OPIC
OFFICE DE LA PROPRIÉTÉ INTELLECTUELLE DU CANADA

CIPO
CANADIAN INTELLECTUAL PROPERTY OFFICE

(12) (19) (CA) **Demande-Application**

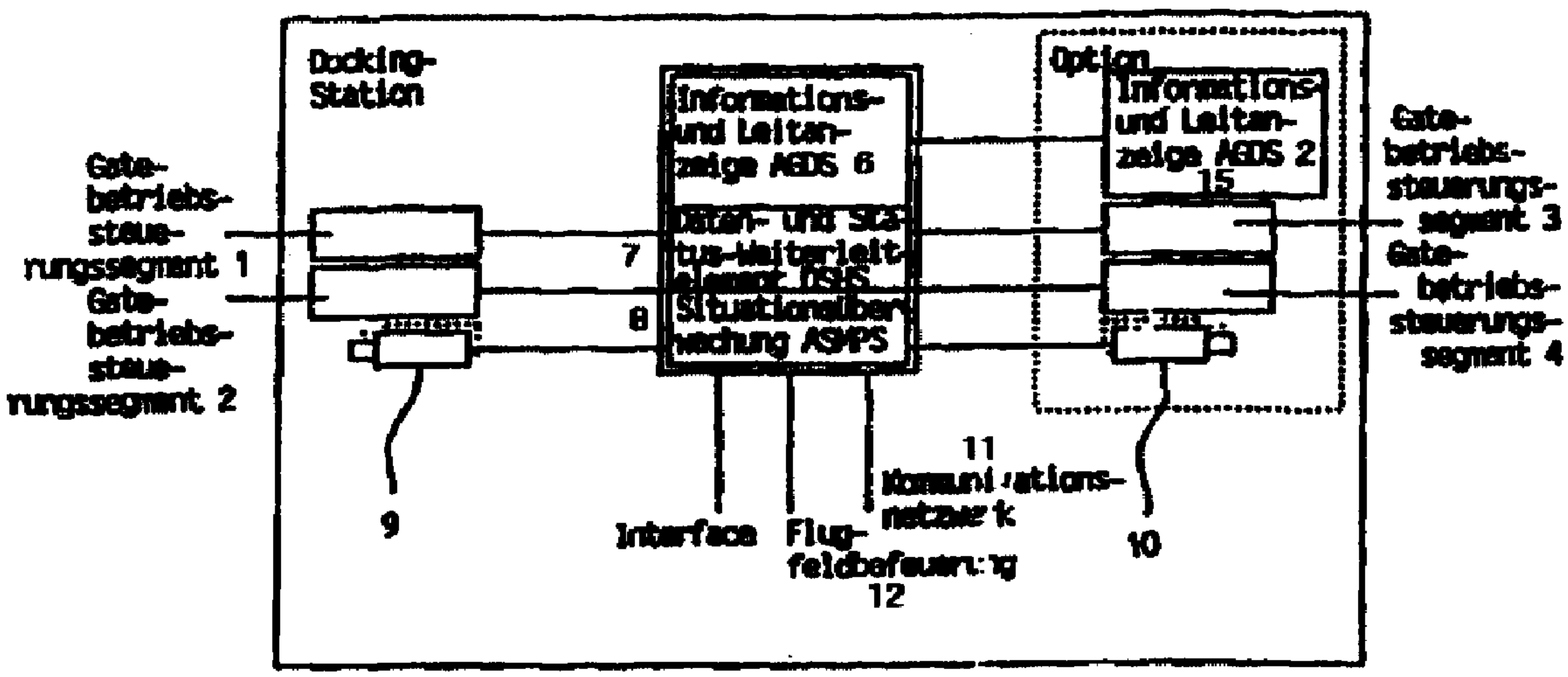
(21) (A1) **2,303,879**
(86) 1998/09/22
(87) 1999/04/01

(72) BAUMGARTNER, KLAUS, DE
(72) BRENNFLECK, MARTIN, DE
(72) KONERTH, JOHN, DE
(72) LINK, NORBERT, DE
(71) SIEMENS AKTIENGESELLSCHAFT, DE

(51) Int.Cl.[7] B64F 1/00
(30) 1997/09/22 (197 41 669.1) DE

(54) **DISPOSITIF D'ACCOSTAGE POUR AEROGARES**

(54) **AIRPORT TERMINAL DOCKING SYSTEM**



1. Gate operation control segment 1
2. Gate operation control segment 2
3. Gate operation control segment 3
4. Gate operation control segment 4
6. Information and guidance display system AGDS
7...DATA AND STATUS FORWARDING ELEMENT DSHS
8. Situation monitoring ASMPS
11. Communication network
12. Flying field navigation lights
15...Information and guidance display system AGDS 2

(57) L'invention concerne un dispositif d'accostage pour aérogares, comportant une unité ou station d'accostage par poste de stationnement. L'unité d'accostage est reliée par un réseau de communication à un dispositif de commande central. Elle comprend un segment de

(57) The invention relates to an airport terminal docking system with one docking station per gate. The docking station is connected to a central control device by means of a communication network. A flying field situation monitoring and processing segment (ASMPS), at least

OPIC
OFFICE DE LA PROPRIÉTÉ INTELLECTUELLE DU CANADA

CIPO
CANADIAN INTELLECTUAL PROPERTY OFFICE

(21) (A1) **2,303,879**
(86) 1998/09/22
(87) 1999/04/01

surveillance et de traitement de situation sur le terrain d'aviation (ASMPS), au moins un segment d'affichage d'information et de guidage (AGDS), un segment de transmission de données et d'état (DSHS) comportant au moins une caméra vidéo (9, 10) par axe du poste de stationnement, ainsi qu'au moins un segment de commande d'exploitation de poste de stationnement (GOPS). A l'unité d'accostage est reliée une unité d'entrée grâce à laquelle on peut entrer, dans l'unité d'accostage, des informations relatives à des modèles d'avion et au poste de stationnement.

one information and guidance display segment (AGDS), a data and status transmission segment (DSHS) comprising at least one video camera (9,10) for the center line of each gate and at least one gate operation control segment (GOPS) are included in the docking station. The docking station is connected to an input unit which is used to enter aircraft model and gate information.

GR 97 P 8627

Abstract

Docking system for airport terminals

A docking system for airport terminals has a docking station subsystem and a docking station for each gate. The docking station subsystem is connected via a communication network to a central working position. The docking station subsystem includes an airfield situation monitoring and processing segment ASMPS, at least one advisor and guidance display segment AGDS, a data and status handler segment DSHS having at least one video camera (9, 10) for each center line of the gate, and at least one ground operation panel segment GOPS.

The docking station subsystem has an auxiliary subsystem connected to it, by means of which information relating to aircraft models and the gate can be entered in the docking station subsystem.

FIGURE 7

Description

Docking system for airport terminals

The invention relates to a docking system for airport terminals, having a positioning apparatus by means of which an aircraft can be guided to a parking position appropriate for its type, and which has a video device by means of which the aircraft can be detected as it approaches the airport terminal and has an evaluation unit by means of which it is possible to evaluate data which are supplied to it by the video device and relate to the form and the movement of the aircraft.

DE 40 09 668 A1 discloses a procedure in which a video camera is used to detect a two-dimensional image, which is passed to the evaluation unit.

The invention is based on the object of developing the known docking system in such a manner that it can be used even in adverse environmental and weather conditions with an extremely high operational reliability, sufficient for the operation of airports.

This object is achieved according to the invention in that a template set for each different type is stored in the evaluation unit, which set contains at least three, preferably five, specific templates for all types of aircraft or outline sections of the relevant type, and in that the at least three, preferably five, specific outline sections of the aircraft which is approaching the airport terminal can be determined, and can be compared with the stored template sets, in the evaluation unit, from the input signals from the video device.

According to the invention, a docking system is provided for airport terminals, which has a comparatively low level of installation complexity and, furthermore, allows safe airport terminal operation, which can very largely be automated. Precise detection of the type of aircraft approaching the airport terminal is ensured even if the entire contour of the approaching aircraft cannot be detected by means of the video device, for example because there are obstructions in the parking area or ramp area of the airport terminal.

A monochrome camera has been found to be a particularly suitable video device for implementing the docking system according to the invention and its positioning apparatus.

The objective focal lengths of the video device should advantageously be 16 or 25 mm.

Adequate detection of the aircraft approaching the airport terminal is ensured if the video device is arranged approximately aligned with the center line of the airport gate, preferably at a height of approximately 9 m.

The type of aircraft approaching the airport terminal can be detected with a comparatively low level of complexity if a sequence of gray-shade images produced by the monochrome camera can be read to the evaluation unit, the individual gray-shade images in the sequence can be spatially filtered in order to extract gray-shade edges, the sequence of gray-shade images can be filtered in the time domain in order to produce moving images, and a mask can be produced from the moving images, defining areas for subsequent segmentation.

The evaluation unit should expediently have a Sobel filter for spatial filtering of the gray-shade images, and for filtering the gray-shade images in the time domain.

Two engines, the windshield and two landing gear legs have been found to be outline sections which are particularly specific to the aircraft contour of each type, in which case these five specific outline sections or templates expediently form a tempate set which is defined for the respective aircraft type and is stored in the evaluation unit.

Trajectories of the templates or specific outline sections of the aircraft contour can be used as the basis to determine the present position of the aircraft as it approaches the airport terminal.

When the docking system according to the invention is implemented and installed completely, in particular its positioning apparatus, it is possible to allow all the processes required for docking of the aircraft, in particular the docking of the bridge to the aircraft, to be carried out automatically. In this case, it is possible for the video device to have only one video camera.

In a particularly advantageous manner, the pixel processing described above as well as the detection of the type of aircraft approaching the gate of the airport terminal can be used for a docking system for airport terminals by each gate having a docking station subsystem which is connected via a communication network to a central working position, has an airfield situation monitoring and processing segment, at least one advisor and guidance display segment, a data and status handler segment having at least one video camera for each center line of the gate, and at least one ground operation panel segment, and to which an auxiliary subsystem is connected, by means of which information relating to aircraft models and the gate can be entered in the docking station subsystem.

The docking station subsystem expediently has an advisor and guidance display segment for each center line of its gate.

A particularly advantageous refinement of this advisor and guidance display segment is achieved if a microprocessor is provided which controls the display elements and converts display commands into indications by the display elements.

A refinement of the docking station subsystem according to the invention and of the docking system according to the invention which is less complex in terms of equipment and design is achieved if the data and status handler segment of the docking station subsystem runs on the same hardware as the airfield situation monitoring and processing segment, and if the communication between the docking station subsystem and the central working position takes place via the communication network, and the processes within the docking station subsystem are coordinated by means of the data and status handler segment.

In a development of the docking system according to the invention, the data and status handler segment and the airfield situation monitoring and processing segment of the docking station subsystem may be arranged in one housing.

Expediently, the data and status handler segment and the airfield situation monitoring and processing segment may run on a hardware basis comprising a PC motherboard and the video signal processing equipment.

If the design of the docking station subsystem for the docking system according to the invention provides for the data and status handler segment and the airfield situation monitoring and processing segment to be arranged outside the actual gate, it is also possible to arrange the advisor and guidance display segment in the housing jointly used by the two abovementioned components, as well.

In a further specific embodiment of the docking system according to the invention, the docking station subsystem is designed such that it allows advisor and guidance displays to be transmitted to a screen in the cockpit of an aircraft which is approaching the gate. This mode of operation may be used instead of operation of the advisor and guidance display segment, or may be provided in addition to operation of this advisor and guidance display segment.

It is also possible to arrange the airfield situation monitoring and processing segment in a housing with the video camera.

For transmission of data between the airfield situation monitoring and processing segment and the data and status handler segment of the docking station subsystem, it is expedient for the airfield situation monitoring and processing segment to have an associated digital signal processor in which the originally analog video signals are converted into digital signals before they are passed to the input line to the data and status handler segment.

The auxiliary subsystem which is associated with the docking station subsystem of the docking system according to the invention preferably has an aircraft model output, a gate installation planner, a calibration unit and a validation and diagnosis tool.

The communication network of the docking system according to the invention is advantageously in the form of a high-speed network using the asynchronous transmission mode, by means of which originally digital signals and originally analog signals converted into digital signals, for example video signals, can be transmitted.

