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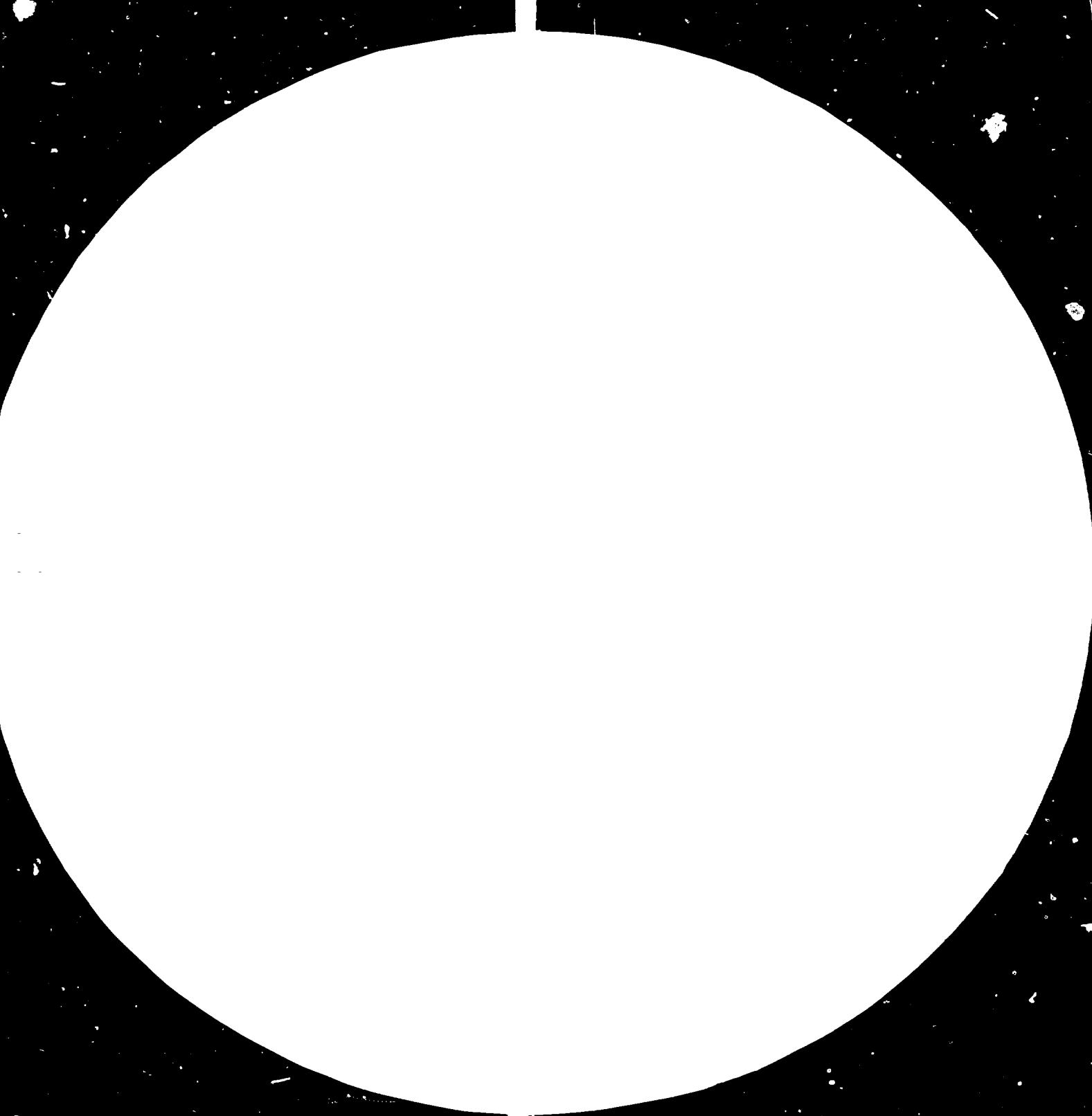

