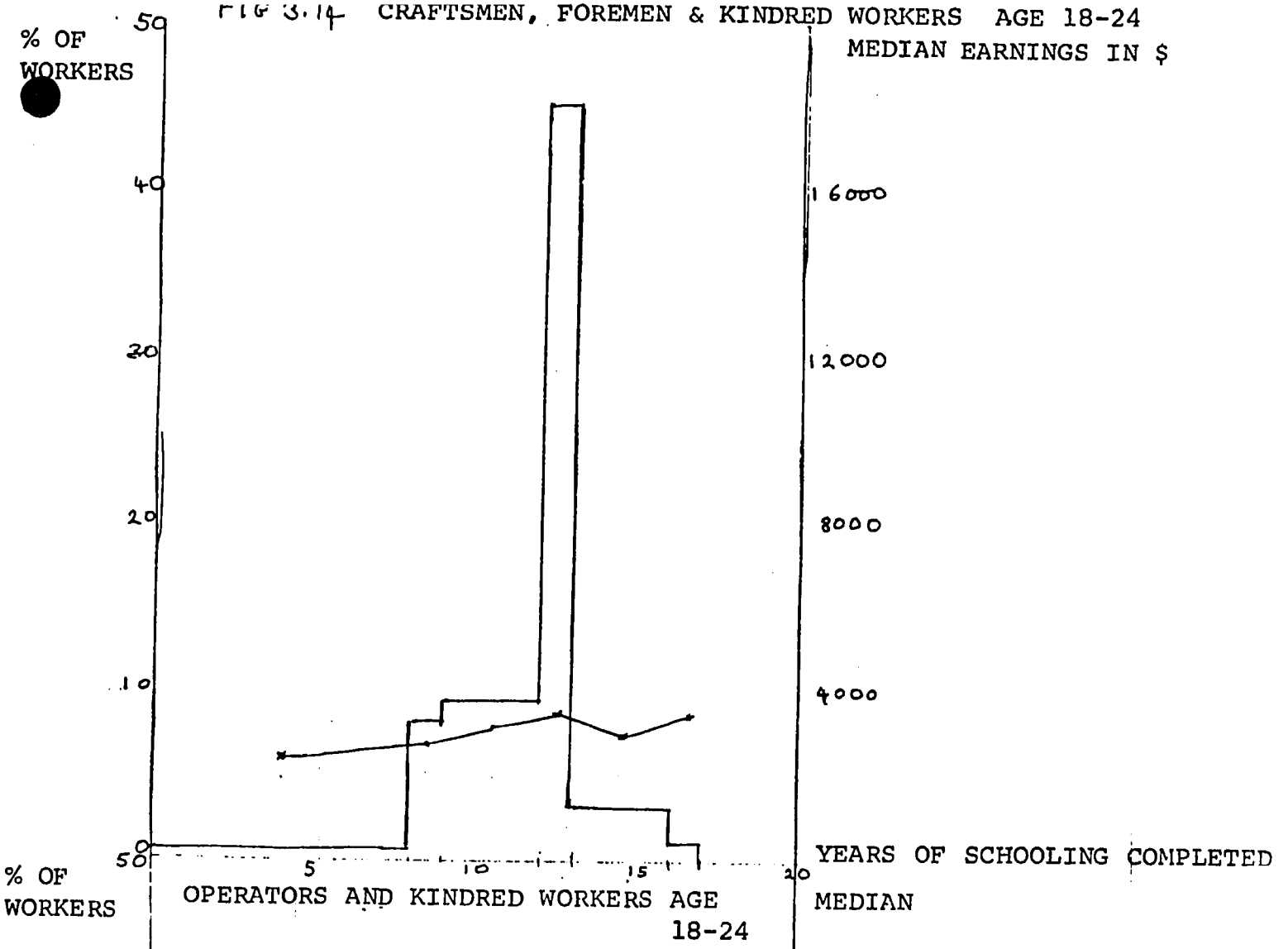


FIG 3.14 CRAFTSMEN, FOREMEN & KINDRED WORKERS AGE 18-24



OPERATORS AND KINDRED WORKERS AGE 18-24

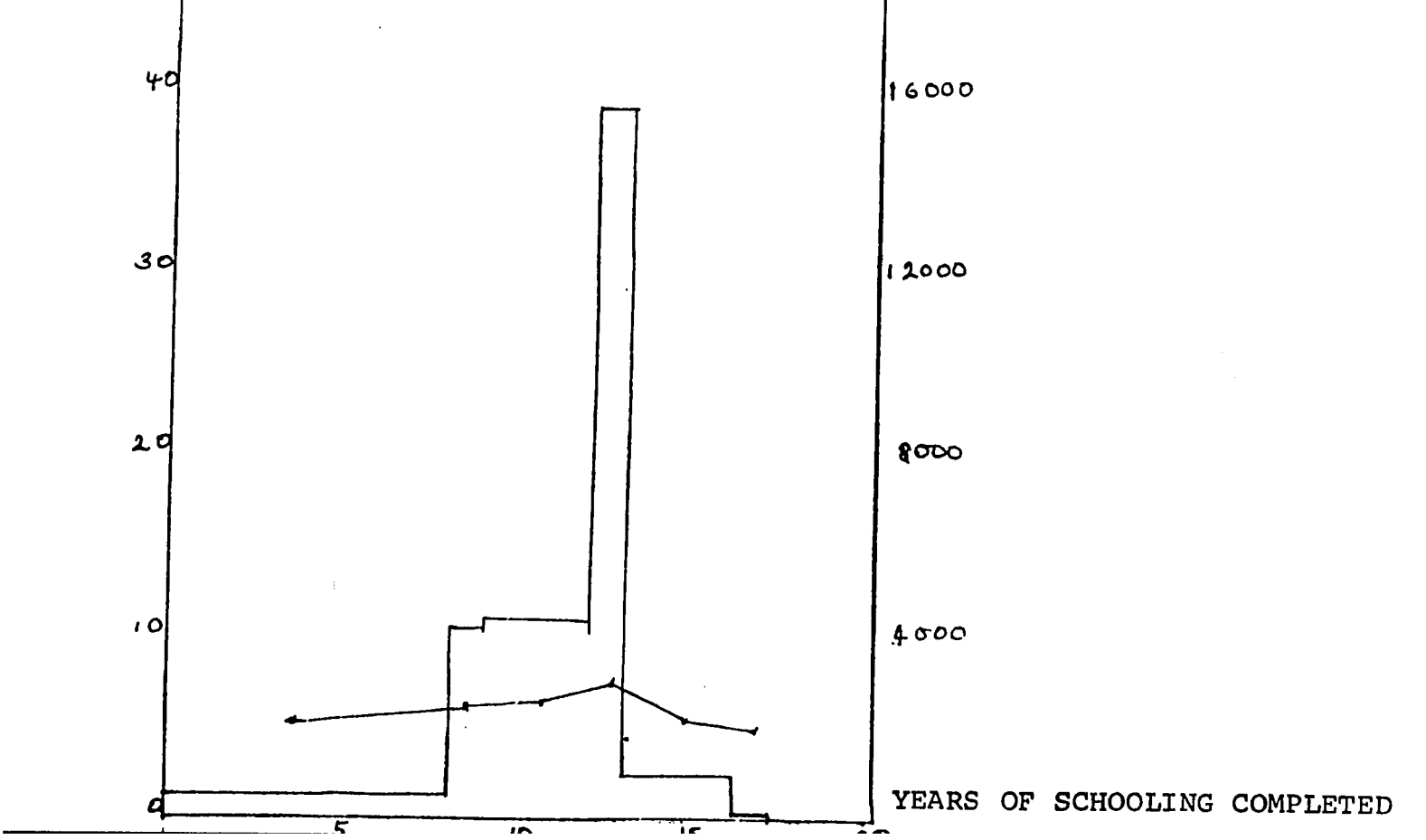
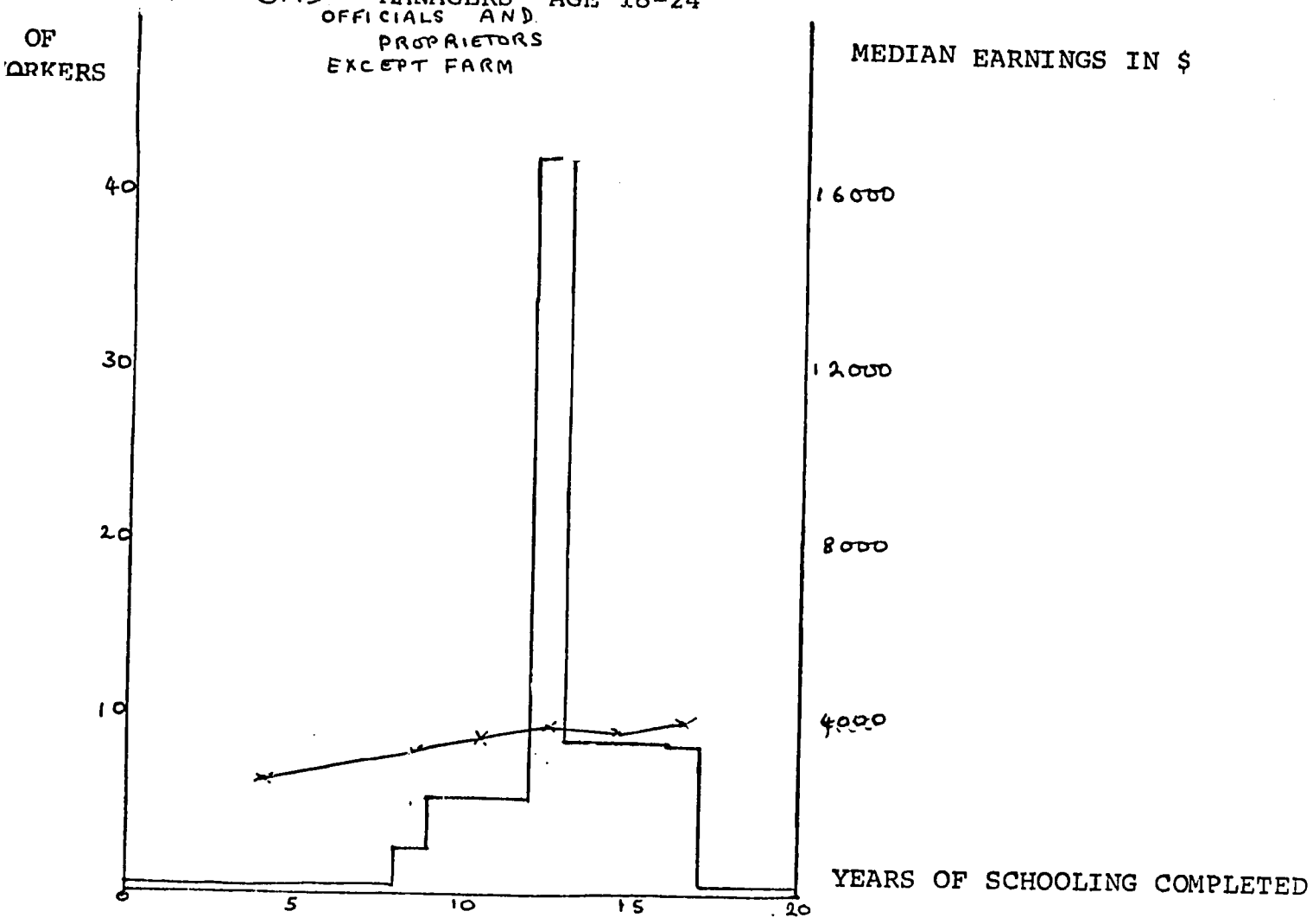


FIG 3.15 MANAGERS OFFICIALS AND PROPRIETORS EXCEPT FARM AGE 18-24



in skill formation. In the absence of any method of summarizing the data from all available occupational categories, and lacking any operational definition of what would constitute a significant departure from the generally high degree of substitutability which is apparent in the observed data, we can claim little more for the above than an illustration of what are apparently the consequences of a high degree of substitutability between formal schooling and other attributes in skill formation. However, the data does suggest that one important source of the high elasticity demand for educated labor is the lack of unique schooling requirements for the acquisition of given occupational skills.

In addition to the possibility of substitution between various types of labor within a skill, there is the further possibility of substitution among skills.[14/] The ability

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14/ Some of the best examples of this process of substitution can be found in the adaptation of the U.S. Second World War economy to the newly recruited labor force generally lacking in industrial skills and possessing a lower level of general education than the labor force in the immediate prewar years. Among other methods used, complicated jobs were frequently subsdivided into a series of relatively simple tasks, each one capable of being performed by a person with rudimentary skills.

