3500 feet from the end of the runway. If he has broken out of the overcast when this point is reached, he can glide on into a landing. If not, he must follow a prescribed Missed Approach Procedure and go round again, and also during this time his watch is a most essential instrument.

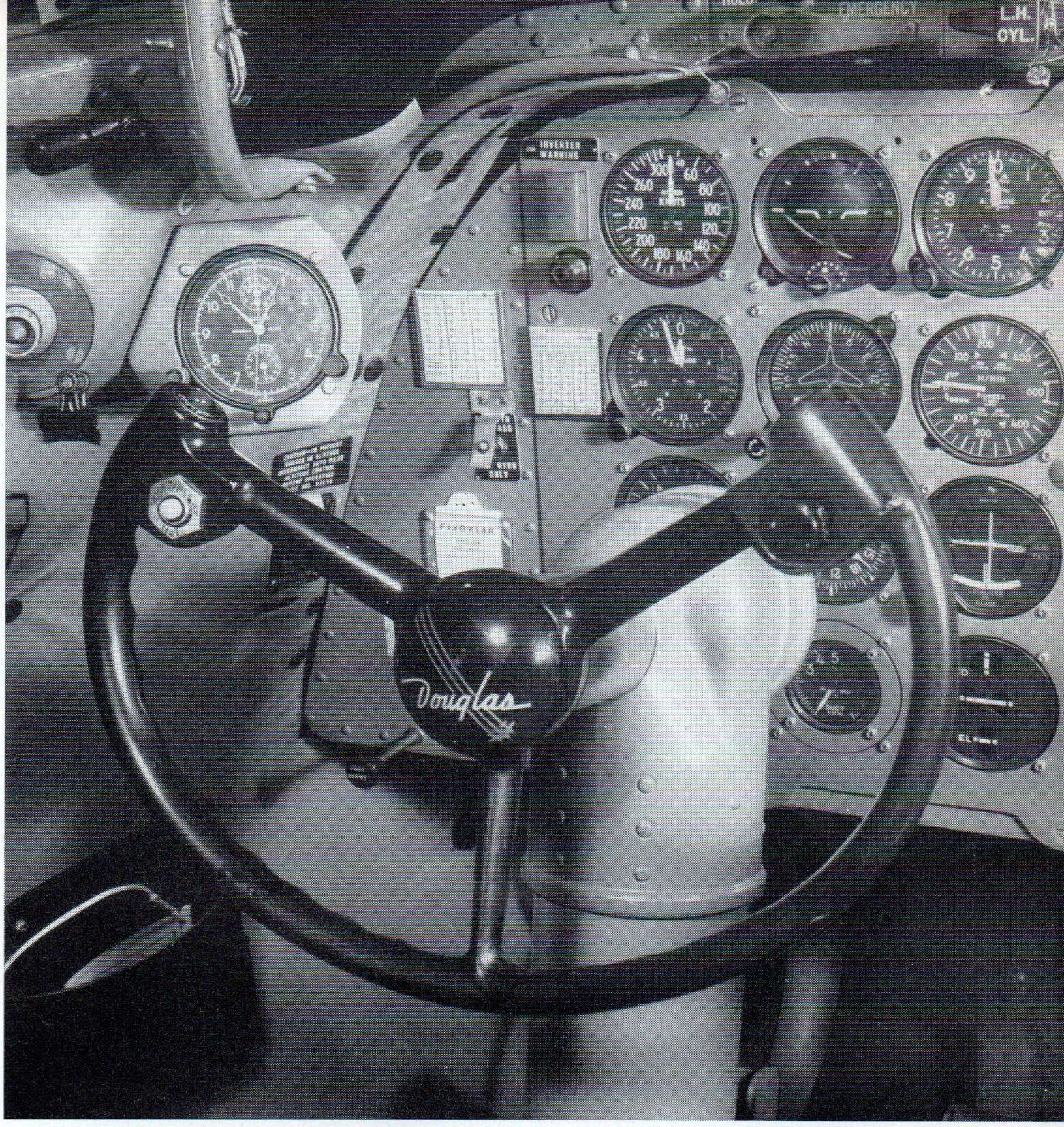
At the Point of Decision, a pilot must make dozens of decisions in rapid sequence. He must be very close to the predetermined point in space, his plane must be travelling at a certain airspeed and must be " set up " at the correct angle with reference to the horizon.

*

To help the pilot, two radio " signposts " are installed along the glide path of the ILS. One is 4 ½ miles from the end of the runway, the other is at the Point of Decision, 12 seconds from destination. As he passes a green light, the Threshold Light, 1000 feet from the runway, he starts easing back on his yoke. He is now off ILS and has a second to go. He eases back further on the yoke and waits. A slight bump, and the 60 or so tons of aircraft touches down, ending another routine flight.