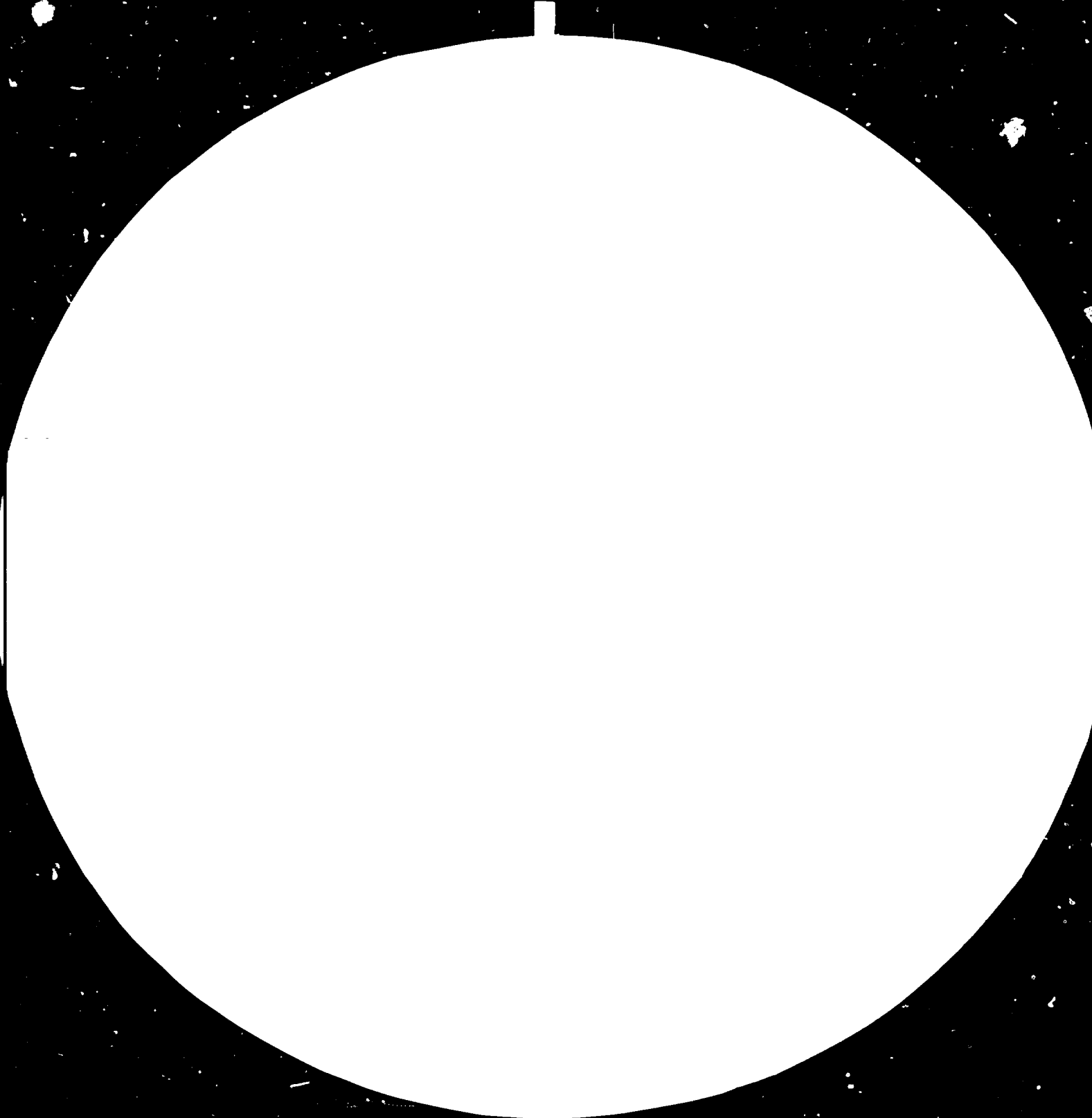

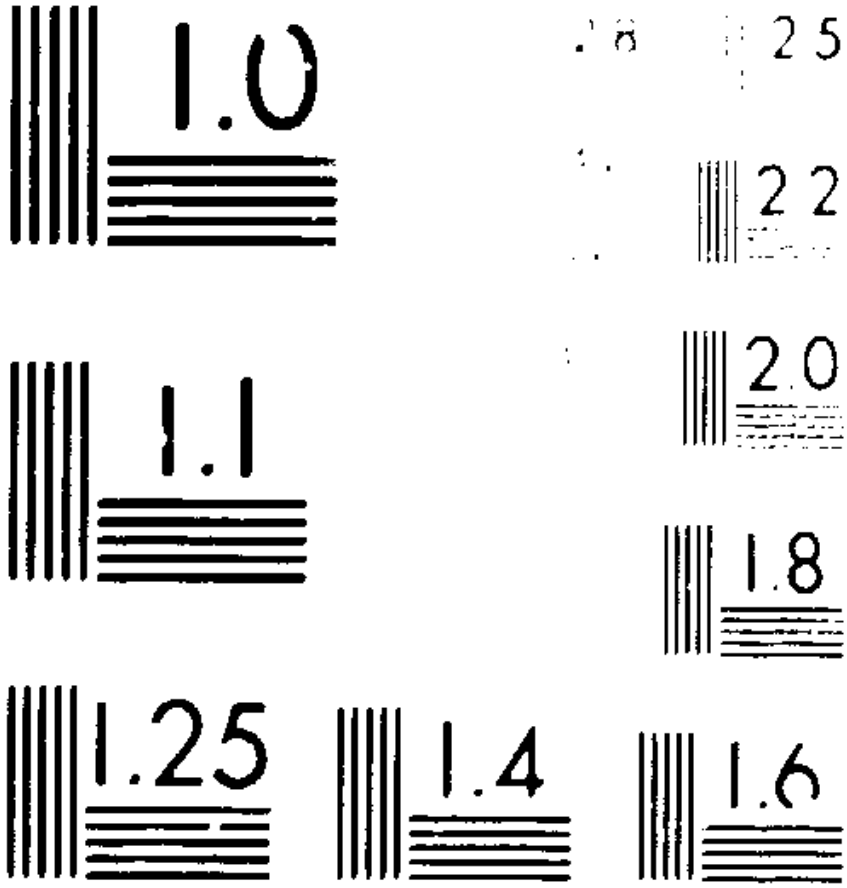
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Distr.
LIMITED
ID/WG.379/1
28 July 1982
ENGLISH

United Nations Industrial Development Organization

Interregional Cement Technology Forum

Benghazi, The Socialist People's Libyan Jamahiriya
13 - 20 April 1982.