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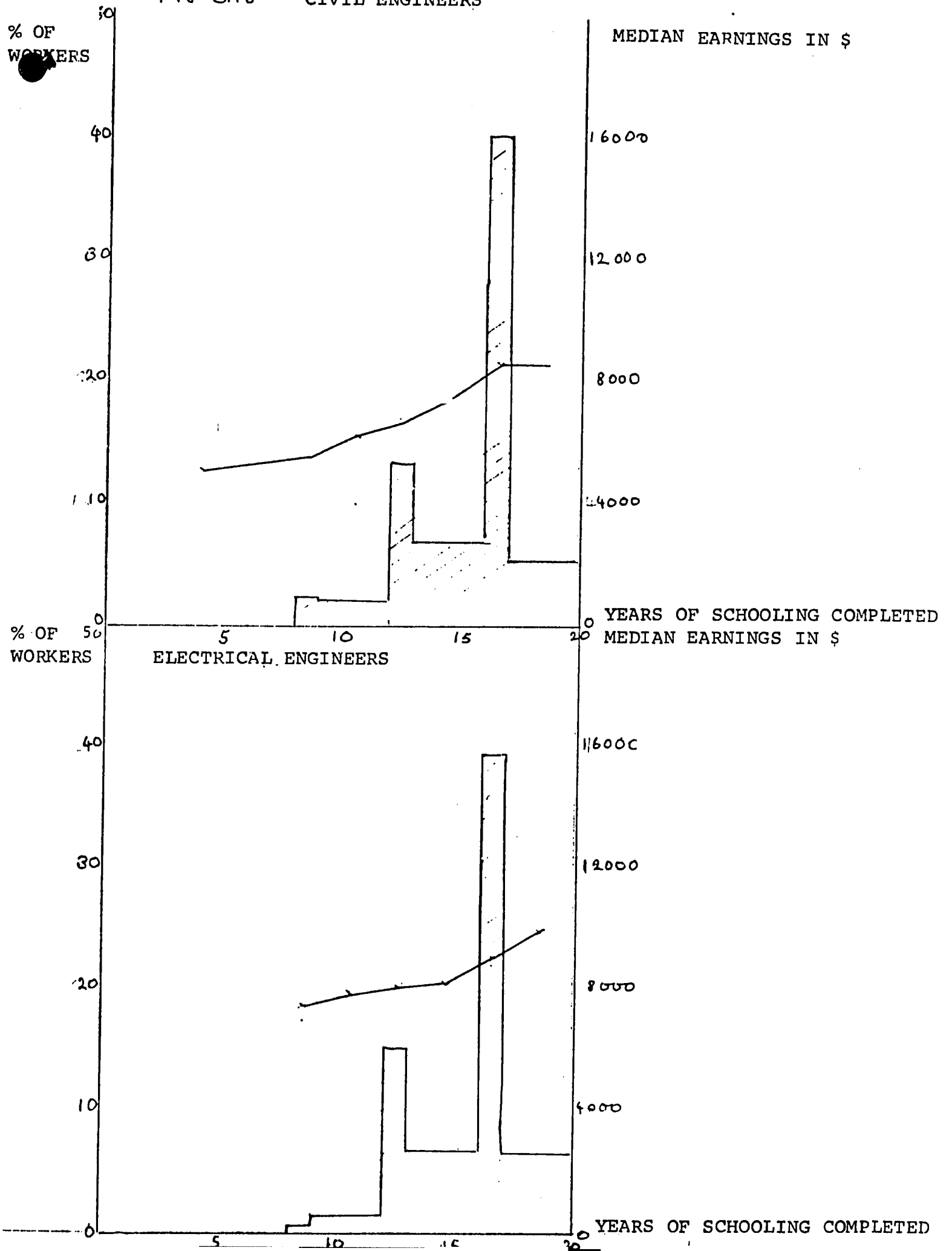
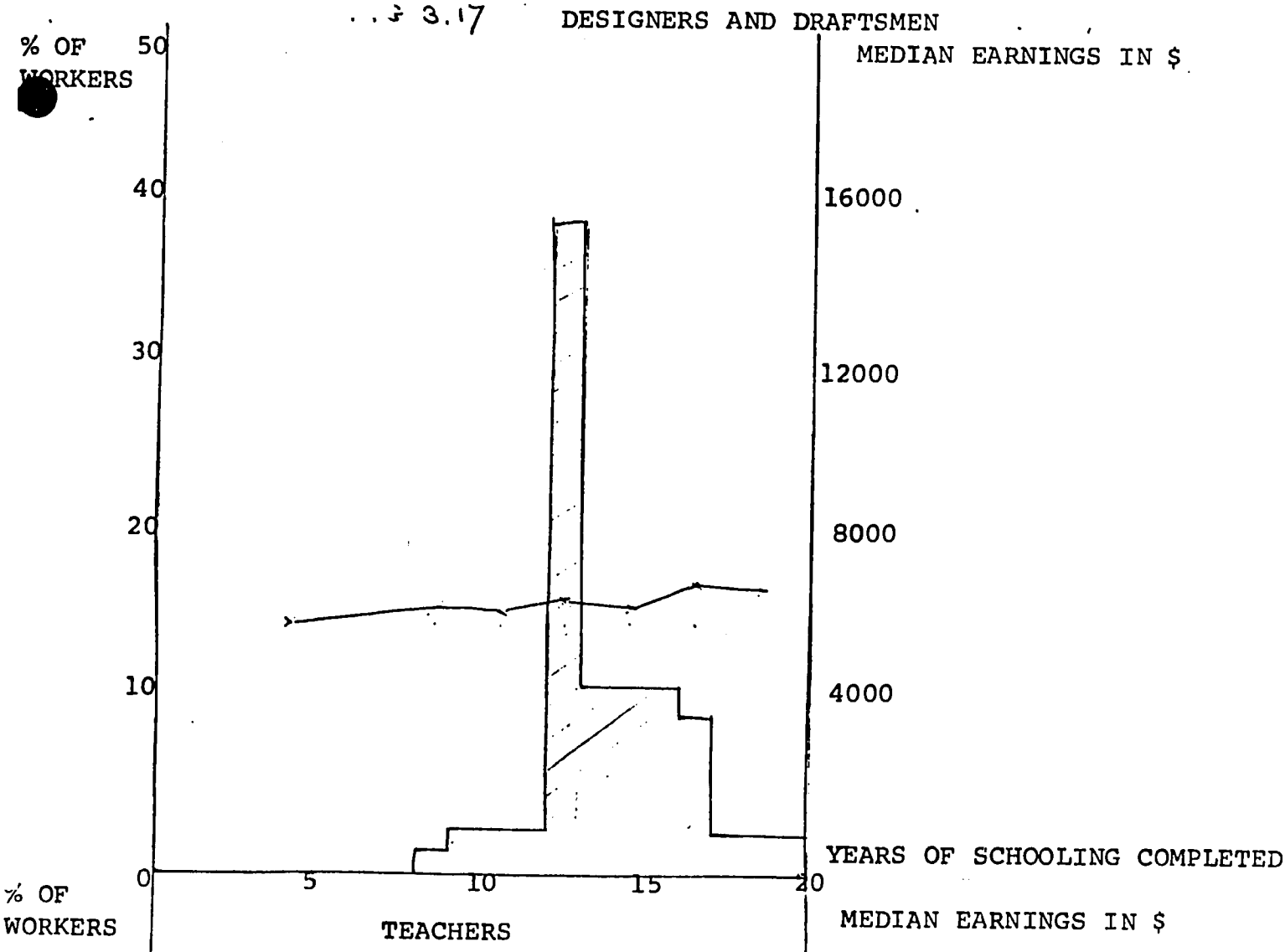
to substitute amongst various skills depends to some extent on the ability to choose in investing in physical capital goods between plant and equipment embodying skill-using techniques as against those requiring few skills. In large part, however, the ability to substitute amongst labor inputs does not depend directly on the form of physical capital employed.

