for the red herring of the ether doctrine, it is hard to believe it would have been necessary to wait for Kramers to put dispersion theory on a solid foundation. In the event, Maxwell's equations showing explicitly the conjugate relationship between electricity and magnetism made further progress possible—at least when they had become familiar. In other words, there is no gulf worth speaking of between Faraday and the modern world. Even the name of field theory has become a science of its own. Given that there have been 100 years, that is a remarkable tribute.

MODEST CLAIRVOYANCE

THE National Science Foundation has embarked on an interesting and possibly important experiment by setting out to forecast future expenditure on research and development in the United States (*National Patterns of R and D Resources*, NSF 67–7, Government Printing Office, \$0·30). Much of the forecast is based on the figures supplied by federal agencies or is derived from estimates obtained by surveys carried out in industry and the universities. The figures are based on 1965 prices, and the forecast makes the assumption that there will be no drastic change in the economic climate. Although the forecasting consists of little more than intelligent extrapolation, and although the foundation—to begin with, at least—has modestly confined itself to a forecast for 1967 (already half gone) and 1968, anything that smacks of being an objective but realistic forecast of the immediate future could prove to be immensely valuable in the management of scientific resources.

So far as it goes, the forecast for 1968 is reasonably cheerful, given the talk there has been in the past few years about the declining rate of growth for expenditure on research and development and the pressure there has been on the American economy for the past year. Vietnam casts a long shadow. In aggregate, the NSF expects that the United States will spend a total of \$23,800 million on research and development in 1967 and \$25,000 million in 1968—a comparatively modest increase of 5 per cent, or rather less than the 6·9 per cent which is likely to represent the average compound rate of growth between 1965 and 1968. But by now, of course, nobody expects that spending on research and development could continue to double every five years as it did between 1953 and 1958. In reality, total expenditure has increased by a smaller percentage each year since the beginning of the sixties, although it is still moving ahead more quickly than the GNP. Even at this rate, research and development in the United States should reach 5 per cent of the GNP—it is roughly 3 per cent now—long before 1990.

The outlook for basic research is more obscure. The NSF has found it easier to produce a forecast for entire expenditure on research and development in 1968 than to say just what proportion of the total the several agencies involved, in industry as well as the Federal Government, will choose to devote to basic work. It has been plain for some time that the unprecedented growth rate in the early sixties for expenditure on basic research, which worked out at an average of 17·0 per cent between 1958 and 1965, had fallen to 10·5 per cent in 1965–66. There is nothing in the US budget for the fiscal year which has just begun to suggest a return to the days of plenty. Indeed, the continuing pressure on government expenditure, of which the 10 per cent income tax surcharge is only one symptom, is a real cause for anxiety now that the Government's contribution to basic research has risen to two-thirds of the total. A little parsimony in Congress could do a lot of damage. Yet the NSF forecast takes a comparatively cheerful view of what the Federal Government will do for the universities in the years immediately ahead. If the figures are to be taken seriously, Washington will contribute \$1,600 million to the cost of university research and development in 1968, which implies that the government's contribution will have doubled in rather less than six years and that it will amount, in 1968, to 61 per cent of all that is spent in the universities. It is to be hoped that this cheerfulness will be justified by events. The next few months will be critical, if only because preparations for the budget for the year beginning in July 1968 will have to be made in an unusually sombre atmosphere. The universities will be lucky if they get the extra 10 per cent of federal money which the NSF predicts. The trouble is that they probably need a good deal more than that if the growth of the universities is not to be checked.

The forecast may, however, be more significant than the numbers suggest. For one thing, forecasts are the essential starting point for what is often called indicative planning. In practice this means that it should be possible to make comparisons of, say, the future scale of expenditure on research and development and the future supply of trained manpower in such a way as to decide whether skilled people will be easier or more difficult to find in the years ahead. This could be important if the Federal Government were for some reason to find itself embarking on a huge new programme of research and development, but industrialists may also find the forecasts useful in similar ways. And if the forecasts stretched three or four years ahead, of course, it would be possible for universities to trim their policies—and for students to adjust their choices of courses to follow—so as to win the greatest advantage from circumstances as they develop. Indeed, the benefits which might be derived from these and other comparisons are potentially so great that everybody will now no doubt be hoping that the NSF will soon summon up the courage to take a somewhat longer look into the immediate future. Nobody expects fortune telling, and there are legitimate doubts of the significance of forecasts which rely, as forecasts must, on hazy evidence such as the guesses by businessmen about the scale of involvement in research and development some years ahead, when economic circumstances may be quite transformed. Thus forecasts may be less an indication of future reality than of present misconceptions. But any forecasts are better than none, especially if their limitations are openly acknowledged. Probably the NSF will want to stick to comparatively modest forecasting until it has won a reputation for clairvoyance, but too much caution would be a mistake. Ironically, the evident value of this beginning will without question set off a clamour for a three or even a five year forecast as well.