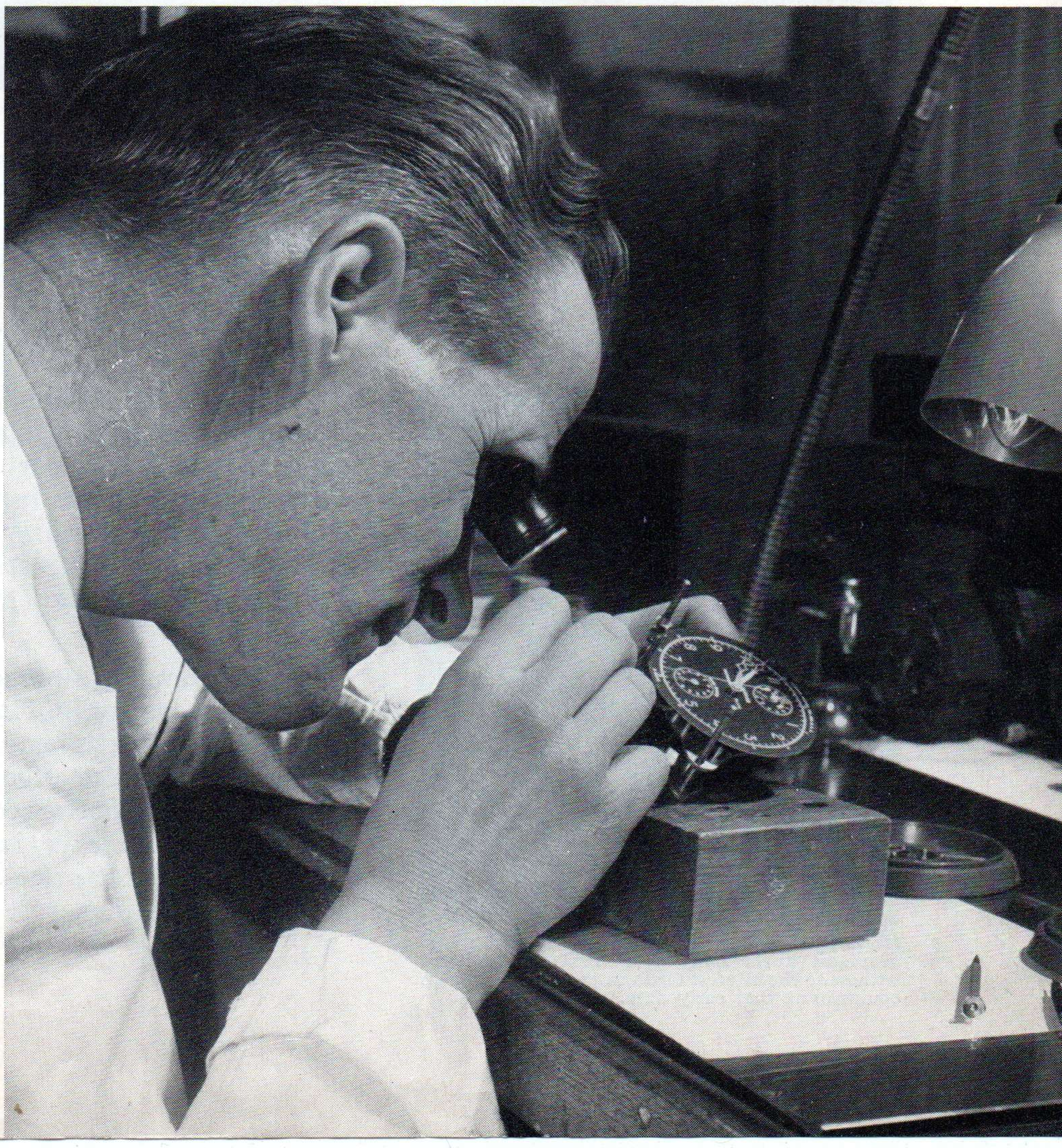
*

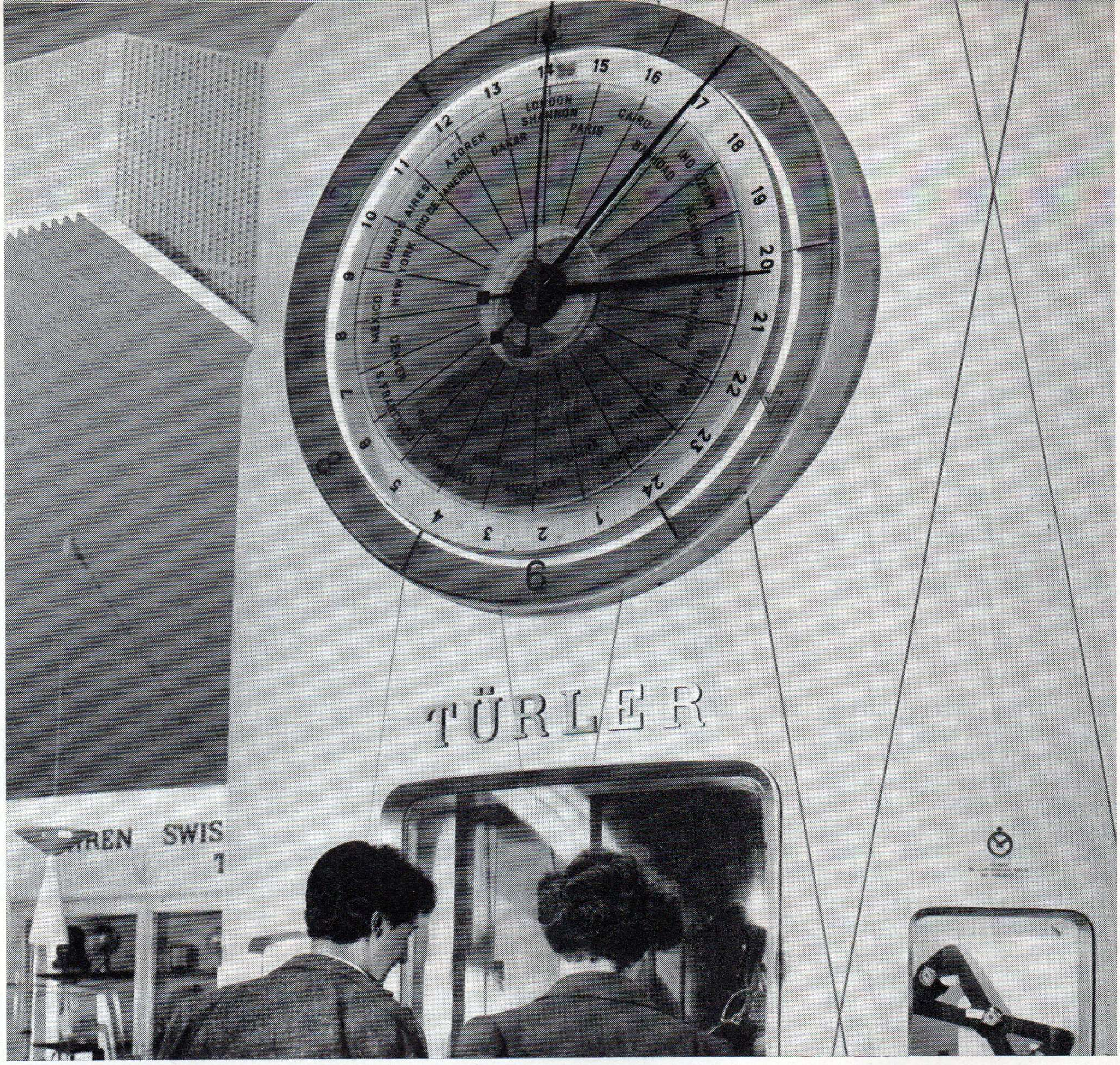
During the summer period, an SAS aircraft is starting or landing every third second somewhere in the world. In each, four clocks with Swiss precision movements assure that all the complicated manoeuvres necessary to operate a modern aircraft are coordinated. None of the many instruments could be dispensed with, and the manoeuvres they instigate could well be made without the clocks. But the clock decides when to do what, perhaps a not quite unimportant function. For this reason, SAS value their clocks highly, and maintain them at standards set by the Swiss watchmaking industry.



Partial view of the navigator's instrument panel in an S A S aircraft. Note clock for the navigator's use on left