FIG 3.16 CIVIL ENGINEERS



3.17 DESIGNERS AND DRAFTSMEN



TEACHERS

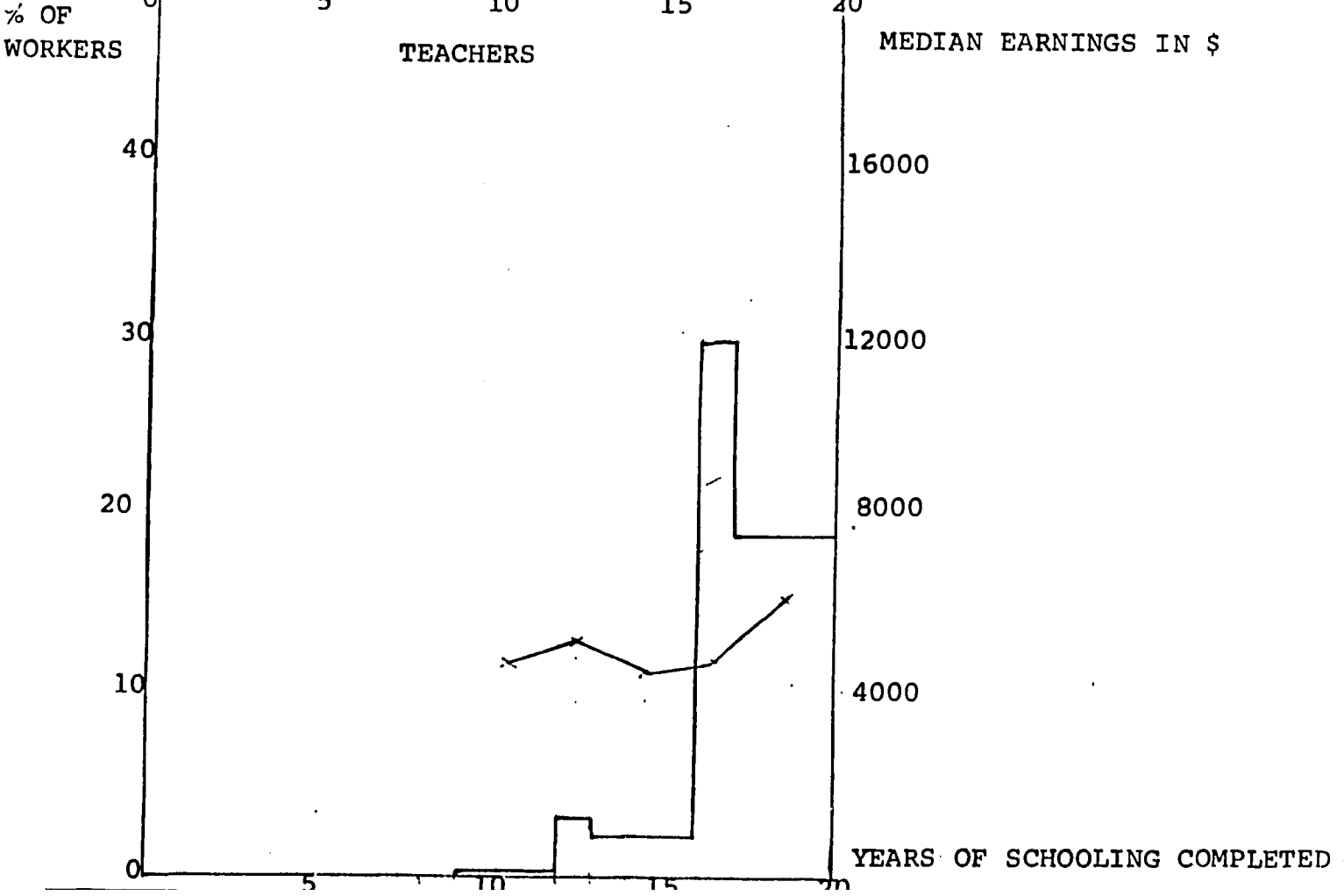
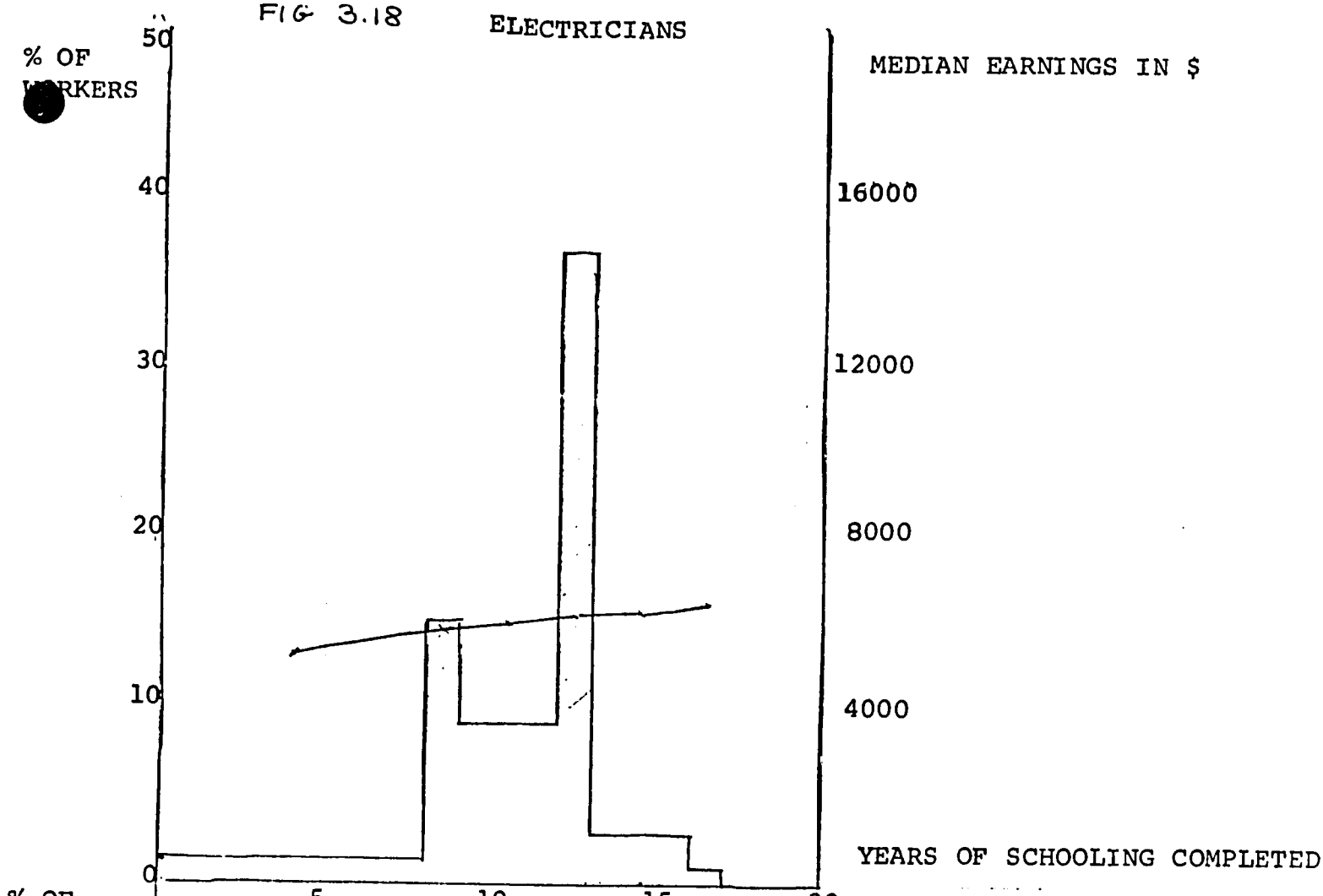
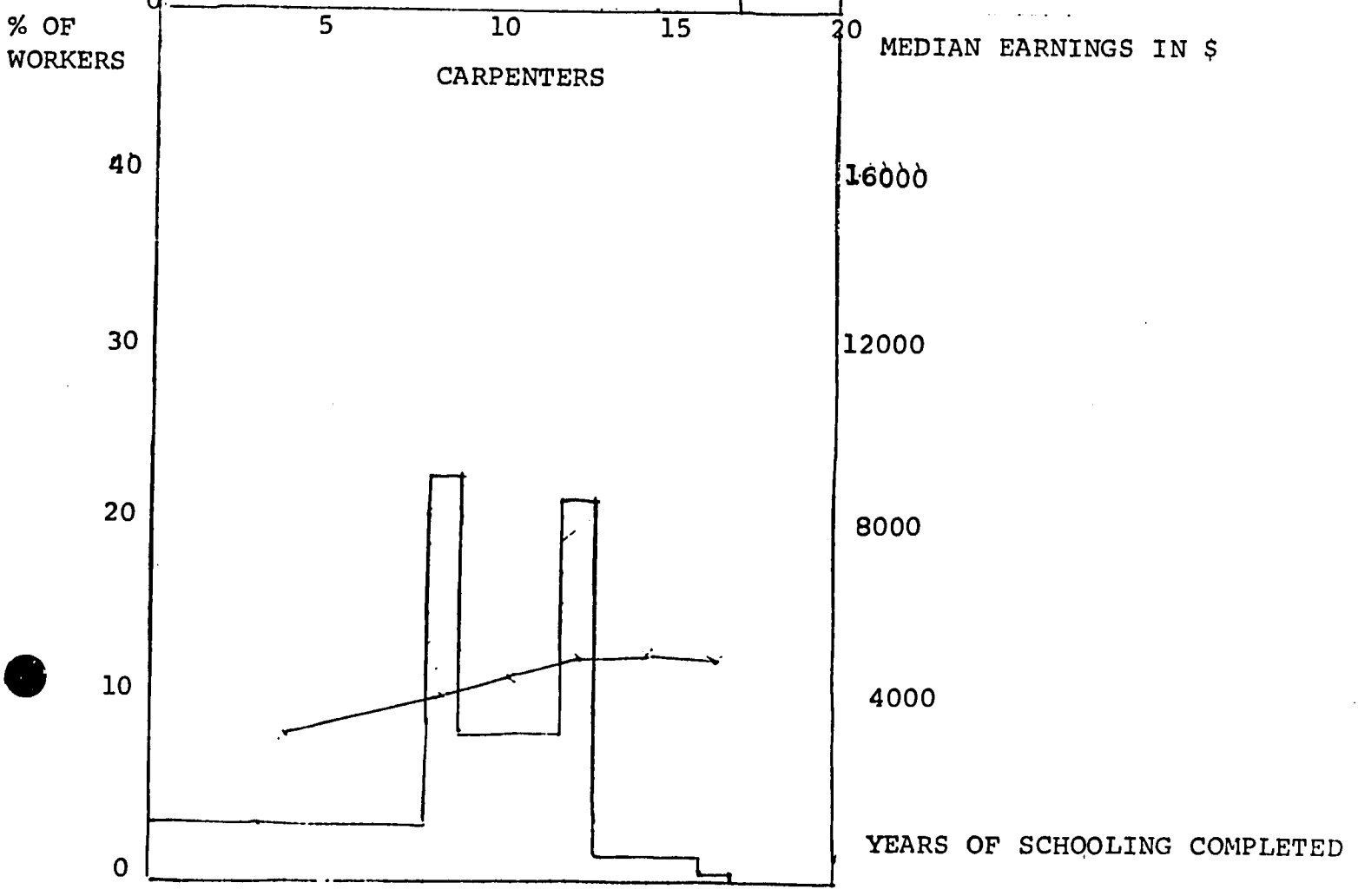


