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THE NA AUTOMATIC NAVIGATION METER - A MODULE OF THE ZEISS RMK CONTROL SYSTEM FOR AUTOMATIC OVERLAP AND DRIFT CONTROL

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1. Introduction

Advanced navigation systems - particularly inertial navigation - permit practically complete automation of photoflights, at least for medium and small photo scales. In this case, the camera can also be automatically tripped in such a manner that the photos will form certain blocks although this does entail a considerable instrument outlay. This is why photoflights even today are primarily based on the technique of photo strips with constant end lap. An experienced crew will solve this task even with relatively simple equipment.

The camera control process itself can in this case be subdivided into two steps:

- Measurement of drift angle and angular speed v/h, that is of the ratio between ground speed and flight height above ground.

- Setting of drift angle on camera, computation of exposure interval and suitable tripping of camera shutter.

The modular RMK Control System is based on the same concept (Fig. 1). Even in the past, the second of these steps could be automated with the aid of an ICC Central Interval Computer and the DCON Drift Control. For measurement proper, various navigation instruments are available to suit the flying technique employed. However, in this case an operator has either to measure the navigational data or set approximate values. In critical applications, such as large-scale flights with a crew of two, this puts a considerable additional stress on the operator so that the reliability of both photoflight navigation and camera control may be jeoparidized. Development of the NA Automatic Navigation Meter was therefore aimed at creating a reasonably priced instrument that would also automate measurement of the navigational data, such as drift angle and v/h-value.

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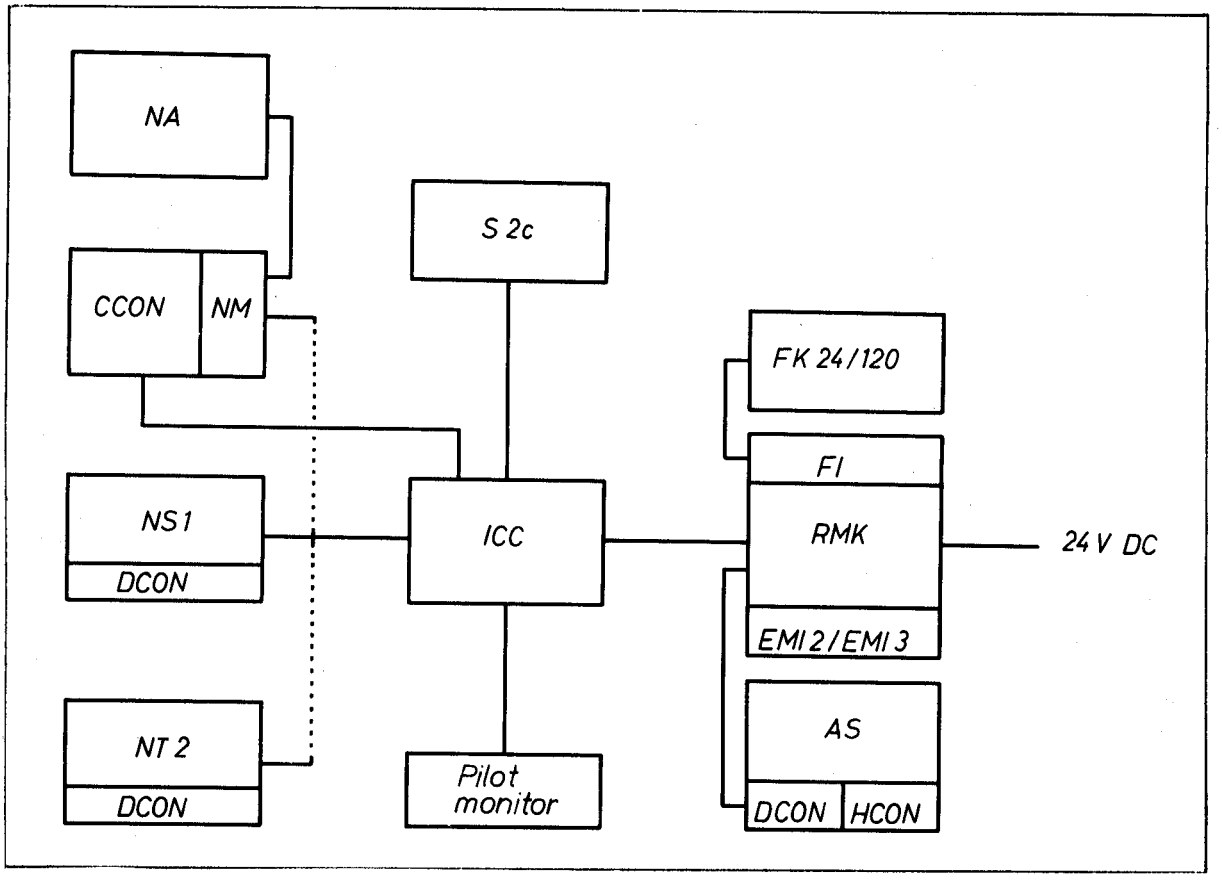

