HARBORSIM

a generally applicable harbour simulation model

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1. INTRODUCTION

Every planning of a port development or design of a new harbour is confronted with the unique physical properties and related problems to be solved.
On the other hand every port can be defined as a link in the transport chain involved in the transfer of cargo from one medium of transport to another.
Every port and its connected transhipment equipment and transport means are designed for the same basic purposed and involves a port consists of a number of systems as:

a. a system of signals (buoys and navigation aids) to enable the ship to make a safe landfall
b. an anchorage for use while a ship is waiting due to tidal conditions or congestion
c. pilot system
d. a system of towage
e. the quays with cargo handling facilities
f. undercover and open storage
g. inland transport system
etc.

It is possible, therefore, to construct an imaginary port which incorporates this features.
Nevertheless to determine the capacity of a portsystem, it is necessary to schematize the reality by leaving out all non relevant aspects.
A powerful method that can be used in the complicated port systems is offered by the discrete computer simulation.
Generally speaking simulation is used to study the dynamic behaviour of the harboursystem by experimentations with a model of that system. In this way it is possible to obtain data which in statistical sense are relevant to the original system.

2. THE OBJECTIVES OF A DISCRETE COMPUTER SIMULATION MODEL

The objectives of discrete computer simulation models are:

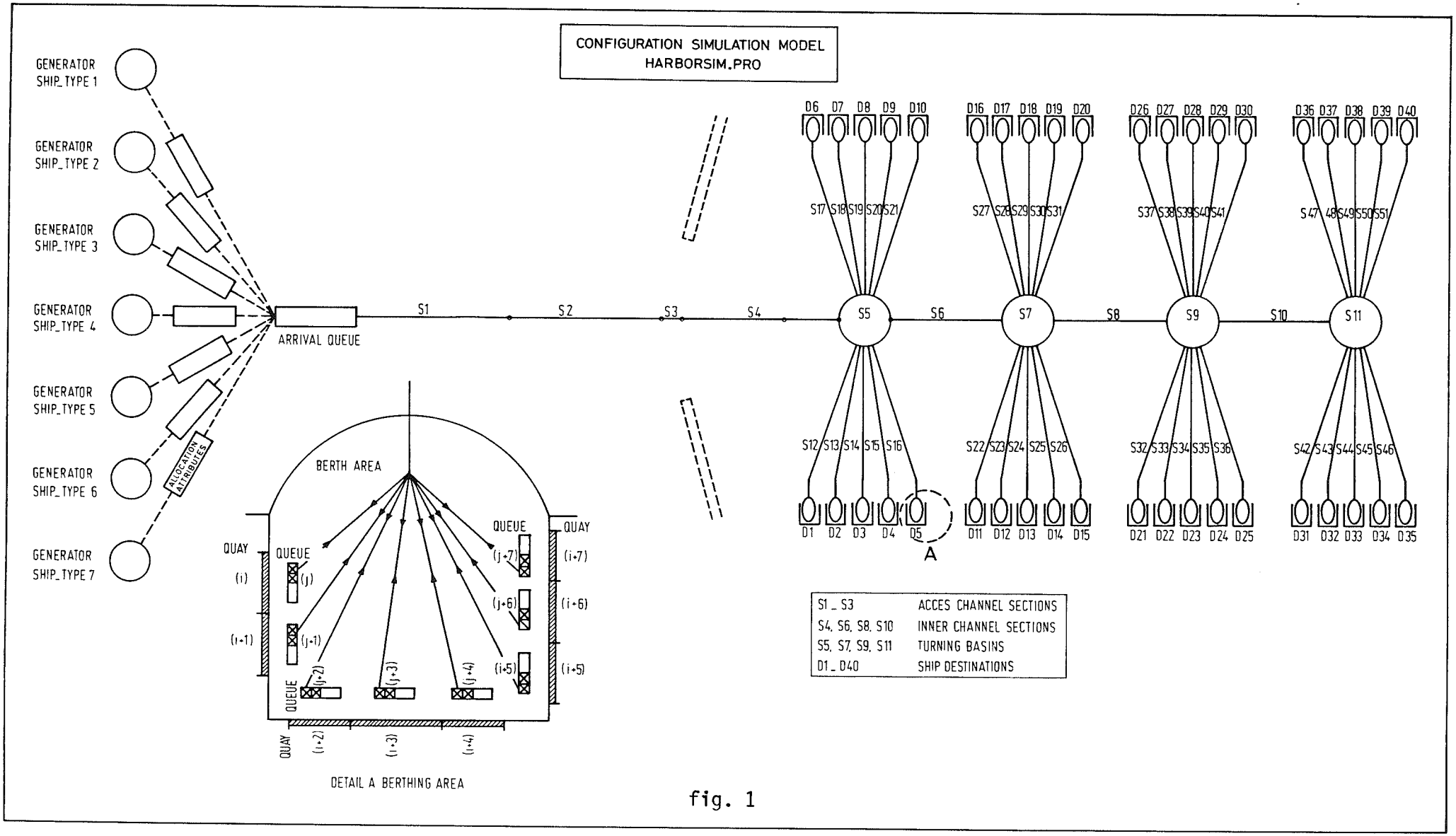
a. With a computer simulation model it is possible to determine the results (contemplated results) of an intervention or a number of interventions. These interventions can be of technical nature as enlarging the transhipment capacity, improvement of the nautical conditions, enlarging of the quaylength or concern management as changing of the priority rules (consequence analysis). In this way it is possible for instance to determine optimal channel depth or quaylength in relation to the waiting times of the ships (optimalisation in port planning).

b. With a number of trial interventions a better insight in the functioning of the system of the port system can be obtained. It is possible to determine the critical parameters and the parameters which affect the system only slightly (structure analysis).

c. If the boundary conditions of the design of a new harbour are available a simulation model can determine whether the design satisfies the design requirements.

For many harbours it is possible to use a generally applicable simulation model. This means the required amount of time and money is rather small concerning the translation from the verbal model to a computer simulation model.

That is why the Hydraulic Engineering Group of Delft University of Technology has developed the general simulation model HARBORSIM.PRO.



DETAIL A BERTHING AREA

fig. 1

3. DESCRIPTION OF THE GENERAL PORT SIMULATION MODEL HARBORSIM

The model Harborsim is a tool for the design of a new port or marine terminal (masterplan and phases in the time) and the extention or improvement of an existing port (improvement of the nautical conditions, enlarging quaylength, enlarging transshipment capacity, etc.). The model includes the movements of ships towards in and away from the port dealing with

- a large number of shiptypes (and if necessary categories per type) with different arrival patterns, service time distribution and priorities;
- tidal conditions (waterlevels and velocities) of each channel section;
- weather conditions (storm and fog);
- day and night navigation.

The general configuration of the model is given in fig. (1) and consists of:

a. an access channel of 4 sections (s1-s4);
b. 4 turning basins (s5, s7, s9, s11) each of which has access to a maximum of 10 basins;
c. each basin may consist of a great number of quays.

Extention of the number of sections in the access channel and the number of turning basins is very easy.
Each channel section in the model can be made one or more way traffic for each shiptype. This information has been put in two three dimensional arrays. These arrays inform whether it is possible that shiptype x overtakes or meets shiptype y in channelsection s.

4. OUTPUT

The model Harborsim.Pro gives per run the following output:

1. The status of the system with data about the queues (number of entries, length, maximum and minimum length during the run, the mean and the maximum waiting time), the status of the components in the model (current, passive or suspended).
2. The number of generated ships per shiptype.
3. For each shiptype:
   - histograms concerning waiting times at the arrival buoy (outside the harbour);
   - histograms concerning waiting times in the harbour;
   - histograms concerning the total waiting times.
4. For each quay or berth:
   histograms concerning the utilization per quay.