The ATM high-speed network may advantageously have at least one network adapter in the form of a SICAN-ATMax 155-PM2.

The docking station subsystem of the docking system according to the invention is systematically and expediently broken down into a ground area monitoring and processing segment, a gate area control segment, a gate schedule segment and a gate data handler segment.

The ground area monitoring and processing segment advantageously has an airfield monitor and an airfield situation processor, which is connected by means of an interface to the gate schedule segment.

The gate area control segment of the docking station subsystem of the docking system according to the invention has airfield ground lighting, an advisor and guidance display, a ground operation panel, a luxometer and a gate area processor which runs on a PC platform to which the airfield ground lighting, the advisor and guidance display, the ground operation panel and the luxometer are connected, and which is connected by means of an interface to the gate schedule segment.

The gate data handler segment should advantageously have a calibration support and static data handler, which run on a PC platform and are connected by means of in each case one interface to the gate schedule segment.

The gate schedule segment of the docking station subsystem of the docking system according to the invention has gate management and a monitor.

The invention will be explained in more detail in the following text using exemplary embodiments and with reference to the drawing, in which:

Figure 1 shows a basic illustration of the docking system according to the invention, and its integration in an airport network;

Figure 2 shows a basic illustration of an aircraft approaching a gate of an airport terminal;

Figure 3 shows a basic illustration of the method for finding an aircraft outline of an aircraft approaching a gate;

Figure 4 shows a sequence for searching for the aircraft outline of the aircraft approaching the gate, and for initiation of tracking and following of the aircraft found;

Figure 5 shows a data flowchart of the docking system according to the invention and its integration in the communication network of an airport;

Figure 6 shows a basic illustration of the major components of the docking system according to the invention;

Figure 7 shows a first embodiment of a docking station subsystem of the docking system according to the invention;

Figure 8 shows a second embodiment of the docking station subsystem of the docking system according to the invention;

Figure 9 shows a third embodiment of the docking station subsystem of the docking system according to the invention;

Figure 10 shows a systematic segment structure of the docking system according to the invention;

Figure 11 shows a ground area monitoring and processing segment

GAMPS of the docking station subsystem illustrated in Figure 10;

Figure 12 shows a gate area control segment GACS of the docking station subsystem illustrated in Figure 10;

Figure 13 shows a gate data handler segment GDHS of the docking station subsystem illustrated in Figure 10; and

Figure 14 shows a gate schedule segment GSS of the docking station subsystem illustrated in Figure 10.

An airport terminal 2 integrated in an airport network 1 as shown in principle in Figure 1 is equipped with a docking system by means of which a connection to the interior of an aircraft 3 can be produced via a bridge.

In order to position the aircraft 3 correctly for the docking process at the airport terminal 2, all the gates 4 of the airport terminal 2 each have an associated positioning apparatus, by means of which the aircraft 3 that is intended to be docked can be guided to a stopping or parking position 5 appropriate to its type.

To this end, the positioning apparatus has a video device 6 which is in the form of a monochrome camera and by means of which the aircraft 3 can be detected as it approaches the gate 4 of the airport terminal 2, an evaluation unit 7 by means of which data supplied to it from the video device 6 and which relate to the form and movement of the aircraft 3 can be evaluated, and a display 8 by means of which a pilot of the aircraft 3 can be provided with information which is required to move the aircraft 3 to the intended parking position 5.

Since the parking position 5 differs depending on the type of approaching aircraft 3, the positioning apparatus first of all has to determine the type of aircraft 3 that is approaching. To do this, the video device 6 is used to produce gray-shade images onto which the aircraft 3 that is approaching the gate 4 is mapped. By means of the video device 6, a sequence of gray-shade images, showing different positions of the aircraft 3 that is approaching the gate 4, are read to the evaluation unit. Evaluation of this sequence of gray-shade images within the evaluation unit allows moving edges to be detected, which correspond to the outline of the aircraft 3 that is approaching the gate 4. This is done firstly by using spatial filtering, by means of which the spatial edges in the individual gray-shade images are found. Filtering in the time domain is used to extract edges which move over time, so that it is possible to distinguish between moving and stationary objects. This makes it easier to determine an aircraft outline from the gray-shade images. Each type of aircraft has a specific aircraft outline which, for its part, has specific outline sections or templates, in which case, for selecting suitable templates, a template set may be formed, to provide examples of the respective types of aircraft. This template set may contain three, or preferably five, individual templates.

A template set is stored within the evaluation unit 7 for each type of aircraft. The aircraft contour determined for the aircraft 3 approaching the gate 4, or the template set resulting from this, is now compared with the template sets stored within the evaluation unit, with the type of aircraft 3 approaching the gate 4 of the airport terminal 2 being determined as the result of this comparison operation. This type has a specific associated parking position 5. Details are now indicated on the display 8 to allow the aircraft captain or pilot to move his aircraft 3 to this parking position 5.

The aim of the following text is to describe in detail how edge operators in physical space are used to extract the stationary gray-shade edges from the gray-shade images, in order to obtain the aircraft contour.

A Sobel operator can advantageously be used for this purpose, which is not derived from a mathematically closed form. This Sobel operator has the following forms:

Form 1:

-1,	-2,	-1
0,	0,	0
1,	2,	1

Form 2:

-1,	0.1
-2,	0.2
-1,	0.1

Form 1 extracts edges located horizontally in the gray-shade image, and form 2 extracts edges located vertically in the gray-shade image. This is done by means of a weighted first derivative in the respective coordinate direction under consideration. Both Sobel operators have been applied to the gray-shade image, and their results have been linked alternately by pixels:

$$b_{i,j} = \frac{\sqrt{b^2_{1,i,j} + b^2_{2,i,j}}}{\sqrt{2}}.$$

Moving edges can be extracted not only by considering a gray-shade image, but also by considering a time sequence of gray-shade images. The filter cores therefore have to have a time dimension. Not only filter cores which have only one time dimension, but also filter cores which have time and space dimensions were investigated.

A Laplace filter, a Mexican hat operator or a HildrethMarr operator and a Sobel operator have been found to be particularly expedient as filter cores, in the latter of which the concept of a two-dimensional edge filter which operates with a weighted first derivative was expanded to three dimensions. This results in the following operator core in three dimensions, of size 3 x 3 x 3:

-1, -1, -1
-1, -8, -1
-1, -1, -1
t = 0
0, 0, 0
0, 0, 0
0, 0, 0
t = 1
1, 1, 1
1, 8, 1
1, 1, 1
t = 2

Filtering using the Sobel filter produced the best results for both the spatial and time edges.

Figure 3 shows the fundamental program sequence for determining the aircraft contour.

A gray-shade image sequence which has been recorded by the video device 6 is passed via a video input to the evaluation unit 7. There, this gray-shade image sequence is subjected to spatial filtering, by which means spatial edge filtering of the respective gray-shade image is carried out. The result of this spatial edge filtering represents the magnitude of a Sobel operator in the x direction and y direction, and is stored. This spatial edge filtering is used to extract gray-shade edges, which are available as an intermediate result.

Time-domain edge filtering of successive gray-shade images is carried out in the time-domain filtering which follows the spatial filtering. The result of this time-domain edge filtering represents the magnitude of a Sobel operator expanded by the time direction, and is stored. An intermediate result is once again available as the result of the time-domain edge filtering.

The thresholding which follows the time-domain filtering is used to produce a binary image from the gray-shade image. The digitization threshold is defined by the variable threshold value. For gray shades below this threshold value, a low value is entered in the output binary image, and a high value is entered in it for values which are equal to or exceed the threshold value. The thresholding provides a further intermediate result.

The thresholding is followed by the functional stage of dilatation, in which the binary image produced in the course of thresholding is subjected to dilatation with a size of one pixel, that is to say all those areas which have a gray level greater than zero are enlarged by one pixel at their boundaries. The functional stage of dilatation provides an intermediate result, which corresponds to the mask or outline contour of the aircraft 3 approaching the airport terminal 2 or its gate 4.

The aircraft contour is positioned by means of the method whose principle is illustrated in Figure 4. In this case, it is assumed that the aircraft 3 that is approaching the gate 4 of the airport terminal 2 will turn in at the latest at a predetermined minimum distance from the parking position in the region of the gate 4, and that the aircraft captain or pilot will in the process orient himself approximately on the center line of this gate 4. To do this, a catchment position is defined on this center line. A search area is defined around this catchment position, in which area the features that define the aircraft contour or the aircraft type are searched for. The defined size of this catchment area depends on the permissible lateral error for the aircraft 3 that is approaching the gate 4.

The individual templates which form the template set for an aircraft type must be chosen such that they are not invariant with respect to displacement and, furthermore, have a high contrast in the sequence of gray-shade images. Furthermore, the selected features or templates must be highly tolerant to external influences, such as lighting and weather. The following features and individual templates have therefore been chosen for the aircraft types so far included in the form of template sets:
The two engines, the windshield and the two landing gear legs. An individual template set is produced for each aircraft type by means of these individual templates.

The aircraft 3 is now looked for around the position defined in the ramp area. Since the aircraft 3 is a rigid body, a fixed arrangement of the features being looked for can be predetermined, and these features may appear distorted only due to the orientation of the aircraft 3 with respect to the video device 6. For this reason, it is desirable to find an optimum or elastic grid. In order to achieve this aim, the system looks for the maximum cross-covariance value in a defined search area around each template. The sum of all the cross-covariance values is a measure of whether the aircraft type has been found. By using an elastic grid, it is also possible in the process of "position determination" that follows later to determine the orientation of the aircraft 3. This orientation information may in turn be used for better tracking.

The search is carried out in the spatial Sobel-filtered image, which reproduces the gray-shade edges and is thus considerably less sensitive to lighting influences than the basic edge image. In comparison to other operators, the spatial Sobel-filtered image has the best edge contrast with the best noise suppression.

The position of a template is determined by shifting the template over the edge image until the similarity measure assumes a maximum. The cross-covariance is used as the similarity measure for this purpose, since this forms better maximum/environment contrast than cross-correlation and has a better maximum-to-noise ratio than Euclidean distance.

The data flowchart illustrated in Figure 5 shows how individual functional components of the docking system according to the invention communicate with other functional components of this system and with further functional components of an airport control system outside the actual docking system. Since many of the terms used in the figures can be expressed meaningfully only in the English language, the original German text of the patent does not include any German translation of the individual terms that occur in the figures described below, although the major components of the invention are expressed in the German language in the German form of the following text, and are related to the English-language expressions and abbreviations.

Figure 5 is subdivided into a first phase and a second phase, as is shown by the dotted boundary lines in Figure 5. The lower part, which describes the first phase, of Figure 5 is the major element for the docking system according to the invention, since the major functional elements of the docking system itself are illustrated there while, in contrast, the upper part of Figure 5 shows a central working position (CWP) of an airport, which is connected to the docking system according to the invention and, for its part, is related to the airport control system via a central monitoring and surveillance system interface (CMSI) and a user defined interface (UDI).

In the illustration in Figure 5, the docking system according to the invention is broken down into four functional units. First of all, a functional unit comprising a docking status/data handler (DSH) and calibration support (CS) are provided there. This functional unit receives central control signals, database updates and monitoring and surveillance data relating to the respective gate (gate i CMS data) from the CWP. From this functional unit DSH, CS the CWP receives status details relating to the respective gate (gate i statuses), live video signals from this gate (gate i live video) and central monitoring and surveillance data relating to this gate (gate i CMS data).

The functional unit DSH, CS has a calibration input and an output to a calibration display. Furthermore, the functional unit DSH, CS outputs recorded video sequences as well as control signals for the airfield ground lighting (AGL control). The DSH operates together with a further functional unit, namely the airfield situation processor (ASP) on a PC-based system. The functional unit ASP receives from the DSH of the functional unit DSH, CS control signals for the ASP (ASP control), initialization data and black-and-white video data (B & W Video Data). The DSH of the functional unit DSH, CS receives from the functional unit ASP tracking results as well as ASP check results.

Furthermore, data relating to the gate configuration are entered in the functional unit DSH, CS while, in contrast, said functional unit outputs data relating to the docking process (docking log data).

