SUMMARY OF PAPERS PRESENTED BEFORE THE « JOURNEES D'ETUDE » OF THE FRENCH INSTITUTE OF NAVIGATION
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CERTAIN DESIRABLE FEATURES OF AIR NAVIGATION EQUIPMENT AND METHODS

by M. BAYLE, Chief Navigator, Air France.

The author deals first with the point that present methods are not fully adapted to the users' requirements. Pointing out some aspects of different systems of navigation he stresses the need for continuous and rapid information rather than for accuracy.

Considering a large survey of the equipment used and of the design of documents such as almanacs and tables, he emphasizes improvements to meet the requirements of the navigator in handling the sextant or consulting the air-almanac. Several types of alternate methods are mentioned in case of emergency or failure of the classical utilisation of observations or calculations and the writer aims et providing aircraft in the near future with a simple electronic computer combined with appropriate display. The author concludes with a request for a close cooperation between the engineering people who design the equipment and the navigator who uses it, with due consideration for his physical limitations.

AN ASPECT OF THE PRESENT DEVELOPMENT ASTRONOMICAL EQUIPMENT FOR AIR NAVIGATION

by R. CLARET, Ingénieur de l'Aéronautique.

— Recall of the present methods of localization in air navigation.

— Brief statement of the grounds militating in favour of astronomical navigation.

— Working conditions aboard modern airplanes.

— Astronomical processes now in use.

— Drawbacks of these processes.

— General conditions required for a modern device.

— Principle of the spherant. — Why it has been chosen. — The satisfying possibilities presented by the actual technique. — The absolute character of its use.

— Various possibles types. — The three imperative principles to be observed : accuracy, speed and convenience of use.

— Consequent essential measures which should govern its design :

1. Simple, intuitive pointing ; accurate, adaptable mounts, easily fitted on board.
2. A clear field, slightly magnified, as wide as possible and at least equivalent to 1.5 time the average amplitude of the mobile during observation (Principle of first filtration).
3. No limitation of movements, no masking and no dead zones.
4. Minimum number of precise adjustments, simplified controls, and certainty as to their position.
5. No operating of display controls should intervene during observations.
6. No calculation, no drawing or plotting should be required of the operator.
7. During observations, the length of which is left to the operator, both his hands and the forehead should be free in order that he may carry out the only operation required from him, i.e. sighting.
8. Possibility of immediate use of any pair of stars normally used in astronomical navigation, without recourse to special tables.
9. Possibility of operation at any time deemed necessary or favourable, without restriction to an assigned time.
10. Automatic averaring of readings and permanent checking of its adjustment (Principle of second filtration).
11. Readings without interruption in sighting, including bearings to true North or headings.
12. Limitation of accessory parts to minimum.

— Field of application of such devices. — The question of the vertical.

— Anticipated possibilities. — Realizations.

— Conclusions.

A REVIEW OF APPLICABLE PROCEDURES IN MARITIME ASTRONOMICAL NAVIGATION

by Captain R. Ch. DUVAL (C. R.)

Like Captain Weems, the author is fully convinced of the tremendous possibilities still offered by celestial observations to navigation, and that the latter has good grounds for fully expressing its requirements.

He is anxious that navigation should take every advantage of all current scientific discoveries.

Nowithstanding, he wishes to stress the point that it remains possible to make efficient progress by way of normal developments, and strives to promote notable improvements in results so far obtained by a better turning to account of methods which have already proved effective, and of the equipment now available, or which can immediately be developed.

PRESENT DEVELOPMENT AND PROSPECTS OF MARITIME ASTRONOMICAL NAVIGATION

by P. HUGON.

The methods and equipments of maritime astronomical navigation were used originally as a basis and as an example for aerial navigation, but later on, whereas the demands of air-transport development found an answer in an adaptation and a revolutionary transformation of processes and devices, maritime navigational practice underwent detail changes only.

The astronomical fix is obtained in several stages in which the observation instrument : the watch, the astronomical almanac and finally the navigation table intervene successively.

With a view to improving the nautical almanac and the navigation table, persistent research has been undertaken, whereas the observation instrument, in this case the sextant, has only slightly evolved from its earliest structure which remains that of the Hadley octant.

