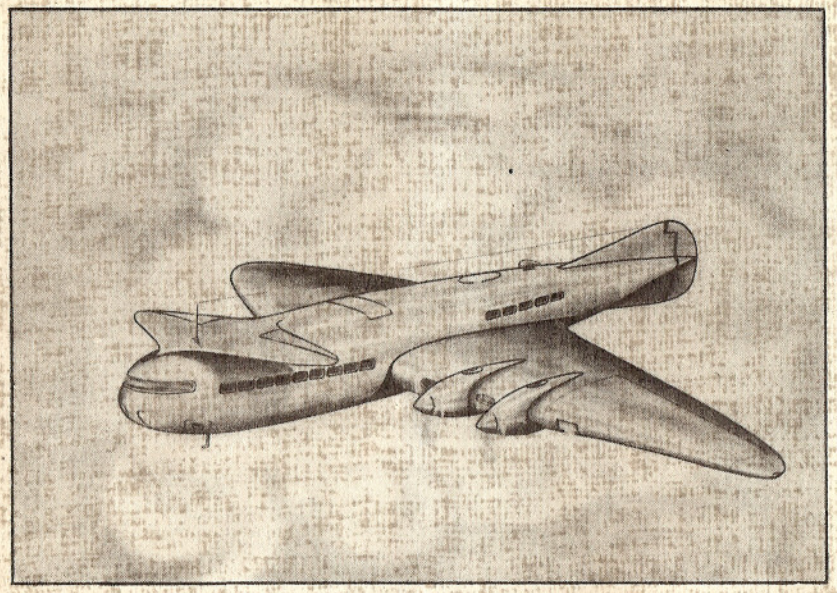
The LIBRASCOPE

as applied to aircraft



In Appreciation

To the members of the aircraft industry who have so successfully guided our progress with their unselfish support and constructive criticism, we wish to pledge our entire resources to the construction of LIBRASCOPES which will provide a practical and efficient solution of the loading problems connected with the airplane of the future. The LIBRASCOPE of the present is yours—built to your specifications. Because of the complex and specialized nature of the problems involved the LIBRASCOPE of the future will continue to need your whole hearted co-operation.

Foreword

FROM the tricycle, tail first airplane of twenty-five years ago, designers have followed a devious and painstaking path.

It is significant that certain features of these earlier airplanes are being revived in the designs of today.

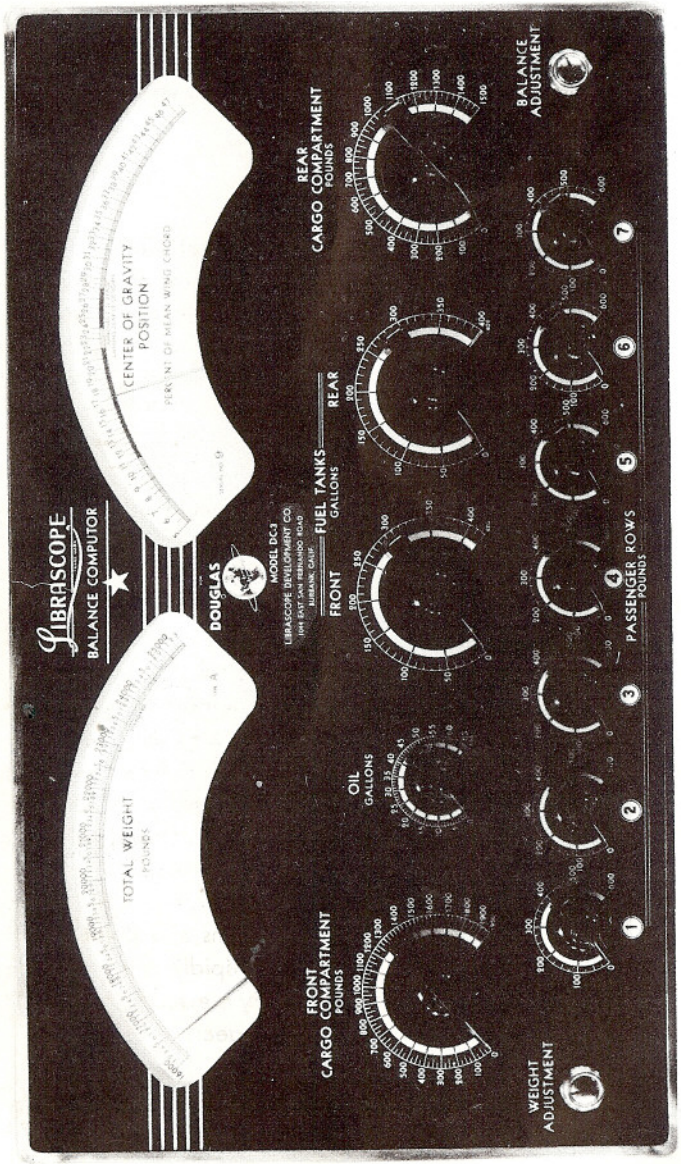
The rise in commercial importance of aircraft is the one great difference which has come about during this process of evolution. This has been brought about by the struggle to improve upon previous designs and reach into newer aspects of the art.

