project? I cannot assign a price tag to this factor, but I think it can be easily argued that we have all benefited from the at times violent debate that has raged over whether the mule is essentially bass or baritone. In these speculative controversies, I believe it is no exaggeration to say, careers have been placed on the line, and we all eagerly await the outcome.

The first stages of the project were, as we all remember, halting and cautious but, at the same time, immensely encouraging. When Owl-I mounted the podium at the Center and, before the eyes and ears of the world, uttered the first word of the *Star-spangled Banner*, "Oh," there were those who scoffed, those who contended it was not a word, those who, with not a few snickers, pointed out that a Soviet ox had already recited the first four words of the *Internationale*. Well, so it had, but we started late, and we had to pay for our lack of foresight with time—time to develop the capacity to work with heavy animals. But we are making progress.

Now, where do we stand? The answer is that we are advancing across a broad front, with peaceful and military efforts closely coordinated to assure maximum efficiency. The Defense Department, of course, has had great success in its project to develop a reconnaissance squirrel, as well as other projects that I need not go into here. We are on our way.

With the advice and cooperation of some of our leading scientific institutions, which have at last wised up, we can with confidence begin to formulate plans for post–Mother Goose. Should we perhaps strive for a duet of St. Bernards doing *Old Man River*? I don't know. But, needless to say, this proposal is being given serious consideration.

The next step, however, remains to be determined. But what is certain at this point is that we have the momentum, the talent, and the will to succeed. In conclusion, let us recall that it was Benjamin Franklin, or possibly Benjamin Spock, who said, "What good is a baby?" And I believe it was Faraday who, when asked about nuclear fission, said, "Someday you'll tax it." I think the lessons of history are there for us to read. Let us hope that we can read them clearly. Thank you.

(Dr. Swinger wishes to thank his colleagues at the Institute and at the Center for their kind assistance in the preparation of this manuscript. Since all their recommendations were followed, he thinks it is only fair that they share responsibility for any errors of fact, emphasis, or interpretation.)

—D. S. GREENBERG

Trained Manpower: British Studies Call for Better Use of the Supply

London. The brain drain has been back on the front pages in Britain with word of a government inquiry into the emigration of the technically trained, heralded by headlines such as "Drift to the US leaps by 50 percent." But while the brain drain represents an obvious loss of premium manpower, a much less easily dramatized and more serious problem for the British economy lies in the pattern of utilization of the total "stock" of scientists, engineers, and technologists.

Two reports* published by the government in October have given clearer definition to manpower problems at home. The verdict of the two reports is that a disproportionate number of the abler graduates in science and technology find employment in universities and in government research and that, unless more of the graduates take up work in industry and teaching in the schools, the country's ability, on the one hand, to finance scientific research and education and, on the other, to produce new crops of good candidates for university programs in science and technology will be impaired.

The two studies suffer from the same shortcomings which afflict similar manpower studies in the United States. There is a seemingly inevitable lag of at least a couple of years between the time data are gathered and the time they are published. Statistics for some sectors of employment are unavailable and must either be left out or more or less crudely estimated. Classification is usually by qualification, and this can be misleading. A man classified as a physicist may, for example, be functioning as an engineer, or vice versa.

In Britain, as in the United States, classification methods are under scrutiny and ways are being sought to apply occupational rather than disciplinary criteria. But the urgent need for manpower data makes it necessary to get on with the job with the tools available.

Manpower reports are usually accompanied by recommendations for action, and since World War II the British have done reasonably well in achieving round-figure goals set by a succession of survey panels. In the years immediately after World War II, Britain was producing scientists at the rate of about 2000 a year, approximately the prewar figure. A Treasury committee did a survey on the supply of scientists only, using straightforward actuarial methods, and recommended a very substantial increase in the output.

By 1956 the annual output of scientists and engineers had risen to about 10,000. A subcommittee of the advisory council on scientific policy took a national survey of science and engineering, with a look at demand, and urged that output be doubled in 10 years. Now, a decade later, the annual output of scientists and engineers has, in fact, reached approximately 20,000.

The increase has been achieved by a briskly implemented policy of expansion of higher education since the war and particularly in the past decade. By explicit design, at least half the new places created in higher education have been in science and technology.

Recently, however, manpower plan-

**Report on the 1965 Triennial Manpower Survey of Engineers, Technologists, Scientists and Technical Supporting Staff* by the Committee on Manpower Resources for Science and Technology, Professor Sir Willis Jackson, chairman, and *Interim Report of the Working Group on Manpower Parameters for Scientific Growth,* Professor M. M. Swann, chairman.

ners have found themselves confronting some troublesome conclusions. The assumption that there would prove to be a more or less direct relation between the production of scientists and engineers and support of research on the one hand and the rate of economic growth on the other looks increasingly to be a naive formulation. British expenditures on basic and applied research have run at a rate about double that for other major European countries, but Britain's economic growth rate has been one of the lowest in Europe.