The author details the progress achieved in the matter of tabular records such as the nautical ephemeris and tables, but he notes that, apart from the development of recent prototypes, the sextant could be made the subject of research, in various unexplored directions. He reviews briefly the graphical records and the slide-rules which have been proposed without much success to navigators. The latter seem to accept easily the subjection imposed by present means of calculation ; however, it seems that the electronic and mechanical technique may point to the future vulgarization of a simple and economical computer which would find its place on all bridges. From simultaneous improvements brought to the observation device and to the calculation system, savings in time and increased reliability would result, which would not be without interest for all types of maritime navigation.

RADAR DISCIPLINE

by Commandant OUDET.

With reference to regulations for preventing collisions, the radar position is now very clear, but this does not suffice to reduce the number and the seriousness of accidents occuring in fog to ships equipped with radar. Traffic density and speed are the basic causes of these accidents. That is the reason why the regulation imposes a reduction of speed taking into account « conditions » and « circumstances ». The radar improves the « conditions » under which the mariner may evaluate these « circumstances ». It therefore allows him to proceed rapidly under favourable circumstances, but makes speed reduction peculiarly imperative in the face of dangers which it reveals.

At a remote distance, however, it is possible to avoid the danger by altering course. This must be done over a wide area, preferably to the right ; a change in course on the left side is very dangerous, and a slowing down must be preferred.

When danger is close, presenting the side of the ship must be avoided ; the stem should be offered, without speed.

Neither a change in the regulations nor a technical improvement will minimize the accident frequency : the only effective remedy consists in publicizing a few simple principles such as those set forth above and the ones upon which they are based. By neglecting these principles, the qualified organizations would incur a heavy part of responsability in accidents to come.

DOES RADAR JUSTIFY A REVISION OF THE RULES AIMED AT PREVENTING COLLISIONS IN POOR VISIBILITY ?

by R. LABARRIERE.

Under present conditions of radar operation, is it reasonable to consider « moderate » a travelling speed higher than the « reduced » speeds recommended by practical experience, prior to the introduction of radar into navigation ?

One should distinguish between what is feasible at the present time, in strict compliance with the International Rules aimed at preventing collisions at sea, and what it would be desirable to achieve by a modification modernizing these Rules in accordance with technical developments. The lecturer endeavours to answer this question.

TECHNICAL AND LEGAL ASPECTS OF THE USE OF RADAR TO PREVENT COLLISIONS AT SEA

by Commandant L. LEMOINE-KARMOR.

We may say that radar came into use in France during the year 1936, when the Ponte detector had been tested on the « Normandie ». This equipment was proposed to « detect » icebergs and to ensure safety of life at sea. Its performance was very satisfactory unless power was found to be poor.

At a later period, with Sir Watson Watt, Randall, Boot and Sayers, the magnetron cavity was discovered and manufactured with the assistance of the U.S.A.

Today, the question is to know exactly the kind of assistance we are authorized to expect from Marine radar. What sort of help, with regard to the rules of the road, is this equipment able to bring to the ship in thick weather ?

Another question is to know whether the spot trace of the P.P.I. has the same value as direct sight. Is the uncertainty of the position of a ship broken down by the vanishing trace on the screen ?

In poor visibility is a ship fitted with radar compelled to observe the Rules of the Road and especially Arts. 15 and 16 ?

What is to be done ? To make special allowance for ships fitted with radar or to insert important modifications in the rules ?

For our own part, we think that, except in the case of emergency, radar detection is generally more efficient than a direct sight which may be obscured by darkness and fog.

Our opinion is that the facility in following the bearing and the range of a radar spot is equivalent to a direct localization by eye. Since radar is able to determine the position and the course of any ship within the range of 20 miles, it gives us the possibility, by watching and plotting, of establishing counter measures for avoiding collision.

Consequently, it may be wise to consider three sorts of speeds while entering in the fog zone and to mention these speeds in the regulations. Say, for example : « Stand by », moderate speed » and « dead slow » according to the kind of waters, the proximity of shore, the streams and tides of the place.

Our experience allows us to believe that, in any case, even in the middle of the ocean, in bad visibility, fog or heavy rain, any risk of collision may be avoided if the engines are maintained in the « stand by » position.

From another point of view, our first wish is to see, as soon as possible, the status of radar delimited and put into force by international agreement, which shall require the training of officers with regard to radar, during their period in school as well as during their effective action as navigation officers on the bridge and, if possible, require frequent checking of the equipment and the use which is made of it.

Since we see that the delay between the meeting of 1948 which promulgated the last regulations and their effective observance, on the 1st of January 1954, is nearly six years, we must have no doubt about the fact that present radar equipment, which is already efficient and operational, shall in the near future be improved again and be qualified by its new performance to justify and support new regulations.