As a further functional unit, the docking system according to the invention has a gate operation panel (GOP) from which transfer data are entered in the functional unit DSH, CS, and which receives transfer data from the functional unit DSH, CS. Furthermore, operation commands and test commands are entered in the GOP, while the GOP outputs the docking status, test results and an aircraft type table.

An advisor and guidance display (AGD) is provided as a further functional unit of the docking system according to the invention, which enters self-test results in the functional unit DSH, CS and receives from this functional unit data to produce the characters for the display information (display information character generation data). The AGD outputs guidance and verification signals and test patterns.

As can be seen from Figure 6, the docking system CS according to the invention in principle has three partial operating systems, namely a docking station subsystem (DSS), a central controller working position subsystem (CWPS) and a communication network subsystem (CNWS). The DSS contains all those system segments which are arranged at the gates. The CWPS comprises a display and control system which is based on a workstation and is provided in a central control room at the airport. The CNWS is the network which connects these two subsystems to one another, in order to transmit data between these subsystems.

An auxiliary subsystem (AuxS) associated with the DSS contains a number of auxiliary functions, for example the production of new aircraft models, the gate configuration and maintenance.

The DSS is connected on the one hand to the airfield situation, and on the other hand to the maintainer, calibrator, bridge personnel, ground personnel, (co-)pilot and the AGL. The gate specifier, the aircraft model specifier, the installation personnel and the research department can be connected to the DSS via the AuxS.

The CWPS of the docking system according to the invention is on the one hand connected to the administrator, the maintainer, the supervisor and the controller, while on the other hand it is connected to the central monitoring and surveillance system, to the airport database, to user defined gate systems, to the AGL, to time reference systems and to a surface movement guidance and control system (SMGCS).

The DSS controls two or more central lines or center lines for the gate. Two center lines or central lines can be controlled by one DSS, provided the two are mutually dependent and/or provided the one cannot be used while the other is in use.

As can be seen from Figures 7, 8 and 9, the DSS has four different segments:
the airfield situation monitoring and processing segment (ASMPS);

the advisor and guidance display segment (AGDS); if there are two mutually dependent central or center lines, a second AGDS may be required, depending on the configuration and/or arrangement of the central or center lines at the gate. The AGDS contains an integrated microprocessor, which controls the display elements and converts display commands into displays;

the data and status handler segment (DSHS) with one or two video cameras for each central line or center line; the number of video cameras for each central line or center line depends on the aircraft types which may dock at the respective gate; the DSHS runs on the same hardware as the ASMPS. It provides the communication between the DSS and the CWPS via the CNWS, and coordinates the processes within the DSS.

The gate operator panel segment (GOPS) is a microprocessor-based system having a small keyboard or keypad and a liquid crystal display LCD, which transmits only the input data to the DSHS and outputs the data from the DSHS to the LCD.

Three different embodiments of the docking station subsystem DSS differ essentially by the arrangement of the ASMPS and DSHS.

A first embodiment, illustrated in Figure 7, provides for the ASMPS and the DSHS to be arranged in the same housing together with and at the same location as the AGDS, as can be seen from the double line surrounding said segments in Figure 7.

The ASMPS and the DSHS run on a PC motherboard and on the video processing equipment which includes, for example, a so-called frame grabber; interface elements are provided to the GOPS 1 to 4, to the AGDS 1 and 2, to the auxiliary interface and to the CNWS, but without any mechanically operating parts.

The auxiliary interface can be used, for example, to calibrate the video camera 9 and the further video camera 10, or to test the DSS. If the DSS is operated on its own, the auxiliary interface may be used to input the gate configuration and the aircraft database, or to output recorded video sequences. The AGDS has a simple microprocessor and three, or possibly four, LED arrays. The simple microprocessor provides the communication with the DSHS and controls the LED arrays.

RS 232, RS 422 and RS 485 type interfaces, or interfaces based on optical links, may be used as the interface between the DSHS and the GOPS 1 to 4 or the AGDS 2. An RS 232 type interface may be used as the interface between the DSHS and the AGDS.

The second version or embodiment of the docking station subsystem illustrated in Figure 8 has a common housing just for the ASMPS and the DSHS, as can be seen from the double line which surrounds the two segments in Figure 8. These two segments are arranged separately from the other equipment in an equipment room. The AGDS is, furthermore, arranged in the outer gate area, of course. It can be seen from this that the interfaces between these segments differ from those in the first embodiment. The interface between the AGDS and the DSHS now corresponds to the other RS 232, RS 422 etc. type interfaces.

A video monitor 11 and a keyboard or keypad 12 are now provided instead of the auxiliary interface, and can carry out the functions of the auxiliary interface provided in the first embodiment.

In the third embodiment of the DSS illustrated in Figure 9, the ASMPS is accommodated inside a housing 13 or 14, respectively, of the video camera 9 or 10, respectively. The required software runs on a digital signal processor, which transmits the aircraft position digitally to the DSHS. The DSHS may be in the form of a PC or microprocessor board of relatively low performance. In principle, it is also possible to accommodate the DSHS in a housing with the AGDS or the AGDS 2.

The major difference between the described embodiments is the arrangement of the hardware that forms the ASMPS and the DSHS. There are more minor differences in the auxiliary interface and in the interface between the AGDS and the DSHS.

The first embodiment requires the capability for the hardware that forms the ASMPS and the DSHS to operate in outdoor environmental conditions.

The advantage of the first embodiment is that it involves only a minimum level of installation complexity. The interface between the AGDS and the DSHS has a simple configuration. On the one hand, the reliability may be greater since less installation complexity is involved and since no mechanically operating equipment parts are required but, on the other hand, operation is required in outdoor environmental conditions; this reduces the reliability, even if cooling or heating measures are provided.

The auxiliary subsystem which is used as the auxiliary system AuxS is required to start and to maintain the system during system installation and during system maintenance. It includes an aircraft model editor (AME), a gate installation planner (GIP), a calibration tool (CT), a validation and diagnosis tool (VDT) and a maintainer support tool.

The AME may be installed on a separate PC. In the second embodiment of the DSS, the aircraft model may be transmitted by means of a floppy disk to the operating system, while in the first and third embodiments it may be transmitted by means of a laptop PC and the auxiliary interface. If all the isolated systems are connected by means of a network, such data can be integrated via the CWPS.

The GIP produces a hard-copy installation plan and the gate configuration on a disk. The gate configuration may be entered in the operating system in the same way as the aircraft models.

The VDT may run on a separate PC. The data may be entered in this PC via the auxiliary interface if the system is isolated, or may be input via the CNWS and CWPS. In the second embodiment of the DSS, the VDT may also run on the isolated system.

The CT supports the calibration process with a graphics display. The calibrator can carry out the calibration interactively. The calculated calibration data remain in the DSS.

The CNWS may be in the form of an ATM network, in which at least one switching unit may be provided. A UNI 3.1 or UNI 4.0 should be used for signaling. 155 Mbit/s or 25 Mbit/s adapters may be used, depending on the bandwidth requirements. The distances which can be achieved depend on the transport medium: monomode fibers for long distances, multimode fibers for medium distances, or twisted double wires for short distances.

The advantages of such a high-speed ATM network are that long distances are possible, no electromagnetic interference occurs, DC isolation is provided, a guaranteed bandwidth is ensured between two data end points, and a guaranteed delay is ensured between two data end points.

The CWPS may run on a PC system using the Windows NT operating system. Furthermore, a Video-HW-ProVisionBusiness and an ATMax 155-PM2 ATM adapter from SICAN GmbH are preferably used as the hardware components.

In the DSS illustration chosen in Figure 10, the subsystem level illustrated in Figures 7 to 9 has been omitted; based on the illustration in Figure 10, the DSS has the following segments:

a ground area monitoring and processing segment (GAMPS);

a gate area control segment (GACS);

a gate schedule segment (GSS),

a gate data handler segment (GDHS),

a communication network segment (CNWS);

a central working position segment (CWPS); and
an auxiliary functionalities segment (AuxS).

The GAMPS illustrated in Figure 11 has airfield monitoring (AM) and an airfield situation processor (ASP). This supports the following functions: frame grabbing, calculation of the display information from the position data which is provided by the ASMPS, processing of the airfield situation, calculation of real-world positions, and video recordings.

The GAMPS assists the GSS in investigating the airfield situation during the docking sequence. It provides self-test and calibration information as well as video images for calibration of the GSS. In addition, the GAMPS supplies the AuxS with recorded video sequences.

The GACS comprises the airfield ground lighting (AGL), the advisor and guidance display (AGD), the gate operator panel (GOP), the luxometer (LM) and the gate area processor (GAP), in which case the GAP runs on a PC platform to which the AGL, the AGD, the GOP and the LM are connected.

The GACS supports the following functionalities:

Measurement of the light intensity in the area of the gate,

Switching for the AGL,

Display of guidance and verification details for the aircraft pilot and display of test patterns for the ground personnel, with one or two AGDs being provided,

Input of operating and test commands by the ground personnel via one to four GOPs, output of test results and docking status to the ground personnel via the GOP, self-testing all parts of this segment, and communication and data interchange with the GSS.

The GACS has to measure the light intensity in the gate area, and has to convert this into dark or light information. The GACS converts the GOP inputs and forwards them to the GSS. On the other hand, the GACS receives commands from the GSS, interprets them, and passes the corresponding display information to the AGD and to the GOP, switches the AGL on or off, and tests the communication lines to the AGD and GOP.

The GDHS illustrated in Figure 13 has calibration support (CS) and a static data handler

(SDH), both of which run on a PC platform.

The main tasks of the GDHS are management of the calibration process, management of the update to the gate configuration, and storage of the gate configuration and the aircraft types.

During the setting-up phase in isolated operation, it reads the gate configuration data from a file which has previously been produced by the GIP. In network operation, it reads the data via the GSS from the CNWS/CWPS, and stores this data internally.

The GSS illustrated in Figure 14 comprises the gate manager (GM) and the watchdog (WD).

The main tasks of the GSS are to control the action sequence within the signal, to supply the GAMPS with calibration and aircraft data, to produce time stamps and time inhibits, to trigger the monitor and to interchange data with surrounding segments.

In isolated operation, the GSS provides the information input and output for the GOP via the GACS. In network operation, the interface to the CNWS/CWPS is also controlled. The GSS transmits compressed live video images and status information to the CNWS/CWPS. Alternatively, the docking sequences may be controlled via the CWPS. In this situation, the information input and output for the GOP is interchanged via the GACS and via the CNWS with the CWPS.

During the setting-up phase, system control is passed to the GDHS. In network operation, the GSS supplies the GDHS with the transmission of configuration data via the CNWS/CWPS.

During the calibration process, the GSS passes system control to the GDHS. It transmits video images from the GAMPS to the GDHS. It uses the GAMPS to verify calibration data. When the gate configuration is being updated, the docking mechanism is deactivated.

After the end of a docking sequence, the live video signals for the last docking sequence can be repeated either by means of the PC monitor, the keyboard or keypad and the mouse in isolated operation, or via the network on the CWPS in network operation. It is impossible to initiate a docking sequence while a recorded video sequence is being viewed.

Maintenance tests may be initiated through the GOPS by the ground personnel or, controlled by the CNWS/CWPS, through the GSS.

The GSS triggers the watchdog periodically; otherwise, the watchdog resets the PC.

The CNWS provides the communication between the CWPS and the GSS at the various gates, and vice versa. It transmits commands, data and compressed video images; the latter are transmitted only when specifically requested.

The main tasks of the CWPS are:
Display of the planned and actual gate occupancy, display of the status of a docking process for the control center personnel, inputting of gate configurations for a specific gate, inputting of new aircraft models, data interchange with surrounding systems, for example maintenance, flightplan data, planned gate occupancies.

The planned and the actual occupancy of gates may be displayed graphically at any time. The global picture can be split up into a number of smaller areas. One panel with all the gates occupied and with the associated calling symbols is shown. The control center personnel can occupy a specific gate manually. Information about a specific gate and live video transmission may be selected. The planned data is shown in a specific block diagram. The planned occupancy may be changed or modified as required. The CWPS ensures that any change does not contravene gate restrictions, for example by aircraft types being assigned to a gate which is unsuitable for such aircraft types.

The main functionalities of the AuxS are to assist the specification of a gate, that is to say the coordinates of the central line or center line and the stopping position, aircraft types permissible for that gate, the specification of new aircraft models, and displaying the repetition of recorded docking sequences for evaluation.