Career Patterns

The new surveys document what was well known: a high percentage of graduates in science, particularly the best graduates, remain in the higher education system or move into research work in government. (In the 3 years covered by the triennial survey, 64 percent of science graduates with first-class honors and over a third of those with second-class honors continued in the category of higher education and research.) British industry in general seems to have a much lower capacity to absorb scientists, particularly those with postgraduate degrees, than American industry. Many firms don't want Ph.D.'s, and other firms might like to use them but don't know how. In only a relatively few industries are the technically trained prominent in management (the chemical industry has been traditionally run by chemists). In general, the scientist who might consider working in industry is deterred on the one hand by the uncertain prospects of using his research capacities and on the other by the fact that it is a very long jump from the lab bench to the executive's desk.

One problem, as the triennial survey panel puts it, is that "in Britain, the universities, industry, and the government sector are largely distinct sectors of employment for qualified manpower without the degree of mobility of people and ideas desirable to a healthy and rapidly changing economy, and certainly less than appears to be the case in countries such as Germany and the U.S.A. We think," the panel continues, "that there should be more movement between these sectors and more emphasis on meeting industrial requirements."

Encouraging such mobility obviously entails a change in attitudes in both industry and the universities. What is implied is not a minor reordering of incentives but a major engagement with such imposing elements as the craft tradition, the class system, and the academic *Zeitgeist*, all of which have complex root systems in British society.

It is the view of some informed observers that British industry has maintained a competitive position internationally in large part through the exceptional abilities of its skilled workers and foremen, a legacy of the 19th-century British industrial primacy. This position has been maintained until now despite shortcomings in design and the absence of an adequate scientific base. In some industries, managers and magnates have commonly come from the shop floor and may be cool to innovation. The result is that the outlook is hardly bright for industries where technological sophistication is an increasingly important factor in competition.

In Britain, a middle-class education is no longer the only way to gain access to the levers of the society, but the middle class still prefers careers in the old professions, the civil service, or finance, or in the new eldorados of advertising or communications. And an old prejudice against commerce and industry persists.

In the university science departments, success for the brightest students, from whatever social class, lies in distinguished work in what the British tend to call, probably revealingly, "pure research." The same is true, of course, in universities anywhere, where serious research work is done, but in Britain little attention has apparently been given to building bridges to either industrial research or management.

There have been no M.I.T's or Caltech's or Harvard Business Schools in Britain and, until recently, no serious attempts to create them.

These are some of the elements which must be taken into account as manpower policy is made. The triennial survey of manpower provides the quantitative facts with which the planners must work. Between 1962 and 1965 the total active stock of scientists, engineers, and technologists rose from 273,000 to 313,000, or by about 14.6 percent. In the sectors of employment actually covered by the survey, employment rose from 183,207 to 211,231, or by 15 percent. In these sectors employment in university-level institutions rose by 35 percent (from 18,273 to 24,612); in local government, by 22 percent (7913 to 9650); in central government, by 18 percent (15,039 to 17,702); in manufacturing industry, by 14 percent (86,221 to 98,540); and in the schools, by only 5 percent (25,939 to 27,143).

The rapid rise in employment in higher education is a direct result of the expansion of the university system, particularly in the areas of science and technology. The rate of absorption of scientifically and technically educated manpower by higher education is expected to drop markedly in the next few years. The bulge in university intake caused by the peak in the postwar birthrate will not be passed until after 1968, but the buildup in university science and engineering faculties is nearing completion, and new employment in universities is due to slacken.

In industry the picture is mixed. Employment of scientists, engineers, and technologists in electrical engineering and electronics rose by 17 percent (from 18,045 to 21,048), not much above the overall average. The increase in scientists alone employed in electrical engineering and electronics, however, rose by 50 percent (3611 to 5410); in oil refining the rise was 41 percent (859 to 1207).

The figures seem to indicate a changed employment policy toward scientists in the chemical, mechanical, and electrical fields, but the same industries show a relatively low rate of increase in employment of engineers and technologists. Percentage figures need examination. The most dramatic percentage increase in the employment of scientists occurred in the motor vehicle industry, but, on examination, the reported 202-percent rise is seen to denote an increase from just 52 to 157.

Future Demand

While statistics on the present supply of manpower are useful, planning requires projection of future requirements. As the surveys point out, future "demand" is established essentially by the employers' statements of willingness to pay for particular skills. In the context of Britain's present situation a different concept is necessary. In the surveys this is referred to as "need" and is understood to be defined "in relation to the stated objective of an organization or community; thus at any time the scale and composition of a country's productive activity, the stage of its technological and managerial evolution and its national economic objectives give rise to a postulated need for highly qualified skills if economic, technological and cultural progress is to be sustained."