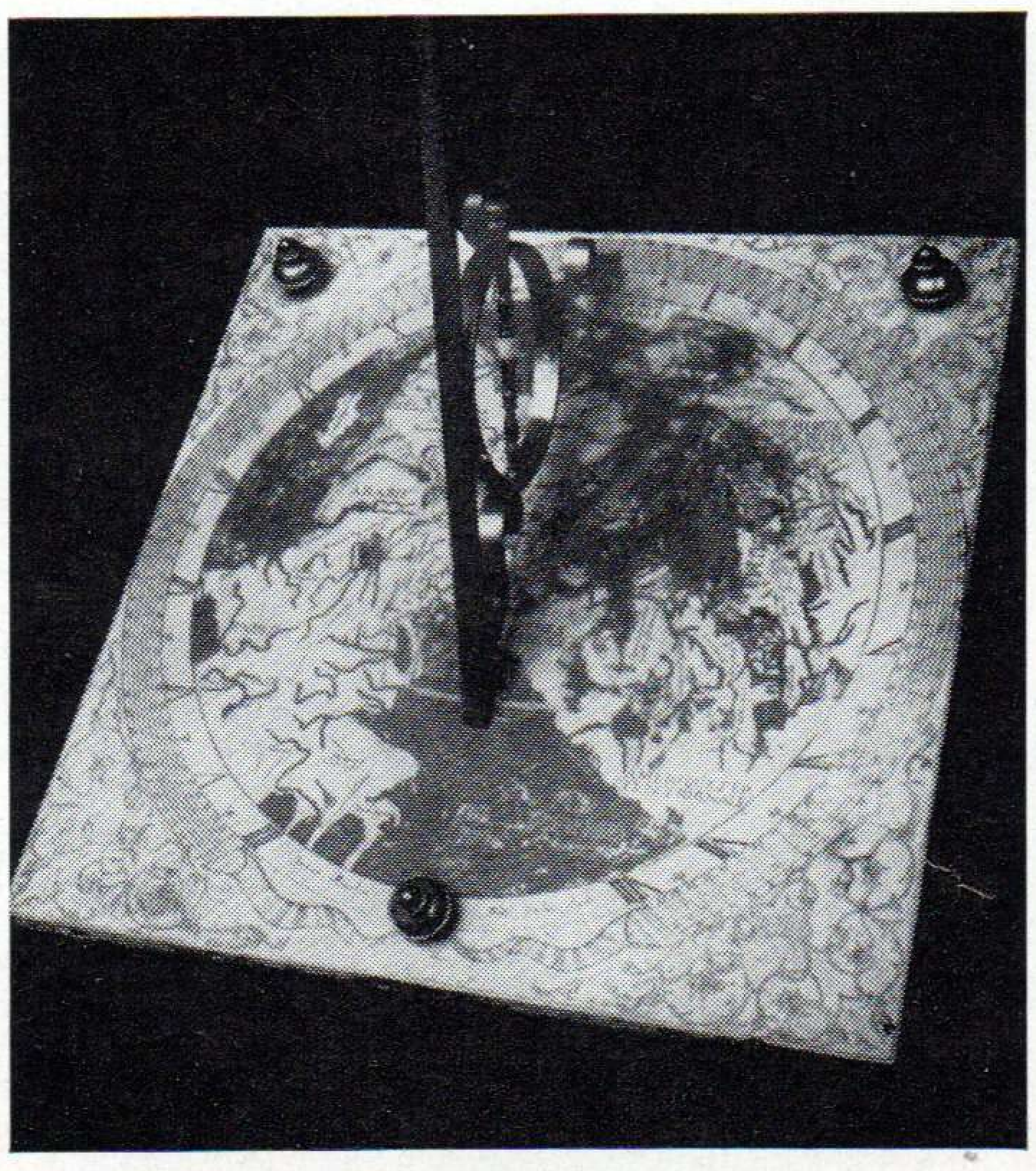
A watchmaker carefully controlling an instrument panel clock.





CHRONOMETRY IN THE SERVICE OF AVIATION

by LOTHAR M. LOSKE, HOROLOGICAL ENGINEER, ZURICH



Horizontal sundial on Solenhofen stone with geographical world zones of F. Textor 1725, bears witness to the interest taken in the time of foreign countries at that early date.

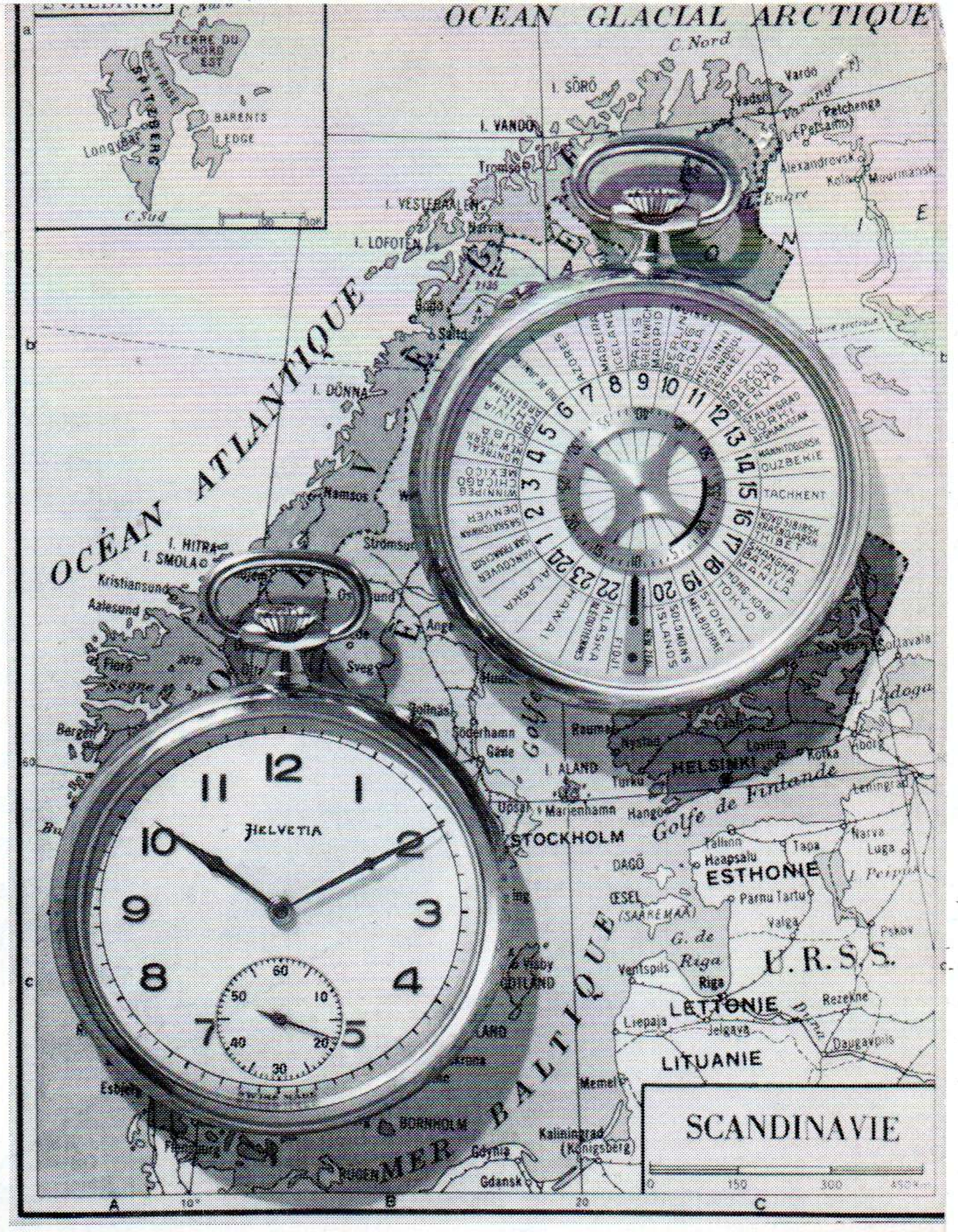
Thanks to the tremendous progress made in the construction of jet and delta-winged aircraft, aviation has taken first place in world transport. Soon it will be possible to cross oceans and continents in non-stop flight with perfect regularity and complete security. From year to year air travel will go on expanding and, with it, the interest in that category of watches which so far have been regarded as horological curiosities.

