latter counts are not avoided in a "maximum string" technique.

It will be seen readily from Fig. 2 (in Jones's own notation) how comparatively simple is the programming for the technique suggested by me. It is interesting that Mr. Jones observed that the maximum string technique in practice requires $[\log_2 N]$ passes, i.e. the same number as would be needed for my system, since this appears to bear out my claim that "only a proportion of the theoretical savings, if any, will be realized in practice"; it is hardly consistent with his somewhat cavalier dismissal of "fixed string" methods in the previous paragraph.

Granted that the maximum string technique has a theoretical advantage, where the data is already partially ordered, over the simple technique described by me, I claim that this advantage is apparent mainly at the first pass, for which I have advocated special treatment. Tests made on Pegasus by Mr. Windley of my laboratory indicate that, for the rearrangement of random keys occupying not more than one word length, it is best, with this particular machine, to start to build up strings of the length of a single block (i.e. 8 words) using an insertion technique, and, subsequently, to merge these base 3 in the (high-speed) working storage. However, we have an open mind on these details, since different considerations will apply if the keys are longer or the working store available is larger.

Finally, a note on terminology: I have been careful to distinguish between sorting, merging and rearrangement of data, in order to avoid confusion of thought on this matter. The techniques discussed by Mr. Jones concern rearrangement by merging and are in no way related to "sorting" (in my sense), a term which I have reserved exclusively for the collection together of things of a like kind.

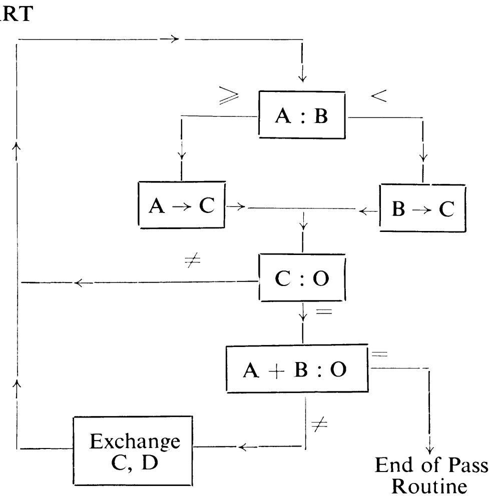

Fig. 2.

A. S. Douglas

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Gray or Gros?

Various analogue-to-digital conversion systems use numerical coding procedures in which numbers differing by unity have their coded representations different only in a single digit. Spurious transients due to lack of simultaneity in multiple digit changes do not then arise. Binary or decimal (also binary-coded-decimal) schemes are all possible, and will now be familiar to many, in various practical applications.

A particular binary scheme with simple conversion relations and other advantages is of special interest (see for instance *Bell System Technical Journal*, Vol. 38 (1), 1959 (January) for two articles and other references). Here digits of the ordinary binary representation are changed if and only if their more significant neighbour is a unit digit (before any changes are made). This is frequently referred to as the *Gray* code.

This coding system actually appeared earlier in a different context, in recreational mathematics, in the theory of the pastime of *baguenodier*, or the so-called Chinese Rings, as given by Gros in 1872 (see for instance Ball, *Mathematical Recreations and Essays*, 11th revised edition, London, 1939, also earlier editions).

The apparatus of the pastime is a set of rings with wires linking them in sequence to one another, and possibly also to a bar. The arrangement was described by Cardan in 1550 and examples are currently available in toy shops. The rings have two states, *on* and *off* the bar, which can be taken as corresponding respectively to unit and zero digits. The state of the *end* (or least significant) ring may *always* be changed, and the state of any other ring may be changed if, and only if, its less significant neighbour is *on*, with all still less significant rings *off*. Ordinarily the aim is to get all the rings either on or off the bar.

Two, and only two, moves are possible with every configuration other than two terminal positions. One of these has *all* rings off, the other has only the most significant ring on. If no steps are re-traced, the successive configurations in fact are Gray-code representations of a succession of increasing or decreasing integers which give the number of moves separating these configurations from a zero configuration where all rings are off the bar.

Since only one ring changes state in a move, only one digit changes in the coded representation of the move number. Gros gave rules equivalent to those for Gray-to-binary conversion, to solve the problem of determining the minimum number of moves required to convert one configuration into another.

The *de*coding of the Gray code is thus historically prior to its *en*coding, and the question arises, whether the *Gros* code is not a more appropriate name. These facts may well have been realized by others, but I know of no reference in print.

It may be well to remark that the literature of recreational mathematics includes much else which should be of interest to the computer designer.

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