SCHEME COMPUTER SIMULATION MODEL HARBORSIM

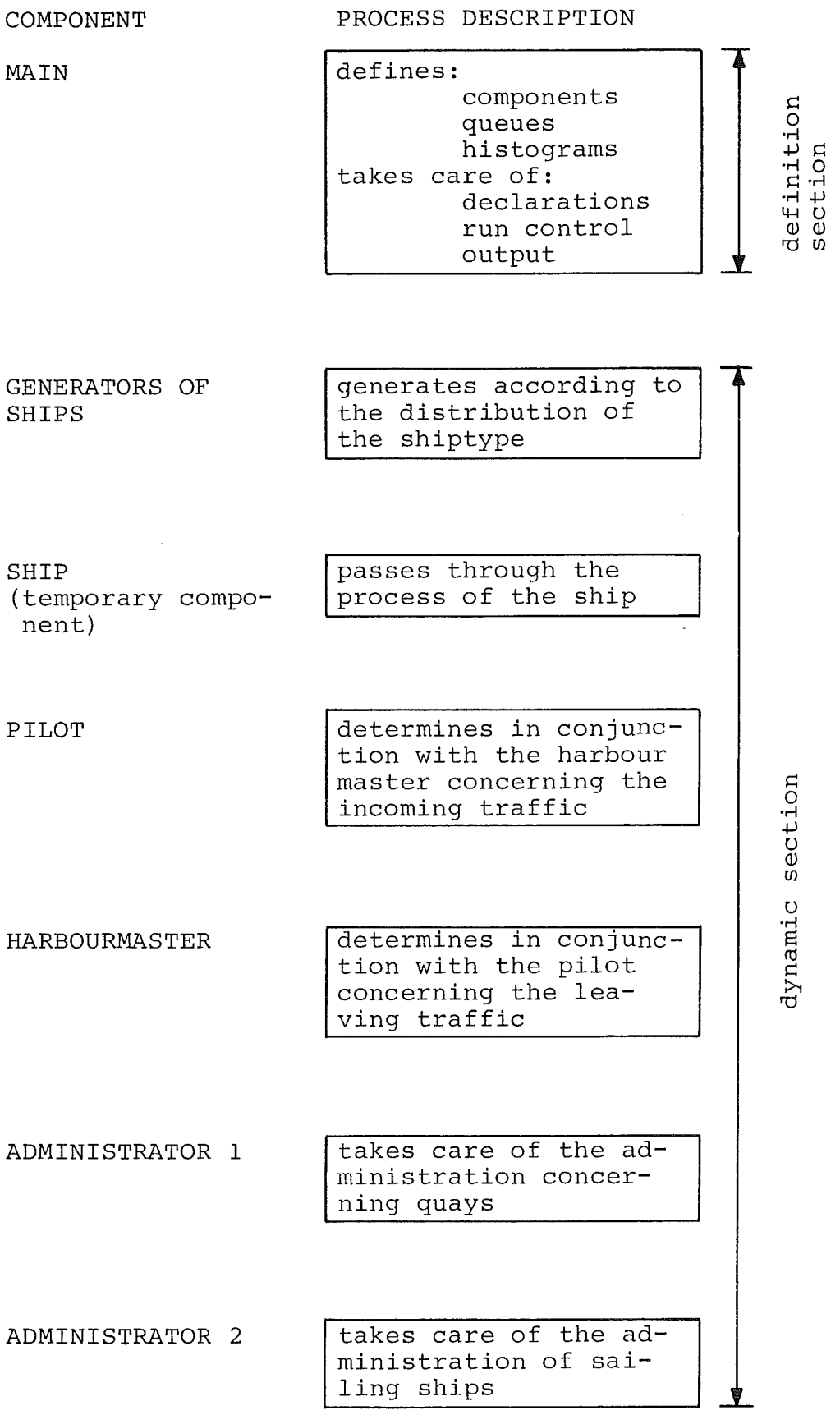


Fig. 2

5. THE MODEL IN DETAIL

5.1. COMPOSITION OF THE MODEL

The computer simulation model has been written in the simulation language Prosim; this simulation language has been developed by the Delft University of Technology.
In Prosim every statement is thought being carried out by a system component as a part of the description of the behaviour of that component. There will remain a number of technical matters such as declarations, activations, run scheduling etc. These matters are considered to be carried out by the Prosim system component MAIN. MAIN exists already before the simulation starts (fig. 2).
The first section of the model, the definition section, is carried out by the component MAIN and shows how the model is composed.
The second section of the computer model, the dynamic section, shows the behaviour of the different components in this model. The process description of the components is given in the next pages.

5.2. PROCESS OF THE COMPONENT MAIN

ACTIVATION — The component MAIN exists already before the simulation starts.

TASK — The component MAIN defines the components GENERATORS, the class of components SHIP and DUMMY-SHIP, the components HARBOURMASTER, PILOT, ADMINISTRATOR 1 and ADMINISTRATOR 2.
MAIN carries out the declarations, the initialization, activations of components and the run scheduling.
At last MAIN takes care of the output of the simulation model.

5.3. PROCESS OF THE GENERATORS

ACTIVATION — The components GENERATOR 1 to 7 are activated by the component MAIN.

TASK — The generator of a shiptype generates ship according the statistical arrivaltime distribution as Poisson, K-Erlang, uniform, normal, etc.
When the arrival of a ship has been generated at the same time, the attributes of that ship are determined as:

1. sailing times
2. the stay in the turning circle
3. sailing stretches
4. quay destination
5. draught for incoming and leaving ships
6. keel clearance
7. length
8. priority coëfficiënt of the ship
9. critical water velocities
10. servicing times

The determination of the servicing time is done according to the statistical servicing time distribution of the ship as Poisson, K-Erlang, uniform or normal etc.