Fig. 1: General outline of RMK control

2. Description of equipment

The NA Automatic Navigation Meter is based on an optical measurement principle. As in the case of the well-known NS-1 and NT-2 navigation instruments, ground visibility is therefore indispensable. However, in general photoflight practice, this is a basic requirement anyway.

2.1 NA Automatic Navigation Meter

The image-forming optical system of the NA - a system of cylindrical lenses - basically breaks up the moving ground structure into two mutually perpendicular motion components. Two lines of diodes are arranged in parallel perpendicular to each of these motion directions. The time difference with which identical structures are imaged on these two lines then give the corresponding speed component. If during installation the NA is aligned with the longitudinal axis of the aircraft, the electronic system of the instrument will compute the v/h-value and the drift angle from the two components. A suitable integration time makes the measurement data largely independent of the effect of accidental variations of aircraft motion.

As regards instrument accuracy, only provisional information can be presented that is based on an evaluation of the first test flight. Based on a strip of 13 models generated in a C-100 PLANICOMP, an accuracy of $\pm$ 2.5 % is obtained for overlap and one of $\pm$ 1.5^{g} for drift angle. However, these values not only include instrument errors but also, for example, the effect of changes of flight path within the strip. Even so, the results obtained up to date fully confirm the manufacturer's expectations.

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The general appearance of the NA Automatic Navigation Meter differs only slightly from that of the NS-1 Navigation Sensor (see Fig. 2). It therefore can easily be exchanged for the latter without any modification of the aircraft. However, since the NA does not contain any controls, it may even be installed in a place that is not readily accessible during the flight.