These functionalities may be carried out at a separate workstation. The data transmission from and to these functions is carried out by means of a disk or some other medium, depending on the required capacity.

Patent claims

1. A docking system for airport terminals, having a positioning apparatus as part of a gate operating system for an airport terminal, by means of which an aircraft can be guided to a parking position appropriate for its type, and which has a video device by means of which the aircraft can be detected as it approaches the airport terminal and has an evaluation unit by means of which it is possible to evaluate data which are supplied to it by the video device and relate to the form and the movement of the aircraft, with a template set in each case being stored in the evaluation unit, for different types, characterized in that the template set contains at least three, preferably five, specific templates for all types or outline sections of the relevant type, and in that the at least three, preferably five, specific outline sections or templates of the aircraft (3) which is approaching the airport terminal (2) can be determined, and can be compared with the stored template sets, in the evaluation unit (7), from the input signals from the video device (6), in which case trajectories of the templates or specific outline sections are used as the basis to determine the present position of the aircraft (3) as it approaches the airport terminal (2).

2. The docking system as claimed in claim 1, in which the video device (6) is in the form of a monochrome camera.

3. The docking system as claimed in claim 1 or 2, in which the objective focal lengths of the video device (6) are 16 or 25 mm.

4. The docking system as claimed in one of claims 1 to 3, in which the video device (6) is arranged approximately aligned with the center line of the airport gate (2), preferably at a height of approximately 9 m.

5. The docking system as claimed in one of claims 1 to 4, into whose evaluation unit (7) a sequence of gray-shade images can be read, the individual gray-shade images in the sequence can be spatially filtered in order to extract gray-shade edges, the sequence of gray-shade images can be filtered in the time domain in order to produce moving images, and a mask can be produced from the moving images, defining areas for subsequent segmentation.

6. The docking system as claimed in claim 5, whose evaluation unit (7) has a Sobel filter for spatial filtering of the gray-shade images, and for filtering the gray-shade images in the time domain.

7. A docking system for airport terminals, preferably as claimed in one of claims 1 to 6, having one docking station subsystem DSS per gate (4), which is connected via a communication network CNWS to a central working position CWPS, has an airfield situation monitoring and processing segment ASMPS, at least one advisor and guidance display segment AGDS, a data and status handler segment DSHS having at least one video camera (6; 9, 10) for each center line of the gate, and at least one ground operation panel segment GOPS, and to which an auxiliary subsystem AuxS is connected, by means of which information relating to aircraft models and the gate can be entered in the docking station subsystem DSS.

8. The docking system as claimed in claim 7, in which the docking station subsystem DSS has an advisor and guidance display segment AGDS for each center line of its gate (4).

9. The docking system as claimed in claim 7 or 9, in which each advisor and guidance display segment AGDS has a microprocessor which controls the display elements and converts display commands into displays.

10. The docking system as claimed in one of claims 7 to 9, in which the data and status handler segment DSHS of the docking station subsystem DSS runs on the same hardware as the airfield situation monitoring and processing segment ASMPS, which provides communication between the docking station subsystem DSS and the central working position CWPS via the communication network CNWS, and coordinates the processes within the docking station subsystem DSS.

11. The docking system as claimed in one of claims 7 to 10, in which the data and status handler segment DSHS and the airfield situation monitoring and processing segment ASMPS are arranged in one housing.

12. The docking system as claimed in claim 11, in which the data and status handler segment DSHS and the airfield situation monitoring and processing segment ASMPS run on a hardware basis comprising a PC motherboard and the video signal processing equipment.

13. The docking system as claimed in claim 11 or 12, in which the advisor and guidance display segment AGDS is also arranged in the housing.

14. The docking system as claimed in one of claims 7 to 10, in which the docking station subsystem DSS is designed such that it allows advisor and guidance displays to be transmitted to a screen in the cockpit of an aircraft which is approaching the gate.

15. The docking system as claimed in one of claims 7 to 10 or 14, in which the airfield situation monitoring and processing segment ASMPS is arranged in a housing (13, 14) with the video camera (9, 10).

16. The docking system as claimed in claim 15, in which a digital signal processor DSP is provided for transmission of data between the airfield situation monitoring and processing segment ASMPS and the data and status handler segment DSHS.

17. The docking system as claimed in one of claims 7 to 16, in which the auxiliary subsystem AuxS has an aircraft model output AME, a gate installation planner GIP, a calibration unit CS and a validation and diagnosis tool VDT.

18. The docking system as claimed in one of claims 7 to 17, in which the communication network CNWS is in the form of a high-speed network using the asynchronous transmission mode ATM, by means of which originally digital signals and originally analog signals converted into digital signals, for example video signals, can be transmitted.

19. The docking system as claimed in claim 18, in which the ATM high-speed network has at least one network adapter in the form of a SICAN-ATMax 155-PM2.

20. The docking system as claimed in one of claims 7 to 17, in which the docking station subsystem DSS is systematically broken down into a ground area monitoring and processing segment GAMPS, a gate area control segment GACS, a gate schedule segment GSS and a gate data handler segment GDHS.

21. The docking system as claimed in claim 20, in which the ground area monitoring and processing segment GAMPS has an airfield monitor AM and an airfield situation processor ASP, which is connected by means of an interface to the gate schedule segment GSS.

22. The docking system as claimed in claim 20 or 21, in which the gate area control segment GACS has airfield ground lighting AGL, an advisor and guidance display AGD, a ground operation panel GOP, a luxometer LM and a gate area processor GAP which runs on a PC platform to which the airfield ground lighting AGL, the advisor and guidance display AGD, the ground operation panel GOP and the luxometer LM are connected, and which is connected by means of an interface to the gate schedule segment GSS.

23. The docking system as claimed in one of claims 20 to 22, in which the gate data handler segment GDHS has a calibration support CS and static data handler SDH, which run on a PC platform and are connected by means of in each case one interface to the gate schedule segment GSS.

24. The docking system as claimed in one of claims 20 to 23, in which the gate schedule segment GSS has gate management GM and a monitor WD.