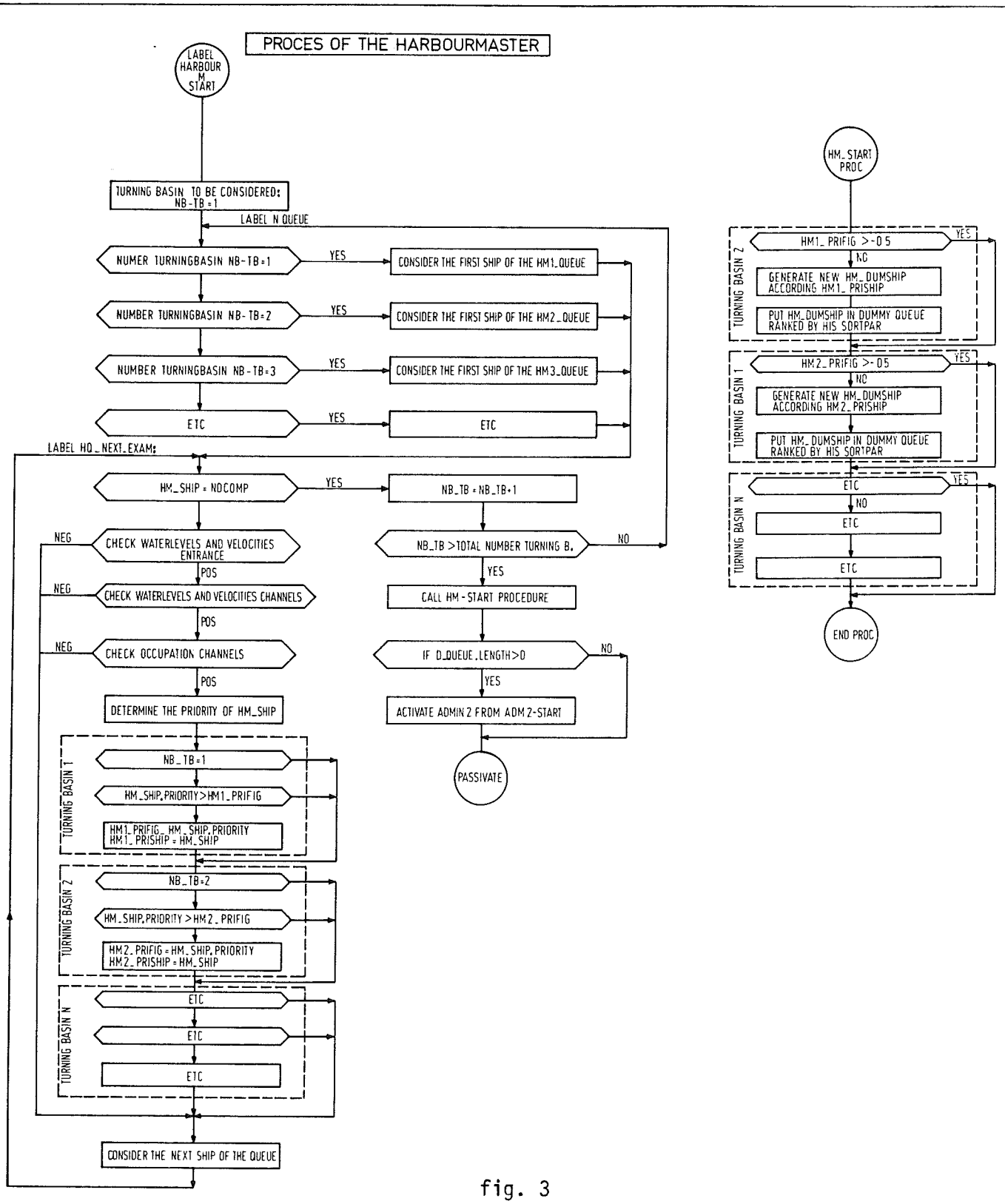

PROCES OF THE HARBOURMASTER
LABEL HARBOUR M START
TURNING BASIN TO BE CONSIDERED: NB-TB=1
LABEL N QUEUE
NUMER TURNINGBASIN NB-TB=1
YES
CONSIDER THE FIRST SHIP OF THE HM1_QUEUE
NUMBER TURNINGBASIN NB-TB=2
YES
CONSIDER THE FIRST SHIP OF THE HM2_QUEUE
NUMBER TURNINGBASIN NB-TB=3
YES
CONSIDER THE FIRST SHIP OF THE HM3_QUEUE
ETC
YES
ETC
LABEL HQ_NEXT_EXAM:
HM_SHIP = NOCOMP
YES
NB_TB = NB_TB+1
NB_TB >TOTAL NUMBER TURNING B.
NO
YES
CALL HM-START PROCEDURE
IF D_QUEUE.LENGTH>0
NO
YES
ACTIVATE ADMIN 2 FROM ADM 2-START
PASSIVATE
NEG
CHECK WATERLEVELS AND VELOCITIES ENTRANCE
POS
NEG
CHECK WATERLEVELS AND VELOCITIES CHANNELS
POS
NEG
CHECK OCCUPATION CHANNELS
POS
DETERMINE THE PRIORITY OF HM_SHIP
TURNING BASIN 1
NB_TB=1
HM_SHIP.PRIORITY>HM1_PRIFIG
HM1_PRIFIG = HM_SHIP.PRIORITY
HM1_PRISHIP = HM_SHIP
TURNING BASIN 2
NB_TB=2
HM_SHIP.PRIORITY > HM2_PRIFIG
HM2_PRIFIG = HM_SHIP.PRIORITY
HM2_PRISHIP = HM_SHIP
TURNING BASIN N
ETC
ETC
ETC
CONSIDER THE NEXT SHIP OF THE QUEUE
HM_START PROC
TURNING BASIN 2
HM1_PRIFIG >-0.5
YES
NO
GENERATE NEW HM_DUMSHIP ACCORDING HM1_PRISHIP
PUT HM_DUMSHIP IN DUMMY QUEUE RANKED BY HIS SORTPAR
TURNING BASIN 1
HM2_PRIFIG >-0.5
YES
NO
GENERATE NEW HM_DUMSHIP ACCORDING HM2_PRISHIP
PUT HM_DUMSHIP IN DUMMY QUEUE RANKED BY HIS SORTPAR
TURNING BASIN N
ETC
YES
NO
ETC
ETC
END PROC

fig. 3

5.4. PROCESS OF THE HARBOURMASTER

ACTIVATION

The process of the Harbourmaster is activated by the component Pilot.

TASK

The Harbourmaster in conjunction with the Pilot and Administrator 2 controls the leaving navigation traffic. The Harbourmaster considers for this purpose the queues HM1-QUEUE, HM2-QUEUE, HM3-QUEUE etc. of ships ready to leave.
The HM-1-QUEUE for example contains the ships with the destinations (1-10) connected with turning basin 1 (s5), see fig. (1).

FLOW CHART (fig. 3)

The Harbourmaster considers the first ship of the queue HM1-QUEUE.
For this ship a number of checks are done:

1. the free quaylength (FREEQUAY-LENGTH)
2. the tidal conditions (WATERLEVELS AND VELOCITIES)
3. the occupation of the channels (OCCUPATION CHANNELS)

If all these checks are satisfactory the priority of the ship is calculated. If the priority is higher than the value of the variable HM1-PRIFIG then:

1. the value of the priority is given to the variable HM1-PRIFIG
2. the ship of issue is considered to be the priority ship HM1-PRISHIP

Hereafter the next ship in the HM1-QUEUE is considered and above mentioned handlings are repeated from the label HQ-NEXT-EXAM.
If the HM1-QUEUE has been passed through (HM-SHIP = NOCOMP) the HM2-QUEUE containing ships ready to leave with the destinations 11-20 connected with turning basin 2 (s7) is considered and the cycle is repeated from the label N-QUEUE.
In this way if necessary HM3-QUEUE and HM4-QUEUE are passed through.
The priority ships (HM1-PRISHIP, HM2-PRISHIP, HM3-PRISHIP, HM4-PRISHIP), if extant, are copied in the shape of dummy ships and put in the dummy queue (D-QUEUE) ranked by the priority.
Then, provided the length of the D-QUEUE > 0, the component Administrator 2 (ADM2) is activated in the procedure HM-START-PROC.
The Harbourmaster is passivated.