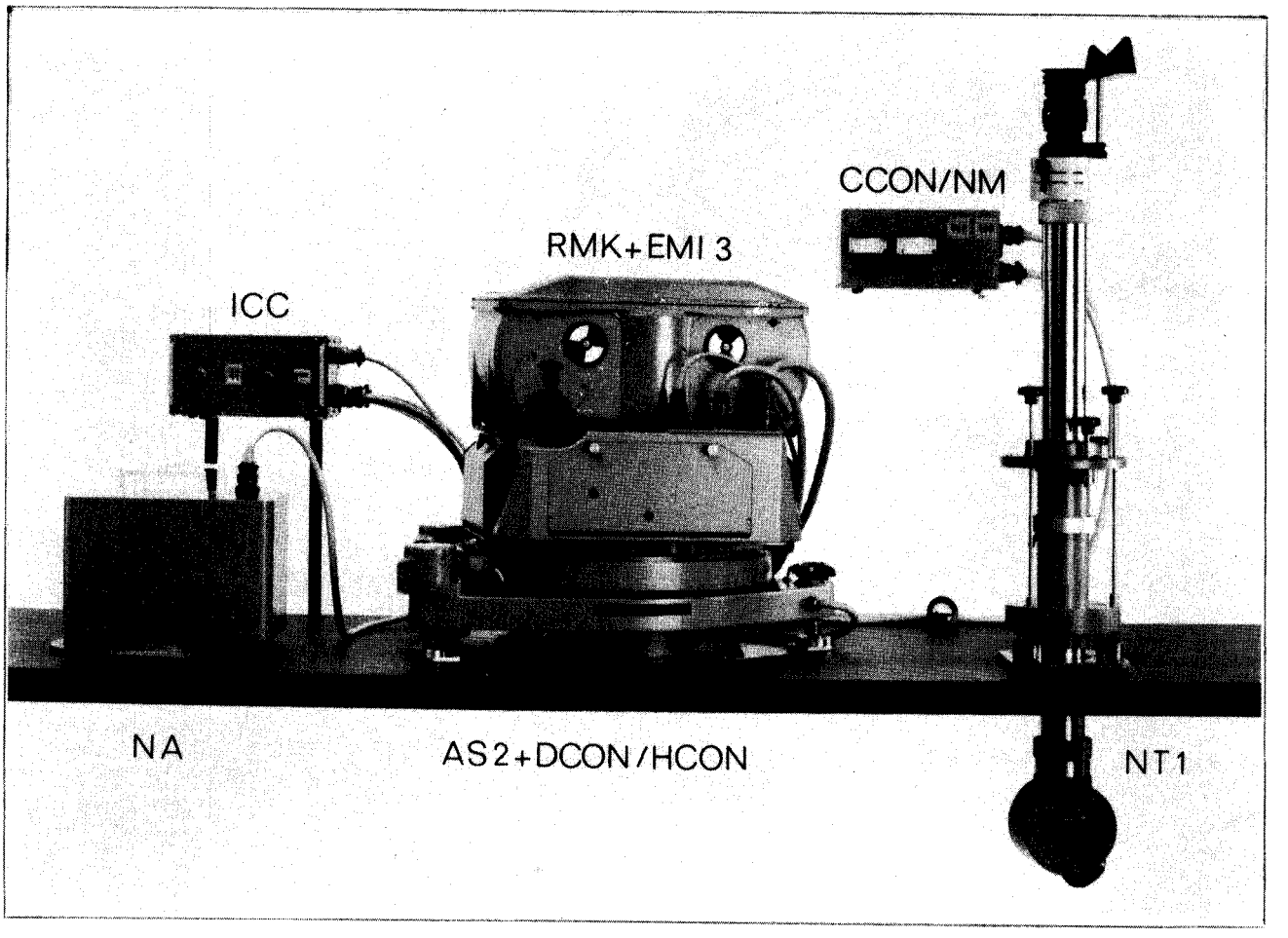

Fig. 2: RMK Control with NA Automatic Navigation Meter

2.2 Control panel

Although the NA Automatic Navigation Meter itself does not require any attendance, a few minimum functions for operation of the camera system still are indispensable during the flight. In addition to the starting and stopping of serial photography or the tripping of pin-point photography, these include indicators for the different functions such as camera operating cycle, overlap control, automatic exposure control, drift control, film advance and blower motor. The NS-1 and NT-2 navigation instruments do contain the corresponding controls, since these instruments have to be attended to continuously for measurement anyway. In the case of the NA, however, a separate RMK control panel is more appropriate in order to preserve the outstanding flexibility of the unit as regards its location within the aircraft.

Normally, a CCON/NM Remote Control is used with the NA. This unit can also be switched over from automatic NA operation to manual input of navigational data (see Fig. 3). However, an existing NT-2 Navigation Telescope can likewise be used as a control unit for the NA. In this case, the overlap-control and drift-control functions of the NT-2 are automatically inactivated.

