tence of errors, cyclic or otherwise, in the sources from which the radar data is drawn; nor have I disagreed with the evidence and the theories about the size and character of such errors, and the resulting prediction errors they might cause, which have been adduced by the various experts (in electronics), under the conditions and within the limits which they postulate.

What I have questioned from the beginning of these exchanges is the *belief* that the magnitude of the errors which will be present *in realistic conditions when offered to an automatic plotter of current* (although, of course, sophisticated) *design* will lead to the serious deception of an averagely intelligent and instructed operator. Admittedly, the foregoing sentence contains as many imprecisions and imponderables as those of the experts mentioned but, although I have expressed the same sentiment several times, no one has yet produced operational evidence from seagoing ships which does other than support my contention and disprove those of which I complained originally. Evidence based on a 'computer without data filtering' does nothing to alter my question.

A great deal of what Mr. Harrison advocates for the future is already the present as far as seagoing automatic equipment is concerned. The wiggling trail of the K-H display becomes an even more evocative wiggling vector in Digiplot and is shown in wiggling figures on the digital readout, which provides hard evidence for the anxious operator. The data is processed over more than five minutes and 'present' data is weighted more heavily in the computation, thus achieving response to actual target manœuvres, as opposed to error wiggles.

This sophistication has been achieved the hard way; based on deep knowledge and experience of the computer field, prolonged study of the sensor error probabilities and hundreds of trials at sea. It is in use, not only in Digiplot, but in hundreds of ships and being proved by Masters and officers of many nationalities.

REFERENCE

1 Harrison, A. (1975). This *Journal*, 28, 363.

Multiple Sun Sights with One Reduction

John P. Budlong

THE small-craft navigator is beset by a number of problems in taking sextant observations; of these wave motion is foremost for the constantly changing height of eye makes the dip correction uncertain. One alternative is to take a number of sights and average the times and altitudes; but averaging angles, and especially times, is an error-prone occupation and if one of the sights is badly in error it will probably not be noticed, and will bias the resulting average. This would be avoided if all the sights were individually reduced and plotted, but the work involved is prohibitive. The method here described permits several sights to be taken and the individual position lines plotted, but requires practically no increase in work over a single sight. Inspection of the position lines will give a

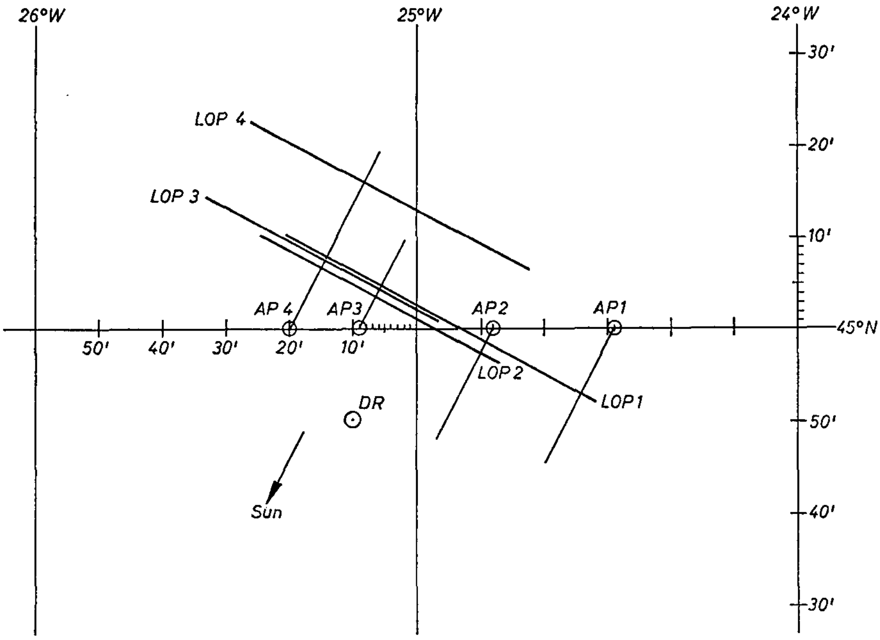

FIG. 1.

very accurate average and also indicate immediately if one of the sights was in error either in recorded altitude or time.

The method is based on two principles. When several sights are taken within a few minutes the G.H.A. changes relatively little and by adjusting the assumed position the local hour angle can be kept constant. Accordingly one calculation of altitude and azimuth will serve for all the sights. Secondly, during this short time span the observed altitude also changes very little, the maximum rate of change being one degree in four minutes, so that the altitude corrections can be worked out once and used, with negligible error, for all the sights. The time and longitude increments may all be referred to the time of the first sight and it is easy to add a time scale (04^m to a degree of longitude) to the plotting sheet. This avoids the possibility of cumulative error in plotting the assumed positions.

Instead of the usual practice of applying corrections to the sextant reading, we may reverse their signs and apply them to the calculated altitude to give a precomputed altitude. The advantage of a precomputed altitude is that we can compare the four sextant readings directly, and obtain the four values of the intercept. The time intervals and assumed position increments are worked in the same way as before.

The resulting position lines are plotted in Fig. 1. Notice that three of them fall in a nice group but not the fourth (LOP 4). Evidently there was an error in the sextant reading or in recording it. This sight is best discarded and the centre of the group of three taken as the most probable position line.

The method can be applied to any reasonable number of sights taken within five or ten minutes and is applicable to the Sun, stars or planets. Moonsights may be liable to an error of up to 03′ in longitude.