WARTAS - AN AUTOMATIC CONTROL AND INFORMATION SYSTEM FOR INSPECTION AND MAINTENANCE*

by

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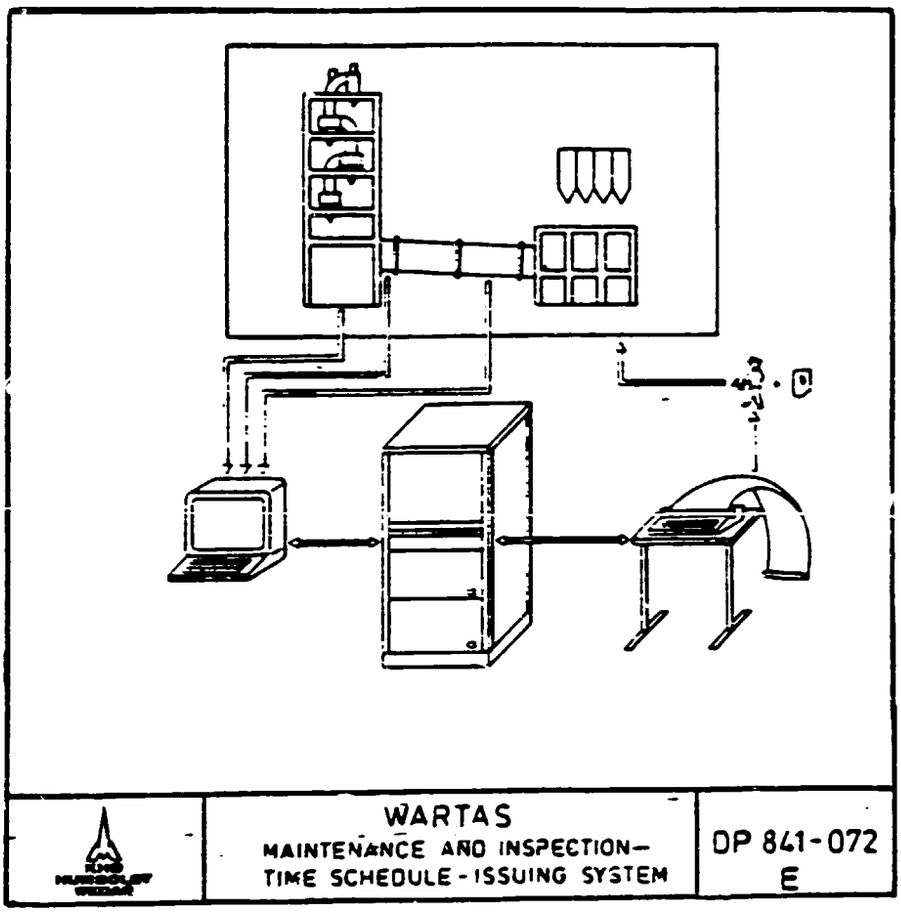
1. Introduction

Modern cement plants frequently reaching outputs of more than 3.000 t/day include some 4.000 main and secondary units.
Consequently, the requirements for servicing and maintenance are consistently raised because the costs implied in a failure of such production line may equal up to 0.1 % of the capital expenditure per day.

For guarenteeing a continuous and economic production of cement, KHD HUMBOLDT WEDAG AG developed the " Wartungs-Termin-Ausgabe-System " WARTAS (maintenance and inspection-time schedule-issuing system) thereby establishing significantly improved organisational preconditions for a reliable control and check of all service and maintenance jobs. Based on practical experience, an easily manageable information-, time-scheduling and checking system was set up which benefits of the advantages offered by electronic data processing.

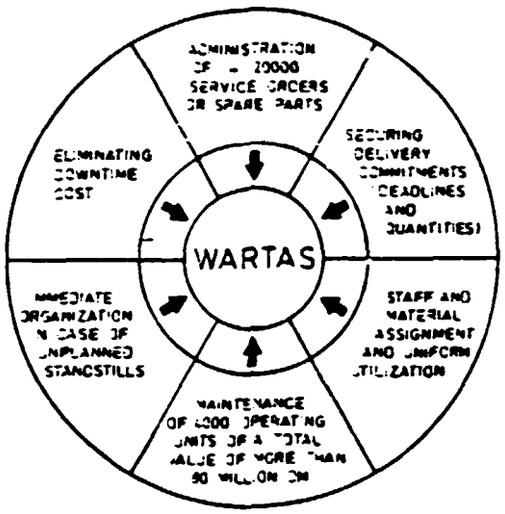
2. Duty specification for WARTAS

A broad and, hence, safe inspection and servicing system shall acquire more than 20.000 instructions and orders for carrying out the necessary work to mechanical and electro-technical plant equipments. For an organisation which relies primarily on capacity and qualification of its staff, such huge quantity of instructions necessarily implies the danger of a selection being made which might result in approximately one third of all orders being considered only partially or not at all.



With respect to WARTAS, the number of some 20.000 instructions and service orders mentioned earlier, has been stored in the computer in the form of a data base. These data are organized either by the calendar or as a function of the machine service times and are activated by means of a regular dialog communication between computer and operator via display. The maintenance orders are logged by the printer, classified in accordance with varying criteria.

However, the overall duty of WARTAS is significantly more extensive.



WARTAS
MAINTENANCE AND INSPECTION-
TIME SCHEDULE - ISSUING SYSTEM

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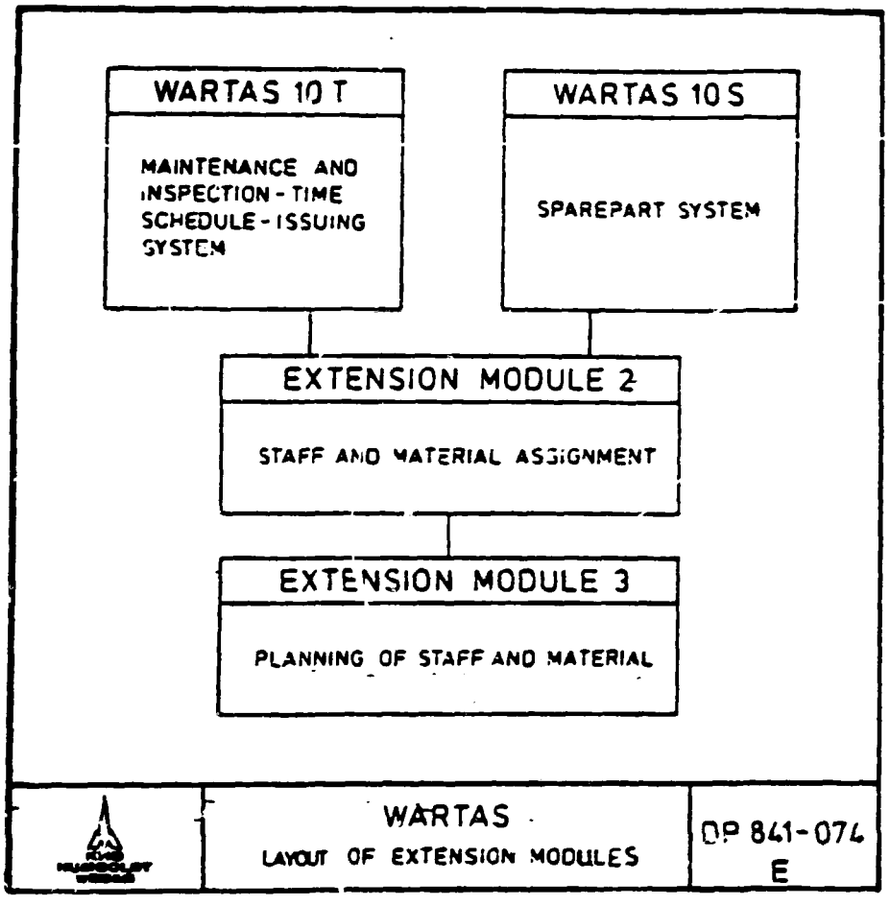
WARTAS as a whole includes functions for :