FIG 3.18


ELECTRICIANS
% OF WORKERS
MEDIAN EARNINGS IN $
50
40
30
20
10
0
16000
12000
8000
4000
5
10
15
20
YEARS OF SCHOOLING COMPLETED


% OF WORKERS
MEDIAN EARNINGS IN $
CARPENTERS
40
30
20
10
0
16000
12000
8000
4000
YEARS OF SCHOOLING COMPLETED

Often overlooked in this respect are the various institutional choices facing an economy. Plantation or collective agriculture may economize on the use of entrepreneurial and technical skills, at least in the cultivation of some types of crops. Likewise rigid civil service rules of procedure are often a device to insure that bureaucrats arrive at decisions which will be appropriate in most situations and thus allow the adequate performance of complicated jobs by individuals of relatively little education or judgment.[15/]

15/ Max Weber, "On Bureaucracy,"

The abundance of bureaucratic red tape in many underdeveloped countries may in some degree reflect this process of substitution of decision-making rules for decision-making skills.

3.3 Substitution in Final Demand

In addition to the possibility of substituting labor educated to different levels within given occupations, and the further possibility of substituting between skills in the production of a given good, there remains the possibility of achieving indirect substitutability through variations in the composition of the economy's output. Thus, substitution in production is complemented by substitution in final demand, through the alteration of the composition of final output so as to produce relatively little of those goods in which the relatively scarce labor categories are intensive inputs. Changes in the composition of the final bill of goods produced may arise either from changes in the composition of goods domestically consumed, or in changes in the pattern of exports and imports.

Because of transport costs and other barriers to trade, relative domestic commodity prices are not equalized among countries. Thus we may expect that other things being equal, countries with relatively abundant supplies of labor of one type will not only tend to export goods using relatively large amounts of that factor, but will consume more of those goods relative to other countries of a similar level of income.

The effect of the differential skill intensiveness of exports and imports is to allow the exportation or importation of skills embodied in internationally traded goods or services. On the other hand, substitution in consumption allows a country to "consume" its labor surplus in one area and to forego consumption of embodied scarce labor inputs. The effect in both cases is, of course, to increase the elasticity of demand for each type of labor, and thus to enable an economy to absorb large quantities of labor of one type while at the same time coping with a labor shortage in some other field.