AUTOPILOTING WITH ASV 23 6 CHANNELS ICAO

by Jean HUGON,

Ingénieur, Compagnie Générale de Télégraphie Sans Fil.

After recalling the general principles of operation of the blind landing system ASV 23 6 channels ICAO, the author gives the results obtained when coupling this device with a Lear L2 autopilot 2. Test flights took place with a Beechcraft B 18 aircraft at the beginning of 1956 on Saint-André-de-l'Eure runway.

The side and altitude deviations of the aircraft from the theoretical approach course have been indicated at a reference point situated on this course 600 meters ahead of the line joining the two localizer aerials.

The side and altitude average deviations calculated from 19 approaches accurately observed from the ground are respectively 1 meter and 0.7 meter. The maximum side deviation does not exceed 9 meters with a 40 km. p.h. crosswind which gives the aircraft a 13° drift.

COMPARISON OF NAVIGATION METHODS

by Captain P.V.H. WEEMS U.S.N. (Rtd).

The paper gives a brief description of navigation methods, including the new methods of inertial, Doppler, and radio navigation, after which it is demonstrated that inertial and Doppler systems are refinements of dead reckoning navigation. In the same manner, electronic systems are classed with piloting, and radio systems with celestial.

The conclusion reached is that all methods should be used as needed, and that celestial navigation should be used to monitor all other methods. Equipment should be miniaturized and automatic, so far as possible.

TRANS AND SUPERSONIC AIR NAVIGATION
THE TACAN NAVIGATION SYSTEM

by R.I. COLIN et S.H. DODINGTON
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presented by H. DE LANOUVELLE,
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TACAN is a radio aerial navigational system of the polar-coordinate type to provide in the airplane direction and distance of a reference ground beacon. It is possible to multiplex on the TACAN channels additional navigational functions such as localizer, glide-slope, marker and air traffic control transponder at medium range through the airborne receiver. These facilities are obtained by transmitting and receiving both on board and from the ground on two different frequencies.

Distance is determined by measuring the time of round-trip travel of radio pulse signals between the interrogator and the beacon with the accuracy of radar. For direction the accuracy of radar is obtained without the disadvantages of the pencil beam (narrow coverage) or of the cardioid (broad, inaccurate beam), by the use of a multilobe diagram made of 9 maxima distributed over 360°. A complete 360° coverage is obtained but the accuracy is approximately 9 times greater than with the simple cardioid diagram used in the VOR.

Site error is greatly reduced by use of the 9-lobed fine-bearing operation of TACAN which gives good services in mountainous regions.

Average TACAN omnirange complete system errors are about 3/4 degree. TACAN distance measurement accuracy is within about ± 600 feet (180 meters) plus 0.2 percent of the distance measured.

INTRODUCTION TO INERTIAL NAVIGATION

by P. SCHNERB, Ingénieur en Chef de l'Air.

Higher speed of aircraft increases interest for *inertial navigation*. This new technique will determine position independently of ground based aids or external reference, using only inertial effects noticeable on a moving vehicle.

The basic principle is as old as the demonstration of earth rotation by Foucault. The inertial method had been experimentally applied to the guidance of V2 missiles. Inertial navigation of aircraft, however, hinges upon solving extremely challenging design problems.

The various possible combinations of the basic components are discussed as deriving from two fundamental concepts.

1. The position is determined by comparing the local vertical and a fixed spatial orientation.

2. The distance travelled is measured by twice integrating with respect to time the horizontal projection of the vehicle acceleration.

The first concept leads to design a gyroscopic system having extremely low drift rates. However, the vertical remains to be determined. Conventional devices are about as inaccurate as a bubble level of a sextant.

The other concept too demands an accurate determination of the vertical to stabilize the accelerometer movements, so that these accelerometers remain unaffected by the components of gravity.

Both concepts lead to design a stabilized platform supporting accelerometers. This platform is rotated with reference to a space fixed direction in accordance with signals from second integrators fed by the accelerometers. This arrangement causes the platform to rotate through an angle which is proportional to the vehicle displacement and identical to the angular displacement of the local vertical. In this way the accelerometers are positioned to sense horizontal accelerations. This system is a gyroscopic equipment equivalent to a SCHULER pendulum, that is a physical pendulum having the same period of oscillation as a string pendulum of length equal to the radius of the earth. The equilibrium of such a pendulum is not disturbed by the displacement of the vehicle; spurious disturbance of the pendulum will start undamped 84 minute period oscilllations.