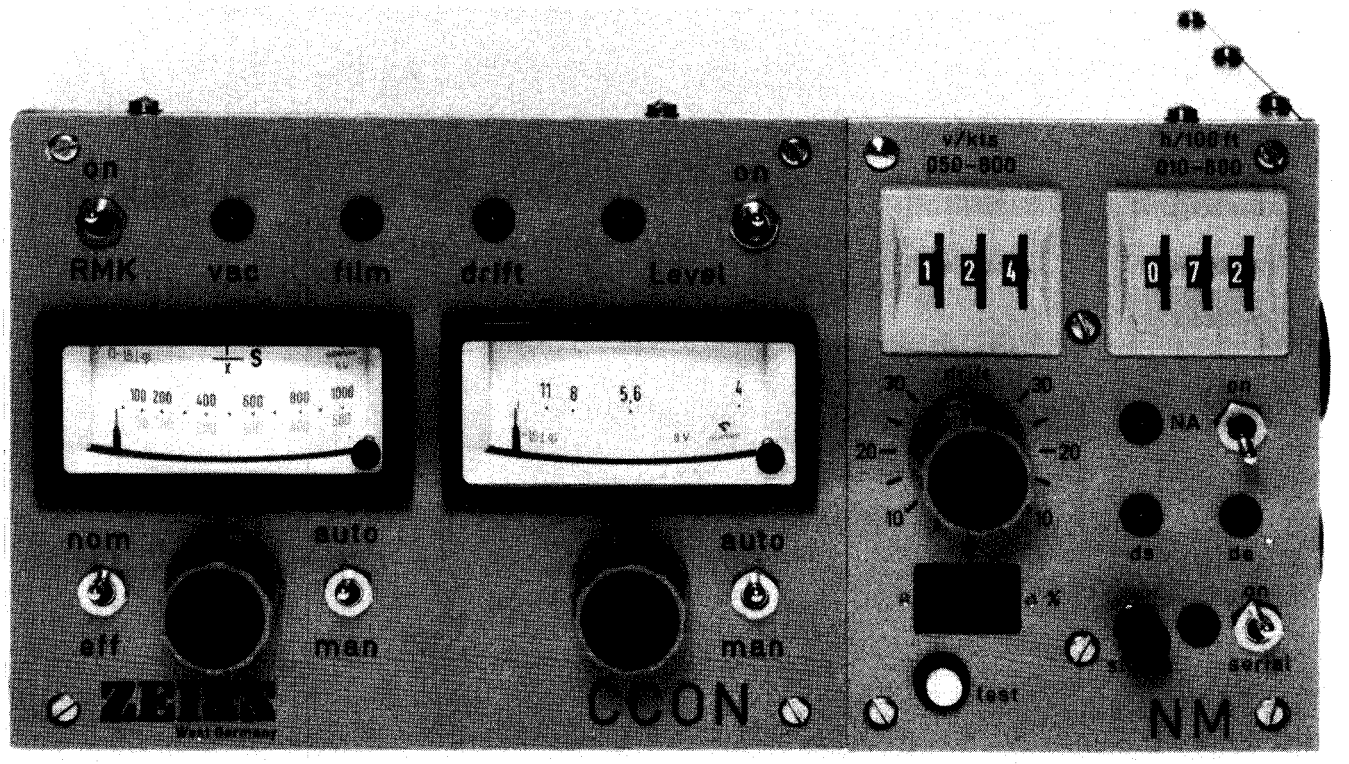

Fig. 3: CCON/NM Remote Control

3. Use

The NA Automatic Navigation Meter may be used instead of an NS-1 Navigation Sensor or NT-2 Navigation Telescope for automatic determination of the navigational data required for camera control. All other components of the RMK system are fully compatible with the NA. It seems advisable to use the most sophisticated equipment system shown in Fig. 1. In this case, operation of the camera system during the flight is limited to switching serial photography on and off and monitoring a few indicators.