The influence of a nation's relative factor endowments on the commodity composition of its exports and imports has recently been much debated, particularly with respect to the relative capital and labor intensity of commodities in foreign trade.[16/] The inclusion of labor skills or human

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16/ W. Leontief, Domestic Production and Foreign Trade; the American Capital Position Reexamined. Proceedings of the American Philosophical Society, Vol. 97, No. 4, pp. 332-349, September 1953.

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capital in the discussion is a recent development. Research by Keesing strongly suggests the validity of the basic factor endowments approach when labor skills are taken into account.

Using United States labor input coefficients, Keesing estimates the skill intensiveness of U.S. exports and imports, as well as those of the major European countries and Japan. His work establishes clearly that in terms of U.S. skill requirements, American exports are the most skill-intensive, followed by Sweden, West Germany and Great Britain. The order of skill intensity for imports is generally the reverse of that for exports. The striking point about Keesing's results is that trade patterns tend to reflect the level of general educational development in each country; education-rich countries are net exporters of skills embodied in traded goods and services. This remains true when extreme cases such as Hong Kong and India are included.

A supplementary result of Keesing's work is that the composition of U.S. domestic final demand is considerably more skill-intensive than any of the other countries in his study. Apparently the lower relative price of skill-intensive goods in skill-abundant countries explains both the tendency towards skill-intensive exports and a skill-intensive composition of domestic consumption.[17/] Thus we may expect that even

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17/ Presumably some relative price differential persists even in the presence of world trade, due to transport costs, tariffs, and other obstacles to relative price equalization. I. Svennilson cites the emergence of the German organic chemicals industry in the late 19th century as an example of the effect of the supply of educated labor -- in this case the abundance of university-trained chemists -- on the composition of output. ("Targets for Education in Europe in 1970," Vol. II of OECD, Policy Conference on Economic Growth and Investment in Education, Paris, 1962, p. 19.)

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in a world characterized by no substitution in production between inputs of different levels of educated labor, we will find that the total level of national income does not uniquely determine the educational composition of the labor force.

3.5 The Supply of Substitutes for Educated Labor

Where there exist close substitutes for a factor of production and where the supply of these substitutes is elastic, the elasticity of demand for the factor itself will be high. The finding in the first section of this chapter that the elasticity of substitution between two types of labor classified by years of schooling is as high as ten is in part attributable to the fact that skills needed in production may be acquired by a variety of means, only one of which is formal education. On-the-job learning, both in formal training and through experience are at least as important in most jobs. Employers ordinarily develop methods to generate the skills needed for the functioning of their organization, given the educational characteristics of supply of labor available for hiring in the labor market. Where the skills may be developed relatively simply and quickly outside of the formal schooling system, the elasticity of supply of substitutes for educated labor will be relatively high even in the short run.

The above data suggest that experience is a fairly good substitute for education, at least in those occupations investigated. To some extent, of course, experience represents more than simple unsupervised on-the-job learning. Much of the appearance of substitutability arises because the older workers have had the benefit of training and other programs designed to create needed skills. Among methods of skill creation, training within the firm is of particularly great importance. Training in the firm may take the form of on-the-job learning informally supervised by co-workers or it may be more formal, involving some kind of classroom work. In many craft occupations the master-apprentice relationship is still

the major source of skill creation, even in countries where the rudiments of craft skills are taught as a part of the formal educational program.[18/]

18/ Archibald Callaway, "Nigeria's Indigenous Education: The Apprenticeship System," ODU, Vol. I, No. 1, July, 1964, provides a well-documented case study of the major role of apprenticeship in the economy of a major African city.

A second major source of skill creation is the privately operated labor market-oriented vocational courses. These courses are generally short in duration and are designed to train the worker in a skill of which there is an immediate shortage. These vocational education businesses may offer courses in typing and shorthand, sewing machine operation, auto mechanics, metal working skills, Fortran programming, or whatever skills happen to be scarce enough to induce workers to acquire the skills at some private cost.

A third source of supply of scarce skills is job switching by people possessing more than one skill. When a scarcity of a particular skill raises its remuneration, workers presently using other skills may be attracted into the field.[19/]

19/ Movement in and out of the elementary and secondary school teaching profession is a good example.

In many countries skills are available from a fourth source: foreign labor markets. International movements of labor of all levels of skills and education are ordinarily limited to countries of similar language and cultural background, although recent movements of labor within Europe (and from Turkey to Europe) provide a major exception.

Foreign and domestic labor (even with identical formal education) are not perfect substitutes; additional costs are generally incurred in acquiring and assimilating foreigners. Nonetheless, international movement of labor is of considerable significance in the labor markets of many countries. Europe may be moving towards a single labor market, at least in some skills.[20/] The Commonwealth nations have for many

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20/ See Charles P. Kindleberger, Europe's Postwar Growth and Labor Supply. Harvard University Press: Cambridge, Mass., 1967, pp. 171-195.

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years traded in human skills of various levels. Most poor countries depend in a major degree on foreign professional and technical personnel. Labor movements among poor countries are also significant.[21/] In the United States, which is in

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21/ Consider the importance of West African magistrates in the East African judicial profession, of Egyptian and Sudanese teachers in the Muslim areas of Africa, and of Dahomeyan civil servants throughout ex-French West Africa. Indian white-collar workers in East and South Africa, North Vietnamese teachers in Guinea and Mali, and Lebanese commercial personnel in West Africa are additional cases in point.

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many ways relatively isolated from the world economy, foreign labor markets constitute a major source of the supply of skilled labor.[22/] Both the brain drain and the brawn drain are two-way

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22/ In 1964, for example, immigration of natural scientists, engineers, and physicians and surgeons constituted respectively 3, 11, and 29 per cent of the first degrees in science and engineering and M.D.'s awarded in U.S. universities and colleges in 1963-64. Over 11 per cent of the 83,000 professional scientists holding Ph.D.'s recorded in the National Register of Scientists

and Technical Personnel maintained by the National Science Foundation are of foreign origin. "Foreign origin" is defined as having completed secondary school abroad; it is not synonymous with "foreign born." The above data are from T. J. Mills, "Scientific Personnel and Professions" in The Annals of the Academy of Political and Social Science, September, 1966, pp. 33-42.

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streets; the elasticity of demand for domestic labor is increased both by the availability of foreign substitutes, and by the presence of foreign employers in the market. For example, emigrant engineers constituted a major share of the annual output of first degree engineers in a number of European countries. Western Germany lost 9 per cent, Greece 20 per cent and Norway 24 per cent.[23/]

23/ H. Grubel and A. Scott, "The International Flow of Human Capital" in American Economic Association, Proceedings, May, 1966, pp. 268-274. No year for these data is given

3.5 Conclusion

On the basis of international cross-sectional data we have found a high degree of substitutability in the economy between labor classified by different levels of schooling. The fact that relative earnings of different types of labor are insensitive to differences in the composition of the labor force is explained in part by the fact that most skills may be acquired by a variety of means. Moreover, technological choices often exist which allow substitution between skills in production. Thus we find that laborers of different educational levels are generally substitutable, and that training and on-the-job experience, as well as capital and foreign labor, provide substitutes for education. The possibilities of substitution in production are supplemented by indirect substitution

between goods of differing education intensities in the composition of final output, both through changes in domestic consumption and through foreign trade. These findings bear a number of important implications for the choice of an appropriate planning model for education.