Several possible arrangements based upon the fundamental principle will be examined. They vary in the platform rotating device (gyro precession or relative rotation). Analysis of the systems shows that the errors which arise, whatever the particular arrangements of components, are made of two elements: one is the gyrodrift, building up with time ; the other is an error about the vertical and is oscillatory (84 minute period).

The present stage of realization of inertial navigation systems is a tribute to the technique of *floated integrating gyros*.

APPLICATIONS OF THE DECCA NAVIGATOR TO SEA-TRIALS

by M. JOURDAIN,
Ingénieur en Chef du Génie Maritime (C.R.),
Ingénieur, Institut de Recherches de la Construction Navale.

The Decca Navigator, known as a navigational aid, is also able, when properly operated under favourable conditions, to supply data accurate enough to be used in conjunction with other measurements in sea-trials.

The author quotes these conditions and studies especially instrumental errors whose influence is often noticeable in turning trials in correlating theoretical previsions with data from actual plotting.

He also surveys various procedures for speed-trials and suggests several original methods for measuring the service-speed of a ship without unduly affecting its operation.

In conclusion, the use of the Decca Navigator is compared with conventional procedures for the various kinds of sea-trials.

UTILIZATION OF RADIO-ELECTRIC SYSTEMS IN HYDROGRAPHY

by M. LUNEL,
Ingénieur Hydrographe Principal.

After having defined the term « regular hydrographic survey » and shown its necessity, the author points out that its realization has been conditioned by the development of supersonic sounding and of accurate localization out of sight of land.

Even though acoustic sounding has met the needs of hydrography for a long time, the efforts made to obtain an accurate localization took longer to succeed. Sound ranging solved the problem partially in the year 1920, then, after 1946, radio-localization systems were resorted to.

The author then gives the typical characteritics of a radio-localization system for hydrography (fidelity and accuracy, calibration and consistency by three position lines, range, mobility, flexibility of siting, intensive use, identification system, plotting of position lines on survey sheets. Then he looks over a few of the systems used, emphasizing their adaptability to the above mentioned conditions. The various RAYDIST processes are thus analysed, as well as the DECCA variants, the SHORAN-EPI devices, the LORAC equipments and the RANA patterns.

The author comes to the conclusion that it is necessary to make new strides as to the lightening and the mobility of the equipments, as well as to reliability. Finally, it would be desirable to have a better knowledge of modes of wave propagation.

THE RADIO-WEB SYSTEM

by P. GAUDILLERE,
Graduate of Ecole Polytechnique
Director, Société Française des Télécommunications.

I) *Principles of the system.*

The system is based on a phenomenon of radio-electric interference fringes, so-called « isophase lines ».

These isophase lines are generated by transmitting, from two remote stations, two signals the frequencies of which are adjacent though distinct.

A « position line » is obtained, on a mobile, by measuring the time interval which elapses between the passages of two isophase lines. A fix may be obtained with a chain of three or four transmitters.

One isophase line, passing over a mobile, may generate the transmission of a short signal, the so-called « position signal ».

By receiving such signals at a control station, one can obtain a « plan of position » of the mobiles in a given area and thus obtain the necessary data for traffic control.

By receiving such signals on a mobile, one can obtain the positions of nearby mobiles and avoid collisions.

II) *Development.*

An experimental set-up has been built near Paris, on a site sixty miles square ; it allows the principles of the system to be tested.

III) *Extension to long range.*

Extrapolation of the results of these trials supplies the basis for a proposed device for navigation and traffic control over large areas, such as the eastern half of the North Atlantic Ocean.

THE MARK 10 DECCA RECEIVER

by M. H. G. HAWKER,
Decca Navigator Co., Ltd.

Mark 10 DECCA is a development of the Decca Navigator System primarily intended to meet current and future air navigational needs in the most effective manner. For these applications it represents a significant advance over the existing system in terms of improved night-time coverage, simplified operation and minimum residual ambiguity of position fixing. The additional transmissions required from the ground stations are compatible with the present system and will in no way affect operation of existing receivers.

ATMOSPHERICS AND NAVIGATION

by M. BOST.

Atmospherics, by their origin and propagation, provide means of conducting studies in various fields. With special reference to navigation, their study is applicable to transmissions and to the meteorological determination of squalls and thunderstorms as well as, generally speaking, to phenomena of atmospheric turbulence.