For cost reasons, crews of two are being used increasingly on photographic flying missions. The navigator then also has to operate the camera. This method saves personnel and also allows better utilization of the aircraft. With suitable equipment, such as an NT-2 Navigation Telescope, this method will also be very reliable. However, it will present problems in the case of large-scale photography, since photoflight navigation here has to satisfy special requirements. The NA now permits operation of the RMK to be automated to an extent that the operator can essentially concentrate on navigation. As a result, the required accuracy can thus be attained even under critical conditions.

In certain cases, use of the NA Automatic Navigation Meter may involve an additional saving. This is if the pilot also has to take care of navigation. It goes without saying that this technique cannot be used in general, since the pilot also has to take full responsibility for the safety of the aircraft and may thus find it difficult to assume additional responsibilities. However, there will be cases where solo flights can be a viable alternative. It is then particularly important to

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reduce operation of the camera to a minimum. In addition to the NA, the other automatic capabilities of the RMK Control System should therefore likewise be used, above all automatic exposure control by the EMI-3. Use of an NT-2 Navigation Telescope instead of an NT-1 and a CCON/NM Remote Control could likewise prove to be of advantage, since navigation and operation of the camera would then be limited to one unit.

With development of the NA Automatic Navigation Meter, the expansion of the RMK Control System has reached a certain final phase. The system now contains all the modules required for assembling a suitable control setup for the most diverse kinds of work, right up to completely automatic camera control for solo photoflights. Like the other modules in the system, the NA is based on the idea that existing RMK outfits should be suitable for further expansion at minimum cost.

Abstract

Mapping flights today are generally based on strips of photography with a constant end lap. The work is here normally divided into two phases:

- Measuring the drift angle and the angular speed v/h.

- Setting the drift angle on the camera, computing the necessary cycling time and tripping the camera shutter accordingly.

The RMK Control is a modular system based on this functional division. Even now, the second of these steps can be automated with the aid of an ICC Central Interval Computer and a DCON Drift Control. For measurement, various navigation instruments are available for the different kinds of flight techniques. In every case, however, these require an operator. The NA Automatic Navigation Meter now allows this gap to be closed by automatic measurement.

The NA Automatic Navigation Meter is an optical measuring instrument. An image-forming optical system resolves the ground structure into the two components of motion along and across the line of flight. The electronic system of the instrument then determines the v/h-value and the drift angle. First testflights have given an accuracy of $\pm$ 2.5 % for overlap $\pm$ 1.5^{0} for the drift angle.

The general appearance of the NA hardly differs from that of an NS-1 Navigation Sensor. The NS-1 can be exchanged for an NA without modification of the aircraft. Unlike the NS-1, however, the NA has no controls so that it can be installed anywhere within the aircraft. When an NA is used, the control center during the flight is a CCON/NM Remote Control. However, an existing NT-2 Navigation Telescope may also be used as a control center instead of a CCON/NM. And, of course, the NA is also suitable for simultaneous control of several cameras.

With the aid of an NA Automatic Navigation Meter, the camera control system can be expanded to an extent where camera operation during the flight is limited to starting and stopping serial exposure pulses and monitoring. This offers the following possibilities:

- A crew of two can now be used even on critical flights, for instance for large-scale photography.

- If the pilot also acts as a navigator, high accuracy can be attained even on solo photoflights.

Der Navigationsautomat NA - ein Baustein des ZEISS RMK-Steuerungssystems zur automatischen Überdeckungs- und Abdriftsteuerung

Zusammenfassung

Photogrammetrische Bildflüge werden heute überwiegend nach der Methode durchgeführt, Bildstreifen mit konstanter Längsüberdeckung aufzunehmen. Der Ablauf erfolgt dabei in den beiden Schritten:

- Messung des Abdriftwinkels und der Winkelgeschwindigkeit V/H;

- Einstellung der Kammer auf den Abdriftwinkel, Berechnung der Bildfolgezeit und entsprechende Auslösung der Kammer.