- maintaining approximately 4.000 units
- administering about 20.000 maintenance orders
- concentrating activities in connection with plant standstill or spontaneous organisation of unplanned shut down
- administration of spare parts stockkeeping
- personnel organisation and uniform utilization
- preventing downtime expenses
- guaranteeing delivery obligations

For tackling this broad range of duties, the software system has been made up of various extension packages which can be implemented stepwise.



This offers two advantages to the user:
Servicing can "grow into" the system by way of the existing organisation. The sophisticated make-up of the control instrument WARTAS enables it to be matched to the growing experience of the user. Therefore, starting the system will not require highly qualified staff. Instead, the staff will be trained during practical application and becomes qualified by using WARTAS.

The modular layout makes it possible to take the specific requirements of the customer into account regarding capital expenditure and organization. Including individual modules into the process makes the situation more easily understandable and reduces the causes for misunderstanding between supplier and user.

3. WARTAS extension packages

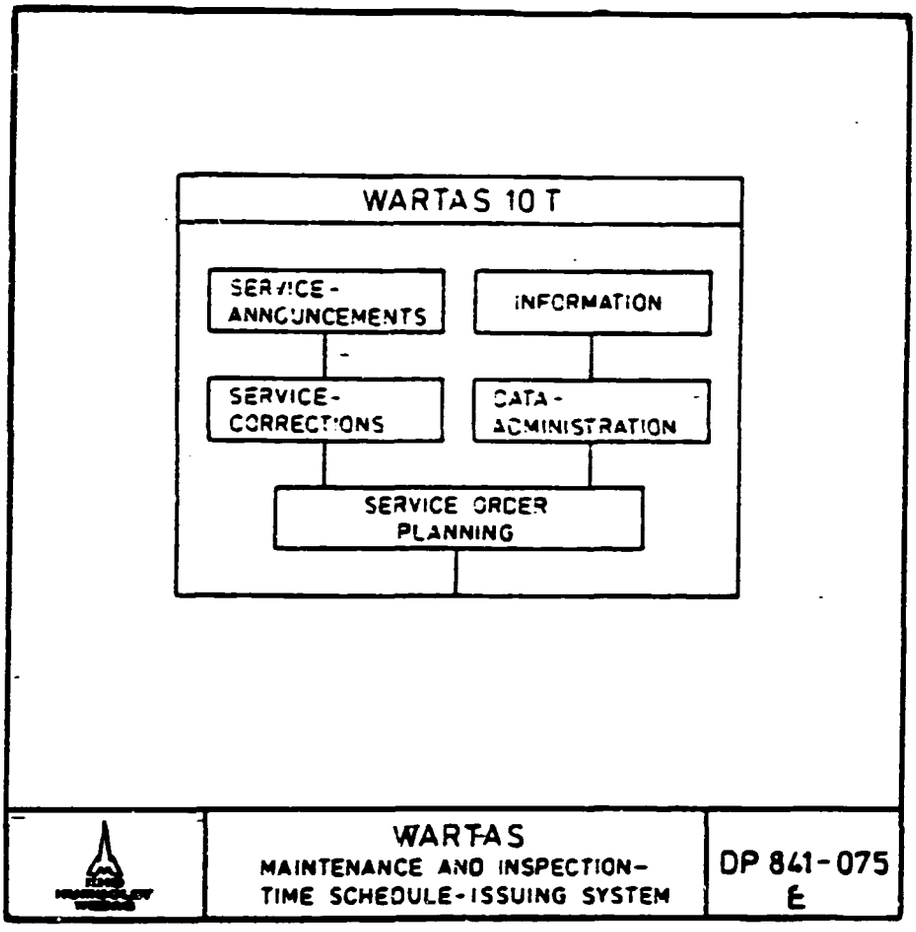
The different modules of the WARTAS system are each characterized by another crucial aspect:
The basic module WARTAS-10T assures the timely calling of preventive service jobs for every equipment of the cement plant earmarked for such work.

The first extension module WARTAS-10S can be used alternatively or additionally if in the line of spare-part stockkeeping, the assortment of the stock shall be controlled. This module enables monitoring the inventory and controlling the availability of important parts.

The second extension module joins service order controlling and spare-parts stockkeeping. There is a possibility to issue availability lists for spare-parts and devices/tools for the orders, i.e. after their availability has been checked.

Moreover, expensive spare-parts will no longer be procured on the basis of the statistically ascertained requirements but by the spare-parts requirements derived from the planned orders (requirement control).