Never before has so much importance been attached to the actual time prevailing in lands abroad where relatives or acquaintances are living, or to the exact moment at which an event of world-wide significance has taken place overseas. Modern man is confronted with problems which overstep the usual division of the day into hours and minutes. The duration of the flight is a factor of the utmost importance in air transport. " Time is money ", runs the saying and it is indispens-

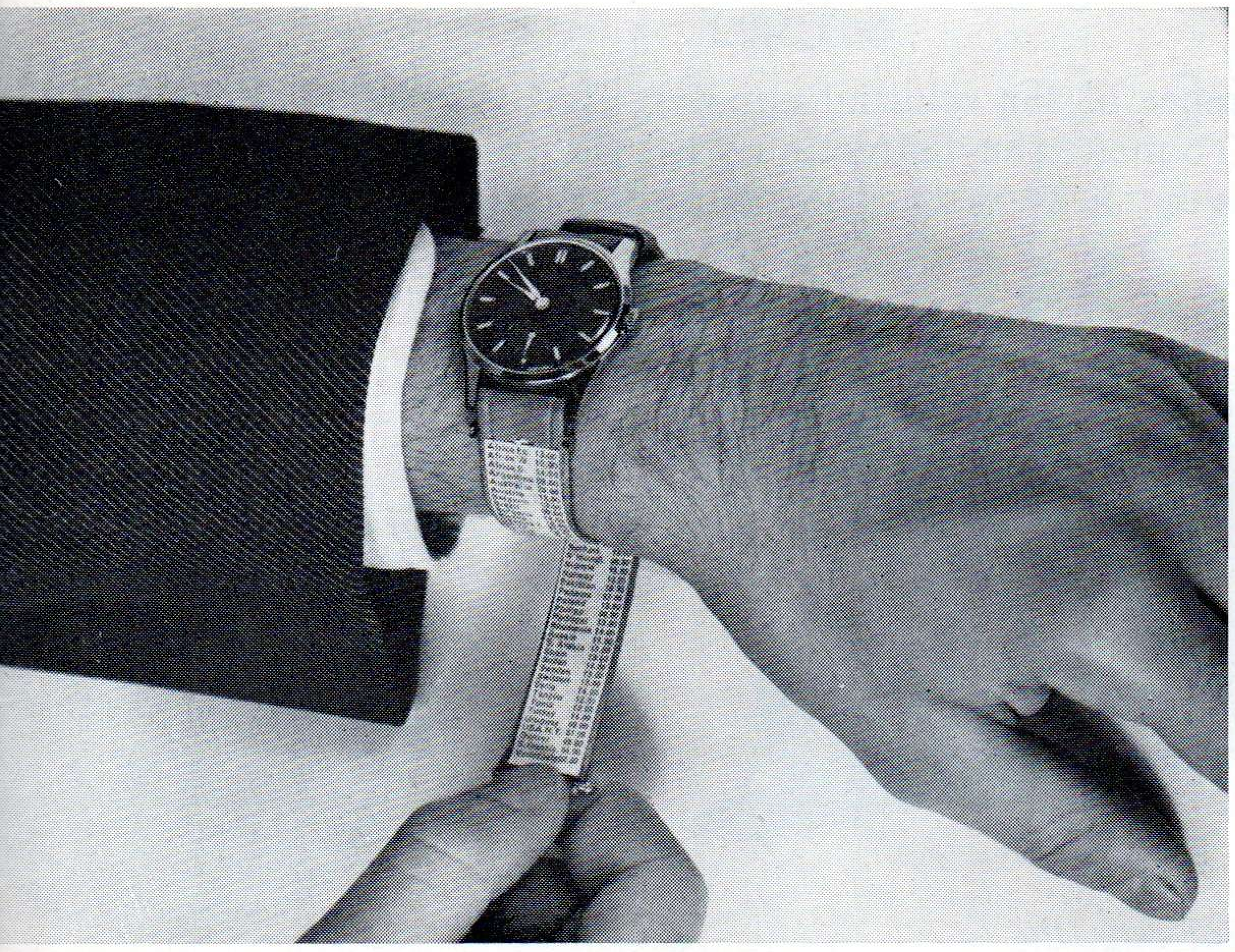
Universal clock on the " Clock Tower" of the Zurich-Kloten Airport. On this clock the earth is represented as a disc of which the North Pole is the centre. The names of the towns figure on the circumference of the disc in the order of the time zones to which they belong, beginning with London at the top (e. g. the basic meridian = G. M. T.). The hours indicated represent the normal time of each town and surrounding region. The clock measures 1.50 m. ; made entirely of plexiglas it has a secondary electric movement. (Constructed by the author.)

able to know at what time one's destination will be reached. The time of arrival after a ten-hour flight in no way corresponds to a ten-hour journey by car or train. An interesting example of this is furnished by the transpolar air-lines recently inaugurated between Scandinavia and California passing over the North Pole : a traveller arriving in California after a 25 hour flight has only aged by 16 hours and can put his watch back 9 hours compared with the time he has " brought over " with him. Obviously to take advantage of this modern method of rejuvenation one must not use the return ticket nor prolong the journey beyond the date line.

The watch, to meet all these new requirements, has been the object of constant improvements preceded by all kinds of theoretical preparatory work. The majority of people today are lacking in the most elementary knowledge about