Entsprechend dieser funktionellen Gliederung ist auch die RMK-Steuerung als Baukastensystem aufgebaut. Der zweite Funktionsbereich kann schon bisher mit dem Intervall-Central-Computer ICC und der Abdriftsteuerung DCON automatisch erledigt werden. Für die Messung stehen verschiedene Navigationsinstrumente - entsprechend der jeweils angewendeten Bildflugtechnik - zur Auswahl. In jedem Fall ist dabei die Bedienung durch einen Operateur erforderlich. Mit dem Navigationsautomaten NA, der diesen Meßvorgang automatisch durchführt, kann nun auch diese Lücke geschlossen werden.

Bei dem Navigationsautomaten NA handelt es sich um ein optisches Meßgerät. Die Geländestruktur wird durch die Abbildungsoptik in die beiden Bewegungskomponenten längs und quer zur Flugzeugachse zerlegt. Die Elektronik des Gerätes ermittelt daraus den V/H-Wert und den Abdriftwinkel. Die Genauigkeit ergibt sich aus den Aufnahmen des ersten Testfluges zu $\pm$ 2.5 % für die Überdeckung und $\pm$ 1.5^{0} für den Abdriftwinkel.

Äußerlich unterscheidet sich der NA nur unwesentlich vom Navigations-Sensor NS 1 und kann gegen diesen ausgetauscht werden, ohne daß eine Modifikation am Flugzeug notwendig ist. Im Gegensatz zum NS 1 enthält der NA jedoch keinerlei Bedienungselemente, so daß er an jeder beliebigen Stelle eingebaut werden kann. Das eigentliche Bedienungsgerät während des Bildfluges ist beim Einsatz des NA die Fernbedienung CCON/NM. Anstelle von CCON/NM kann aber auch ein bereits vorhandenes Navigationsteleskop NT 2 als Bedienungsgerät eingesetzt werden. Selbstverständlich ist auch mit dem NA die gleichzeitige Steuerung mehrerer Kammern möglich.

Mit dem Navigationsautomaten NA kann die RMK-Steuerung nun so ausgebaut werden, daß die Bedienung während des Bildfluges sich auf das Ein- und Ausschalten der Reihenauslösung und die Überwachung der Kontrollanzeigen beschränkt. Damit bieten sich insbesondere die folgenden Einsatzmöglichkeiten an:

- Das Verfahren des Zweimann-Bildfluges kann auch bei solchen Anwendungen benutzt werden, bei denen es bisher problematisch erschien, z. B. bei großmaßstäbigen Aufnahmen.

- In den Fällen, in denen der Pilot die Bildflugnavigation übernimmt, kann auch der Einmann-Bildflug mit hoher Zuverlässigkeit durchgeführt werden.

Le navigateur automatique NA - une unité du système de commande des chambres aérophotogrammétriques de ZEISS pour la correction de la dérive et le déclenchement des expositions

Résumé

A l'heure actuelle, la couverture photographique aérienne d'un terrain s'effectue le plus fréquemment bande par bande, avec un recouvrement constant des bandes consécutives dans le sens longitudinal. Les opérations requises par une telle méthode de levé photogrammétrique s'exécutent en deux étapes:

- Mesure de l'angle de dérive et de la valeur v/h (vitesse angulaire)

- Correction de la dérive, calcul de la cadence correcte des expositions et déclenchement respectif de l'obturateur

La commande des chambres RMK est réalisée comme ensemble modulaire, en conformité avec cette organisation fonctionnelle. Les opérations de la seconde étape pouvaient être exécutées jusqu'à présent par l'Intervall-Central-Computer (ICC) et l'unité de télécommande DCON. Différents instruments de navigation étaient en outre disponibles pour la mesure de l'angle de dérive et de la valeur v/h. Un opérateur devait en tout cas desservir l'instrument de navigation.

La navigateur automatique NA se charge des processus de mesure et assume ainsi la tâche de l'opérateur. Il se comporte comme un appareil de mesure optique. Son système optique décompose la configuration du terrain en deux composantes de mouvement, dans la sens de la ligne de vol et perpendiculairement à cette ligne. A partir des deux composantes, l'électronique du navigateur NA détermine la valeur v/h et l'angle de dérive. La précision de mesure relevée au cours du premier vol d'essai atteint $\pm$ 2,5 % pour le recouvrement et $\pm$ 1,5^{0} pour l'angle de dérive.