This commercial importance is the result of the ability of aircraft to carry ever larger loads, more swiftly and more safely. The proper disposition of the variable loads in an airplane is fundamental in achieving this result.

Rarely has the airplane taken to its medium with its "most" weight carried in its "best" location. No doubt this condition of the past has been due to cumbersome and ineffective methods of weight distribution control.

This is no longer true, however. The data herein are intended to illustrate the way many operators have solved this problem by the use of the LIBRASCOPE.

—you can read this booklet in five minutes—it will pay you to do so—



THE LIBRASCOPE ✶

AN EFFECTIVE AND SIMPLE WEIGHT AND BALANCE CONTROLLING DEVICE

THE trend of modern transport aircraft design is definitely toward greater carrying capacity, more spacious baggage compartments and larger, more comfortable passenger accommodations. Almost the entire length of the fuselage is now being converted to the carrying of payload. Seat spacing is approaching five feet between rows as opposed to three feet. Altogether, there is indicated a larger per cent of over-all center of gravity range as full utility of available space is realized. It appears, however, that the center of gravity range during take-off, flight and landing has, if anything, been reduced, due to the large upsetting moments resulting from high lift devices.

Military aircraft as well, particularly the larger sizes, also are carrying improved useful load ratios. The loads are even more widely distributed than commercial transports, particularly when a gunner is at each extremity of the main body and a bombsight operator is near the nose. If, for example, on a 50,000-pound airplane, 100 feet long, the rear gunner were to move to the nose position, a center of gravity movement of nearly five inches would result. **It is indicated therefore that an effective, simple and rapid device for weight and balance control be provided as an adjunct to all flight operations.**

In connection with the current trend of landplanes into the tricycle type of alighting gear, preliminary calculations and flight tests indicate that in order to become air borne rapidly, with ease and a minimum of stick forces, the center of gravity is even more critical than in the case of the "conventional" land type gear.

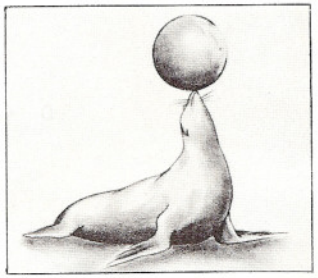
LIBRASCOPE IS THE TRADE MARK OF BALANCE COMPUTERS MANUFACTURED BY LIBRASCOPE DEVELOPMENT COMPANY

It appears as though take-off runs with a "too-far-forward" center of gravity position on a tricycle alighting gear may produce more serious consequences than with the conventional gear. If the tricycle gear is desirable from the standpoint of improved safety, another variable in the center of gravity is to be controlled in addition to % MAC (per cent of mean aerodynamic chord); this variable is the per cent distance **forward** of main landing gear chassis. Likewise, a **"too-far-aft"** location of the center of gravity on a tricycle alighting gear will produce results which are at once apparent. Since the optimum center of gravity range may vary with the total weight of the airplane, either in flight, in landing, or take-off, it is surely reasonable that some control be provided to insure fair agreement between the actual and optimum conditions.

In the field of flying boats the correct location of the center of gravity and angle of planing of the hull bottom has been fairly well established. "Hump" resistance and take-off time have been found to be reduced twenty-five per cent (25%) by the proper handling of the variables which influence them, aside from power available. Also, since engine cooling is a major problem in flying boat operation during take-off, all reasonable means should be taken to insure proper preparation for minimum take-off time. Designers of floats and boat hulls have concluded that in addition to aerodynamic balance, the center of gravity with respect to the main step must be controlled—and here again as in the case of landplanes the optimum location is different for heavy loads at take-off than it is for light loads at landing. Flying boats are somewhat more sensitive to the center of gravity position during

A SEAL CAN BALANCE

BY INSTINCT



take-off, particularly, than landplanes of equivalent size. The relative position of the center of gravity and the main step should be determined, controlled and rationalized against gross weight in the same manner as discussed under landplanes above.