First, the high degree of substitutability between different types of labor makes it impossible to derive an estimate of the number of each category of labor demanded solely on the basis of the level of output. Reference must be made to the relative wages of each type of labor, as well as the relative costs of schooling.

Second, the degree of substitutability in the economy is not immutable, but may be increased by a conscious policy to increase the occupational and geographical motility of labor. Because of the short-run nature of most of the training and other programs designed to achieve this mobility, the planning approach for these activities must differ considerably from that for the formal educational system. Yet neither planning operation can be effectively pursued in a vacuum. Educational planning for the formal school system must be complemented by policies designed to perfect such short-run labor market adjustment mechanisms as on-the-job training and short vocational courses in scarce skills.

APPENDIX: Relative Supplies and Remuneration of Educated and Uneducated Labor; Extensions, Sources, and Methods.

1. Extensions

In the body of the paper we suggested that the estimated elasticity of substitution is in part a reflection of the effect of changes in the sectoral composition of output and the capital labor ratio which ordinarily accompany the increase in education in the labor force as part of the normal growth process. As the relative abundance of educated labor increases the portion of output originating in relatively education-intensive sectors is likely to increase. The effect of this sectoral change is, of course, to shift the demand function for educated labor to the right. Similarly as the quantity of educated labor increases relative to less well educated labor the capital to total labor ratio is likely to increase. Thus if capital is more complementary to well educated than to less well educated labor,[/] the process of

[/] Capital is here defined as more complementary to L_2 than to L_1

where: $$\frac{\partial y}{\partial k \partial L_2} \Big/ \frac{\partial v}{\partial L_2} > \frac{\partial y}{\partial k \partial L_1} \Big/ \frac{\partial y}{\partial L_1}$$

capital accumulation will offset the supply induced downward pressure on the relative wages of the well educated by shifting the demand function for this type of labor upwards by an amount proportionately greater than the analogous shift in the demand function for less well educated labor.

Both the sectoral change in the composition of output and the accumulation of capital (given the above assumptions about the complementarity relations) will thus give rise to a higher estimated elasticity of substitution than would result if both the sectoral distribution of output and the capital labor ratio were held constant.

In order to test this inference we have regressed log (w_1/w_2) on both log (L_1/L_2) and on measures of the composition of output and the capital labor ratio. The measure of the composition of output used was the percentage of national product originating in agriculture (A/Y).[/]

[/] In all cases U.S. weights were used in computing w_1/w_2. The figures for the percentage of output coming from agriculture were taken from the UN, Yearbook of National Accounts Statistics and are, for all but the U.S., for the year 19 . The definition of national product used is somewhat inconsistent. Definition of the concepts used appear in the notes to the individual country tables in the Yearbook. The historical series for the U.S. was obtained from the Survey of Current Business Supplement (Washington, 1966). The National Income and Product Amounts of the U.S. 1929-65., Table 1.8.

The results are presented below.

$$\log \frac{w_1}{w_2} = \underset{(.08)}{-.51} - \underset{(.06)}{.18} \log \frac{L_1}{L_2} + \underset{(.006)}{.012} (A/Y)$$

$$R_c^2 = .295$$

The results are consistent with the explanation suggested in the paper. The effect of holding constant the share of national product originating in agriculture is to reduce the estimated elasticity of substitution to 5.4, or about half of its previous value. Similar, though not as significant, results were obtained using income per capita as an indirect measure of the composition of output.[/]

[/] The income per capita measure is highly co-linear with log L_1/L_2 $(r = -.95)$.

An attempt to test the parallel hypothesis using data on the capital stock per worker for five observations for the U.S. and single observations for 6 other countries failed to produce any significant results. None of the regression coefficients were anywhere near significantly different from zero at conventional significance levels.

2. GENERAL NOTE ON DEFINITION AND WEIGHTING OF L_1, L_2, W_1, W_2.

The cut-off point used to distinguish the two types of labor and their corresponding earnings was between those with less than 12 years of completed education and those with 12 or more. For the United States, this corresponds to those with less than and those with as much or more than completed secondary education.

Within the groups, the earnings of a) those with less than completed elementary education, b) those with completed elementary but less than completed secondary education were calculated in the former, and c) those with completed secondary but less than completed college education, and d) those with completed college education or more, were calculated in the latter. Hence weighted mean earnings of each group could be calculated, assuming that their percentage composition was that of the United States (in 1960) or of India.

Completed elementary schooling was taken to be 8 years and completed college as 16 years, again based on the American system.

As far as possible the same divisions have been used for other countries, but where the divisions do not correspond exactly, as indicated in the notes, the ratios of laborer percentages and earnings will be distorted.

Throughout, whenever possible, the earnings of males in their early thirties were used rather than those of all ages, in order to exclude the effects of longer experience, and in an effort to concentrate on earnings differentials associated with additional years spent in schools in the fairly recent past. Since school systems have changed greatly over the last fifty years, the earnings of older workers may reflect even greater differences in quality between a year's schooling in one country and the same in another, than are found nowadays.

3. SOURCES AND METHODS BY COUNTRY

a. INDIA

Sources: Marcelo Selowsky, Education and Economic Growth: Some International Comparisons, Ph.d. thesis, Chicago University, 1967, pp. 57-61

A. M. Nalla Gouden, Education and Economic Development, Ph.D. thesis, Kurukshatra University, 1965, p. 69.

Selowsky gives figures for the active population by year of schooling for 1960-61 derived from that year's Census. For 1961 Gouden gives data for the average annual income (no earnings figures) of the male active population by age group so that figures for those aged 30-34 could be used. For those with less than completed primary education (7 years), figures are given for literates and illiterates in both sets of figures. Those with completed primary education are in fact junior in years of schooling to American leavers with 8 years of elementary education, but are taken as equivalent educationally.

The earnings figure used for those with completed elementary schooling but less than completed secondary was the average of those given for males with completed primary education and males with middle school education, (which is intermediate between primary and matriculation), since a combined percentage of the labor force was given for these two categories.

The matriculation earnings figure (11 years of schooling) was taken as the figure for those with completed secondary education but less than completed college. However, since it presumably applies to 16-year-olds, it is too low. The only other figures given are for those with Bachelor's degrees (15 years) and Technical degrees (17 years).

b. MEXICO

Source: Marcelo Selowsky, Education and Economic Growth: Some International Comparisons. Unpublished Ph.D. thesis, University of Chicago, 1967, p. 36.

Data is given for the earnings of males by years of education in 1964 from a sample, and the educational distribution of the labor force is also given.