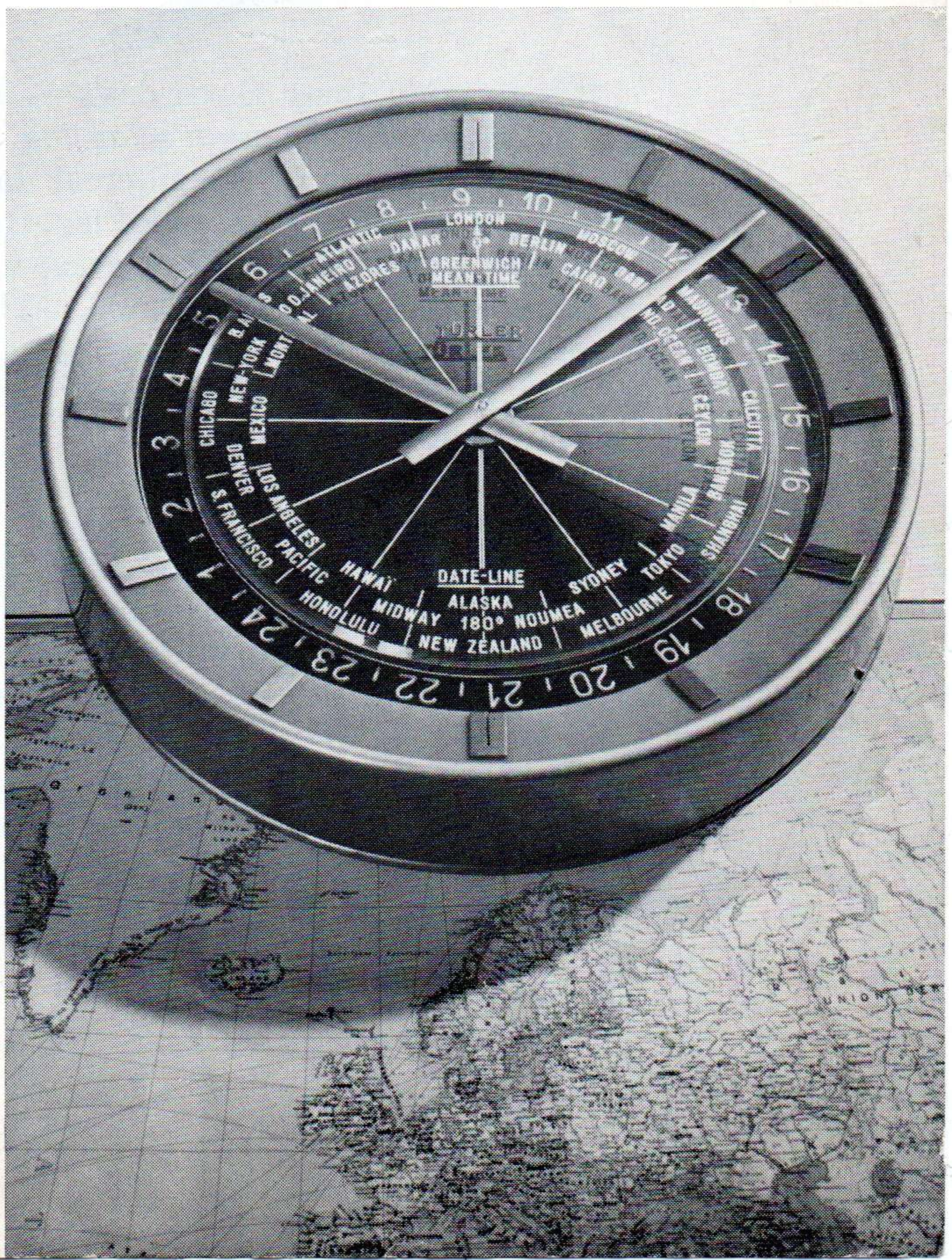


Pocket watch " Univertime " indicating the time simultaneously in the 24 time zones. (Montres Helvetia S. A., Reconvilier.)



Wrist watch with comparative Timetable. The names of the countries are followed by figures indicating their normal time at noon G. M. T. = world time. This table can be closed. At any moment the wearer can find out the time differences all over the world. Patented by A. Türler & Co. (Constructed by the author.)

Universal clock for aviation bureau, resembling that of illustration, page 32. Diameter 35 cm. executed in multicoloured plexiglas, made by A. Türler & Co. (Constructed by the author.)



the various measurements of time. The sundial helps us to understand the conception of " true time ", the primitive measurement of time determined on our planet by the sun in contrast to the *continuum* space-time of the universe.

The time necessary for a fixed star to describe its circuit on the celestial sphere which appears to revolve around us — or, stated technically, the time between two consecutive culminations of a star — determines the sidereal day. The horary angle of such a star which measures 0° at the moment of its passage across the meridian and which constantly increases up to the next culmination, thus covering the 360° of a circle, is like the veritable hand of a tremendous universal clock.

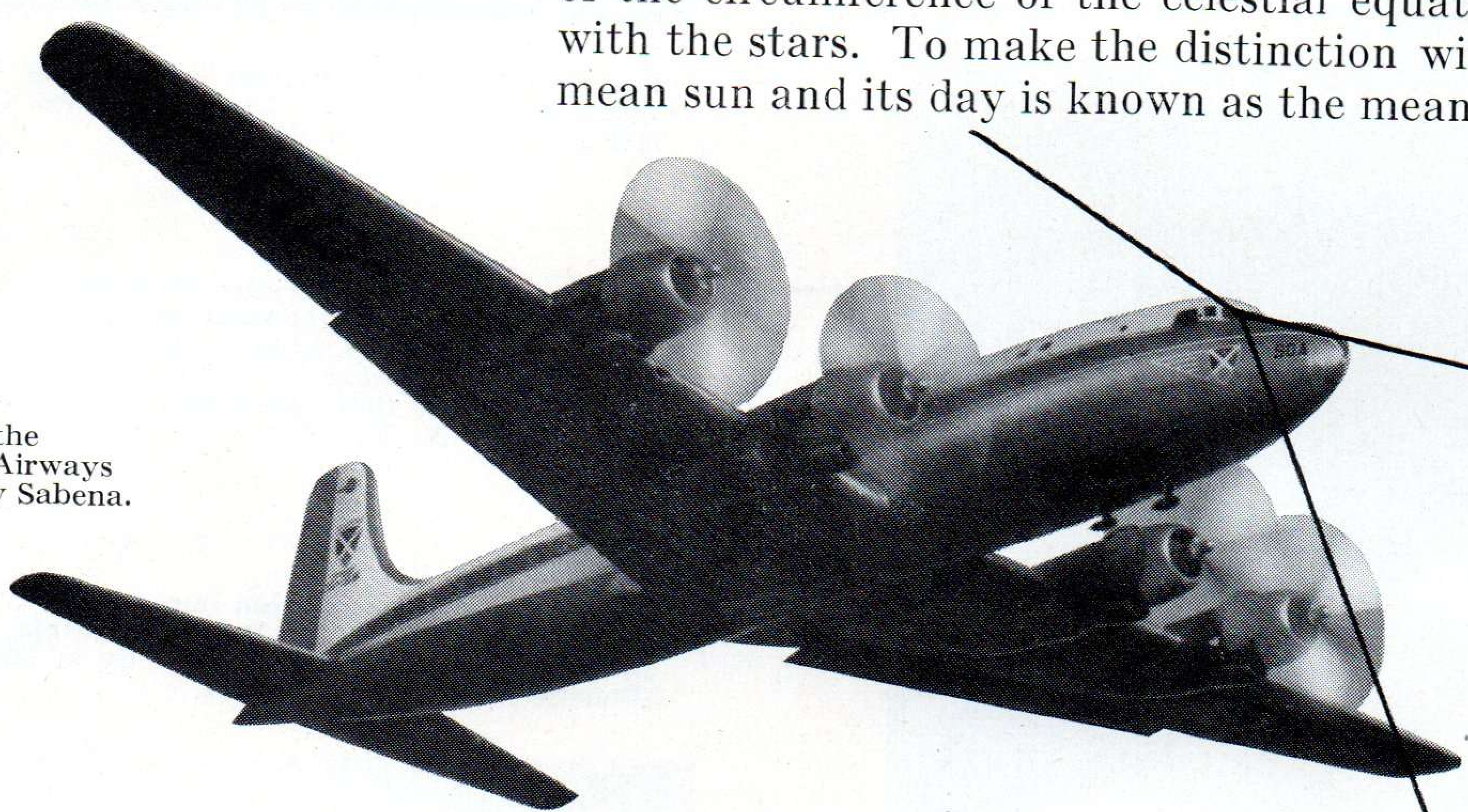
If man regulates his life according to the sun, that source of light which, as a result of the rotation of the earth about its axis, separates day from night, he must also take into account the elliptic curve described by the earth round the sun. The second law enunciated by Keppler states that the speed of the earth is variable according to the points it has reached on the curve. The apparent time-lag of the sun compared with the movement of the stars proves that the earth describes an orbit in the shape of an ellipse since the horary angle of the sun is variable. This movement of the earth results in an irregular solar time-lag and makes the true solar day longer than the sidereal day. Solar days are thus not of equal length. It follows that we cannot utilize them as a fixed unit for the measurement of time as would be possible with sidereal days. In order to have an absolutely invariable time measurement corresponding to the rhythm of the rising and setting of the sun, astronomers have calculated the mean solar day.