The third extension module considers, in addition, the availability of the service staff. Utilization of the teams is evened with due consideration of the deadlines fixed. This results in a better overall assignment of the service staff.
The different modules (extension packages) shall be explained in detail below:



3.1 Basic module WARTAS-10T

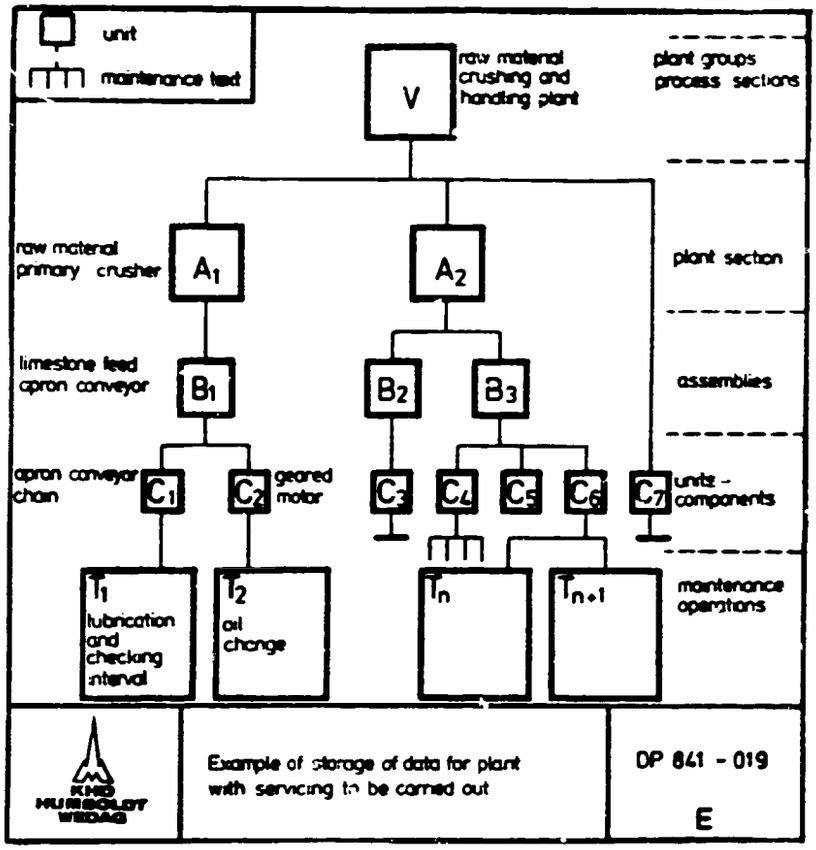
The programme package is meant for ing and controlling all inspection-, organisation and m enance jobs

It processes

- all service message inputs, e.g., acknowledgement of completed jobs, order chaining, unplanned repairs.
- service corrections, such as correcting or acknowledging service hour meter reading
- information on service statistics, detailed equipment description, content of the data base
- administration of the equipment master data, system meter data, service texts
- finally, service order planning which - subject, e.g., the service hour meter readings for the different plant sections - establishes and issues the service orders.

All equipment-, service- and inspection data of an industrial plant are stored in so-called data files. These data files can be compared with card files whithin manually controlled system. The so-called WARTAS data base is essentially made up of the equipment master file, the service and/or inspection order file and the service text file. This data base is stored on magnetic disks. According to the specific right-of-access of the maintenance staff all data can be inquired or modified direct during a dialog via a display unit.

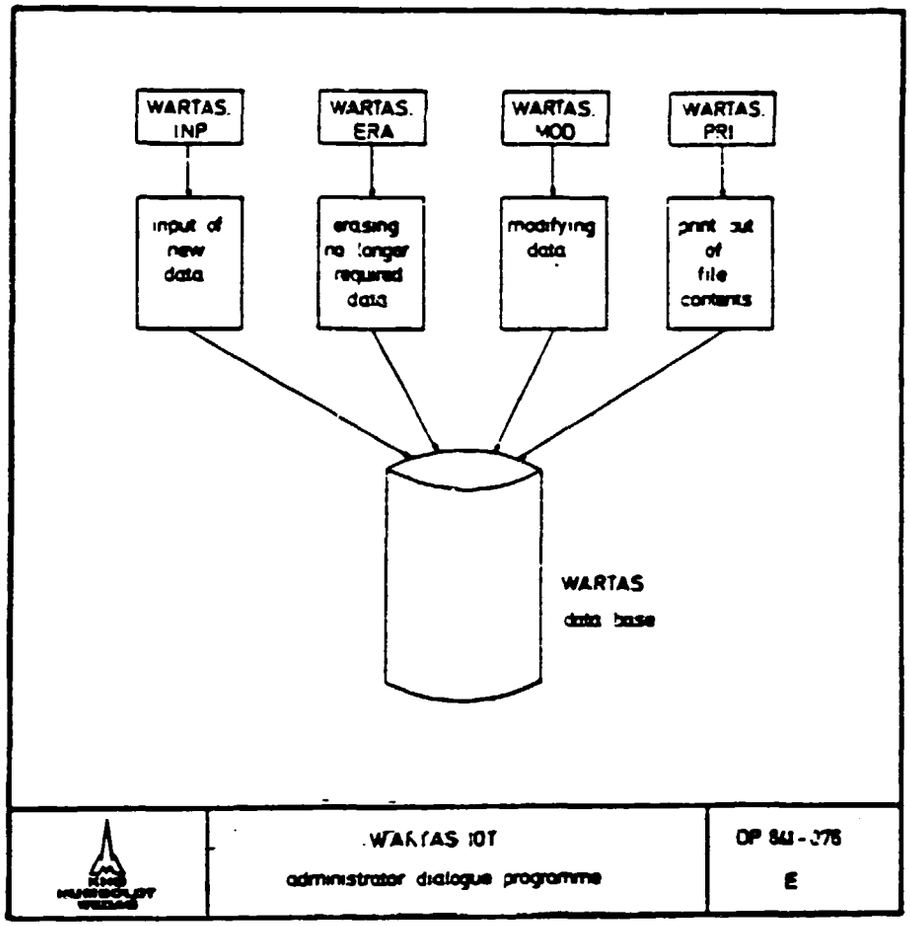
Similarly, the operator initiates by a dialog print-out and processing of WARTAS data.



As an example we would like to show the detailed equipment break down as it has been organised in the equipment master file.
All plant process sections (V) have been grouped in a tree-like structure in process components (A), main machines (B) down to machine components (C) at which the various service and maintenance jobs (T) have to be done.