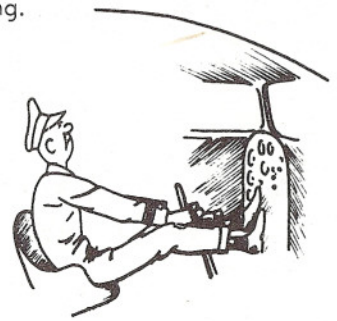
One of the primary factors in the present trend toward improvements in safety of air transportation is the elimination of pilot fatigue. Pilots' errors usually are charged to a man who is operating under high mental and ocular stress for extended periods of time. In addition to this already critical tax on the physical limitations of flying personnel, often the crew is burdened additionally due to incorrect loading which incurs adjustment of trimming tabs or constant trim correction, which might otherwise be avoided. Operating units should seriously reconsider this problem if they do not have proper controlling instruments on the ground and in the air.

It is uneconomical to use trimming tabs while the plane is in flight to correct for an improperly distributed load. Aside from the more obvious faults of this procedure, it is pointed out that if an airplane were loaded so that it flies under a nose-heavy condition, the force of air on the horizontal surfaces in effect adds the same amount of additional weight as would be necessary to pull the airplane back into a level position. **That is, this amount of weight is then added to the airplane over and above the static weight.** While this would not in every case mean that the airplane would be carrying a load over its permissible gross weight, it will cause added consumption of fuel, reduced speed and more difficult handling.

BUT IT'S HARD WORK

FOR

PILOTS AND ENGINES



For a solution of these troublesome problems, Mr. Lewis W. Imm, President of the LIBRASCOPE DEVELOPMENT COMPANY, has made a major contribution in the field of air transport by the development of a portable, compact, weight and balance computor known as the LIBRASCOPE.

This specialized form of calculator will show the weight and balance of any contemplated loading, or how to distribute a given load to attain a desired center of gravity location at any time prior to or during the process of loading or unloading. The very essence of the LIBRASCOPE is simplicity of settings and accuracy of readings. This goal of all instrument makers is the direct result of planning to produce this fortunate result. No skill and very little judgment is required to set up the proposed or existing weight distribution. **All settings can be checked by visual inspection and there are no trial and error solutions such as are involved in the slide rule type of balance computors.** In addition to this very important feature, only the LIBRASCOPE provides for automatic totalizing and precise indication of under or overweight. The gross weight and the center of gravity are indicated on separate calibrated dials upon which are superimposed limiting graduations.

The utility of the instrument is graphically illustrated by a recent round-the-world record flight which employed a LIBRASCOPE in preparation for loading, unloading, and in the selection of fuel from the various main and auxiliary storage tanks. Since the airplane was seriously overloaded to begin with, a very accurate control of the center of gravity was necessary. By means of the fuel dial settings on the LIBRASCOPE at any particular time, the flight engineer could also quickly determine the endurance available and, preparatory to landing, make out a loading schedule to facilitate accurate refueling.

As it is designed for the Douglas DC-2, DC-3, DS-T and the Lockheed 14, the LIBRASCOPE is contained in an attractive and compact carrying case, which provides snap locks and a carrying handle. The dimensions of the unit are (approximately) 3 inches deep, 11 inches wide and 18½ inches long. The weight is between 6 and 8 pounds depending upon the number of dials.

The basic weight empty and weight empty center of gravity of all aircraft is determined by weighing, upon leaving the factory and at periodic intervals thereafter. This basic weight empty includes the crew and items of equipment which are carried in the airplane at all times.

Values which correspond to the weight empty and weight empty C.G. (including crew and fixed equipment) are adjusted on the weight and balance scales of the LIBRASCOPE by the respective weight and balance adjustment screws. If the LIBRASCOPE is to be used for an individual airplane or a fleet of airplanes which use average weight empty and weight empty C.G.s, the adjustments are not disturbed after the initial setting except to allow for the installation of additional equipment or to correct for service "pick-up," as determined by periodic actual weighings. If one LIBRASCOPE is to be used on a number of airplanes of the same model, but which have different basic weight and C.G. values due to difference in equipment, it has been found advantageous to install pointer knobs, similar to the ones used for useful load items, in the place of the screws. Blank dials are provided under the adjustment pointers and these dials may be marked to show the individual settings for each airplane. Using this procedure, the first step is to set the adjustment pointers to the mark representing the serial number of the airplane to be loaded.