Fetherstonhaugh & Co.
Ottawa, Canada
Patent Agents

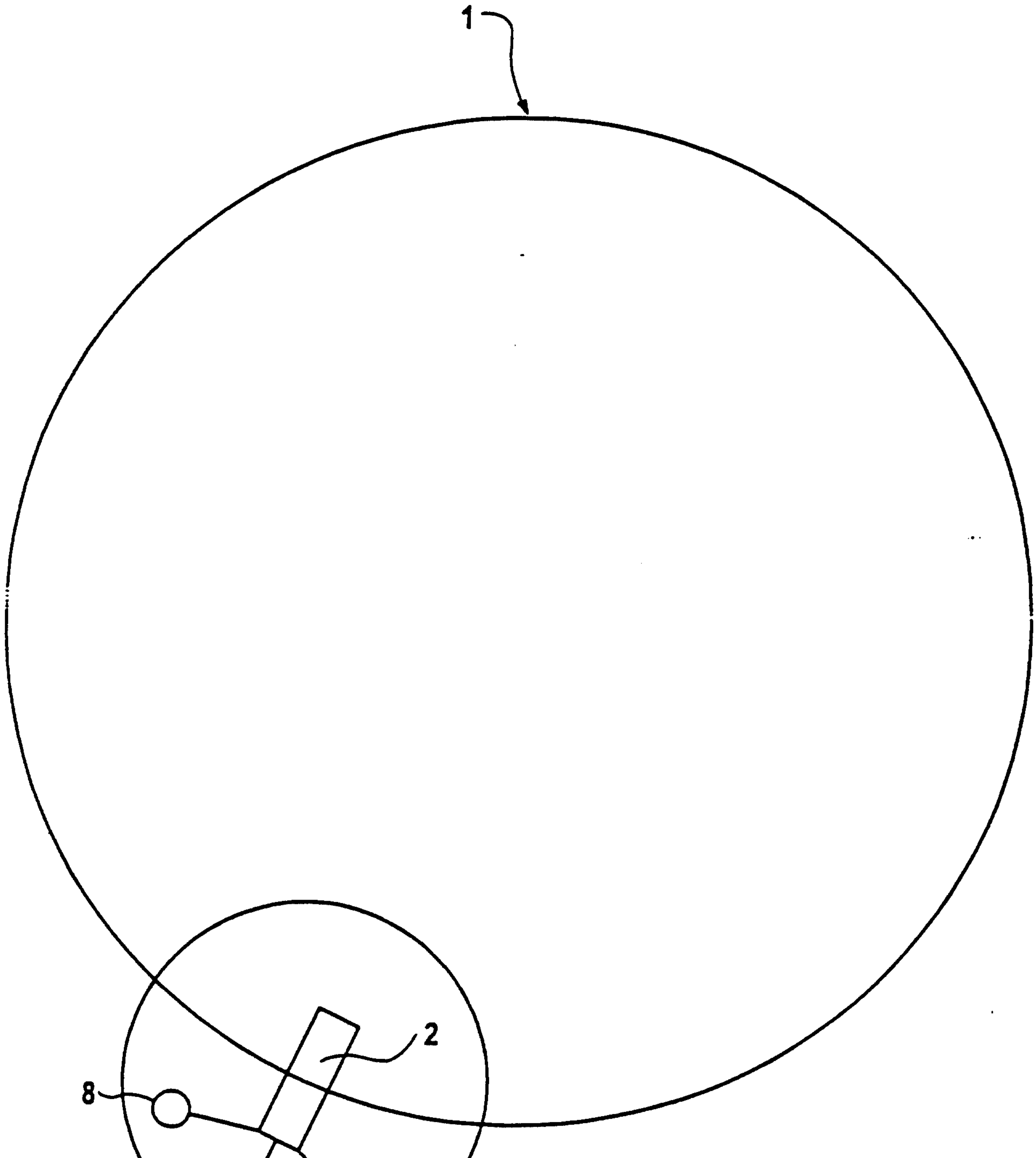


FIG 1

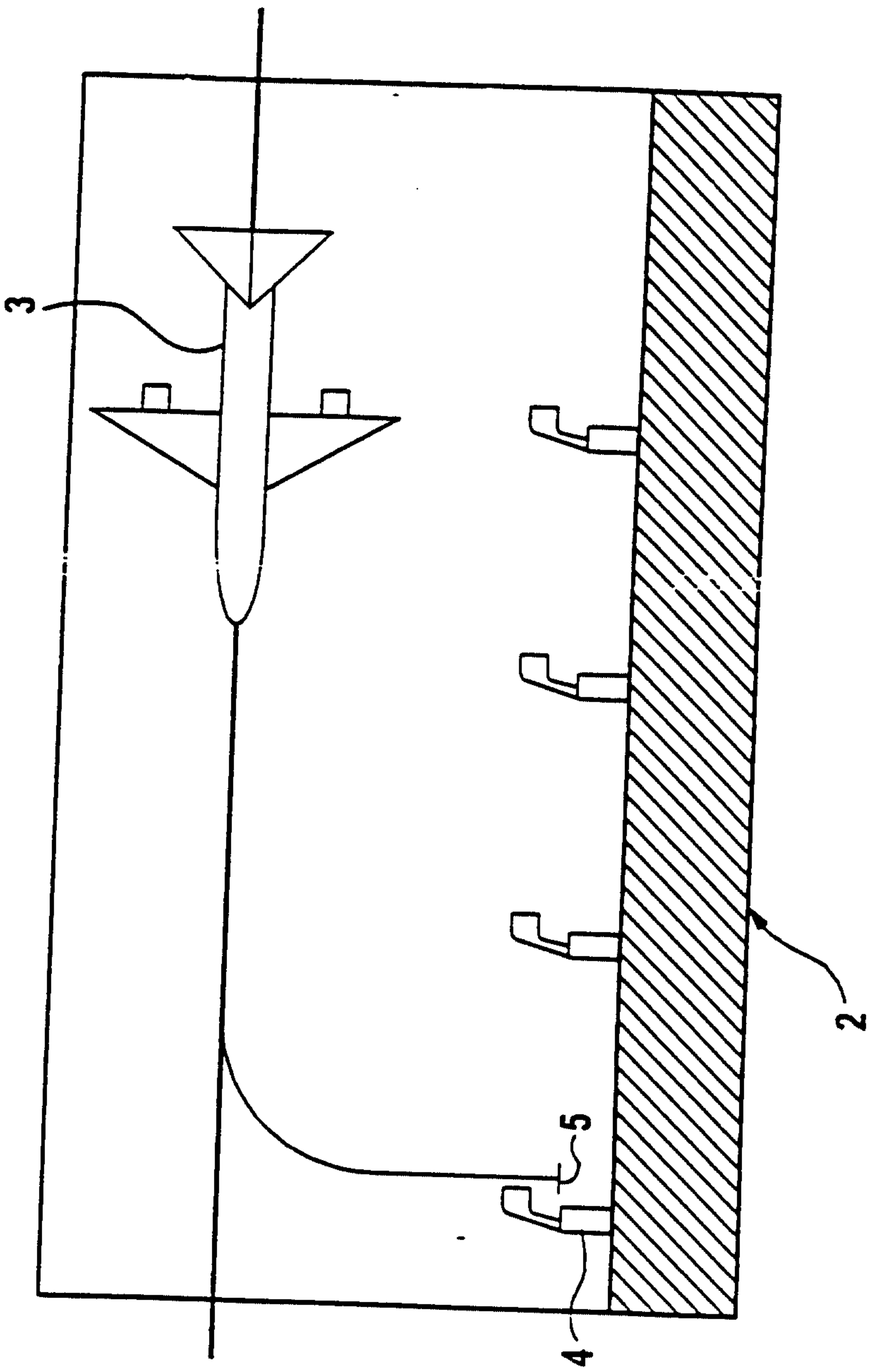


FIG 2

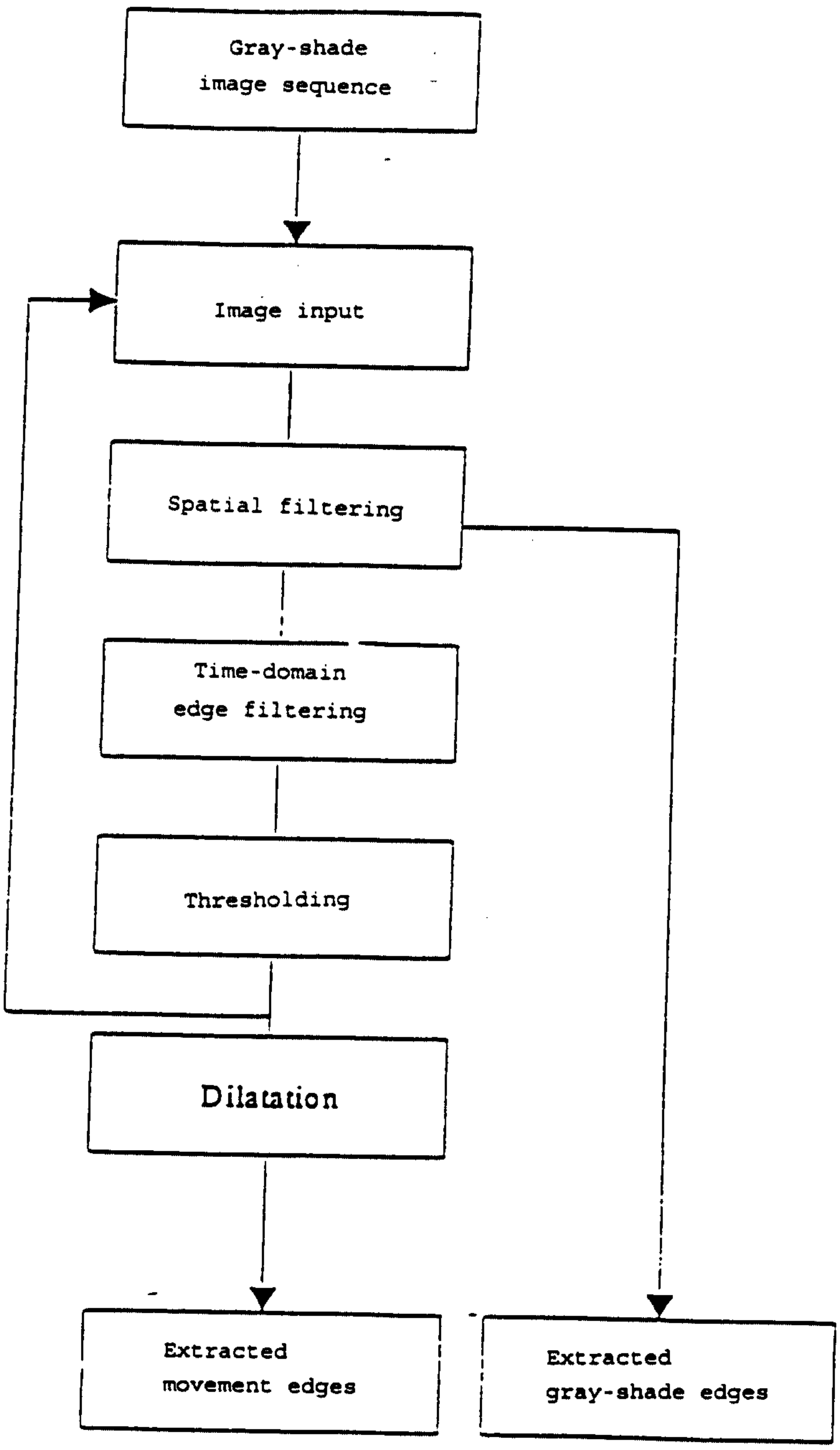

Gray-shade
image sequence
Image input
Spatial filtering
Time-domain
edge filtering
Thresholding
Dilatation
Extracted
movement edges
Extracted
gray-shade edges

FIG 3

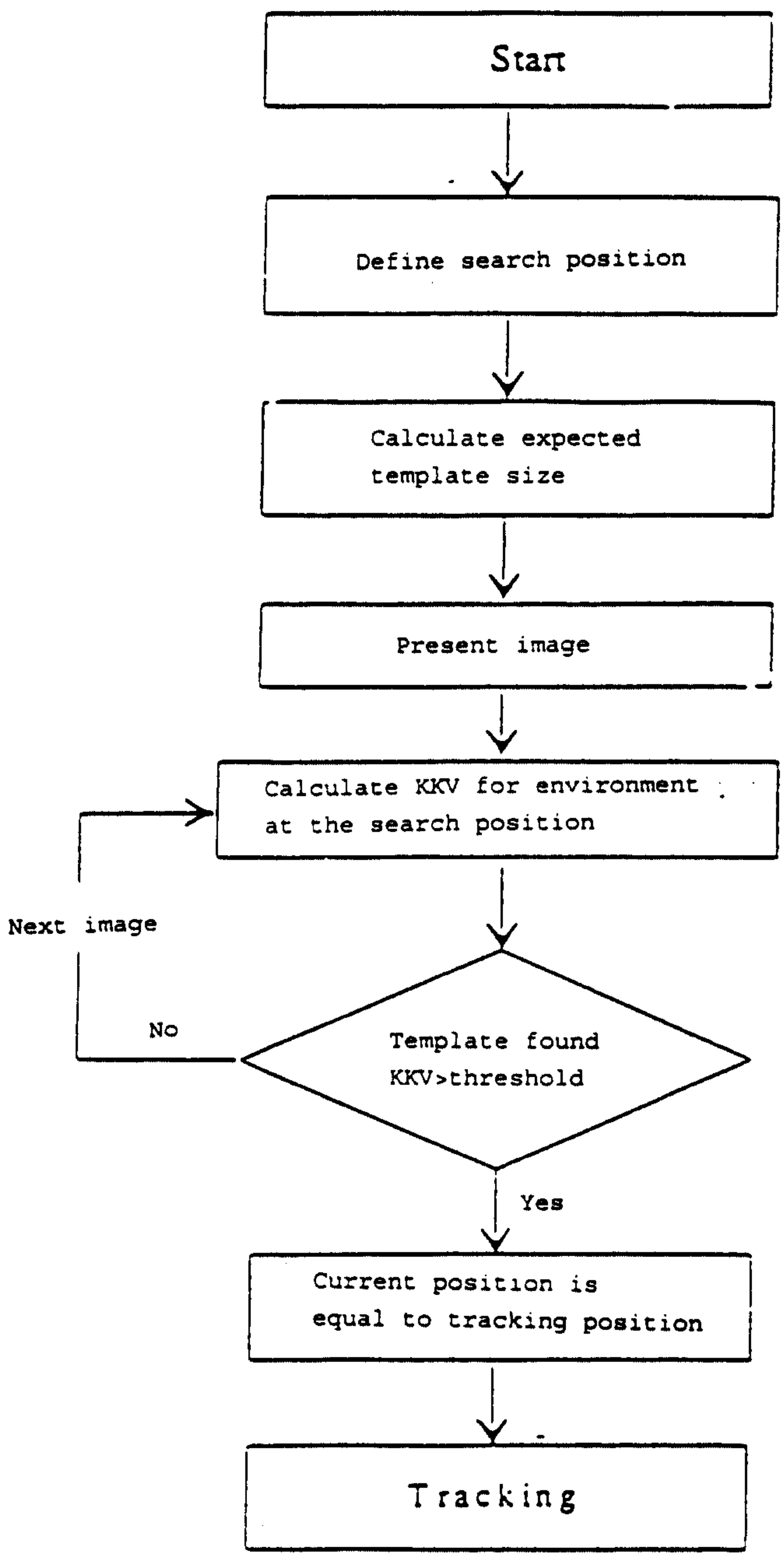

Start
Define search position
Calculate expected template size
Present image
Calculate KKV for environment at the search position
Next image
No
Template found KKV>threshold
Yes
Current position is equal to tracking position
Tracking