Extérieurement, le navigateur automatique se distingue à peine du senseur de navigation NS-1 dont il peut prendre la place, sans aucune transformation dans la carlingue de l'avion-photographe. A l'encontre du senseur de navigation NS 1, il ne comporte pas d'organes de manoeuvre et peut donc avoir un emplacement quelconque. L'unité de télécommande CCON/NM joue alors le rôle de poste de manoeuvre. Un télescope de navigation NT 2 peut être également utilisé. Le navigateur automatique NA se prête à la commande simultanée de plusieurs chambres RMK.

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En présence d'un navigateur automatique NA, la commande d'une chambre RMK peut être conçue de telle façon que l'actionnement du bouton qui déclenche et termine les séries d'expositions, ainsi que l'observation des témoins de contrôle constituent les uniques manoeuvres nécessaires au cours d'une mission photographique.

Le navigateur automatique NA s'avère très utile pour les photovols entrepris avec un équipage de deux personnes, dont la tâche s'avérait parfois problématique, p.ex. pour les levés à grande échelle. Il assiste de même efficacement les pilotes qui accompagnent seuls une mission de couverture.

El medidor automático de navegación NA - un módulo del sistema de control de cámaras ZEISS para el mando automático del recubrimiento y de la deriva

Resumen

Los vuelos fotogramétricos se basan hoy día generalmente en fajas de fotos con un recubrimiento longitudinal constante. El trabajo normalmente se divide en dos fases:

- La medición del ángulo de deriva y de la velocidad angular v/h.

- El ajuste del ángulo de deriva en la cámara, el cálculo de los intervalos entre exposiciones y el disparo correspondiente de la cámara.

El control de cámaras es un sistema modular que se basa en esta división funcional. Incluso ahora es posible automatizar la segunda de estas fases mediante una computadora central de intervalos ICC y un mando de deriva DCON. Existen varios instrumentos de navegación para las mediciones correspondientes de acuerdo con la técnica de vuelo que se emplee. Sin embargo, en cada caso se necesita un operador. Ahora, el medidor automático de navegación NA rellena este hueco porque permite hacer la medición automáticamente.

El medidor automático de navegación NA es un instrumento óptico. Un sistema óptico resuelve la estructura del terreno en dos componentes de movimiento longitudinal y transversal respecto al eje de vuelo. El sistema electrónico del instrumento determina el valor v/h y el ángulo de deriva. Los primeros vuelos de prueba han dado una exactitud del $\pm$ 2,5 % para el recubrimiento y del $\pm$ 1,5° para el ángulo de deriva.

Exteriormente, el NA apenas se diferencia del sensor de navegación NS 1. Este último puede cambiarse pour un NA sin modificación alguna del avión. Contrariamente al NS 1, sin embargo, el NA no tiene mandos algunos, de manera que puede instalarse en cualquier sitio dentro del avión. Si se emplea un NA, sirve un telemando CCON/NM de centro del control durante el vuelo. Sin embargo, también es posible emplear como centro de control un anteojo de navegación NT 2 en lugar de un CCON/NM. Y, desde luego, el NA también se presta para mandar simultáneamente varias cámaras.

Con la ayuda del medidor automático de navegación NA es posible ampliar el sistema de control de cámaras de manera que durante el vuelo se limite el manejo de la cámara a conectar y desconectar los disparos en serie y a supervisar los indicadores. Esto ofrece las posibilidades siguientes:

- Es posible volar con una tripulación de dos hombres incluso cuando parezca problemático por ejemplo para fotos en grandes escalas.

- Cuando el piloto también actúa como navegador, es posible obtener alta exactitud incluso en vuelos fotográficos con un solo hombre.

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