however, is impossible because the shapes of the real anomalies are unknown.

A second possibility is that the thermal conductivity correlates with the production of radioactive heat in the upper crust. This is more attractive because it has already been shown that both quantities vary systematically with the chemical and mineralogical compositions of rock. This model is also more amenable to experimental testing although no data are yet available. Meanwhile, Horai and Nur have shown analytically that for igneous rocks at least the hypothesis is not unreasonable for such provinces as the Canadian shield, the Australian interior lowlands, areas of Palaeozoic-Mesozoic and Caenozoic orogeny in Australia and the Pre-Cambrian shield and stable basin areas of South Africa. On the other hand, it cannot be valid for such provinces as the Appalachian and Cordilleran systems of North America, much of Europe, the Australian Pre-Cambrian shield, areas of Caenozoic orogeny in North America and areas of Palaeozoic-Mesozoic orogeny in Japan. Thus neither model is sufficient to explain all the data. It would seem that to accommodate all the correlations of heat flow and thermal conductivity both explanations, and possibly others not yet thought of, are required.

REDSHIFTS

Comfort for Gravitational View

from our Cosmology Correspondent

IN spite of the recent tendency for the consensus of opinion in the controversy over the cosmological versus the gravitational interpretation of quasar redshifts to lie definitely in favour of the cosmological hypothesis, the interest which has been aroused by the discovery of large redshifts in nature has resulted in considerable efforts by relativists to construct stable models which could produce very large gravitational redshifts ($z \gtrsim 2$). The latest such models to receive attention are those of G. S. Bisnovatyi-Kogan and Ya. B. Zel'dovich, who recently constructed general relativistic models of gas spheres and collisionless star clusters in which the redshift of light travelling from the centre to infinity is arbitrarily large (*Astrofizika*, **5**, 223; 1969). They did not at that time resolve the question of stability for their models, but now Bisnovatyi-Kogan has joined forces with Kip S. Thorne in showing that the gas spheres at least are indeed stable against radial perturbations, and although their results for the star clusters are rather more inconclusive (*Astrophys. J.*, **160**, 875; 1970), there is certainly no evidence that these will be unstable.

The success of the Russian astronomers in winning over Thorne to their camp (he has previously appeared to favour the idea that no stable models could be constructed with gravitational redshifts greater than ~ 2.3) places these models in a strong position should the cosmological hypothesis fall from favour.

PROTEINS

Decorating Electron Micrographs

from our Biomolecular Structure Correspondent

MANY practitioners of what Moore, Huxley and DeRosier (*J. Mol. Biol.*, **50**, 280; 1970) call "straight-

forward electron microscopy" must have mixed feelings as they read this account of the application of the three dimensional reconstruction techniques pioneered by DeRosier and Klug to the analysis of electron micrographs of F-actin. For the mathematically less well equipped, their pleasure in the degree to which negative staining studies are being developed must be tempered by the unnerving shadow cast by a deconvoluting physicist over their tilting and twiddling activities.

In this particular analysis the apparently helical symmetry of F-actin is exploited to allow the various views of the thirteen subunits in each 360 Å repeat of the two stranded linear structure to be combined to give a three dimensional image of the individual subunit and the contacts it makes with its neighbours. The analysis is complicated because the fragility and flexibility of individual F-actin filaments result in segments rarely being available which are straight enough and long enough for the assumptions on helix symmetry to be valid. The analysis was therefore performed on paracrystals which consist of F-actin filaments arranged in register side by side. The Fourier transform of this array was deconvoluted to provide the Fourier transform of the individual filament used in the computer reconstruction of the three dimensional image. One of the most interesting results comes from a comparison of this image with that obtained by a reconstruction from an electron micrograph of a single muscle "thin filament" in which the F-actin occurs. The two images are rather similar except that the thin filament has an "extra blob" of material between the two strands of actin subunits in each filament. The size of the blob and its periodicity in the structure make it tempting to identify this structure with the tropomyosin and troponin content of the filament. The reconstruction technique has also been used on electron micrographs of thin filaments decorated with myosin or heavy meromyosin which have a very characteristic arrowhead appearance. From a comparison of the resulting image with that from undecorated thin filaments it is possible to estimate (by assuming the partial specific volume) the weight of the repeating subunit and confirm that it is compatible with physicochemical estimates and also to show that the attached myosin is somewhat curved. The approximate orientation of the long axis of the myosin with respect to the thin filament axis can also be determined.

The straightforward electron microscopist might well ask what came out of the automatic diffractometry, Fourier transformations, deconvolutions and reconstructions which his artefact-weathered eye could not have seen in the original micrographs. He might indeed claim to be more impressed by the indications of the "extra blob" in the original micrographs of thin filaments than by its image in the models and two-colour graffiti produced by the computer. Nevertheless, even if all the features in the reconstructions can by an appropriate amalgam of hindsight and experience be seen in the original micrographs, the reconstruction approach to the analysis of electron micrographs (of which this application is only one example) is taking electron microscopy into a new era where its traditional rather qualitative character is being replaced by a quantitative analysis not only in terms of periodicities but also in the provision of estimates of subunit shape and size.