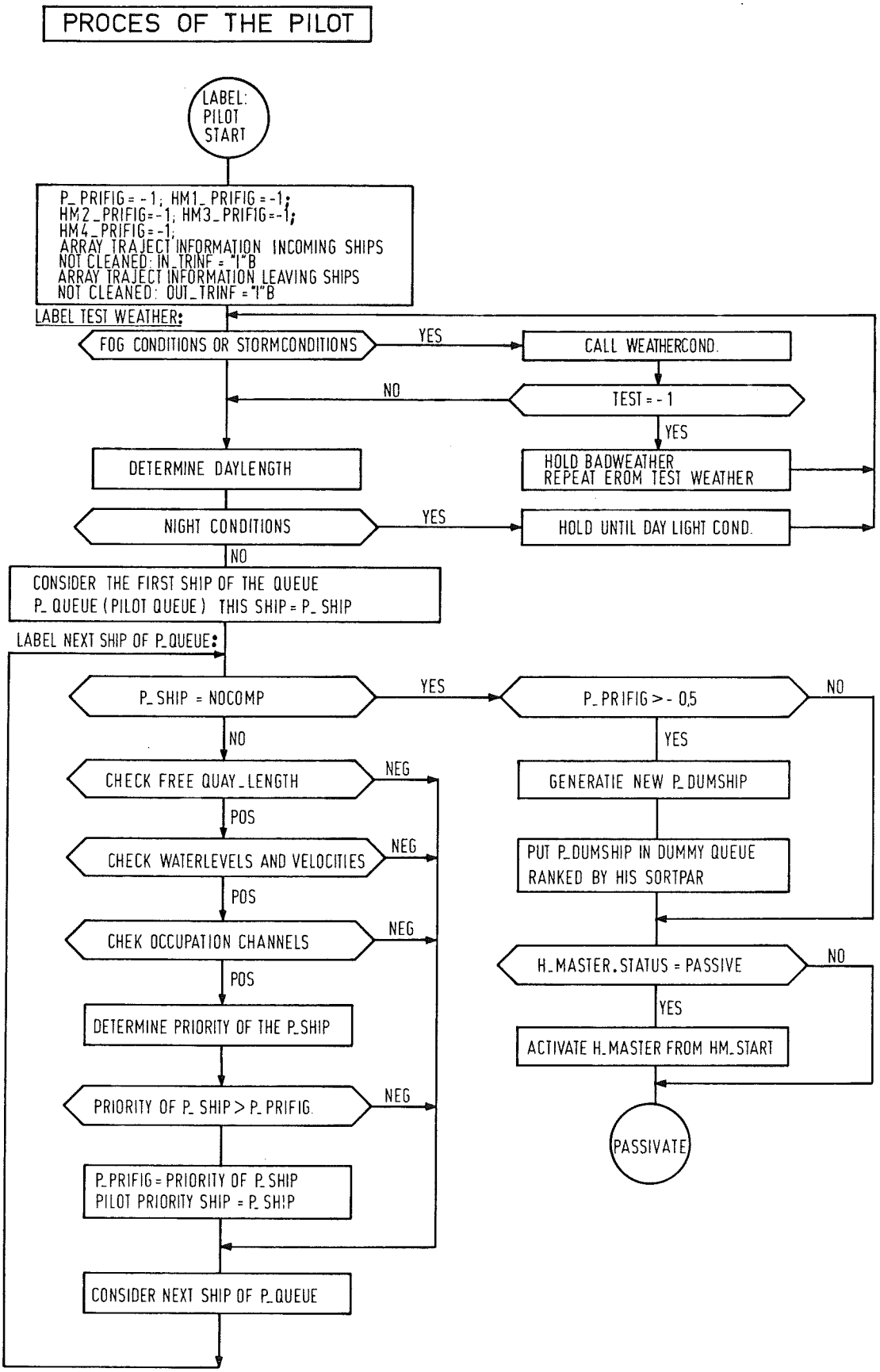

PROCES OF THE PILOT
LABEL: PILOT START
P_PRIFIG = -1; HM1_PRIFIG = -1;
HM2_PRIFIG=-1; HM3_PRIFIG=-1;
HM4_PRIFIG=-1;
ARRAY TRAJECT INFORMATION INCOMING SHIPS
NOT CLEANED: IN_TRINF = "1"B
ARRAY TRAJECT INFORMATION LEAVING SHIPS
NOT CLEANED: OUT_TRINF = "1"B
LABEL TEST WEATHER:
FOG CONDITIONS OR STORMCONDITIONS
YES
CALL WEATHERCOND.
NO
TEST = -1
YES
DETERMINE DAYLENGTH
HOLD BADWEATHER
REPEAT EROM TEST WEATHER
NIGHT CONDITIONS
YES
HOLD UNTIL DAY LIGHT COND.
NO
CONSIDER THE FIRST SHIP OF THE QUEUE
P_QUEUE (PILOT QUEUE) THIS SHIP = P_SHIP
LABEL NEXT SHIP OF P_QUEUE:
P_SHIP = NOCOMP
YES
P_PRIFIG > -0,5
NO
NO
YES
CHECK FREE QUAY_LENGTH
NEG
GENERATIE NEW P_DUMSHIP
POS
CHECK WATERLEVELS AND VELOCITIES
NEG
PUT P_DUMSHIP IN DUMMY QUEUE
RANKED BY HIS SORTPAR
POS
CHEK OCCUPATION CHANNELS
NEG
H_MASTER.STATUS = PASSIVE
NO
POS
YES
DETERMINE PRIORITY OF THE P_SHIP
ACTIVATE H_MASTER FROM HM_START
PRIORITY OF P_SHIP > P_PRIFIG
NEG
PASSIVATE
P_PRIFIG = PRIORITY OF P_SHIP
PILOT PRIORITY SHIP = P_SHIP
CONSIDER NEXT SHIP OF P_QUEUE

fig. 4

5.5. PROCESS OF THE PILOT

ACTIVATION

The process of the Pilot is activated by the component Harbourmaster or the component Administrator 2.

TASK

The Pilot in conjunction with the Harbourmaster and Administrator 2 controls the incoming navigation traffic.

FLOW CHART (fig. 4)

After giving values to a number of auxiliary variables the Pilot asks for the weather conditions (fog and storm) and determines the daylength. If no restrictions concerning weather conditions and daylength exist, the first ship of the queue of the Pilot (P-QUEUE) is considered, if not the Pilot waits until these conditions are satisfactory.
Next a number of checks are done:

1. free quaylength
2. the tidal conditions
3. the occupation of the channels

If all these checks are satisfactory the priority of the ship is calculated. If this priority of the concerning ship is higher than the value of the variable P-PRIFIG then:

1. the value of the priority is given to the variable P-PRIFIG
2. the ship at issue is considered to be the priority ship of the Pilot (P-PRISHIP).

The Pilot has only one priority ship.
Hereafter the next ship in the queue of the Pilot is considered and above mentioned handlings are repeated from the label NEXT-SHIPS-OF-P-QUEUE.
If the queue has been passed through (P-SHIP=NOCOMP) the ship with the highest priority (P-PRISHIP) is copied in the shape of a dummy ship (P-DUMSHIP).
This dummy ship is placed in the dummy queue (D-QUEUE) ranked by its priority.
The Harbourmaster is activated provided his status is idle.
The Pilot is passivated.