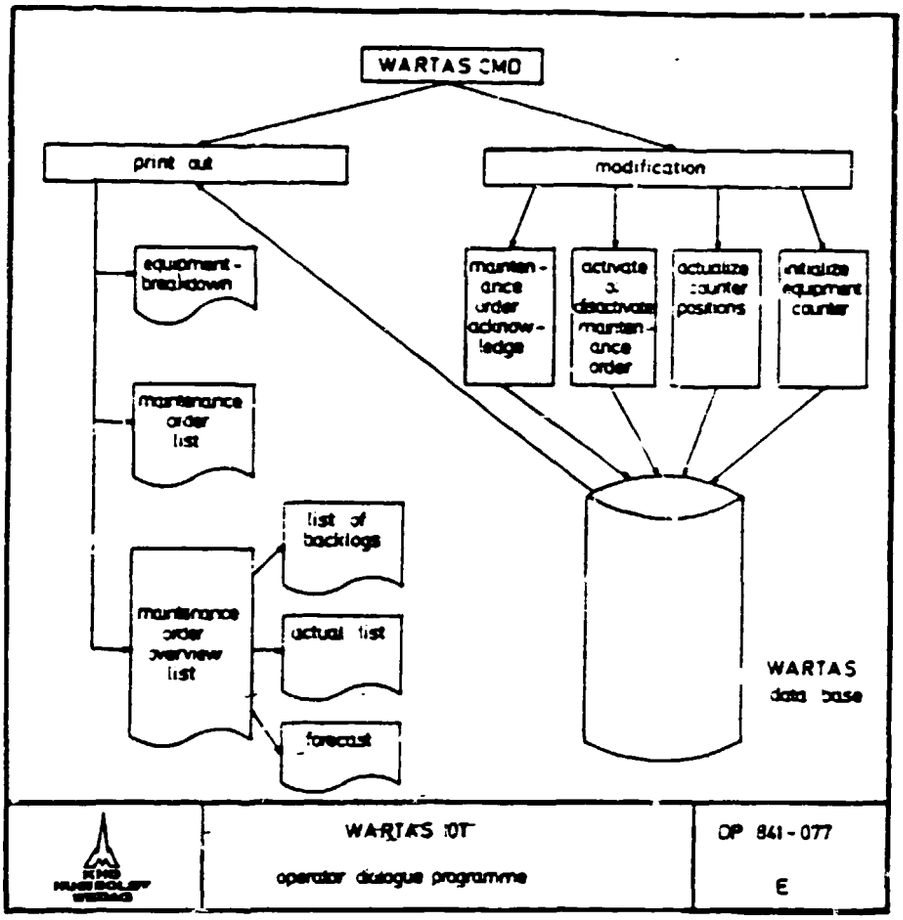
The programme package WARTAS-10T is operated by way of the following two dialog programmes:

- file administration dialog
- operator dialog



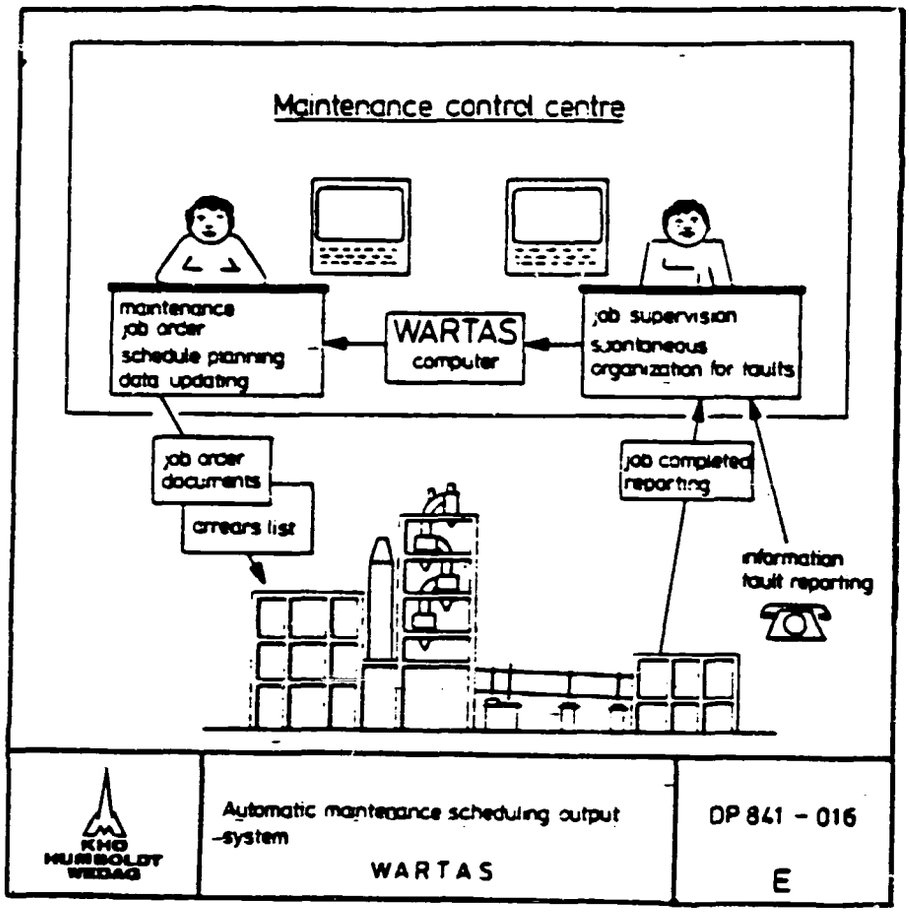
The necessary data are entered in the system and updated respectively with the aid of the file administration dialog.
There is a choice of four different types of dialog, i.e.

- input of new data
- deleting data that are no longer required
- modification of data
- printout of file contents



The operator dialog programme provides for actual control of the service time-scheduling system.
It initiates, for instance

- printout of the current service order lists, of the back-log lists and of the plant forecast,
  as well as
- entry and processing of the corresponding feed back and control statements.