Individual dials with adjustment knobs are provided for all items which make up the variable useful load or payload of the aircraft. These include dials for each fuel and oil tank, each baggage compartment and each row of passenger seats. In addition, it is sometimes necessary to include dials to indicate movement of weight during flight, such as a retractable landing gear.

The LIBRASCOPE has been designed to make its operation logical and natural. The general arrangement is similar to the cross-sectional view of the airplane—looking from the left side. There are no multiple settings and the total weight and total weight C.G. are indicated at any step of the loading process. In addition, the settings of the various pointers indicate to the operator the amount of load which has been placed in each tank, compartment or passenger seat. This latter feature prevents all chance of error, and eliminates the necessity for rechecks.

manipulation of the pointers described under "A", in addition to the basic weight empty as set by the weight adjustment described under "B". (The scale extends from a value below the normal basic weight empty to a value considerably above the normal or provisional gross weight and shall be conspicuously marked by the words "Standard" and "Provisional".) In addition, colored bands shall be provided to indicate the range limits. The customary color band arrangement shall be as follows:

Below standard gross weight.....Green
Between standard and provisional gross weight.....Yellow
Above provisional gross weight.....Red

The weight scale shall be calibrated to provide for a reading accuracy of one-half of one per cent.

(D) A CENTER OF GRAVITY POSITION REGISTERING SCALE

The pointer on this scale registers at all times the position of the center of gravity of the gross weight of the airplane including the loads set into the mechanism by manipulation of the pointers described under "1. (A)" in addition to the basic weight empty set by the weight and balance adjustments described in "1. (B)". This scale is normally calibrated in per cent of the mean aerodynamic chord but may be calibrated from any reference point or points.

The allowable center of gravity range is marked by a green color band and may also be identified by the description "allowable center of gravity range, landing gear up or down."

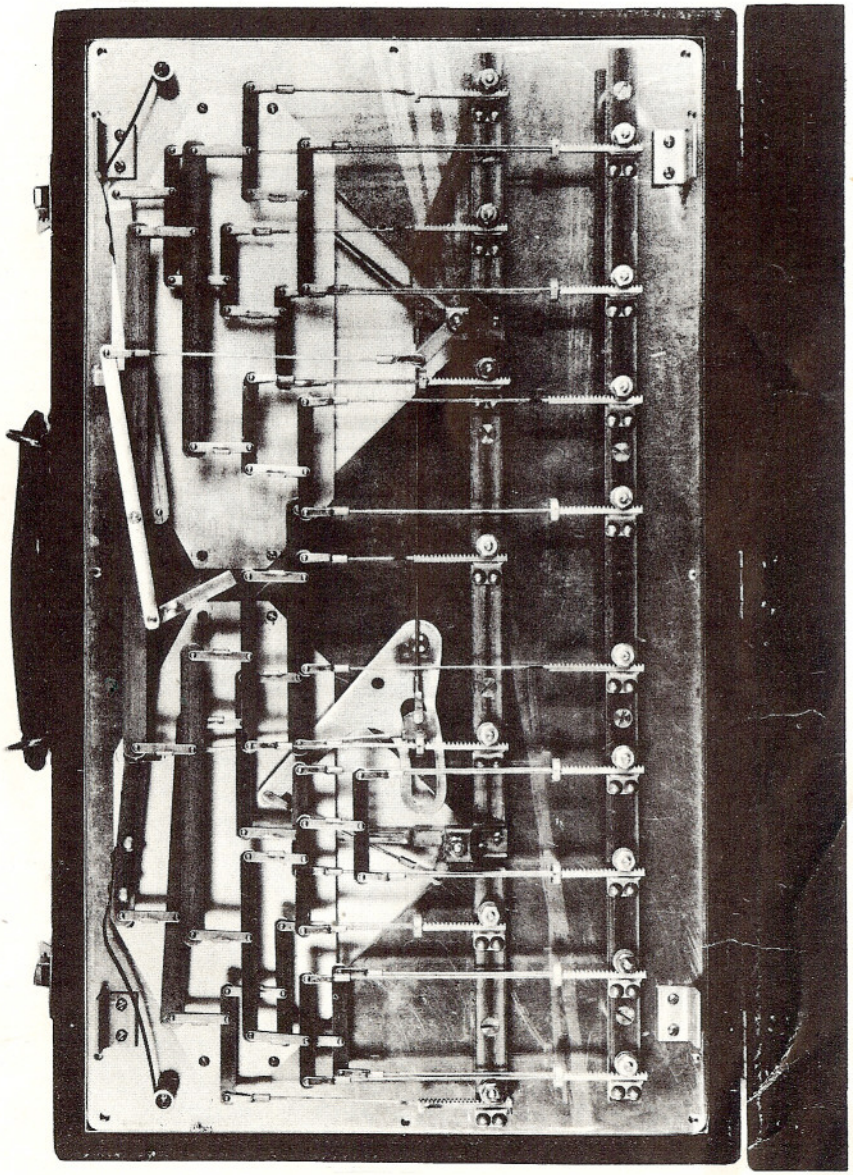
The range forward and aft of the allowable range is marked in red. The calibration is such as to provide a reading accuracy of two-tenths of one per cent of the MAC.