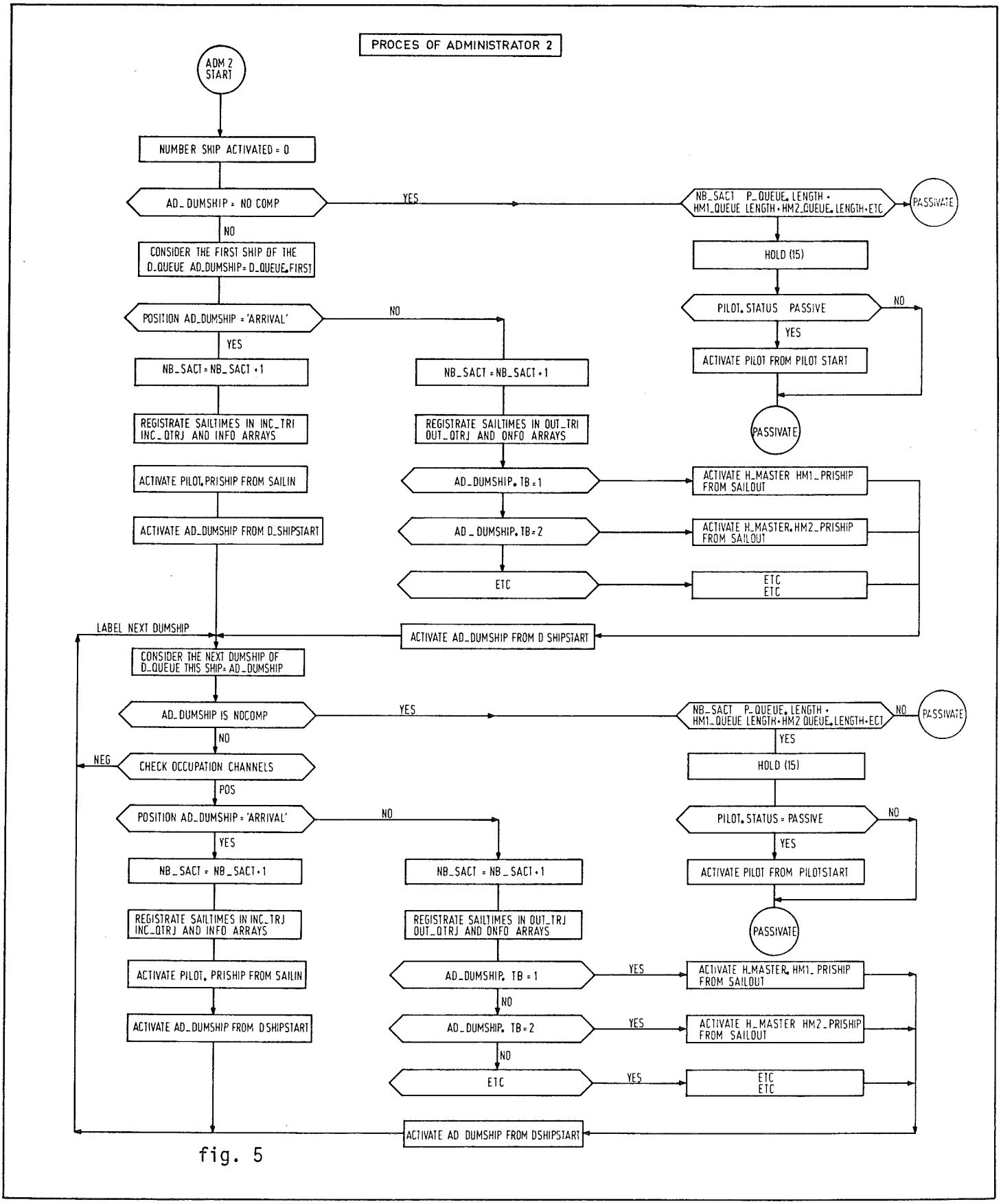

PROCES OF ADMINISTRATOR 2
ADM 2 START
NUMBER SHIP ACTIVATED = 0
AD_DUMSHIP = NO COMP
YES
NB_SACT P_QUEUE_LENGTH + HM1_QUEUE LENGTH + HM2_QUEUE_LENGTH+ETC
PASSIVATE
NO
CONSIDER THE FIRST SHIP OF THE D_QUEUE AD_DUMSHIP= D_QUEUE_FIRST
HOLD (15)
POSITION AD_DUMSHIP = 'ARRIVAL'
NO
PILOT_STATUS PASSIVE
NO
YES
YES
NB_SACT = NB_SACT + 1
NB_SACT = NB_SACT + 1
ACTIVATE PILOT FROM PILOT START
REGISTRATE SAILTIMES IN INC_TRJ INC_QTRJ AND INFO ARRAYS
REGISTRATE SAILTIMES IN OUT_TRJ OUT_QTRJ AND ONFO ARRAYS
PASSIVATE
ACTIVATE PILOT_PRISHIP FROM SAILIN
AD_DUMSHIP_TB = 1
ACTIVATE H_MASTER HM1_PRISHIP FROM SAILOUT
ACTIVATE AD_DUMSHIP FROM D_SHIPSTART
AD_DUMSHIP_TB = 2
ACTIVATE H_MASTER_HM2_PRISHIP FROM SAILOUT
ETC
ETC ETC
LABEL NEXT DUMSHIP
ACTIVATE AD_DUMSHIP FROM D SHIPSTART
CONSIDER THE NEXT DUMSHIP OF D_QUEUE THIS SHIP= AD_DUMSHIP
AD_DUMSHIP IS NDCOMP
YES
NB_SACT P_QUEUE_LENGTH + HM1_QUEUE LENGTH + HM2 QUEUE_LENGTH+ECT
NO
PASSIVATE
NO
YES
NEG
CHECK OCCUPATION CHANNELS
HOLD (15)
POS
POSITION AD_DUMSHIP = 'ARRIVAL'
NO
PILOT_STATUS = PASSIVE
NO
YES
YES
NB_SACT = NB_SACT + 1
NB_SACT = NB_SACT + 1
ACTIVATE PILOT FROM PILOTSTART
REGISTRATE SAILTIMES IN INC_TRJ INC_QTRJ AND INFO ARRAYS
REGISTRATE SAILTIMES IN OUT_TRJ OUT_QTRJ AND ONFO ARRAYS
PASSIVATE
ACTIVATE PILOT_PRISHIP FROM SAILIN
AD_DUMSHIP_TB = 1
YES
ACTIVATE H_MASTER_HM1_PRISHIP FROM SAILOUT
ACTIVATE AD_DUMSHIP FROM DSHIPSTART
NO
AD_DUMSHIP_TB = 2
YES
ACTIVATE H_MASTER HM2_PRISHIP FROM SAILOUT
NO
ETC
YES
ETC ETC
ACTIVATE AD DUMSHIP FROM DSHIPSTART

fig. 5

5.6. PROCESS OF THE ADMINISTRATOR 2

ACTIVATION

The process of the component Administrator 2 (ADM2) is activated by the Harbourmaster.

TASK

The Administrator 2 orders the ships to enter or leave the port and carries out the necessary administrations.

FLOW CHART (fig. 5)

The Administrator 2 considers the first dummy ship (AD-DUMSHIP) of the dummy queue (D-QUEUE).
If this dummy ship refers to a ship in the queue of the Pilot (POSITION AD-DUMSHIP IS ARRIVAL) then:

1. the data of this ship and the sail times are registrated in the arrays INC-TRJ, INC-QTRJ, INFO
2. the priority ship of the Pilot (P-PRISHIP) and the dummy ship (AD-DUMSHIP) are activated

If the first ship of the dummy queue refers to a ship in the port then:

1. the data of this ship and the sail times are registrated in the arrays OUT-TRJ, OUT-QTRJ, INFO
2. the dummy ship and the belonging priority ship in the port (HM1-PRISHIP, HM2-PRISHIP, HM3-PRISHIP or HM4-PRISHIP) are activated

In the case the dummy queue is empty (AD-DUMSHIP=NOCOMP) the ADM2 checks if ships are waiting to enter of leave the port (NB-SACT <P-QUEUE+HM1-QUEUE+HM2-QUEUE+ETC.) and if so the Pilot is activated after 15 minutes and the ADM2 is passivated.
The ADM2 considers the next dummy ship of the dummy queue.
If extant the ADM2 checks the occupation of the channels.
If this check is satisfactory the data and the sail times of the ship are registrated. The dummy ship and the belonging priority ship are activated. This cycle is repeated from the label NEXT DUMSHIP. If the dummy queue has been passed through (AD-DUMSHIP=NOCOMP) and if ships are still waiting to enter or leave the port (NB-SACT<P-QUEUE+HM1-QUEUE+HM2-QUEUE+ETC.) the Pilot is activated after 15 minutes.
The ADM2 is passivated.