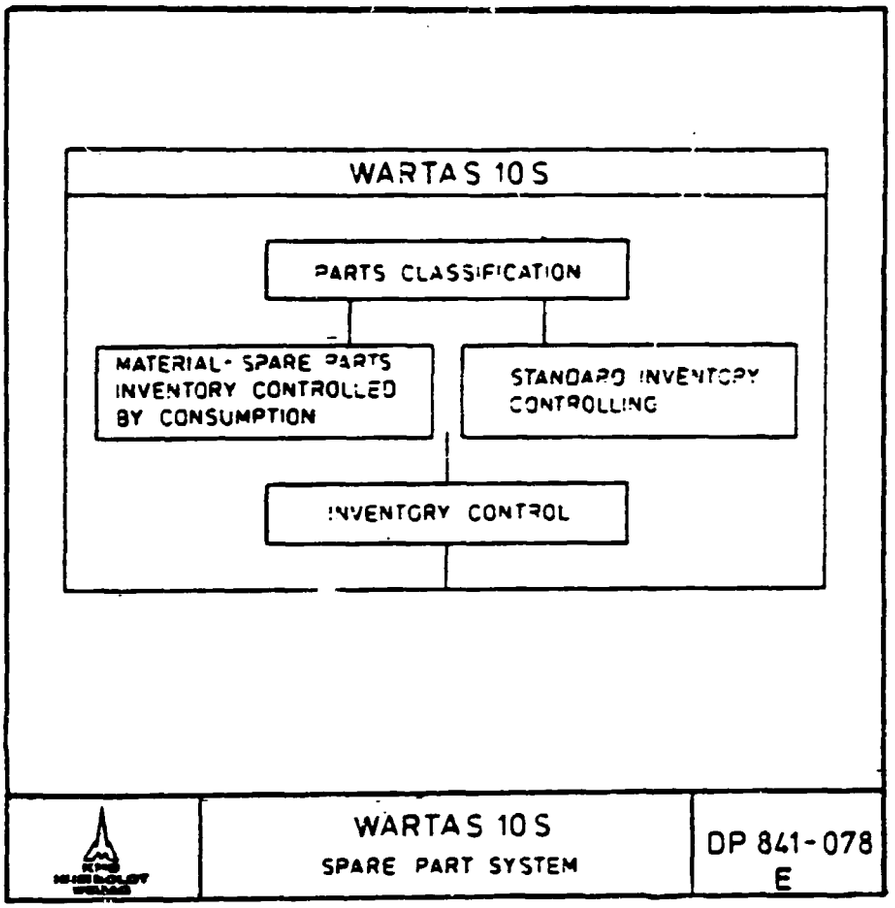
During practical operation of the system, the current service orders (per day/per week) will be printed out via the operator dialog, grouped for the pertinent service team; the service orders will then be assigned in compliance with such grouping. In addition to the current jobs that have been added, the jobs included in the back-log lists have to be ordered for handling once again.

The feed-back information arriving from the plant (acknowledgement of completed orders, new entry of meter readings) are keyed in again and the computer immediately transfers orders that have not been dealt with into the back-log list.

Moreover, unplanned failures and plant shutdowns are communicated to the system which immediately calculates and establishes corresponding service orders.
Any jobs being included in a specific tolerance range and requiring a plant shutdown, are automatically planned and ordered in case of an unplanned standstill.

The basic module of WARTAS alone can be used already economically. This can be proven above all by the labour cost for the number of defined service orders (morethan 20.000) which would be required for basing these orders on sound personnel organisation, i.e. orders that mostly have to be planned and controlled several times a year. The anticipated increase in the number of defined service orders actually performed is a most important argument for justifying the installation of WARTAS in industrial plants.

The basic module which already includes the service statistics offers the user an instrument for eliminating weak points in realizing preventive servicing. The supervisory operating staff is thus relieved from routine control work and can instead use their activities for vocational and personal training of the subordinate staff. Both factors improve the efficiency of servicing which is directly proportional to the expense of the service orders to be fulfilled.



3.2 First extension module WARTAS-10S

This extension module administrates all stocks of spare-parts which are subject to consumption. Additions to, withdrawals from the stock, ordering quantities and ordering details are collected and calculated for each spare-part number.

This extension module operates completely independent, which means that the functions of the basic module WARTAS-10T are not required. Safety stocks are calculated and provided for each spare-part number so as to cover demand fluctuations and varying procurement times.

Normal stocks are provided and administered for spare-parts that definitely have to be available. These are predominantly expensive spare-parts and/or spare-parts difficult to procure, for which there is under normal conditions little demand.

The system has been subcivided into four essential programme groups, i.e.

a) parts classification

The objective of the programme is classifying all spare-parts by tneir proportionate value and urgency of availabilitv.
This results in planning expenditure for managing the spare-parts inventory.

b) Stockkeeping of materials and spare-parts subject to consumption

The anticipated demand of spare-parts and auxiliary materials is derived from the demand in the past. The objective of such forecasting is calculating future demands from requirements of the past with the aid of statistical methods.
The time of ordering is determined on the basis of the demand forecast and of the procurement time, while the quantity to be ordered is calculated by spare-parts requirements and cost of stockkeeping.