2. CALIBRATION:

The various loads and fuel or oil capacities may be described in any language and calibrated in any units. (Translations, if any, are to be furnished by the purchaser.)

3. MATERIALS OF CONSTRUCTION:

The materials used in the construction of the LIBRASCOPE are carefully selected and of the best grade obtainable. Special attention has been directed toward corrosion resistance under extreme service conditions. The etched aluminum dials are protected by a layer of transparent material which is relatively uninflammable. A close fitting chromium plated rim provides an effective seal against dust or moisture entering the mechanism. The standard carrying case includes a cover which makes the unit easily portable. This case is covered with an extremely tough waterproof and wear-resistant material.



The Librascope Mechanism

The LIBRASCOPE offers a simplified solution to loading problems. It is the only computor which gives:

(a) Simultaneous weight and balance changes for a single setting of load placed in any compartment.

(b) A visual record of all loads and where placed.

(c) Automatic distribution of additional cargo, passengers or fuel for a definite C.G. position, the other loads remaining constant.

(d) Solution of last minute additions or subtractions of load with a minimum of time and effort and without necessitating recalculation of loads not affected.

(e) Constant record of the amount of additional load which may be carried without exceeding the gross weight, and where this load may be placed to keep the total weight C.G. within the allowable limits.

In order to accomplish all this, it is necessary that the following equation be solved.

$$D = \frac{(w_1 L_1) \pm (w_2 L_2) \pm (w_3 L_3) \pm (w_4 L_4)}{w_1 + w_2 + w_3 + w_4} \quad \ldots\ldots\ldots\ldots\ldots\ldots !!$$

and simultaneously on a separate dial—

$$W = w_1 + w_2 + w_3 + w_4 \quad \ldots\ldots\ldots\ldots\ldots\ldots !!$$

where—

D = displacement in center of gravity

W = total weight

w_1 = empty weight of airplane

L_1 = location of C.G. of weight empty from common reference point

w_2, w_3, et cetera = additional load placed at point a distance L

Not only does the LIBRASCOPE solve the above computations, but it always shows the correct sign character (+ or —) and, therefore, constantly produces results which are free from error both in sign and magnitude.

Libraettes

Though transoceanic flights are still rare, the LIBRASCOPE has flown both the Atlantic and Pacific Oceans twice.

The fourteen major airlines now using the LIBRASCOPE to load regular schedules serve forty-seven separate countries in all the continents of the world.