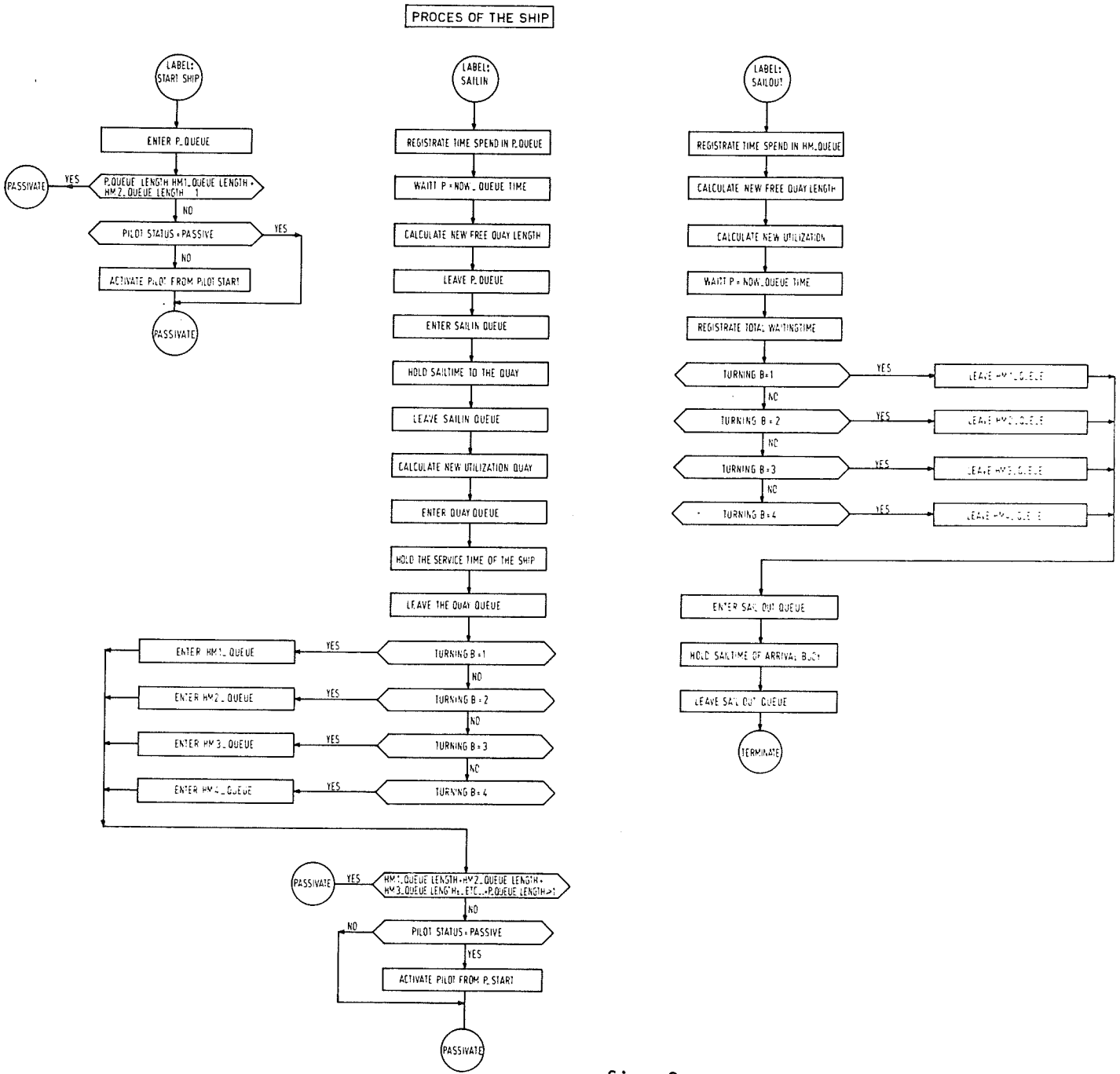

PROCES OF THE SHIP
LABEL: START SHIP
ENTER P_QUEUE
PASSIVATE
YES
P_QUEUE_LENGTH HM1_QUEUE LENGTH + HM 2_QUEUE_LENGTH = 1
NO
PILOT STATUS = PASSIVE
YES
NO
ACTIVATE PILOT FROM PILOT START
PASSIVATE
LABEL: SAILIN
REGISTRATE TIME SPEND IN P_QUEUE
WAITT P = NOW_QUEUE TIME
CALCULATE NEW FREE QUAY LENGTH
LEAVE P_QUEUE
ENTER SAILIN QUEUE
HOLD SAILTIME TO THE QUAY
LEAVE SAILIN QUEUE
CALCULATE NEW UTILIZATION QUAY
ENTER QUAY QUEUE
HOLD THE SERVICE TIME OF THE SHIP
LEAVE THE QUAY QUEUE
TURNING B = 1
YES
ENTER HM1_QUEUE
NO
TURNING B = 2
YES
ENTER HM2_QUEUE
NO
TURNING B = 3
YES
ENTER HM3_QUEUE
NO
TURNING B = 4
YES
ENTER HM4_QUEUE
PASSIVATE
YES
HM1_QUEUE LENGTH + HM2_QUEUE LENGTH + HM3_QUEUE LENGTH, ETC. + P_QUEUE LENGTH > 1
NO
NO
PILOT STATUS = PASSIVE
YES
ACTIVATE PILOT FROM P_START
PASSIVATE
LABEL: SAILOUT
REGISTRATE TIME SPEND IN HM_QUEUE
CALCULATE NEW FREE QUAY LENGTH
CALCULATE NEW UTILIZATION
WAITT P = NOW_QUEUE TIME
REGISTRATE TOTAL WAITINGTIME
TURNING B=1
YES
LEAVE HM1_QUEUE
NO
TURNING B = 2
YES
LEAVE HM2_QUEUE
NO
TURNING B = 3
YES
LEAVE HM3_QUEUE
NO
TURNING B = 4
YES
LEAVE HM4_QUEUE
ENTER SAIL OUT QUEUE
HOLD SAILTIME OF ARRIVAL BUOY
LEAVE SAIL OUT QUEUE
TERMINATE

fig. 9

5.7. PROCESS OF THE SHIP

ACTIVATION

The process of the ship is activated by the component Generator of the ship and the component Administrator 2.

TASK

The ship passes through the port system; the components Pilot, Harbourmaster and Administrator 2 run this process.

FLOW CHART (fig. 9)

When a ship arrives (generated by the component generator) the ship is put in the queue of the Pilot (P-QUEUE).
The ship activates the Pilot if no ships, waiting to get permission to leave or enter the port, are present.
The ship is passivated.
The ship proceeds its process when the component Administrator 2 gives permission. The ship calculates its waiting time in the P-QUEUE, the FREE-QUAY-LENGTH and leaves the P-QUEUE.
The ship is put in the SAILIN-QUEUE and stays in this queue during its sail time from the arrival point to the quay. (HOLD SAIL TIME TO THE QUAY).
Then the ship leaves the SAILIN QUEUE, calculates the new utilization of the quay and is put in the QUAY QUEUE.
The ship stays in this QUAY QUEUE during its service time (HOLD THE SERVICE TIME OF THE SHIP), leaves the QUAY QUEUE and is put in the HM1-QUEUE, HM2-QUEUE, HM3-QUEUE or HM4-QUEUE according to the destination of the ship.
The ship activates the Pilot if no ships waiting for permission to leave or enter the port are present.
Then the ship is passivated.
The ship proceeds the process from the label SAIL OUT QUEUE when the component Administrator 2 gives permission to leave the port. The ship leaves its queue, is put in the SAILOUT QUEUE and stays in this queue during the sail time from the quay to the arrival point (HOLD SAIL TIME TO THE ARRIVAL BUOY).
Then the ship leaves the queue and leaves the system (TERMINATE).

