space efficiently. Higher-level languages are extravagant in storage space and hence generally excluded, making it necessary to use low-level language to program small computers.

Sapega, A. E. (1967). *Decuscope*, 6, 2.

Molecular Modelling and Computer Graphics

By C. D. BARRY and A. C. T. NORTH. (*Laboratory of Molecular Biophysics, Department of Zoology, University of Oxford, South Parks Road, Oxford OX1 3PS, U.K.*)

Computer graphics is a new and rapidly growing branch of computer technology. Its bearing on problems involving molecular structure seems obvious. This communication seeks to examine the field of molecular graphics and aims to outline the achievements and the hardware cost involved.

Specific uses of an interactive graphics system considered include: the display and manipulation of a computer-generated protein model and its application to the crystallographic determination of protein structure; the production of animated sequences and graphs illustrating chemical reactions and mechanisms for teaching purposes; and the use of programs capable of generating trial conformations for small molecular structures starting from input in the form of chemical formulae.

These examples indicate some current applications. There are many fields in which a graphical form of output is more readily comprehended than a digital one, and the true potential of the technique is likely to be limited only by the ingenuity of the user.

On-Line Applications in X-Ray Crystallography

By O. S. MILLS. (*Department of Chemistry, University of Manchester, Manchester M13 9PL, U.K.*)

The relative merits of consoles, terminals, computing terminals and graphical units are discussed in the context of application to crystallographic computation. In all these, there is a play-off between effectiveness, convenience, priority and intrinsic cost. The use to which terminal consoles, whether simple computing or allied with graphical facilities, will be put is discussed.

Computer Control of Mechanical Experiments on Muscle

By R. H. ABBOTT. (*Agricultural Research Council Unit of Muscle Mechanism, Department of Zoology, University of Oxford, Parks Road, Oxford OX1 3PS, U.K.*)

The special property of insect fibrillar flight muscle which enables it to contract rhythmically without synchronous nervous stimulation is the delayed component of the tension that results from an imposed length change. We have been investigating this phenomenon by using small bundles of glycerol-treated fibres of giant tropical water bugs. They are glued between a fixed-tension transducer and a moving-coil vibrator, and are bathed in a solution containing ATP and inorganic ions. The vibrator is mounted on a micro-manipulator to allow changes of mean fibre length, and is itself used to impose only periodic changes of length on the muscle fibres. If sinusoidal length changes are imposed, the delay appears as a phase lag between length and tension changes. Analysis of the change of this phase relationship with frequency shows that the delay is exponential, and its magnitude and time constant can be evaluated.

Information about the contractile mechanism may be obtained by measuring these characteristics under different mechanical and chemical conditions. To obtain a useful amount of information from a single preparation, the manipulation of the apparatus and logging of results must be done as fast as possible, and a human operator is unequal to the task. We have interfaced a PDP8/I computer to all the necessary devices, namely (i) a Solatron JM 1600 oscillator and resolved-component indicator to provide the sinusoidal drive and measure the phase and amplitude of the tension changes, (ii) a stepping motor drive attached to the micro-manipulator that adjusts mean muscle length, and (iii) a mechanism for changing the solution in which the fibres are immersed. The software allows the machine to be controlled by typing individual commands on the on-line teletype. These are single letters followed in some cases by a number. More usually, however, the commands are stored in the computer memory for automatic sequential execution. In this way the computer may be programmed with great simplicity to run an experiment lasting several hours without any manual intervention. A record of the experiment is printed on the on-line teletype, and a codified form of the results may be produced on paper tape.

It is known from other experiments that both Ca^{2+} and an increase of mean fibre length will activate the fibres in the sense of increasing their oscillatory work output. Closer analysis of their effects, by using the apparatus described, has revealed that, although both increase the magnitude