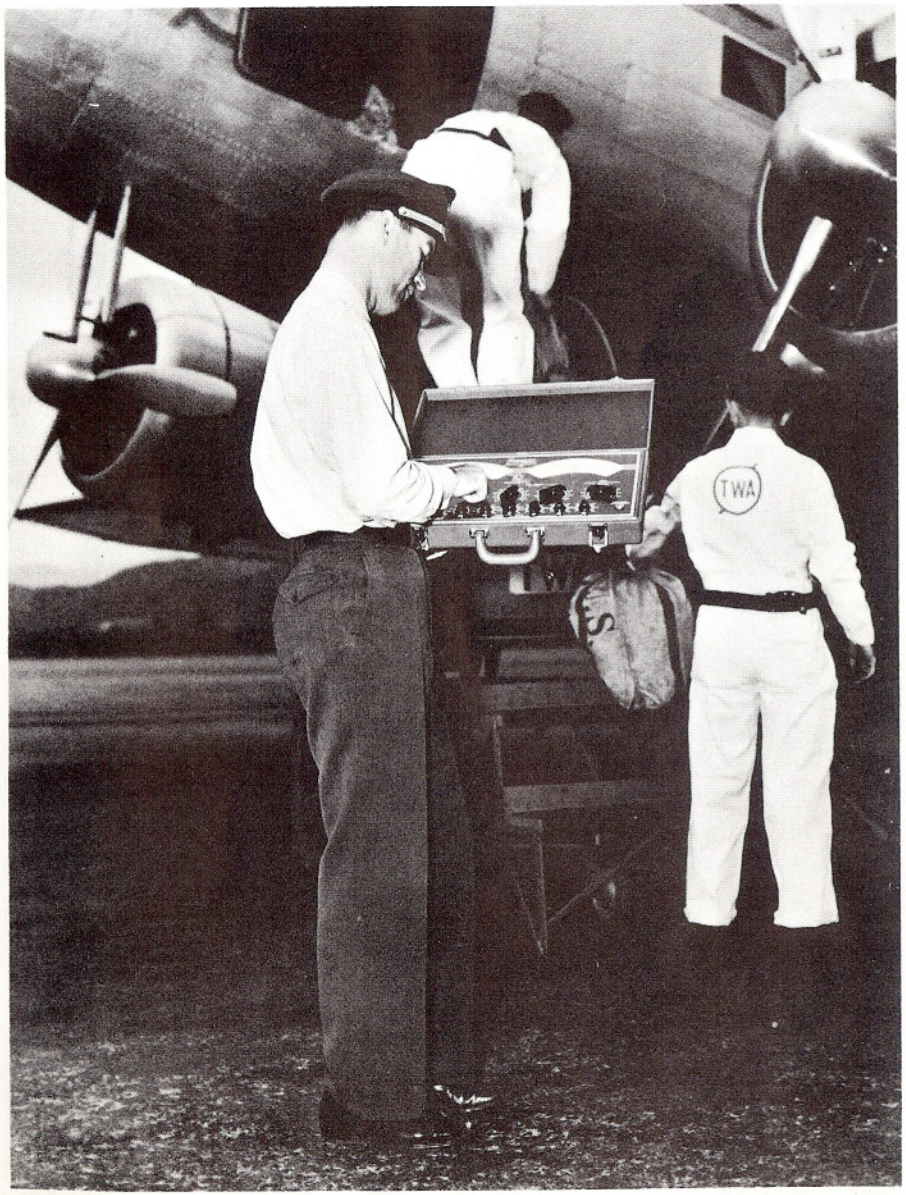
Northwest Airlines claim that with the use of the LIBRASCOPE the average time spent in locating and placing cargo in the four compartments of their Lockheed 14s is two minutes.

TWA use the LIBRASCOPE form—showing exact locations of cargo, oil, fuel and passengers and the resulting total weight and total weight C.G. as a part of their flight schedule which also includes weather reports and other information.

KLM uses the LIBRASCOPE at each station where stops are frequent. On long flights across Asia and the East Indies the LIBRASCOPE is carried in the plane.

Taking advantage of the simple and positive control of weight and balance which the LIBRASCOPE provides, the loading personnel at one terminal of a large United States airline are voluntarily keeping individual records of the C.G. location of the flights which they dispatch. This is being done in an effort to ascertain which one is closest to the goal of loading all flights uniformly with a C.G. location at the point where highest efficiency and maximum ease of handling may be realized. Over a period of nine months, records kept by three dispatchers show that one has averaged a C.G. position within one-tenth of one per cent (0.1 of 1%) of the optimum point. The other two are within three-tenths and six-tenths of one per cent MAC of this location.

By using the LIBRASCOPE to readjust load during flight and by directing the preparation of subsequent flight loads through plane to ground radio contact, manufacturers have been able to save much time and money on test flight programs.



Miscellany

Besides the standard arrangement used by most lines at the present time, an additional feature of the LIBRASCOPE which will be incorporated on some designs now in the progress of construction will be an automatic registering device. When the desired load distribution is attained, a button is pushed which registers the amount of load in each compartment, tank and passenger seat, together with the total weight and total weigh center of gravity on two sheets in the back which bear a fac-simile of the LIBRASCOPE face. One of the sheets is rolled out and forms a part of the flight schedule, while the other is retained as a permanent record.

A master dial which shows the shift in C.G. should passengers leave their assigned seats during flight. The passengers are located in their assigned seats and correct C.G. of this loading is shown. However, by turning the master knob forward the C.G. which would result if all passengers moved to the most forward possible locations in the airplane would be shown; by turning the master knob rearward, the most rearward location is shown.

Recent Developments

One of the latest additions to the LIBRASCOPE family is a master weight and balance computor, which will be of great value to design and weight control departments of manufacturing companies.