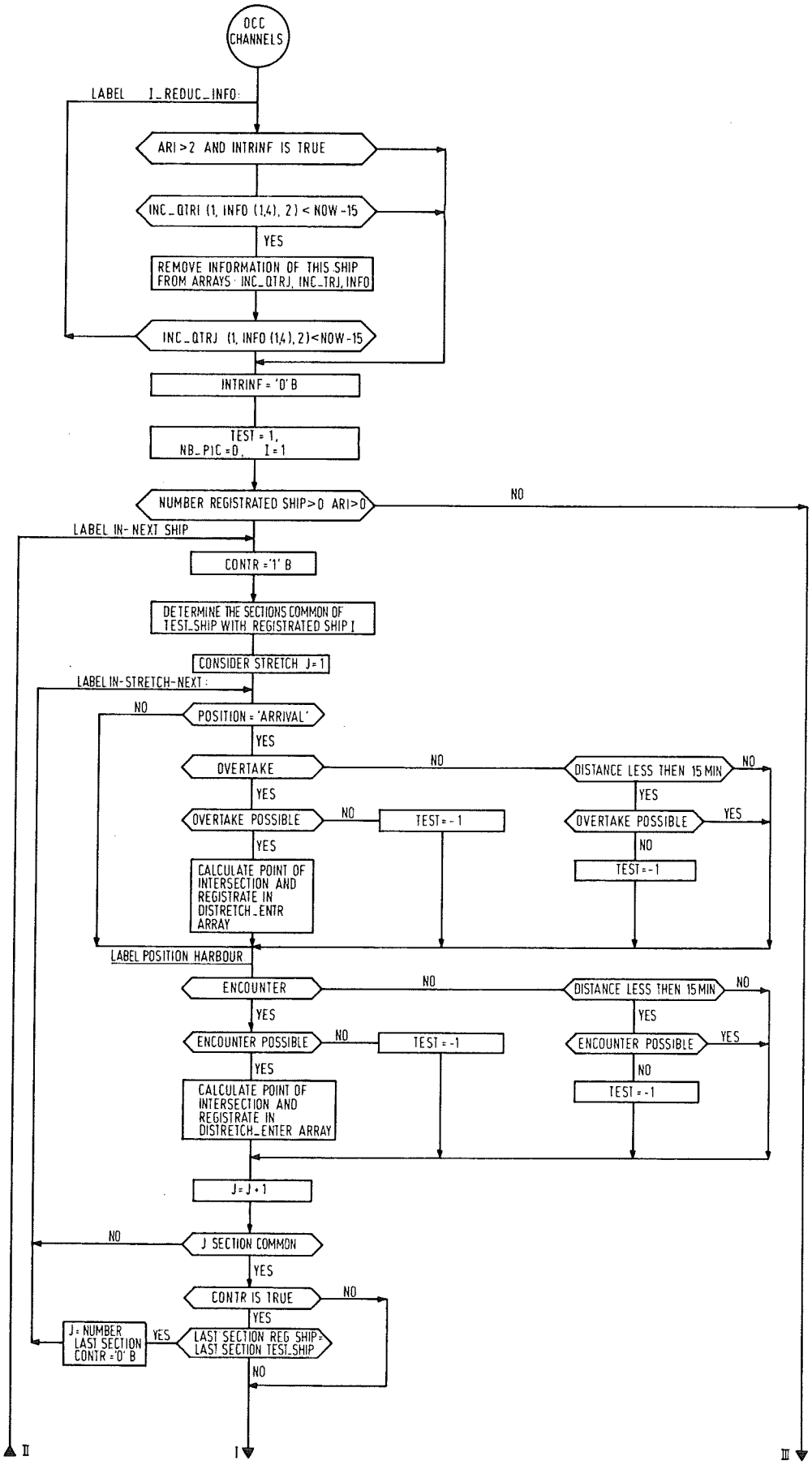

OCC CHANNELS
LABEL I_REDUC_INFO:
ARI>2 AND INTRINF IS TRUE
INC_QTRI (1, INFO (1,4), 2) < NOW-15
YES
REMOVE INFORMATION OF THIS SHIP FROM ARRAYS INC_QTRJ, INC_TRJ, INFO
INC_QTRJ (1, INFO (1,4), 2)<NOW-15
INTRINF = '0'B
TEST = 1, NB_PIC=0, I=1
NUMBER REGISTRATED SHIP>0 ARI>0
NO
LABEL IN-NEXT SHIP
CONTR ='1' B
DETERMINE THE SECTIONS COMMON OF TEST_SHIP WITH REGISTRATED SHIP I
CONSIDER STRETCH J=1
LABEL IN-STRETCH-NEXT:
NO
POSITION = 'ARRIVAL'
YES
OVERTAKE
NO
DISTANCE LESS THEN 15 MIN
NO
YES
YES
OVERTAKE POSSIBLE
NO
TEST=-1
YES
OVERTAKE POSSIBLE
YES
NO
TEST=-1
YES
CALCULATE POINT OF INTERSECTION AND REGISTRATE IN DISTRETCH_ENTR ARRAY
LABEL POSITION HARBOUR
ENCOUNTER
NO
DISTANCE LESS THEN 15 MIN
NO
YES
YES
ENCOUNTER POSSIBLE
NO
TEST=-1
ENCOUNTER POSSIBLE
YES
NO
TEST=-1
YES
CALCULATE POINT OF INTERSECTION AND REGISTRATE IN DISTRETCH_ENTER ARRAY
J=J+1
NO
J SECTION COMMON
YES
CONTR IS TRUE
NO
YES
J=NUMBER LAST SECTION CONTR='0' B
YES
LAST SECTION REG SHIP= LAST SECTION TEST_SHIP
NO
II
I
III

fig. 6

5.8. PROCEDURE OCCUPATION CHANNELS

ACTIVATION

The procedure occupation channels is passed through both in the process of the Pilot and in the process of the Harbourmaster.

TASK

The procedure determines the possibility of entering or leaving of a ship related to the occupation of the channel section, turning circles and berthing areas.

FLOW CHART (fig.6,7,8)

From the label I-REDUC-INFO the superfluous information concerning sailing times of incoming ships is removed from the arrays INC-TRJ, INC-ATRJ and INFO.
The value of a number of auxiliary variables is determined.
If incoming ships are registrated (NUMBER REGISTRATED >0) the common channel sections of the first registrated ship and the test-ship of the sections s1 - s11 are determined. Then starting with section 1 the procedure controls dependently on the position of the concerning ship (POSITION = "ARRIVAL" or POSITION = "HARBOUR") whether overtaking or meeting takes place and if so the procedure checks if that is permitted.
This process is repeated for the next sections (I = I + 1) from the label IN-NEXT-STRETCH.
Then if the registrated ship and the test-ship have the same destination the last channel section is controled.
Further the turning circles are controled and when the ships have the same destinations the procedure controls the berthing area.
This procedure is repeated for every registrated incoming ship from the label IN-NEXT-SHIP.

In the same way the procedure removes the superfluous information concerning sailing times of leaving ships (from the label O-REDUC-INFO) and possible conflict situations in channal sections, turning basins and berthing areas are determined.

If the test-ship meets somewhere a conflict situation the value of the variable TEST becomes -1.