FIG 4

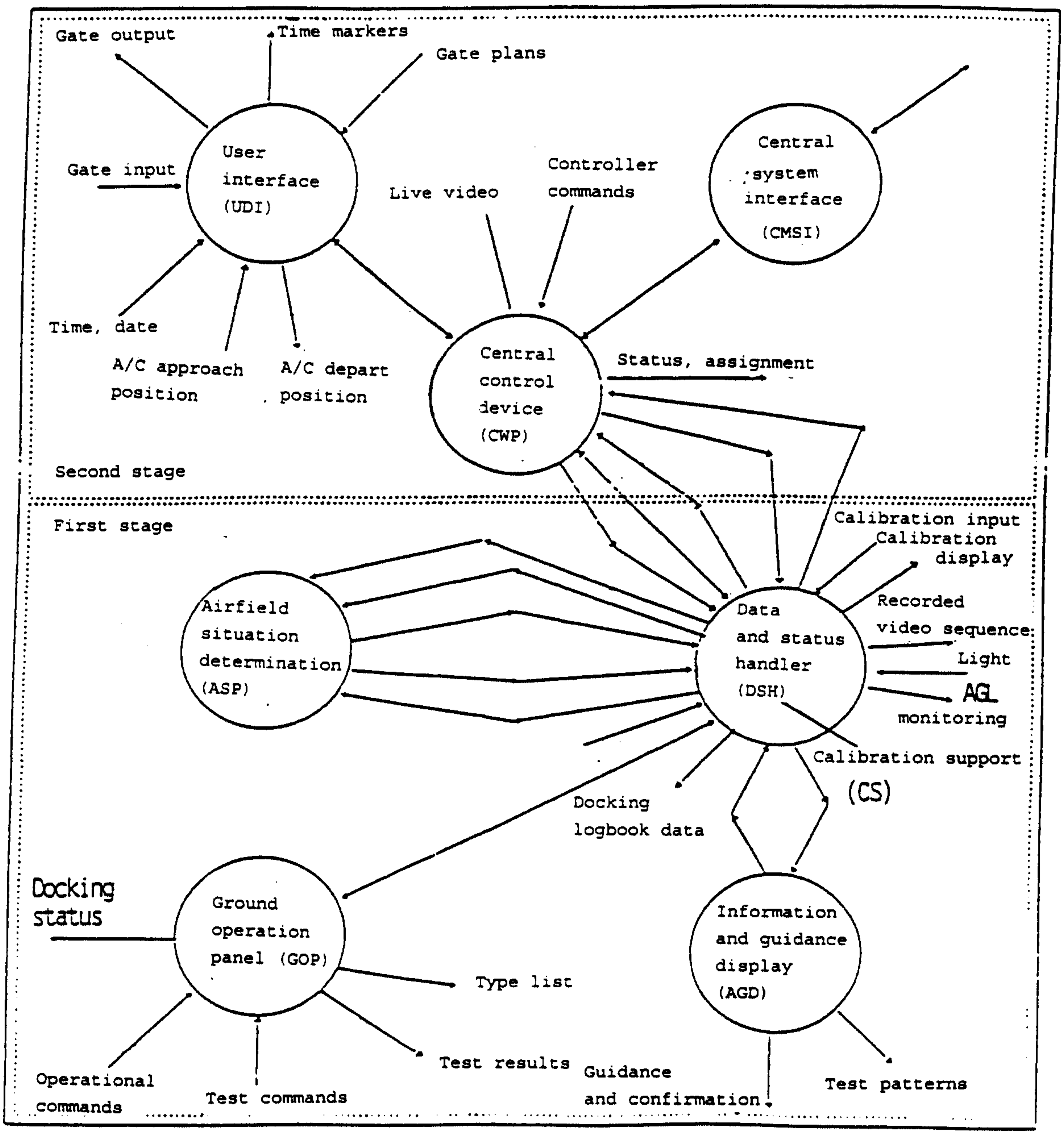

Gate output
Time markers
Gate plans
User interface (UDI)
Gate input
Central system interface (CMSI)
Live video
Controller commands
Time, date
A/C approach position
A/C depart position
Central control device (CWP)
Status, assignment
Second stage
First stage
Calibration input
Calibration display
Airfield situation determination (ASP)
Data and status handler (DSH)
Recorded video sequence
Light
AGL monitoring
Calibration support
(CS)
Docking logbook data
Docking status
Ground operation panel (GOP)
Information and guidance display (AGD)
Type list
Test results
Guidance and confirmation
Test patterns
Operational commands
Test commands

FIG 5

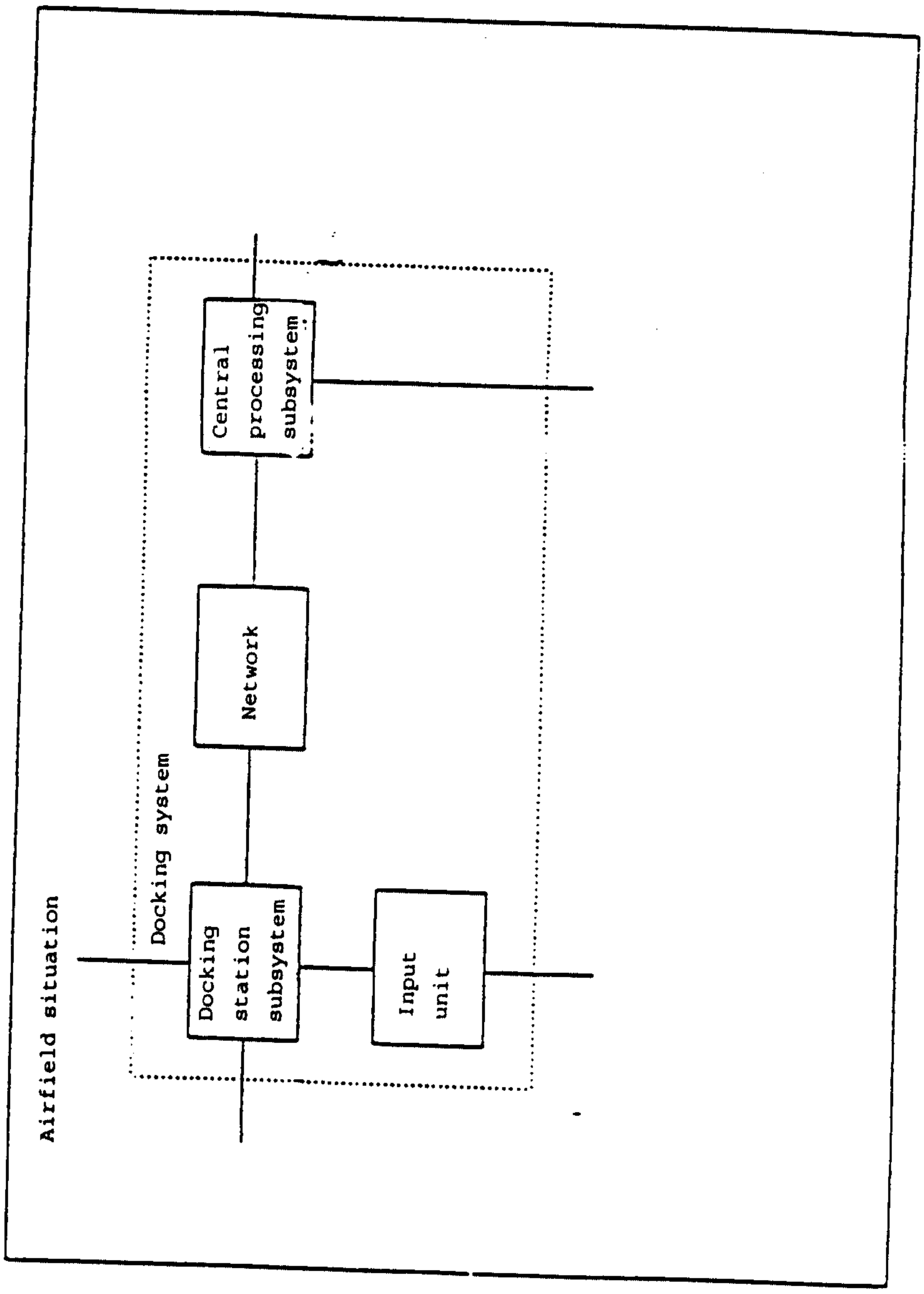

Airfield situation
Docking system
Docking station subsystem
Input unit
Network
Central processing subsystem

FIG 6

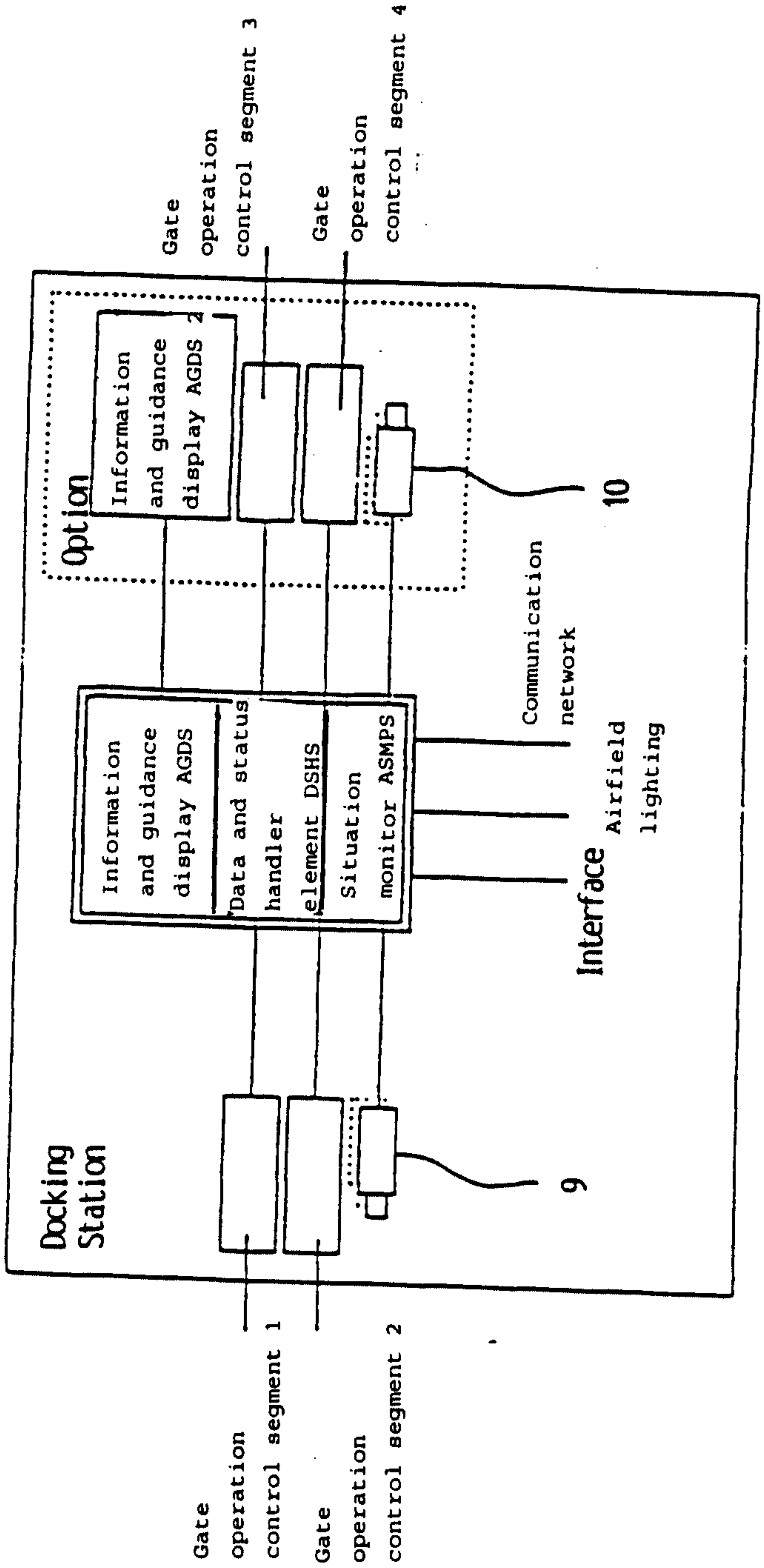

Docking Station
Gate operation control segment 1
Gate operation control segment 2
9
Information and guidance display AGDS
Data and status handler element DSHS
Situation monitor ASMPS
Interface
Airfield lighting
Communication network
Option
Information and guidance display AGDS 2
Gate operation control segment 3
Gate operation control segment 4
10

FIG 7

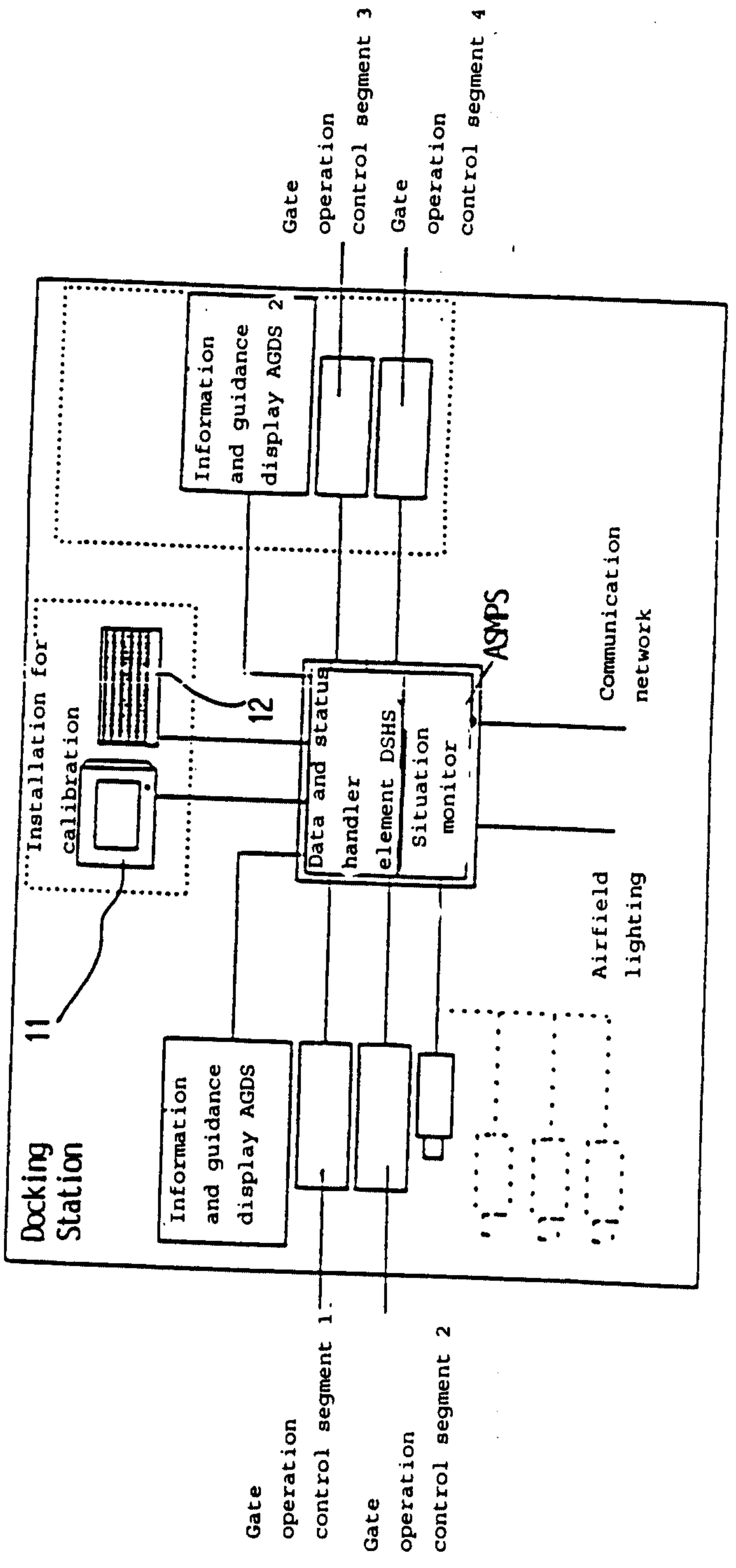

Docking Station
Information and guidance display AGDS
Information and guidance display AGDS 2
Installation for calibration
11
12
Data and status handler element DSHS
Situation monitor
ASMPS
Communication network
Airfield lighting
Gate operation control segment 1
Gate operation control segment 2
Gate operation control segment 3
Gate operation control segment 4