This MASTER LIBRASCOPE contains one hundred dials which represent stations one to ten inches apart. This distance between stations may be varied according to the size of the airplane and according to the state of completion. Use of this computor will enable the keeping of accurate weight and balance inventory at all times. The effect on the C.G. and weight due to adding, subtracting, or changing position of any item or structural part may be quickly and easily determined. Additional particulars on this computor may be had upon request.

The LIBRASCOPE adapts itself to any load-carrying vehicle which must have weight and balance control for efficient and fast operation. This class of load-carrying vehicle includes practically all craft which rely upon a flexible medium for buoyancy. Water-borne vehicles, especially submarines, have a balance problem which in some cases is more critical than that for airplanes. The LIBRASCOPE as designed for submarines not only registers the total weight and total weight C.G., but registers the center of buoyancy by summarizing the buoyant capacity of all compartments or stations.

NEWS FLASHES

(HUGHES "91 Hrs., 8 Min., 10 Sec.")

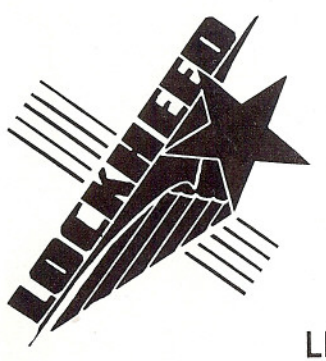
. . . Flying at all times at the altitude which was most favorable to the operation of the plane with the load aboard at that particular time—the load naturally was varying as the fuel was consumed—and using the amount of horsepower at all times that would give the greatest range . . . (Mr. Hughes kept an up-to-the-minute log of the weight-center of gravity condition at all times during his phenomenal flight by means of a LIBRASCOPE.)

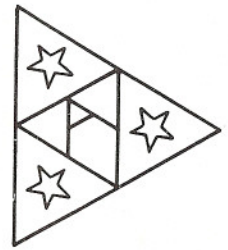
—Aviation, 1938.

(EDDIE ALLEN "Here Goes Nothing")

. . . It happens quite frequently that an airplane thought to be perfect in spin recovery and after many apparently perfect spins, suddenly develops an uncontrollable spin without warning. Possibly a change in weight distribution or some other slight alteration have made the difference in spinning attitude.

—Aviation, 1938.





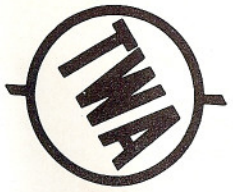
LIBRASCOPE USERS

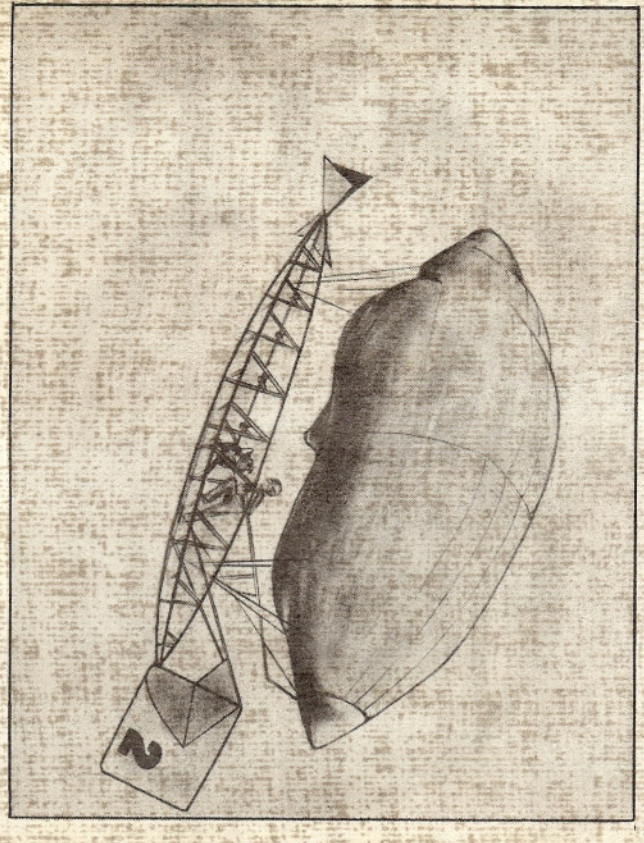
NIPPON KUKU YUSO KABUSHIKI KAISHA
TRANSCONTINENTAL AND WESTERN AIR
UNITED STATES ARMY AIR CORPS
AUSTRALIAN NATIONAL AIRWAYS
GREAT NORTHERN AIRWAYS
ROYAL DUTCH AIRLINES
K. L. M. (WEST INDIES)
DR. RICHARD ARCHBOLD
TRANS CANADA AIRWAYS
UNITED STATES NAVY
NORTHWEST AIRLINES
A. B. AEROTRANSPORT
BRITISH AIRWAYS
GUINEA AIRWAYS
LORENZ IVERSON
HOWARD HUGHES
L. A. R. E. S.
K. N. I. L. M.
L. O. T.
C. S. A.