1

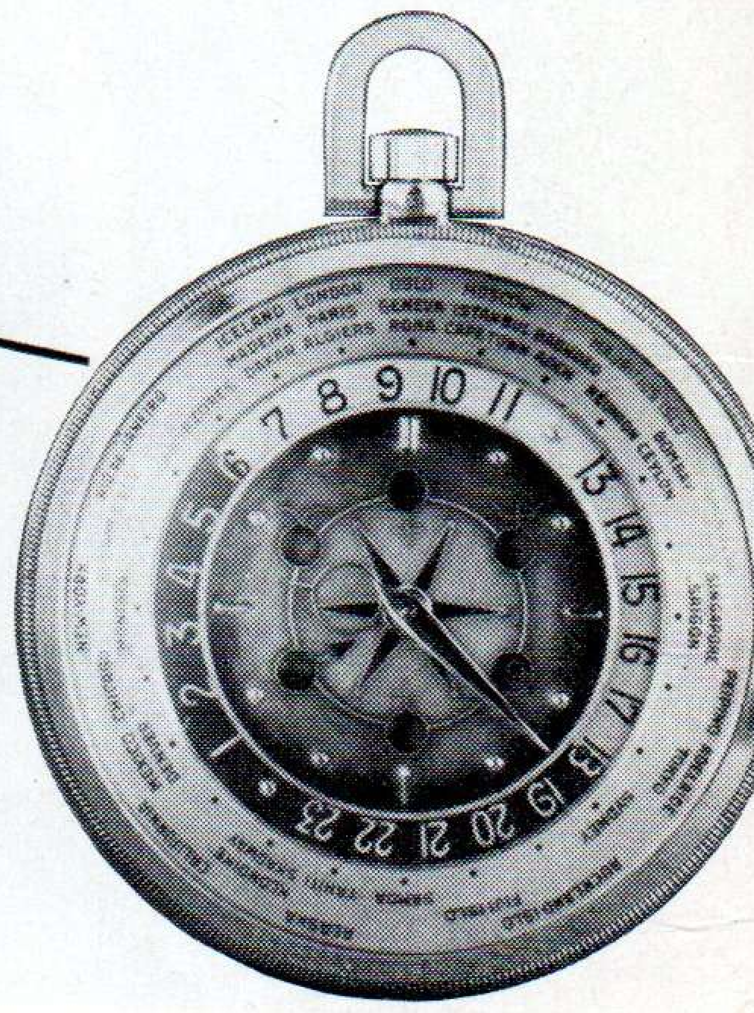
To explain this mean day we must assume the existence of a second sun travelling round the celestial equator with a uniform movement while the real sun describes an ecliptic. The two suns pass at the same moment through the vernal point of the equator when day and night are equal and at that point they meet again exactly one year later. Every day the fictitious sun will lose the fraction of

$$\frac{1}{365{,}2422}$$

of the circumference of the celestial equator, that is 0º 59' 8" 3 compared with the stars. To make the distinction with the true sun, it is called the mean sun and its day is known as the mean solar day.



DC-6 of the Belgian-Airways Company Sabena.



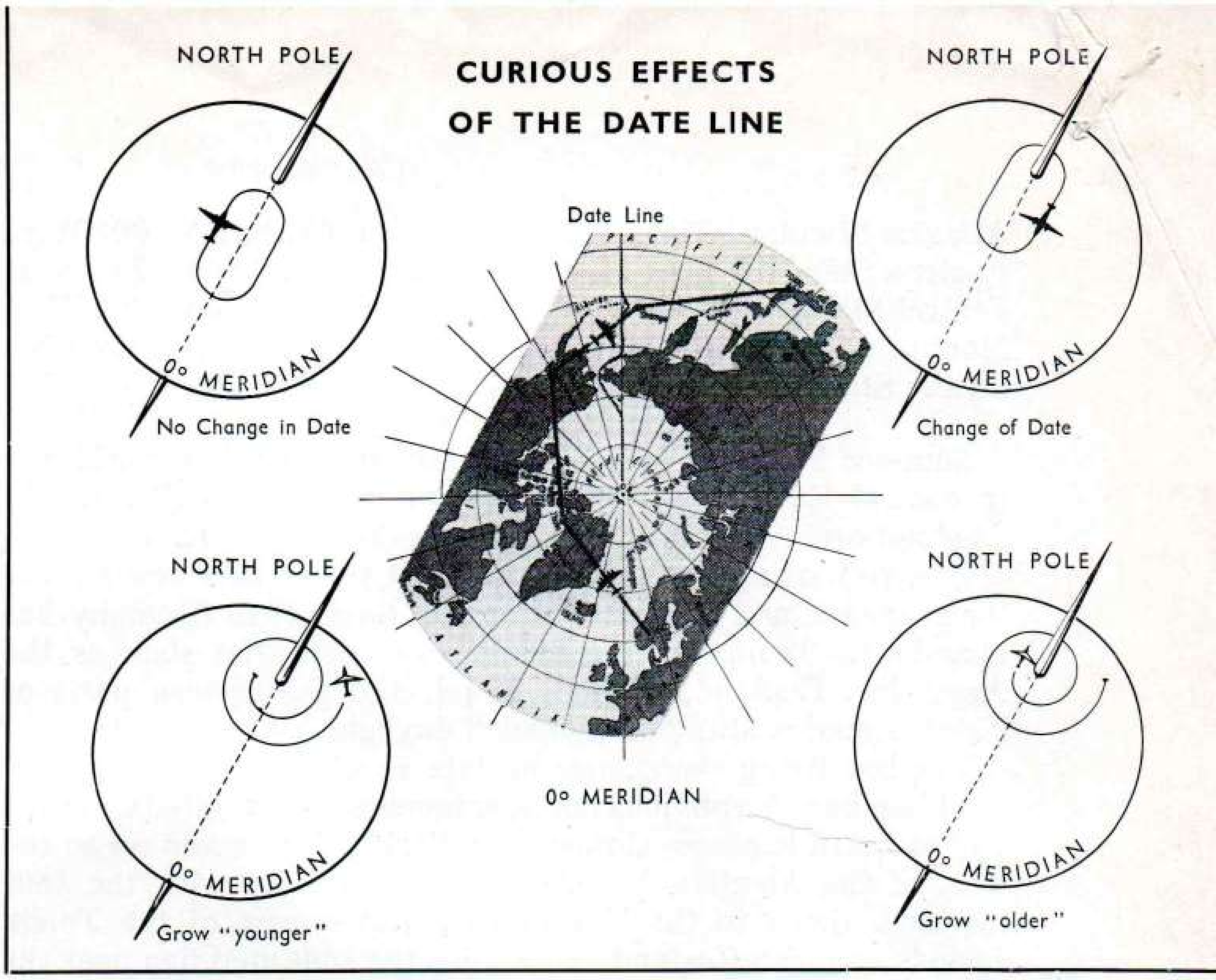
2

If we divide these three days — *the sidereal day, the true solar day* and *the mean solar day* — into 24 hours, we see that the hours of the sidereal day and those of the mean day are always of equal length whereas the hours of the *true solar day* always exceed them by the same number of minutes and seconds. The difference varies, moreover, with the seasons thus giving us longer or shorter days ill suited for the purpose of the exact measurement of time.