One figure only is given for those with 7-9 years of education and this is therefore included with the figures for those with completed elementary education.

c. CANADA

Source: G. W. Bertram, The Contribution of Education to Economic Growth. Economic Council of Canada Staff Study 12, p. 48.

J. R. Podoluk, Earnings and Education (Advance Release from the Census Monograph "Incomes of Canadians"), page 43.

Bertram's data gives mean income for males and females for all ages, combined, by years of schooling and percentages composition of the labor force by educational level for the Census year, 1960-61.

For the same year, Podoluk, using some unpublished data, gives average income from employment for the male non-farm labor force by age group so that earnings of the age groups 25-34 could be used.

However, Podoluk does not give a figure for those with less than completed elementary education and so the figure from the Bertram data was used.

d. FRANCE

Source: E. F. Denison, Why Growth Rates Differ. Postwar experience in 9 Western countries. The Brookings Institute, Washington, D.C., 1967, pp. 376 and 385.

The source here gives figures for earnings by education of the male non-farm labor force for 1962 and, more completely, a distribution of the male labor force by years of education, but for 1954. Between 1954 and 1961 he estimated that the mean years of education had increased by 0.30 years. There are figures for earnings for those with 7 or 8 years of education, 9-12, 13-15 and 16 or more years. Figures for separate age groups are not available.

To get a figure for those with incomplete elementary education the American ratio of the wages of those with incomplete elementary education to those with 8 years of schooling was applied to the French figure for earnings for 7-8 years (complete elementary education).

The figure for earnings for those with 9-12 years of education was broken down to give figures for those with 9-11 years of schooling and those with 12, assuming the two were in the same proportion as the corresponding United States figures.

e. THE NETHERLANDS

Source: E. G. Denison, Why Growth Rates Differ, op. cit., pp. 377-393.

Data is given for the earnings of males, in 1962, by the following years of education completed, 7, 10.5, 13.7, 16 and 20 (by amalgamating several Dutch categories); and a more complete breakdown of the male labor force by years of education received for 1960. No breakdown by age group was available.

Seven years of elementary education was taken to approximate completed elementary education and an earnings figure for those with less than complete elementary education was found in the same way as for France.

f. BELGIUM

Source: E. G. Denison, Why Growth Rates Differ, op. cit., pp. 378-387.

Data is given for earnings of males by number of years of school completed in 1961 in a table inferring educational differentials from occupational ones and a more complete breakdown of the distribution of the male labor force by years of education, also for 1961.

An estimate for the earnings of those with less than completed elementary education was made as for France. No breakdown by age group was available.

It was assumed that the earnings of those with 10-11 years of education was half way between the figure for those with 9 and that for those with 12, since the former figure would be too great an underestimate for secondary school dropouts.

9. UNITED KINGDOM

Sources: Survey of male heads of households by M. Abrams cited by D. Henderson-Stewart in his Appendix to M. Blaug's Rate of Return on Investment in Education in Great Britain. The Manchester School, September 1965, pp. 253-255.

Census of Population, 1961

Abram's survey gives figures for income in 1964, by age groups, for three school leaving ages, 15 or under, 16-18 and 19 and over. The first two figures are given as mean income and are available for the age group 25-34, but the last is only available as median income for the larger age group 20-44.

To convert incomes to earnings, the procedure adopted in the article was followed. It was assumed that the "reported incomes of the group leaving school at 15 years or under was equal to their earnings, but that the combined effect of adding earned pension rights and subtracting property income raises the income of the other groups by 10 per cent."

The figure for median earnings for the 19-year-old or older leavers was converted to mean earnings by applying the American ratio of mean to median earnings for this group to give an estimate of mean earnings, following the procedure adopted by Denison.

An income figure for those with less than completed elementary education was obtained from the figure given for

years or under by assuming that this figure could be broken down into two earnings figures weighted by the United States figures for those with incomplete elementary education and those with completed. It was further assumed that the ratio of the two earnings figures was equal to the corresponding figures for the United States.

The figure of leavers aged 16-18 was taken as the income figure for those completing secondary school and the figure for 19-year-old or older leavers as the figure for those who completed college, on the assumption that the college dropout rate was very low.

The percentage distributior of the active male population was derived from the 1961 Census, which gives a fuller distribution by terminal educational age than was available for earnings.

h. UNITED STATES

1960 Source: U.S. Census of Population, 1960

Earnings of males aged 25-35 were used, together with the distribution of the total male labor force by educational level.

This was the year whose weights were applied to all the other countries.

Source for All Other Years: Dale W. Jorgenson and Zvi Griliches, The Explanation of Productivity Change. Report 6715, Center for Mathematical Studies in Business and Economics, Department of Economics and Graduate School of Business, University of Chicago, 1967.

Mean annual earnings of males 25 and over were used and the per cent distribution of the male labor force aged 18-64 by educational level.

1939	earnings	were	used	with	1940	labor	force	distribution
1949	"	"	"	"	1948	"	"	"
1956	"	"	"	"	1957	"	"	"
1958	"	"	"	"	1959	"	"	"
1963	"	"	"	"	1962	"	"	"

(but in last case the figures referred only to those employed, which means that the higher earnings will be overweighted).

i. GREECE

Source: Samuel Bowles, Sources of Growth in the Greek Economy, 1951-61; and Changes in the Structure of Employment in Greece by Age, Sex and Education, both Development Advisory Service and Project for Quantitative Research in Economic Development, Center for International Affairs, Harvard, 1967.

Earnings of males by age group were computed from the raw individual data in a sample of 2082 workers in the Athens area. These data were collected as part of a survey directed by Harvey Leibenstein. I am grateful to him and to the Center of Planning and Economic Research in Athens for making the data available. The distribution of male labor force by educational level was computed from the 1961 Census.

The earnings figures were given by years of education completed, but the census data was given by the highest level of education achieved: illiterate, literate, primary, secondary and higher. For this purpose primary meant 6 years of education, and since it has been used as equivalent to 8 years of education in other countries, both w_1 and L_1 will be too low.

j. CHILE

Sources: Marcelo Selowsky, Education and Economic Growth: Some International Comparisons, op. cit.

Henry J. Bruton, The Productivity of Education in Chile, Research Memo 12, Center for Development of Economics, Williams College, Williamstown, Mass., 1967.

Selowsky, in some unpublished data, gives estimates for the earnings of urban males by age from a sample of five southern towns in Chile in 1964. His thesis gives percentage distributions of the labor force for various years, of which 1960 was chosen as most comparable to other data.

However, for those with more than 12 years of education, his only figure comes from a sample of commercial engineers and agronomists and is therefore unrepresentative. Moreover, it is for those with 17 years or more of education and consequently has an upward bias compared with the United States figures, which are for those with 16 years or more of education.

However, the study by Bruton gives figures for earnings in 1962 by age group and, if the rate of increase of earnings with each additional year of education in the Bruton study is applied to Selowsky's figure for earnings with 12 years of education, a composite series may be obtained for earnings of those with higher education.