redundant multiplicity it is possible to obtain the overall standard of reliability required of an autopilot for automatic landing.

The servo motor outputs from the three autopilot sub-channels are ganged mechanically to a common output arm and in this way the three output signals are averaged. Torque limiters in each arm effectively compare the torque generated by each channel with the mean torque and provided that three inequalities which are approximately of the form

$$|T_i - T_M| < K \qquad \text{where } T_i = \text{servo torque generated in } i\text{th channel}$$
$$T_M = \text{mean servo torque}$$
$$K = \text{a constant}$$

are satisfied, the system continues to operate. If one inequality is violated not only is a fault detected but also it is automatically identified and rejected by the action of the torque limiter which disengages the errant channel.

By mixing three signals in this way a high average accuracy is ensured. At the same time the torque discriminators which can only fail safe ensure maintenance of high reliability.

'Manœuvres to Ensure the Avoidance of Collision'

THE following comments have been received on Mr. E. S. Calvert's paper, published in the last number of the *Journal*. A further selection of comment, including a note by Captain F. J. Wylie, and possibly a reply by Mr. Calvert, will be published in the next number.

from D. H. Sadler, O.B.E.

THE following comments are restricted to two aspects only of Mr. Calvert's paper, namely the proposal for a new form of radar display and vector diagram, and the geometrical analysis of the collision problem. All forms of display, or of the vector geometry, are equivalent, but it is of great importance to develop one which is capable of showing immediately the changing situation; Mr. Calvert's proposed presentation is worthy of detailed study from this point of view.

An essential preliminary to any comprehensive study of collision avoidance is a complete and detailed study of the geometry of the problem. Whether this conflicts with the Collision Regulations or not, whether some manœuvres are impracticable or not, is irrelevant; as Mr. Calvert says, the geometry is universal and unchanging, and cannot be the subject of opinion. Any manœuvres or rules must be based on a clear understanding of the underlying geometry.

From this point of view Mr. Calvert has written a most important paper and one that will repay detailed study. His proposed manœuvres may constitute a complete answer to the collision problem in certain circumstances; but it will be for practical navigators to determine to what extent these manœuvres can be incorporated in future rules.

from Captain H. D. Harries

(*German Ministry of Transport*)

As 95 per cent of all collisions do not happen in the open sea, but in crowded waters such as the English Channel, the southern North Sea, in the mine-swept routes of the North Sea and the Baltic, in the region of the light vessels and in the confined waterways to the ports, Mr. Calvert's proposals for new Steering Rules do not hit on the real causes of collisions in fog at sea. It is not possible to fix specific course and/or speed actions, based on mutual responsibility of ships not in sight of one another, because there are :

(1) a number of ships without radar or the radar of which is not operational,
(2) navigational hindrances,
(3) third parties, &c.

It seems problematic to introduce additional signals indicating reverse manœuvres; for a lot of collisions at sea have occurred because of misunderstood or unheard signals.

It is problematic too, as to one of Mr. Calvert's manœuvring solutions, to increase speed in fog, because of further dangers, especially in crowded waters.

The German view on decreasing dangers in fog, being laid down in the proposals for the Safety of Life at Sea Conference, is :

(a) to stress the Rules for the precautions in the *close quarter* situation (less than 3 miles)—see German proposals for Rule 16.
(b) to give certain recommendation for conduct at *long range*.

The new radar display, proposed by Mr. Calvert, may be of great help for the handling of ships in fog, independent of the author's proposals for new Steering Rules with mutual manœuvres.

from Commander P. C. H. Clissold, R.N.R.

(1) *Standard Manœuvres*. In clear weather the present Steering and Sailing Rules are satisfactory: in thick weather, with some vessels using radar but unable to tell whether other vessels are using it or not, the Rules are inadequate. The 'Standard Manœuvres' would be effective in thick weather because they can be successfully applied either by a single vessel or by both together. Since there should not be one set of rules for clear weather and another set for thick weather the 'Standard Manœuvres', if adopted at all, would have to apply in all weathers, and if we want a satisfactory code of rules for vessels using radar in fog it may be desirable to adopt the Standard Manœuvres in place of the present system.

The application of Reverse Manœuvres involves the use of radio signals: the attendant uncertainties make this undesirable.

Mr. Calvert writes: 'What is needed is, of course, a simple rule of thumb which can be applied with the minimum of plotting and without special training.' Rather than alter the present rules, it would be simpler and perhaps sufficient to introduce an extra rule for vessels using radar in fog which prohibited an alteration of course to port when the bearing of the other ship was forward of the beam, unless the bearing was moving appreciably to the right.

I believe Mr. Calvert to be right in supposing that his Standard Manœuvres have not been proposed before, but the suggestion that both vessels should take

https://doi.org/10.1017/S0373463300033695 Published online by Cambridge University Press

avoiding action was made by Rear Admiral J. A. Gauw, R. Neth. N. in this *Journal*, 8, 178.

(2) *Proposed new radar display*. This ingenious and interesting variation (which may well be called the Calvert Display) clearly merits extensive simulator and sea trials. The chief advantage over other displays appears to be in the clear indication given of whether the avoiding action taken is effective or not.

from Dr. H. C. Freiesleben

(*German Hydrographic Institute*)

THE nautical referees of the journal *Der Seewart* believe that the proposals made by Mr. Calvert are not an improvement on the present Rules of the Road. These rules are the simplest that may be imagined. The evaluation of collisions which have occurred in spite of radar, demonstrates that it is not the fault of the Regulations but of ignoring these rules. If, in conformity with Calvert's proposals, in future both partners to a possible collision have to manœuvre, the possibility of errors and mistakes will be doubled. Overtaking to starboard and crossing ahead are moments of great danger. Moreover, Calvert's proposals have the disadvantage of being inflexible regulations, whereas the present rules give way to the variety of actual circumstances, e.g. the different reactions of a ship to the alteration of course or velocity, with regard to the state of loading or the drift due to current and wind, &c. The desire to introduce, additional to the three existing radar presentations (heading-upward, north-upward relative and true-motion), a fourth seems to be critical at least for a transition period. In spite of these objections and those made by Capt. Harries, the editorial staff of *Der Seewart* estimates Mr. Calvert's ideas to be so important that they will inform the readers in the next issue by a short essay stating the *pro* and *contra*.

A Miniature Stabilized Platform

from T. McClymont

(*English Electric Aviation Limited*)

THE platform shown in Fig. 1 is one of a series of miniature platforms developed for inertial guidance and weighs only 28 lb. It is a three-axis, four-gimbal platform permitting complete freedom of manœuvre without gimbal lock. Three miniature integrating gyroscopes are used for stabilizing the gimbal system (Fig. 2) and three miniature pendulous accelerometers provide voltage outputs proportional to accelerations experienced by the platform.

These six instruments, together with their amplifiers are carried on the innermost gimbal, which has freedom in azimuth and is surrounded in turn by the inner roll, pitch and outer roll gimbals. The azimuth, inner roll and pitch gimbals are driven by torque motors in response to signals from the three gyroscopes whereas the outer roll gimbal is servo-driven from a synchro resolver on the inner roll gimbal so as to maintain the latter normal to the pitch gimbal.

https://doi.org/10.1017/S0373463300033695 Published online by Cambridge University Press