*

These time differences are called the equation of time (*Aequatio temporis*). They have their maximum values in February and November. If, for example, the equation of time indicates minus 16 m 16.95 s, a mechanical clock set in accordance with local time should only indicate 11 h 43 m, 43.05 s when the shadow of the hand of a sundial which is astronomically faultless, falls exactly over the line of noon, that is to say when the true sun culminates and it is noon by true time. On the other

3



Curious effects of the date line. Flying from Europe to Tokyo via the North Pole, the traveller first becomes several hours younger thanks to the east – west direction of the aircraft, but on crossing the date line he suddenly ages by a whole day.

hand, if the equation of time indicates plus 14 m 31.22 s, an accurate clock should register at that moment 12 h 14 m 31.22 s.

Local mean time was introduced into most of the European countries in the early 19th century, most probably into England first of all. But for over the preceding half century it was no longer admissible for transport purposes that two towns only a few miles apart should have two different mean times, since time is a succession of events and progresses from east to west. A clock at Zurich set according to local mean time would be ten minutes fast compared with a clock set to the local mean time of Geneva. Even between Zurich and Basle there is a difference of 4 minutes, for each locality has its own time conditioned by its geographical position.

How could a timetable be drawn up if the time varied every few miles ? The problem was solved by the creation of a legal time prevailing over an area of a certain distance. The difference between two local mean times compared with the legal time depends on the number of longitudinal degrees separating the two localities. One longitudinal degree is equivalent to 4 minutes of time (24 hours = 1440 minutes divided by the 360° of the earth's circumference = 4 minutes of time).

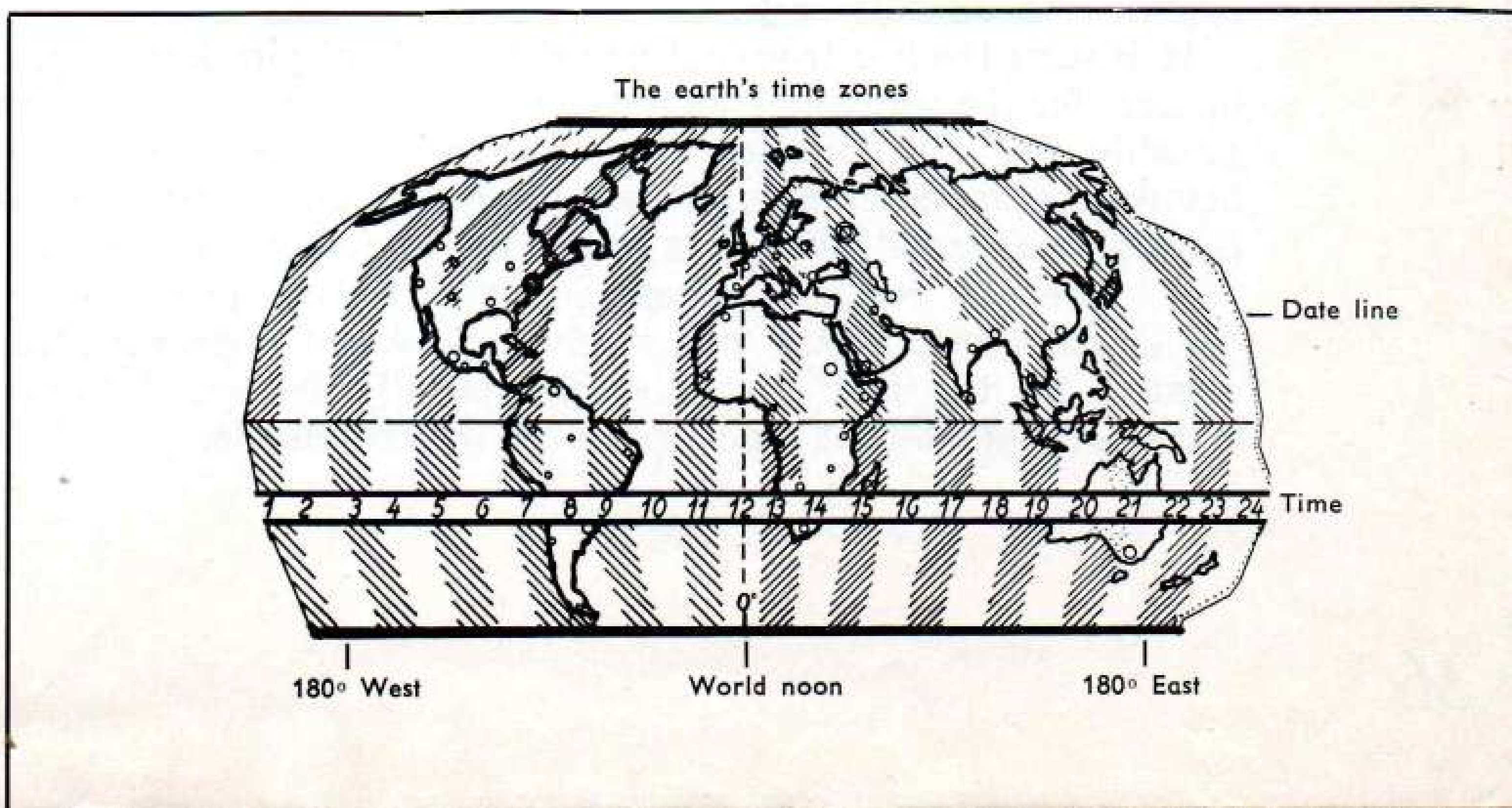
The starting point of this division is the zero meridian of Greenwich, recognized in Rome in 1883, which passes through the centre of the first time zone. Starting from this zero meridian the solar passages succeed one another from east to west conforming with the earth's rotation and are one hour later for every 15° longitude. Thus the longitudes of 15°, 30°, 45°, 60°, 75°, etc. have become known as the meridians of normal time. For central Europe, France, Belgium, Holland, Switzerland and Italy the determinant meridian is that of the 15° east of Greenwich. It coincides with the local mean time of Görlitz (Germany) and provides the time for central Europe. All places situated within this time zone have the same normal time. Eastern European time (30° longitude east) is an hour in advance and western European time (0° longitude) an hour behind that of central Europe.

Certain islands and countries are unable to adhere to this system of time zones for essentially geographical reasons ; these are, for example, Burma, Greenland, the Hawaiian Islands, India, Iran, the Malay Peninsula, Newfoundland, the West Indies, New Guinea, Pakistan (west), Dutch Guiana and Venezuela.