There remains the question of how the forecasts can influence the willingness of the Federal Government to spend money on research and development. (Possibly, it is worth recalling that there are limits to the extent to which an agency like the NSF, itself dependent on the Government for funds, can forecast how much its own benefactor will be prepared to spend on agencies like itself.) Pressures may spring up in all directions, and the greatest danger is that Congress and the others holding purse strings may be mesmerized by the figures which have been produced for the various rates of growth. Experience in Britain as well as in the United States shows that treasuries find it almost irresistible to argue that the rates of growth for expenditure on science ought to be linked somehow to the rate of growth of the GNP or to the change of some other economic indicator. This is like putting the cart before the horse. Too much respect for the GNP as a universal yardstick is one way of bringing growth to a halt. In an expanding economy, it is inevitable that some things should grow more quickly than others, and it would be a great surprise if research and development were not among the most vigorous consumers of extra funds. If Congress wants to use the forecasts now produced as a guide to action in the next year or so, it should start from the forecasts of the skilled manpower that will be available in the year ahead and then reckon that enough money must be allocated for these people to be efficiently employed.

WHERE ARE THE QUASARS?

The most distinctive property of the quasars is that the radiation from them is shifted enormously to the red, and any attempt to account for their existence must begin with that. But does the red-shift imply recession? And is an apparent recession of the quasars to be interpreted as participation in the general expansion of the universe? This is the train of thought which led, immediately after the discovery of the first of these objects, to the supposition that quasars are for one thing extremely far away, and therefore exceedingly powerful sources of radiation even by the yardsticks of astrophysics. But if red-shift implies distance, and if quasars are distributed more or less randomly throughout the universe, there should be a relationship between brightness and red-shift. The quasars with the biggest red-shifts should, on the average, be the faintest. That is how the argument began, but the problem of the quasars has so far been enormously complicated and confused by the failure to pick out anything like a significant correlation between the brightness of quasars and the red-shift of their radiation. A year ago, with an air of resignation, Hoyle and Burbidge wrote that "as new red-shift values become increasingly available, the plot of the observed quasi-stellar objects has assumed more and more the aspects of a scatter diagram" (*Nature*, **210**, 1346; 1966). Although there have been several attempts to explain how a real correlation between brightness and red-shift may be obscured by irrelevancies, the absence of a correlation has been the chief reason why people have been energetically seeking ways of accounting for quasars which do not entail rapid recession at the edges of the universe.

It is too soon to know whether the problem will be simplified by the two articles on the red-shift relationship which appear on pages 917 and 919. Now that more data have accumulated, the beginnings of what seems to be a real correlation between brightness and red-shift does seem to be emerging. Horton and Daintree, writing from Jodrell Bank, argue that the relationship is more clearly apparent at higher radio frequencies than those used in earlier comparisons, and they claim that the most compact and the brightest of the quasars in their sample have a brightness and red-shift related by a simple curve not altogether different from the predictions of some cosmological models. In their view, the failure of all quasars to lie on the same smooth curve may be accounted for by processes such as internal absorption of radiation within particular objects. To them, red-shift implies great distance.

Although Longair and Scheuer agree that the newly accumulated data on quasars imply a significant relationship between red-shift and brightness, their interpretation is quite different. They argue that the observed brightness of a quasar with a pronounced red-shift is not itself a measure of the power emitted, but must be corrected to account for several complicating factors—the fact that a red-shift of any origin will reduce the energy of photons and the rate at which they reach an observer, for example. In other words, to them a faintly significant correlation between red-shift and brightness is not a sign that quasars are distant objects but rather a somewhat unsurprising happening which is entirely consistent with the view that the red-shift of quasars has nothing to do with rapid recession or great distance. The most convincing part of what Longair and Scheuer have to say is based on an analysis of the optical brightness of a number of quasars. The difficulty, of course, is that their negative conclusion may not be valid for the data corresponding to the very high radio frequencies at which Horton and Daintree claim the relationship is most apparent. In other words, the two arguments are not necessarily in conflict. The immediate result, no doubt, will be a careful poring over data. The theoreticians anxious to get on with model building will have to wait a little longer.