FIG 8

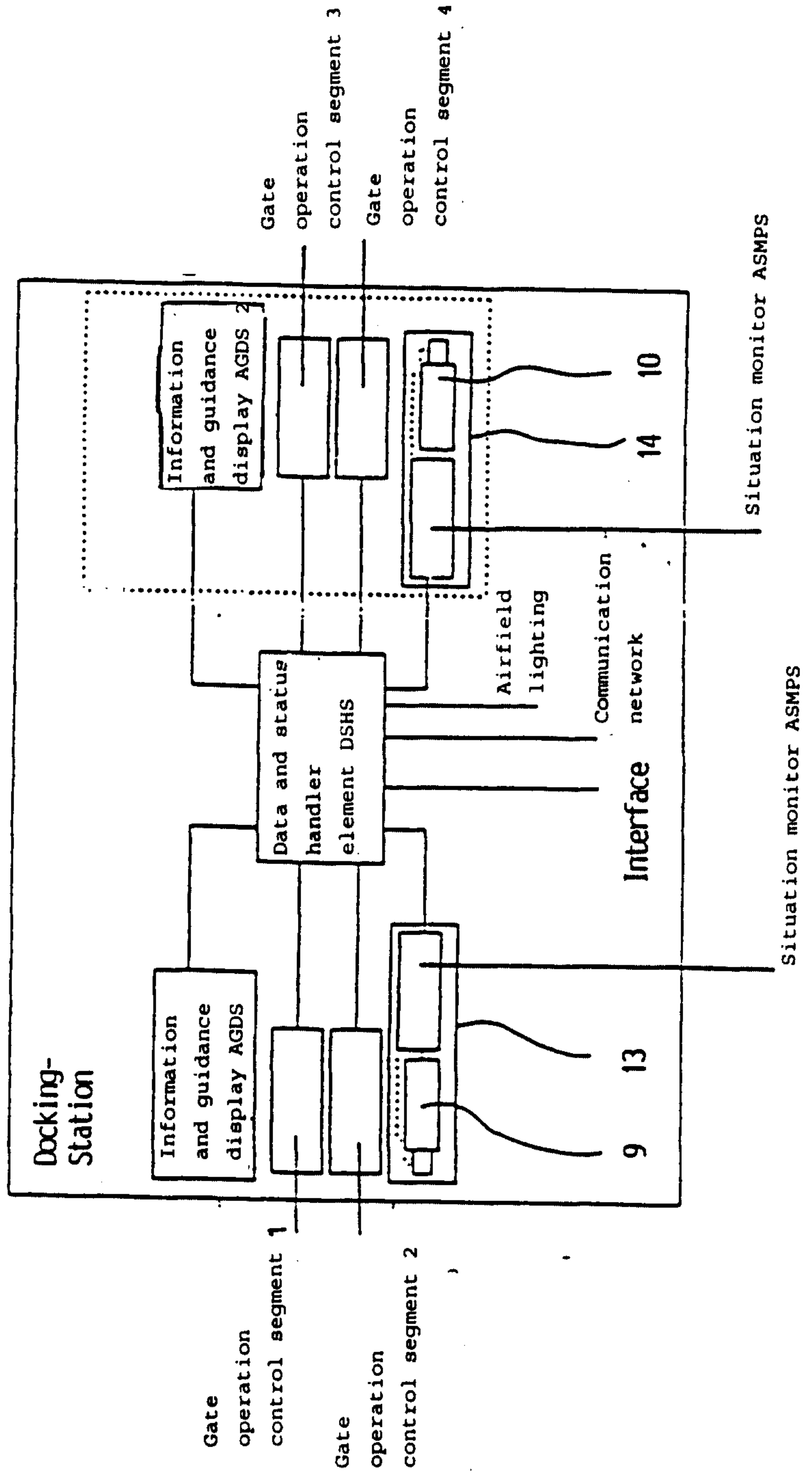

Docking-Station
Information and guidance display AGDS
Information and guidance display AGDS 2
Data and status handler element DSHS
Gate operation control segment 1
Gate operation control segment 2
Gate operation control segment 3
Gate operation control segment 4
Airfield lighting
Communication network
Interface
Situation monitor ASMPS
Situation monitor ASMPS
9
13
14
10

FIG 9

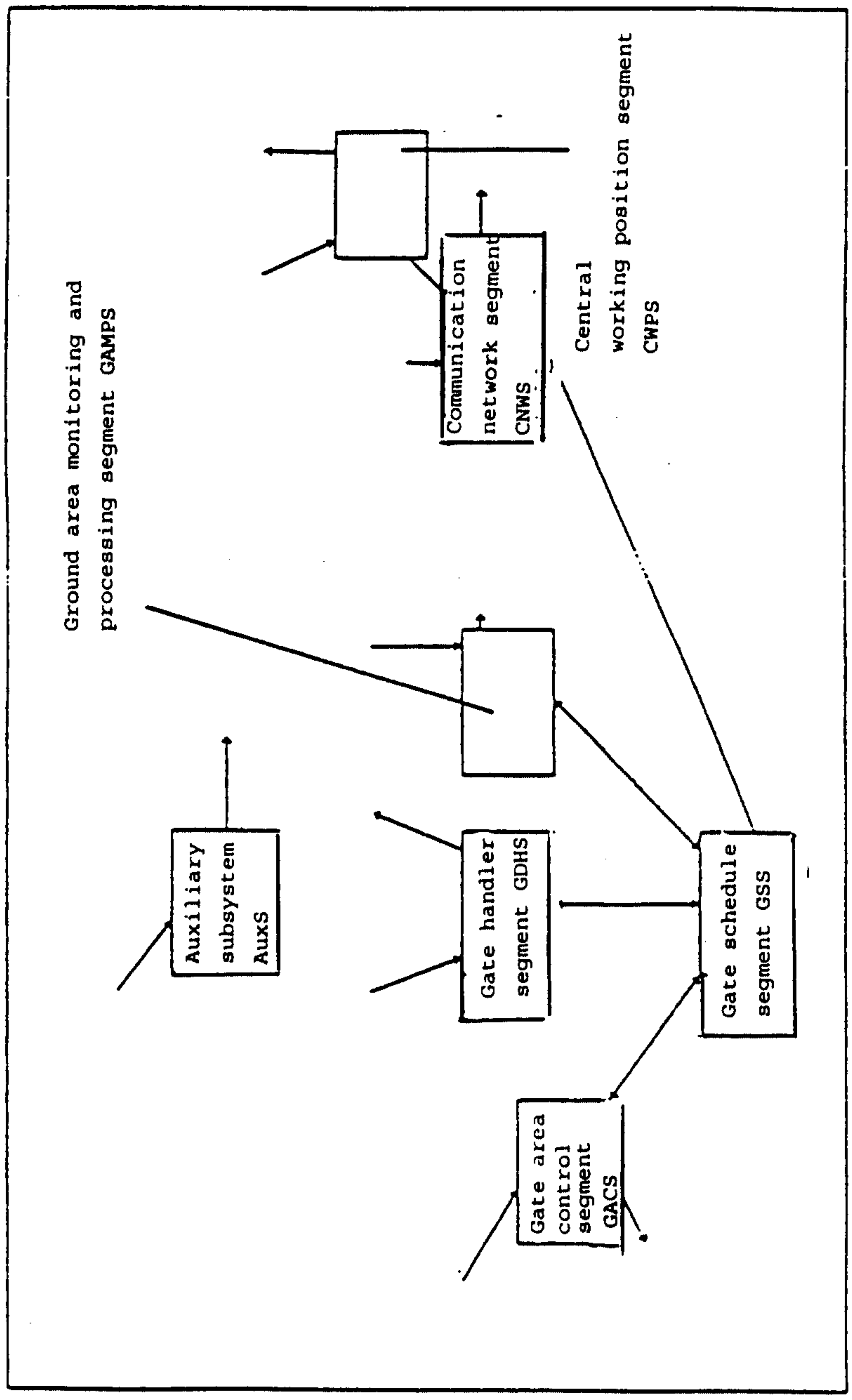

Ground area monitoring and processing segment GAMPS
Communication network segment CNWS
Central working position segment CWPS
Auxiliary subsystem AuxS
Gate handler segment GDHS
Gate schedule segment GSS
Gate area control segment GACS

FIG 10

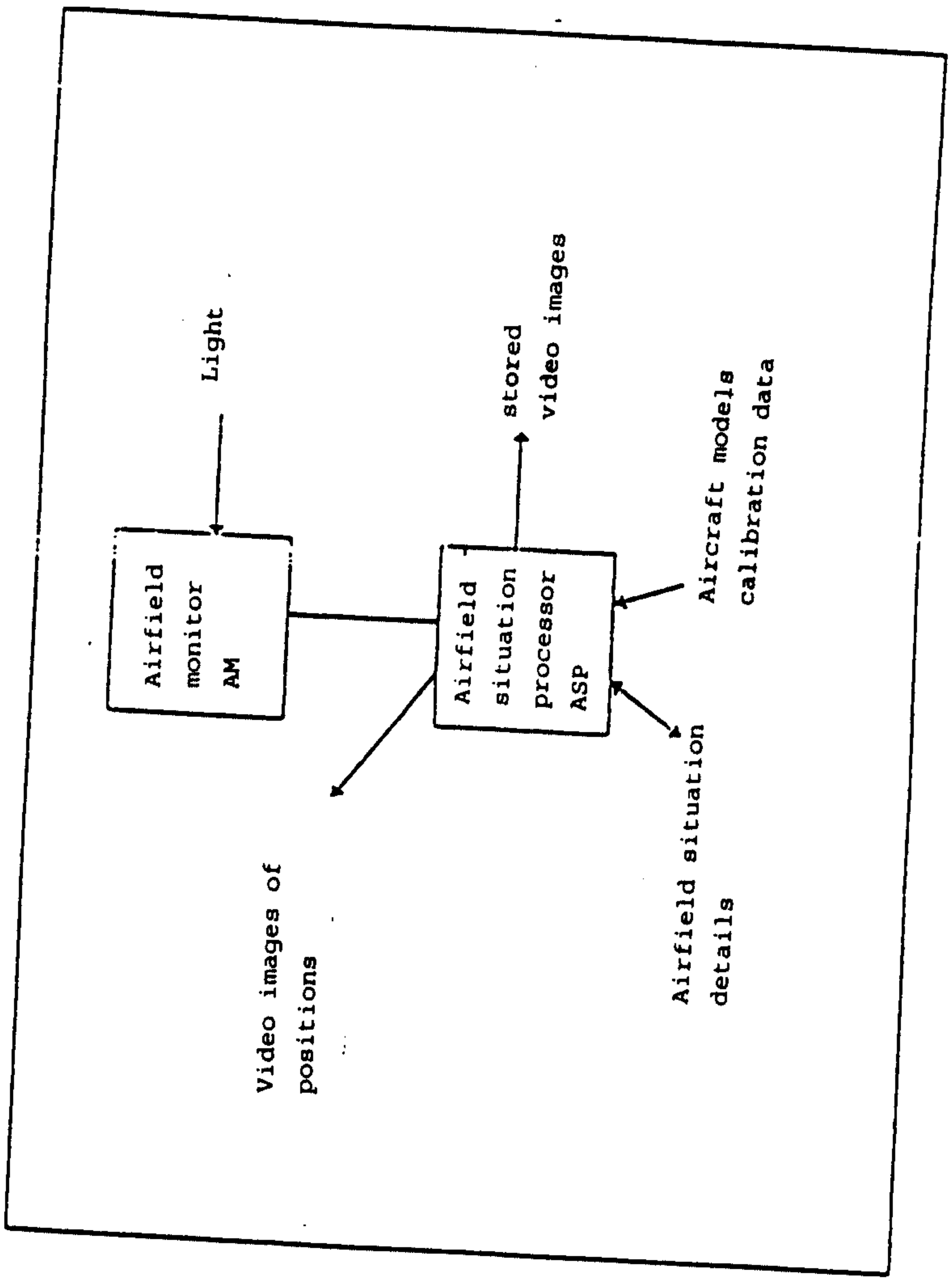


FIG 11

CORRECTED SHEET (RULE 91)

