```
    if x > y then x := y else go to BETA2;
    if p[i] = 0 then begin im := j; jm := i; go to
      BETA2; end
    im := i; jm := j;
BETA2: end k
d[jm] := x; p[jm] := im;
end
```

This procedure is computationally less efficient than the method for directed networks because the whole array $r[k]$ must be scanned for each node labelling.

Memory requirements

We shall now give the memory requirements for networks which have n nodes and m arcs. We shall also give the approximate storage needs for such road nets where there are, on average, four two-way roads on each intersection, the number of nodes being n. We suppose that we are using a variable word-length machine where lengths of $r[i]$ and $d[i]$ are R and D, respectively, the length of the indices being X. Then the storage requirements, in characters, are:

General networks

Method (a): $(D + 2X)n + (R + X)m$
Method (b): $(D + X)n + (R + X)m$

Road networks

Method (a): $(D + 4R + 6X)n$
Method (*b*): $(D + 2R + 3X)n$.

If for example $D = 6$, $R = 4$ and $X = 3$, the storage requirement for road nets would be, for Method (b), approximately $23n$ characters. Consequently we can handle, for example, in a 12K IBM 1401, without difficulty, a road network with 300 nodes.

Reference

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second section will interest those engaged on programming, and is notable for a paper by Crowder. The third section deals with the impact on schools, and is of interest to educationalists. The fourth section includes a curious mixture of technology in education, education of technologists, and the market for teaching machines. It is in this section, in a paper by Finn, that the only direct reference is made to computer-based teaching-machine systems. The last section deals with an assessment of the situation as it stands, and a review of research and development.

In short then, I like this book for the many facts (one or two seem very surprising) it contains and for the most readable presentation; it is recommended for anyone wishing to become acquainted with programmed instruction. For the computer man, however, there is very little, unless, of course, he is also concerned with teaching. And is there not a field which must be explored very, very soon in this country for the adequate and substantial use of programmed instruction for instructing programmers?

O. B. CHEDZOY

Principles of Tunnel Diode Circuits, by W. F. CHOW, 1964; 387 pages. (London and New York: *John Wiley and Sons*, 94s.)

The tunnel diode was first introduced about six years ago, and has now had time to find its place amongst other devices available to the engineer. This fact is reflected by the careful way the content of this excellent book has been considered. The author has applied his wide experience of circuits and semiconductors to give a comprehensive and authoritative description of the principles of tunnel diode operation, and of its uses in both linear and non-linear circuits. It is written in a lucid style which makes it understandable to the newcomer to the field, yet each topic is treated thoroughly, and to a depth which should interest the more advanced reader.

After the first two chapters, which deal with the physics of the device and with its electrical characterization by equivalent circuits, the book divides roughly into two sections. The first section deals with the application of tunnel diodes in amplifiers, converters, detectors and oscillators, and the second with digital applications. Particular stress is laid on the noise properties in the section on amplifiers, since it is as a low noise microwave amplifier that the device finds a major application. Other particular subjects of interest include stability criteria for various forms of amplifier. The treatment is mainly theoretical, but the topics covered relate to considerations which arise from standard circuit arrangements, of which many examples are given.

About half the book is devoted to high-speed switching applications of tunnel diodes. The basic switching dynamics are explained in terms of a piecewise-linear equivalent circuit, which allows the switching cycle to be split into several sections, the effect of circuit parameters in each section being readily calculable. For instance, it is easy to calculate the effect of trigger magnitude and duration on the rise time of a circuit by this means. Many examples are described of systems of logic, etc., using tunnel diodes as the only active element, and the effects of parameter tolerances and the limitations imposed by the bilateral nature of the device are analyzed in some detail. There is also a chapter on hybrid circuits which use transistors as isolating and amplifying units, and others which use charge-storage diodes.

(*Continued on page* 76)

One has then to evaluate the net value of the surface integral of the displacement and equate it to the enclosed charge. Problems in hydrodynamics and heat flow may be solved by this method.

The method developed here is generally applicable to field problems which are

(*a*) not "curl free," where Stokes' theorem applies,
(*b*) not "source free," where Gauss' theorem applies.

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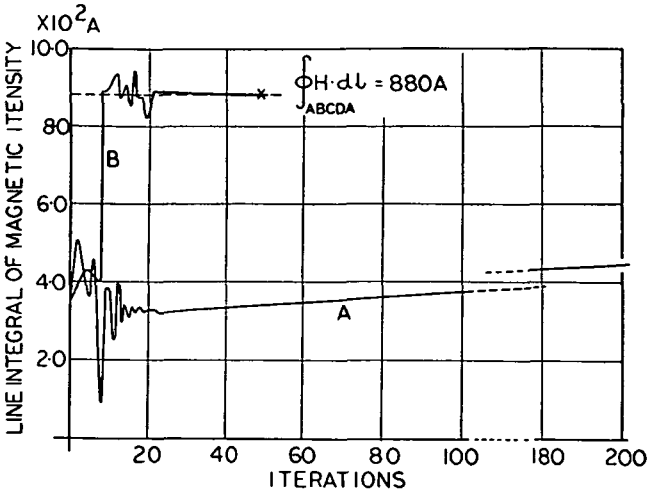

Fig. 4.—Comparison of convergence for a non-linear Poissonian field in iron regions of Fig. 3(a)

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Book Reviews (*Continued from p. 20*)

Whilst the author does not claim to have covered every possible application, the coverage is nevertheless comprehensive, and the material proceeds in a logical way. Many references are given on specific topics for the specialized reader.

Altogether a very readable and informative book which should be an asset to the circuit engineer.

J. C. VICKERY

Reliable Computation in the Presence of Noise, by S. WINOGRAD and J. D. COWAN, 1964; 96 pages. (Cambridge, Massachusetts: *M.I.T. press*, 38s.)

This is one of the series of *Research Monographs* issued by the *M.I.T. Press*. These monographs permit the presentation of research in a more detailed way than is reasonably possible in a scientific journal whilst, at the same time, obtaining earlier publication than would be possible in a standard text-book.

The purpose of this particular publication is to extend Shannon's noisy-channel coding theorem to include the case of computation with noisy modules rather than communication. It then continues to show how error-correcting codes may be employed in the construction of reliable automata from less reliable modules.

The first two chapters give, in eighteen pages, an introduction to the relevant aspects of information theory and the theory of automata. This is followed by a discussion of the work of Von Neumann and others on the reliability of automata, which is then extended in the next chapter to computation with noisy modules. It is shown that such a system may be decomposed into an error-free computation module and a noisy communication channel.

Chapters 6 and 7 contain various arguments leading to the conclusion that it is wrong to consider module networks as separable into encoding, computing and decoding networks in which encoding and decoding are free from error. Chapter 8 therefore considers only noisy modules at each stage, and describes the construction of networks of varying degrees of reliability. These designs depend on the assumption that the probability of modular malfunction is independent of modular complexity.

The final chapter shows that synaptic errors may be incorporated, the effect of such errors being controlled by the use of networks of still greater redundancy. This chapter also discusses the effect of errors of connection in the redundant networks. There is a short appendix followed by a list of about fifty references.

The formal arguments are set out very clearly and they are well illustrated by numerous network diagrams which are beautifully reproduced. Whilst the detailed sections of the book are for the specialist, the general arguments and conclusions are of interest to anyone working in the field of computers.

F. H. SUMNER