*

America is so vast that one time zone does not suffice. That continent — including Canada — is divided into five time zones which, going from east to west, lose an hour each time in the following order :

Diagram of the earth's 24 time zones. The zone boundaries do not always coincide with the meridians for economic and commercial reasons.



Atlantic Standard Time	(A. S. T.)	60° West
Eastern Standard Time	(E. S. T.)	75° West
Central Standard Time	(C. S. T.)	90° West
Mountain Standard Time	(M. S. T.)	105° West
Pacific Standard Time	(P. S. T.)	120° West

Summer Time has been functioning since the first world war in central Europe as " Deutsche Sommerzeit " (S. Z.) and in England and America as " Daylight Saving Time " (D. S. T.) with a view to putting the hours of daylight to the best possible use for economic and touristic purposes. Since 1949 Germany has abandoned " summer time " but other countries such as the Argentine, England, Ireland, Israel, and the eastern parts of North America still " economize " daylight.

The line fixing the change of date is situated near the 180° meridian and, for obvious reasons, touches no inhabited country. In the north it passes through the Bering Straits and on to the west of the Aleutian Islands, then it coincides with the 180° meridian down to the Fiji Islands, passes east of the Tonga Islands and New Zealand and rejoins the 180° meridian near the Antipodes.

*

Going eastwards we journey towards the sun. Boats or aircraft travelling from eastern Asia towards America must, as they cross the date line, recommence the day they have just completed (Sunday the 24th will be followed by another Sunday the 24th) whereas, travelling in the reverse direction, from San Francisco to Yokohama for example, they have to skip a whole day (Sunday the 24th will be followed by Tuesday the 26th).

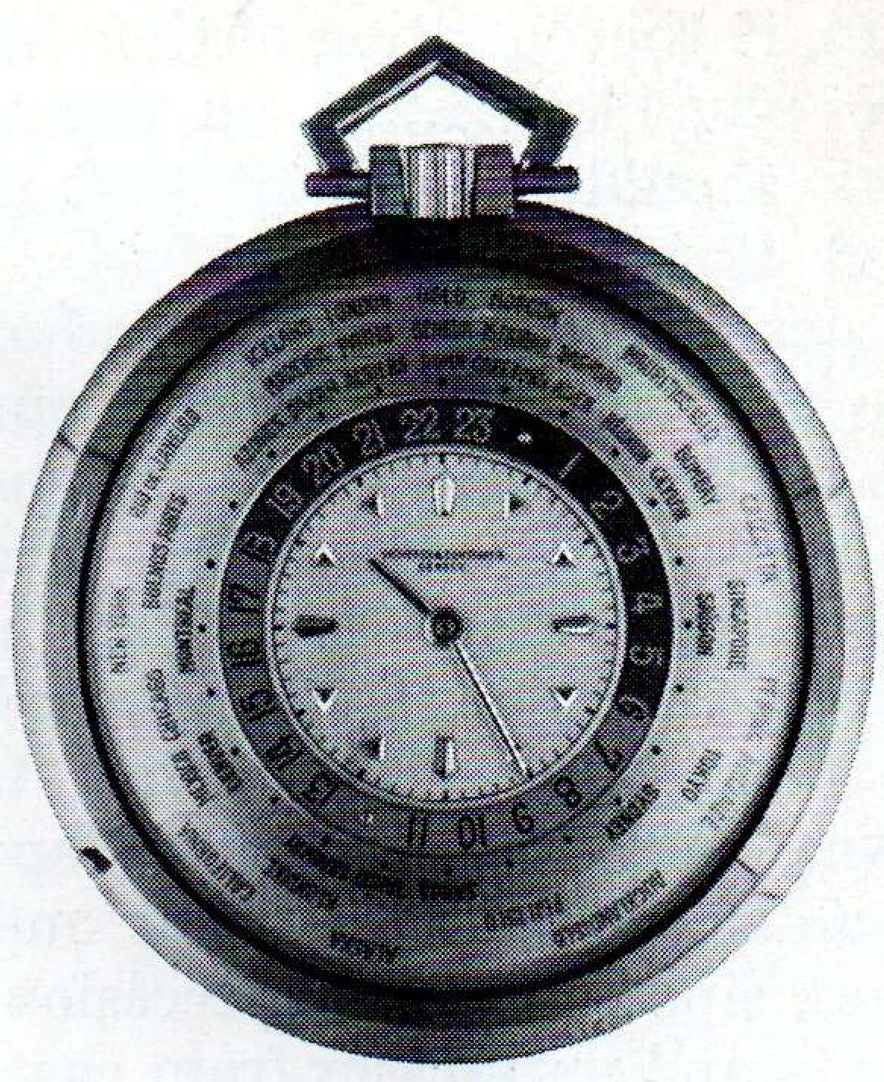
Universal time officially designated as " Greenwich Mean Time " (G. M. T.) is taken as the basis for marine and air navigation timetables as well as for the wireless communications of the police, the press and the meteorological stations.

According to this G. M. T. system, independent of varying local times, it is 12 o'clock G. M. T. at the same moment all over the world. But in actual fact the day will have ended in Tokyo whereas, in Mexico, people will have just risen.

*

The 24 hour day of this universal time starts when the sun crosses the date line on the 180° meridian ; twelve hours later it is " universal noon " and the sun crosses the meridian at Greenwich. Thus G. M. T. is the only time which is considered as universal, all over the world. The use of the G. M. T. system is extremely simple for aviation. A pilot takes off at a certain time G. M. T. and lands so many hours later according to G. M. T. The fact that the official airport clocks indicate quite different times, whether they be fast or slow, presents no problem to an experienced aircraft crew.

It is none the less true that a vast field of activity has opened up here for the watchmaking industry. Many improvements are possible and will doubtless have to face up to severe testing before they are acceptable. It is quite likely that certain innovations such as mobile dials or a completely different order of time zones like the recently patented system called, in Germany, " Buchstabenzeit " may not receive the warm approval anticipated, for the fact that they are completely new does not necessarily mean that innovations are improvements.



5

1. **Chs Tissot & Fils S. A., Le Locle.**

   Automatic " Navigator " watch. The time of the place at which you happen to be is shown by the hands moving as for the normal hour indications.
   The times in the other time zones are indicated on a fixed 24 hour dial within which revolves a disk bearing the names of the capitals. The latter is driven by the watch movement proper at the rate of one revolution per 24 hours.

2. **Patek, Philippe, Geneva.**

   Pocket watch " universal time " with cloisonné enamel dial.

3. **Glycine Watch Co S. A., Bienne.**

   "Airman " model designed to meet the requirements of air-line pilots. An inner 24 hour dial indicates Greenwich time or any other service time used by the crew. A revolving bezel can be regulated to the local time of the place at which the pilot happens to be.

4. **Fabriques Movado, La Chaux-de-Fonds.**

   "Polygraf" universal time watch. In the centre is a fixed dial which, in addition to the usual hour and minute markings, has 24 hour divisions round which moves a hand with a red tip. This hand makes one dial revolution per 24 hours. Round the first dial is a second dial fixed to the bezel with which it turns. This second dial is divided into 24 zones corresponding to the division of the terrestrial globe into 24 time zones.

5. **Vacheron & Constantin, Geneva.**

   Universal time pocket watch.