Since the war, British manpower policy has been based on the assumption that, by increasing the number of university places in science and technology, a kind of invisible-hand mechanism would operate to distribute manpower with optimum effect through the education systems and industry. The British now are coming to grips with the evidence that simply producing more scientists and engineers is not a panacea. What the "need" concept implies is changes both in the way scientists and other technical manpower are trained and in the way they are utilized.

Getting these changes made, of course, is a considerably more difficult task than gathering statistics—even complete, up-to-date, and more revealing statistics. The recommendations of recent manpower survey panels probably foreshadow the sort of measures which will be taken. Review of the scale and type of government support for postgraduate training has been urged and is evidently being carried out. A number of ways to unseal the ivory tower and to make industry both professionally more respectable and more attractive (closer liaison between industry and universities, for example, and opportunities for further education for researchers in industry) are under discussion. Ways to upgrade the existing stock of scientists and engineers are also being sought.

These measures, it should be emphasized, are mainly in the talking stage, and the planners are quite aware that changes will not be made painlessly. The Swann committee in its conclusion acknowledges that "patterns have been set and the expectations raised of careers in research which are unlikely to be satisfied in this country. It cannot be taken for granted that the flow of newly qualified manpower, particularly at the higher degree level, will readily switch to industry and the schools. Employers must make strenuous efforts to make such careers attractive to able graduates. It seems to us that further pressure to emigrate must inevitably be generated among our best graduates if the present attitudes and patterns continue."

While the brain drain is a sore point, it is difficult to draw up an accurate balance sheet on emigration. Britain profits from an in-migration of scientists and engineers from the Commonwealth and elsewhere, and it is not easy to establish a net loss. The triennial survey, however, indicates that, in the years covered, the net loss never exceeded 5 in 1000 of the total stock of technical manpower. An impression prevails, however, that the quality of the migrants has been high, and that emigration acts as a cream separator. Cause for further uneasiness was provided by recent newspaper stories in which U.S. immigration service sources were quoted as putting the number of British workers of "distinguished merit" admitted to the U.S. in the most recent year at 1351 as compared with 881 the year before.

The tempo of recruiting in Britain by American firms seems to be picking up, and a new target for concern is the increasing number of laboratories established in Britain by American companies which hire British researchers but yield no direct technological benefit to the British economy and constitute a kind of invisible brain drain.

Deterring the scientifically trained from emigrating is difficult enough, but getting more of them into school teaching at home appears to be at least as thorny a problem. Graduates with first degrees are primarily involved rather than those with advanced degrees, but the percentages of qualified graduates choosing teaching have been dropping. And within the past year or so two signs have appeared to disturb those concerned with manpower problems: vacant places in science and technology have been reported in the otherwise brimming universities, and, among students in secondary schools who are preparing for university entrance, fewer are taking the combination of subjects in the science and mathematics group.

These developments appear to reflect on the quality of teaching of science and math at the secondary level and cast shadows on prospects for increases in the number of good science students entering the universities.

Some preliminary suggestions have been made about what might be done to make science teaching more attractive, and another study panel is now working specifically on the problem. Teachers' pay, obviously, is a major consideration, and many of the elements in the British situation are familiar in the United States. Science teachers are in short supply in Britain, but differential pay—except on the basis of a university degree—seems to be an unlikely prospect. The negotiating situation between government and teachers is a tight one, and the problem of pay is regarded by at least some government officials as the most resistant of the relevant problems.

In broad context, a chief objective of manpower policy, which is part of economic policy, is to promote greater productivity and a higher rate of economic growth. Britain has had 20 years' experience of economic planning. The results have in many ways been creditable—unemployment, the bogey of the 1930's, appeared to have been beaten until recent squeeze measures were deliberately applied—but a fairly high standard of living and social services has been maintained in Britain at a cost to resources which has made it impossible to achieve a rate of economic growth regarded as sufficient.

A more advantageous use of manpower is now looked to as a means of maximizing limited resources. Tools of analysis and action in this field are still not, however, highly refined. As the current efforts in Britain to effect a redeployment of industrial workers through a "shakeout" suggest, techniques are much more experimental in this realm than in some areas of monetary and fiscal policy.

Some observers see hopes for more effective implementation of policy on highly specialized manpower in the new forms of government organization which have been developing in Britain in recent years (*Science*, 6 May 1966). In the past, manpower panels have often been given wide scope for their surveys but no money and no power. Now, with the responsibility for research and education consolidated in a Department of Education and Science and with a closely allied Ministry of Technology forging links with industry, there seem to be greater possibilities of concerted diagnosis, prescription, and dosage.

Change, as has been suggested, involves dealing with deep-seated attitudes. It is both true and trite to say that society is in transition in Britain. To an outsider, who can easily misconstrue appearances, it seems that in Britain two social systems coexist—the older one rooted in the industrial revolution and the days of imperial power, with its values and institutions under strong pressure, and a newer technocratic society rising fast but with its character still ill-defined. What is clear, however, is that the manpower planners must hasten the transition.

—John Walsh