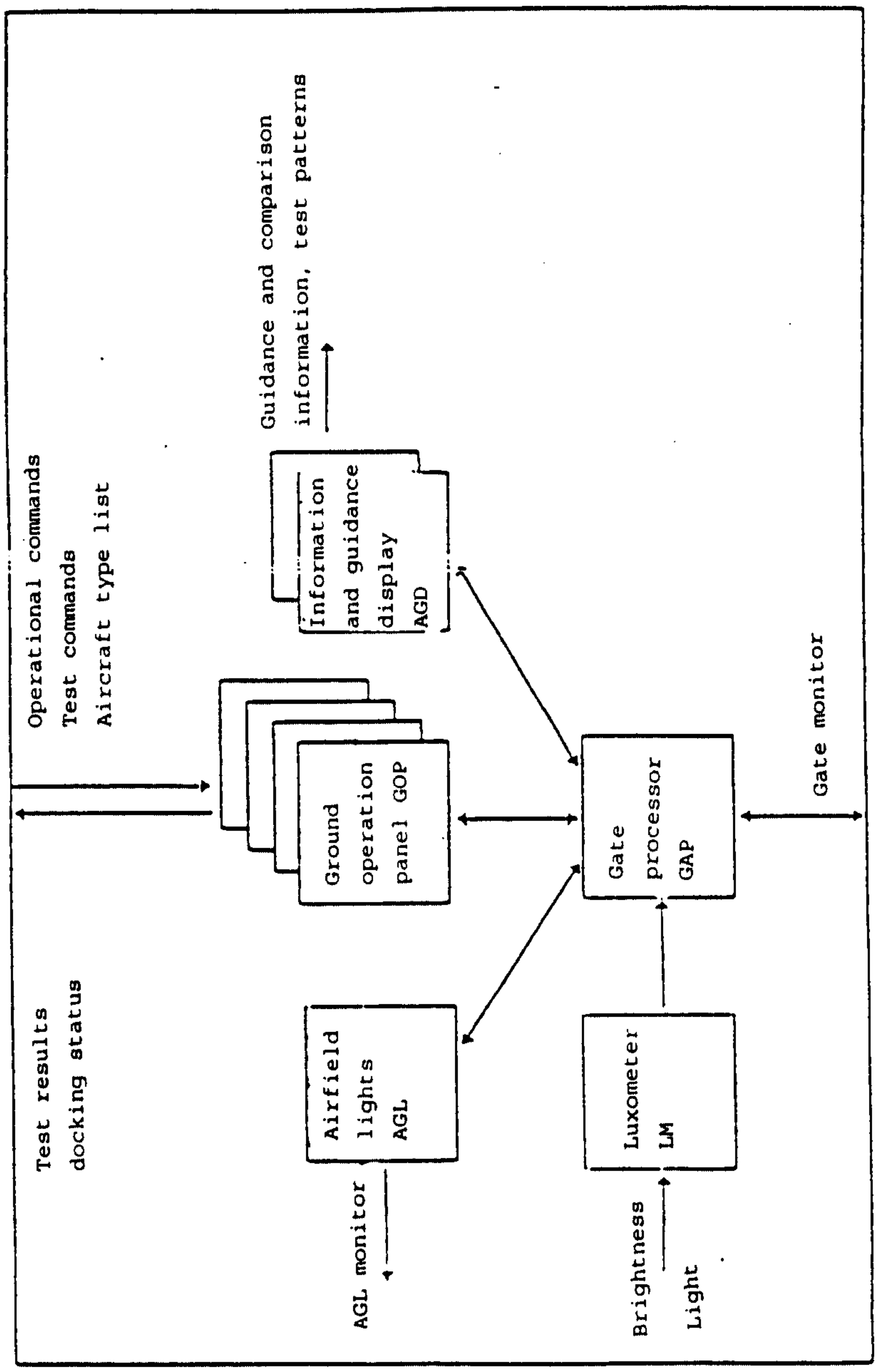

Operational commands
Test commands
Aircraft type list
Test results
docking status
Guidance and comparison
information, test patterns
Information
and guidance
display
AGD
Ground
operation
panel GOP
Gate
processor
GAP
Gate monitor
Airfield
lights
AGL
AGL monitor
Luxometer
LM
Brightness
Light

FIG 12

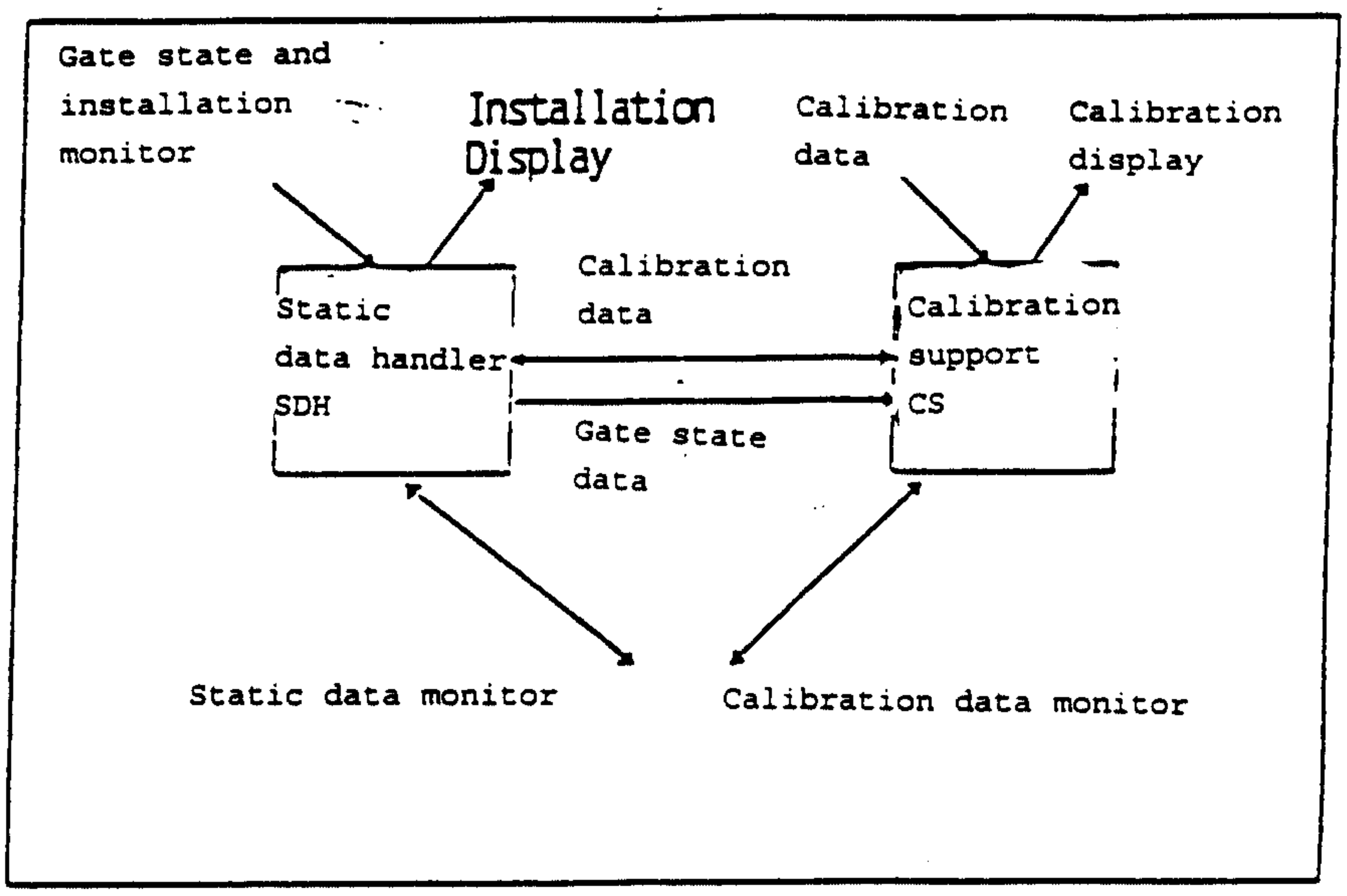

Gate state and installation monitor
Installation Display
Calibration data
Calibration display
Calibration data
Static data handler SDH
Calibration support CS
Gate state data
Static data monitor
Calibration data monitor

FIG 13

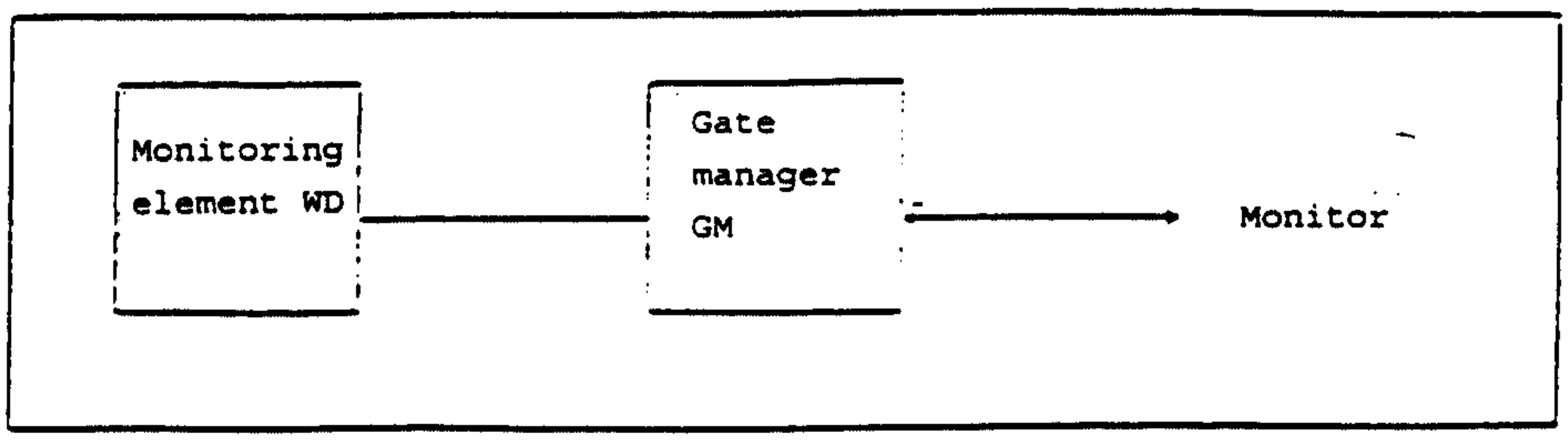

Monitoring element WD
Gate manager GM
Monitor

FIG 14