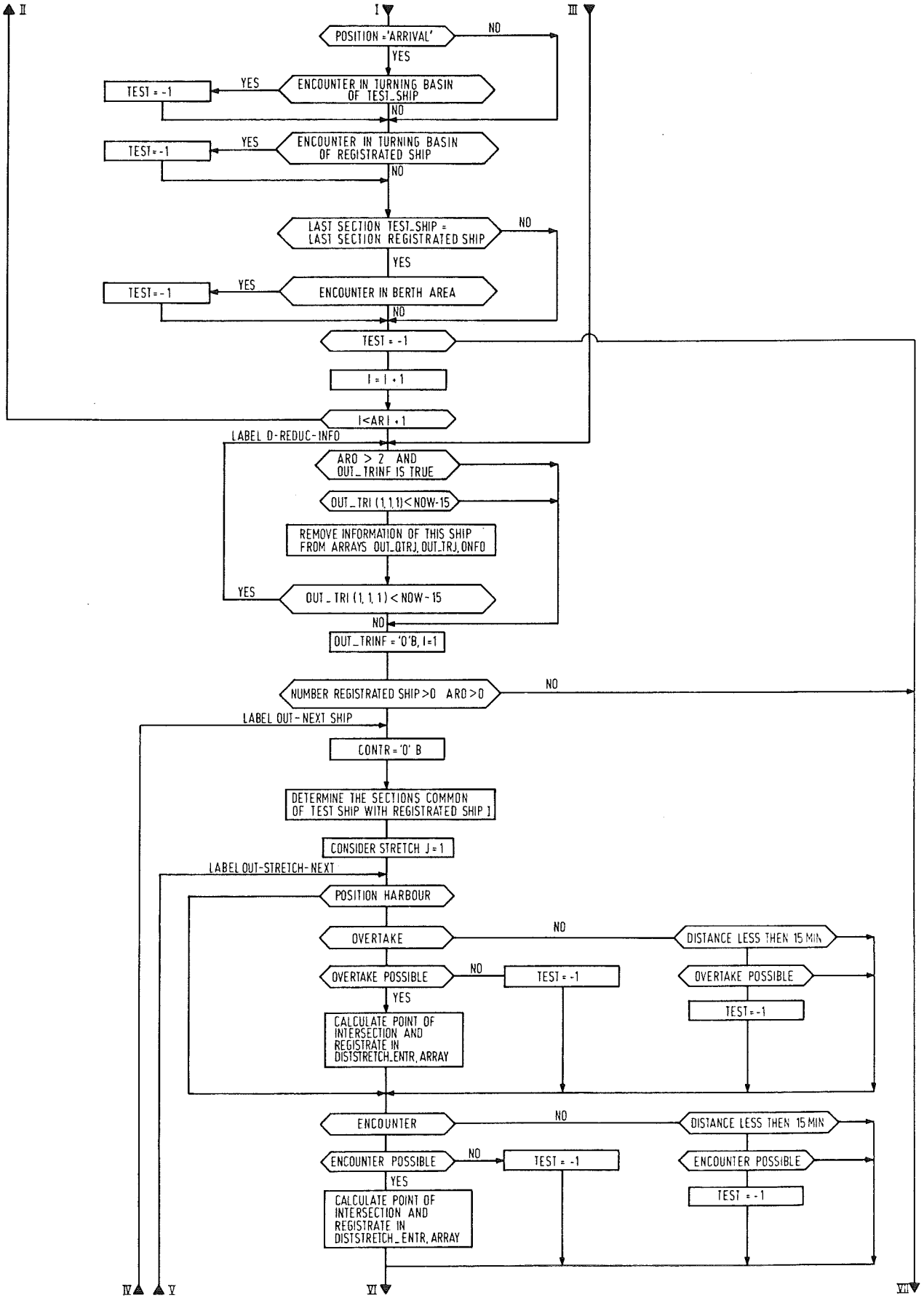

II
I
III
POSITION = 'ARRIVAL'
NO
YES
TEST = -1
YES
ENCOUNTER IN TURNING BASIN OF TEST_SHIP
NO
TEST = -1
YES
ENCOUNTER IN TURNING BASIN OF REGISTRATED SHIP
NO
LAST SECTION TEST_SHIP = LAST SECTION REGISTRATED SHIP
NO
YES
TEST = -1
YES
ENCOUNTER IN BERTH AREA
NO
TEST = -1
I = I + 1
I<ARI + 1
LABEL D-REDUC-INFO
ARO > 2 AND OUT_TRINF IS TRUE
OUT_TRI (1, 1, 1) < NOW-15
REMOVE INFORMATION OF THIS SHIP FROM ARRAYS OUT_QTRJ, OUT_TRJ, ONFO
YES
OUT_TRI (1, 1, 1) < NOW - 15
NO
OUT_TRINF = '0'B, I=1
NUMBER REGISTRATED SHIP>0 ARO>0
NO
LABEL OUT-NEXT SHIP
CONTR = '0' B
DETERMINE THE SECTIONS COMMON OF TEST SHIP WITH REGISTRATED SHIP J
CONSIDER STRETCH J = 1
LABEL OUT-STRETCH-NEXT
POSITION HARBOUR
OVERTAKE
NO
DISTANCE LESS THEN 15 MIN
OVERTAKE POSSIBLE
NO
TEST = -1
OVERTAKE POSSIBLE
YES
TEST = -1
CALCULATE POINT OF INTERSECTION AND REGISTRATE IN DISTSTRETCH_ENTR, ARRAY
ENCOUNTER
NO
DISTANCE LESS THEN 15 MIN
ENCOUNTER POSSIBLE
NO
TEST = -1
ENCOUNTER POSSIBLE
YES
TEST = -1
CALCULATE POINT OF INTERSECTION AND REGISTRATE IN DISTSTRETCH_ENTR, ARRAY
IV
V
VI
VII

fig. 7

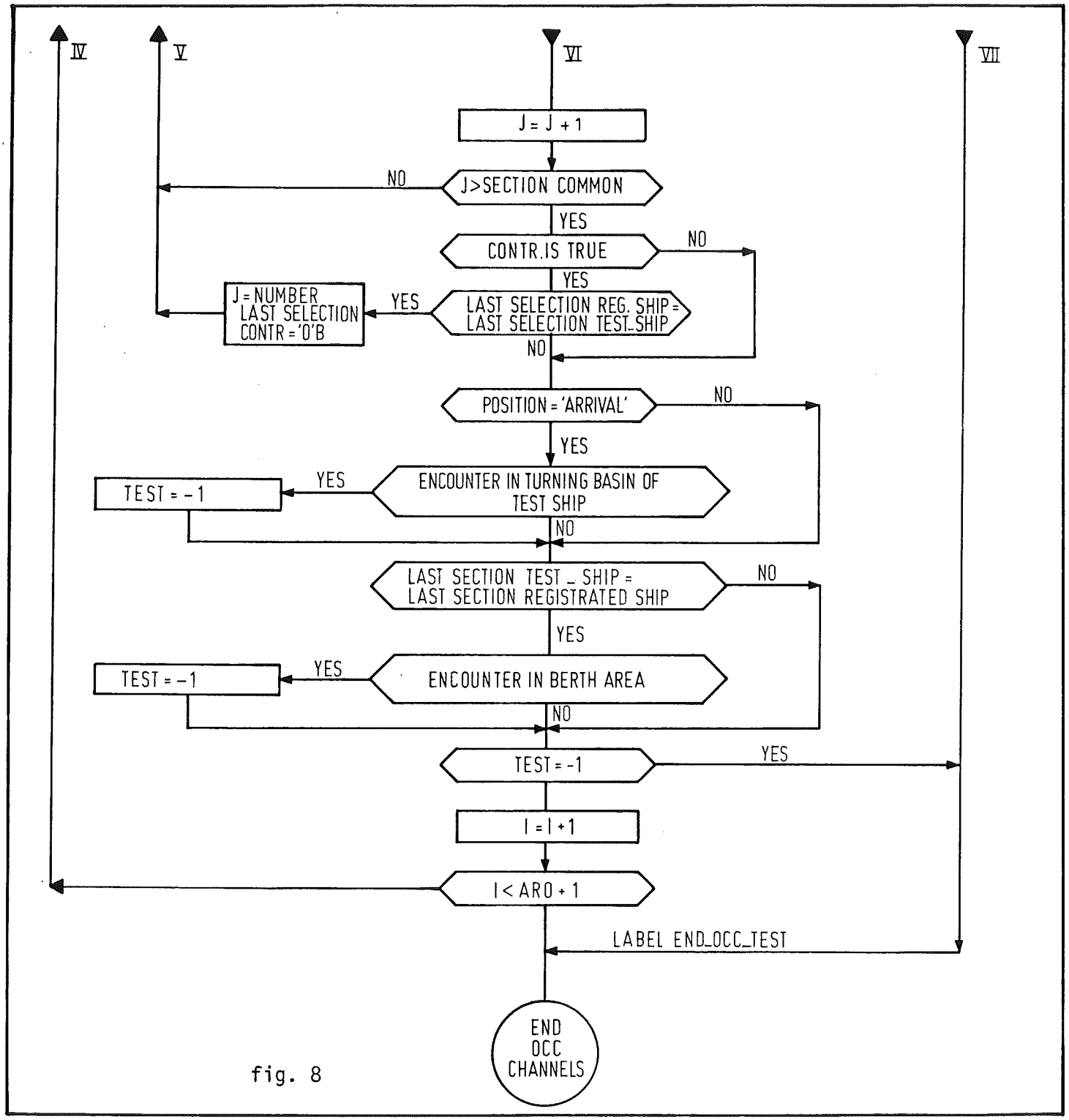

IV
V
VI
VII
J = J + 1
NO
J>SECTION COMMON
YES
CONTR.IS TRUE
NO
YES
J = NUMBER LAST SELECTION CONTR = '0'B
YES
LAST SELECTION REG. SHIP = LAST SELECTION TEST_SHIP
NO
POSITION = 'ARRIVAL'
NO
YES
TEST = -1
YES
ENCOUNTER IN TURNING BASIN OF TEST SHIP
NO
LAST SECTION TEST _ SHIP = LAST SECTION REGISTRATED SHIP
NO
YES
TEST = -1
YES
ENCOUNTER IN BERTH AREA
NO
TEST = -1
YES
I = I + 1
I < ARO + 1
LABEL END_OCC_TEST
END OCC CHANNELS

fig. 8

5.9. PROCESS OF THE ADMINISTRATOR 1

ACTIVATION — The process of the Administrator 1 is activated by the component MAIN.

TASK — The Administrator 1 registrates the utilization of the different quays and berthing points used in the model in the concerning histograms.
The Administrator 1 is suspended during a fixed time interval and registrates again the utilization of quays and berthing points etc.

5.10. PROCESS OF THE DUMMY SHIP

ACTIVATION — The process of the dummy ship is activated by the component Pilot or the component Harbourmaster.

TASK — A dummy ship is used because the computer language Prosim doesn't allow that a component is placed in two queues at the same time. To solve this problem each time a dummy ship is created and placed in the dummy queue.
After being put in the dummy queue the dummy ship leaves this queue and is terminated.