width which can be achieved. Weber talked of a bandwidth of about 3×10^{-4} Hz, which means that noise exceeds the signal by a factor of 10^8, whereas Dyson suggests that by recording signals over a few years and looking for Fourier components at pulsar frequencies it should be possible to attain a bandwidth of 10^{-8} Hz. This brings the discrepancy between noise and signal to 10^6, and to 10^5 if an array of 100 seismometers is used.

At this stage Dyson seems to be whistling to keep his spirits up. He reverts to the now dormant binary theory of pulsars to enhance the predicted seismic displacement by a factor of 10^4, and looks for special geological conditions to amplify the signals by reflexion or resonance to pick up another factor of ten or so. And it may be possible to improve the noise level by selecting only vertically propagating waves, as expected of gravitational waves. But few astronomers now expect to find that pulsars are the binary stars with components of solar mass (describing circular orbits with periods of two seconds and at a distance of 30 pc from the Earth) which Dyson needs to make the seismic search less than hopeless. In the circumstances, it is hardly surprising that the search for pulsar periodicities in seismic data which Dr Frank Press is reported to have begun has so far met with negative results.

ARTIFICIAL INTELLIGENCE

Making Machines Behave

from a Correspondent

PEOPLE interested in the construction of machines to execute tasks which, so far, have required human intelligence gathered in Washington from May 7 to 9. This was a large conference, and the fragmentation of the subject into highly specialized sub-areas was one of its chief impressions. Although the conference was intended to be international, attendance from countries other than the United States was not large, which perhaps accurately reflects the distribution of activity in this line of research.

Those working on machine intelligence are visibly torn between two conflicting desires: to produce some tangible systems which demonstrably perform some "interesting" functions in an observable fashion; and to tackle the deep mathematical and intellectual problems involved in creating intelligent machines. Two visible manifestations of these approaches are, on the one hand, the construction of robot systems capable of analysing the environment visually or by other sensors and manipulating simple objects, like stacking building blocks; and, on the other hand, formal enquiries into the branches of symbolic logic capable of providing a language in which these problems can be formulated and solved, that is, theorem proving.

For the uninitiated the most comprehensible results undoubtedly come from the robot projects, several of which were described. The best known are in progress at Stanford University, at the Stanford Research Institute (SRI), and at MIT. Most of the projects are at the stage where a mechanical arm or wheeled robot is coupled to some artificial "eye" such as a TV camera, and under computer control the system can perform some simple locomotion and/or manipulation tasks. Cordell Green from SRI described his QA3 theorem proving program which is used for problem solving in a robot. The team at SRI have also developed a program for communicating with the robot in English. This translates English statements into the first order predicate calculus, performs deductive inference and generates English output sentences. The deductive component of this program is Cordell Green's QA3 program. The general conclusion from the various projects seems to be that even such simple tasks require an enormous amount of information processing, heavily overloading even the powerful computing systems available today.

On the other hand, some of the theoretical problems underlying the construction of such systems are beginning to be identified. There is now a clearer understanding of the nature and use of heuristics in problem solving, of the way in which symbolic logic can be used as a language for the internal representation and manipulation of problems, of the difficulties involved in trying to make a machine understand human language, and of the problems of pattern recognition. The only theoretical contribution to the conference seemed to be from Eric Sandewall (University of Uppsala), who talked about heuristic search. He analysed the types of operators occurring in problem solving, together with some of the best known heuristics. He then extended the interpretation of heuristic search from a tree search to a lattice search, and later applied the concepts developed to the analysis of Slagle's integration program and to a specific method of resolution.

The conference gave the impression that early great expectations for spectacular advances, such as a champion chess playing machine, have died down considerably, and given way to a sober contemplation of the very deep problems to be solved, even for the mechanization of the lowest levels of true intelligence.

ELECTRONICS

On the Small Scale

from a Correspondent

THE conference on microelectronics, sponsored by the Institution of Electrical Engineers at Eastbourne from June 3 to 5, was concerned with various aspects from circuit design to the technology of semiconductor fabrication.

There was considerable interest in multilayer metallization in the fabrication of complex function integrated circuits. R. J. Gelsing (Philips Research Laboratories), C. Pons (Società Generale Semiconduttori, Milan) and P. G. Eldridge (Standard Telecommunication Laboratories) all described different approaches to the problem. Eldridge and Pons described devices using aluminium as the conductor material, the layers being separated by silicon nitride deposited in a glow discharge vapour deposition process in one case, and radio frequency sputtered silicon dioxide in the other. Gelsing's more novel approach used aluminium as the first interconnect layer and gold as the second, separated by silicon dioxide. To avoid "purple plague" problems a strip of molybdenum was used to provide contact between the gold and aluminium where necessary. One advantage of the use of gold in the top layer is the ease of forming gold beam leads on the chip surface.

Beam lead assemblies were also discussed by A. E. Sarson (Marconi–Elliott Microelectronics), who talked