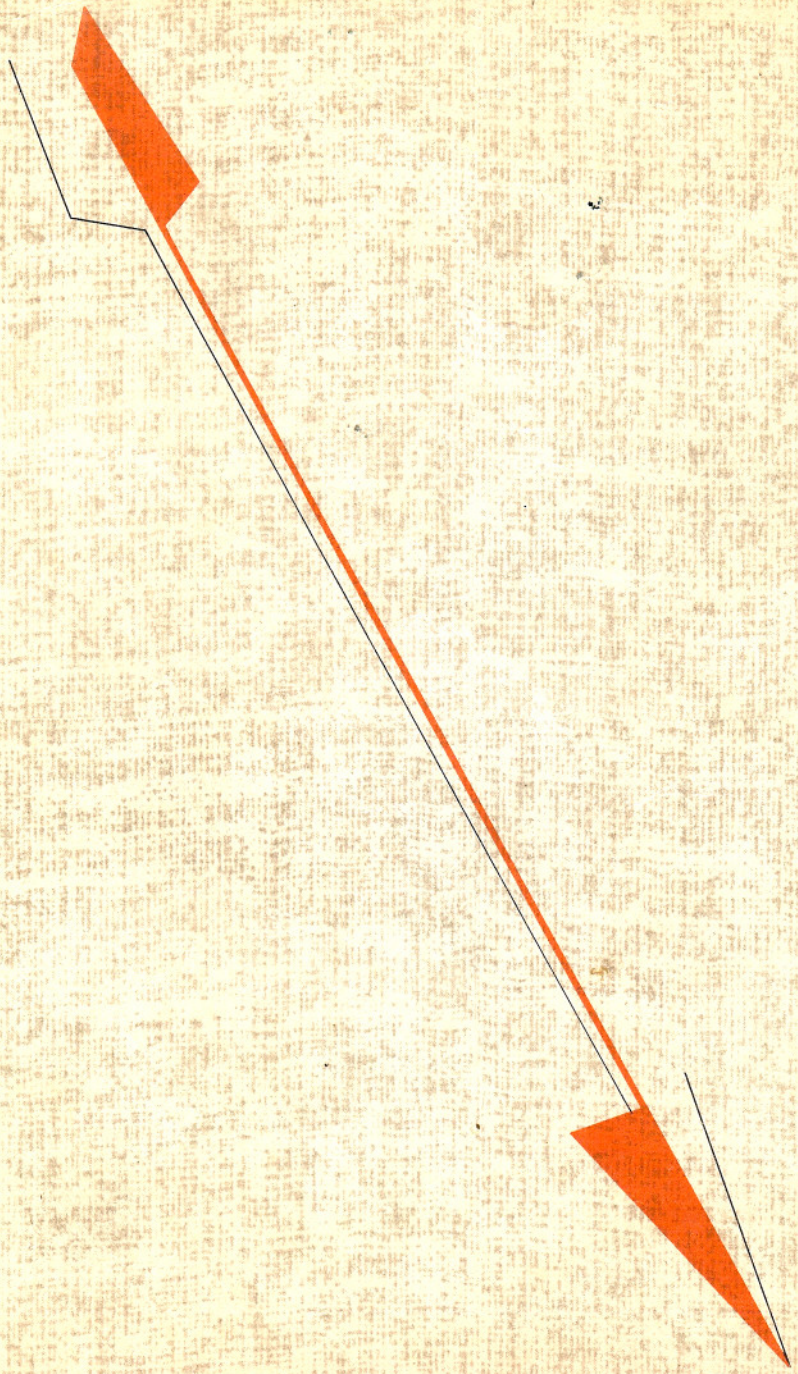
BRITISH AIRWAYS

LOT

C-S-A




2



LIBRASCOPE DEVELOPMENT CO.
1044 EAST SAN FERNANDO ROAD
BURBANK, CALIF.