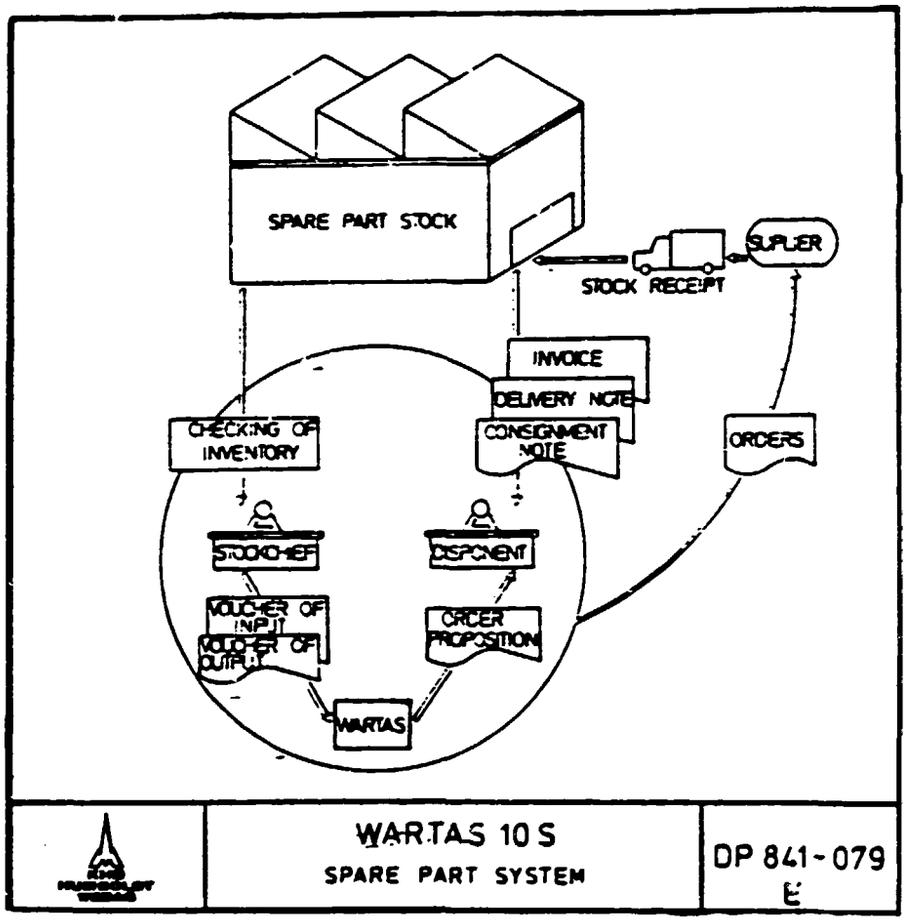
c) Control of standard inventory

Spare-parts which must be available at a high degree of safety are administered by standard inventory methods.
Economic aspects of stockkeeping are subordinate to the request for little downtimes caused by spare-part bottlenecks.

d) Inventory control

The programme se es for recording all inventory changes, aiming updating all spare-parts- and auxiliary materials inventories.
To that end, all inventory movements are monitored. The programme checks any inventory that has fallen below a preset limit value and issues an order proposal card for this spare-parts number. Moreover, a list with all entries is provided as printout.

The following illustration shows how inventory managing is handled via the corresponding computer dialog by the "stock chief" as he has been called in this particular case.

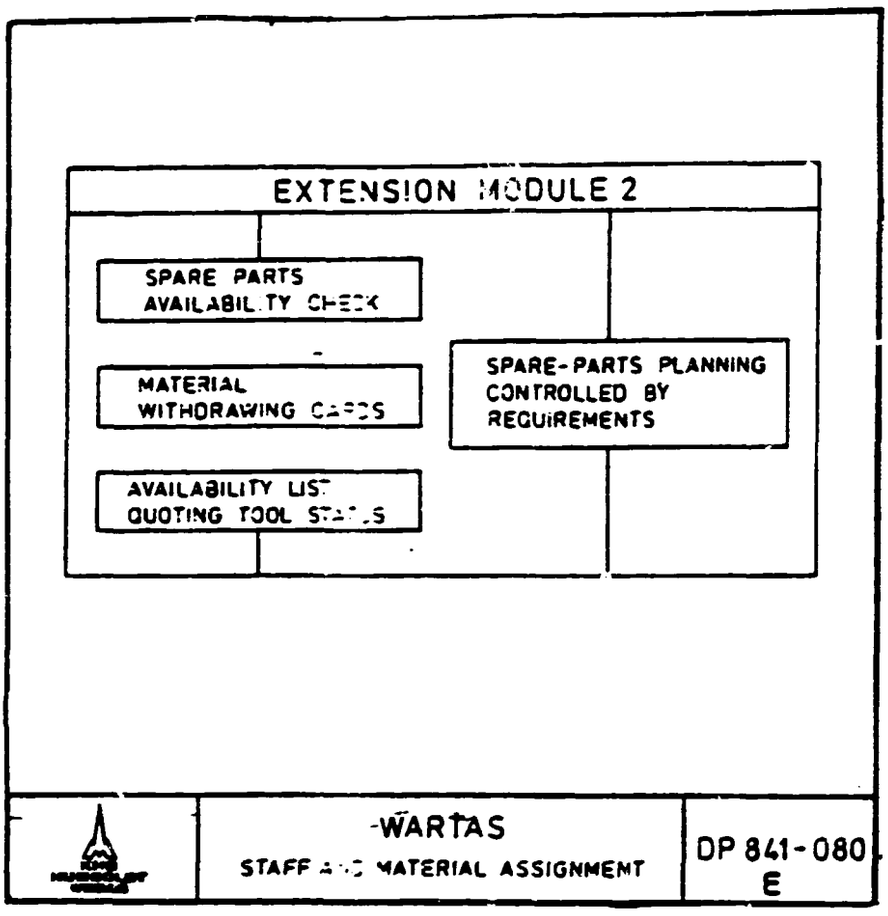


The order requests resulting from inventory monitoring are converted to pertinent supplier orders by the "managing clerk", - here called "disponent" - who will also be respondible for commercially dealing with the spare-parts received.

This system of a computer-assisted material organisation for spare-parts subject to consumption, offers the material managing clerk decision aids with respect to

the quantity of stock to be procured,
the quantities to be ordered and
the procurement times.
In addition, the system
notifies unusual consumptions,
indicates shortages and
issues a forecast survey of anticipated
material movements.

These figures enable the material managing clerk to locate unusual circumstnces well in time, to correct them and to initiate additional measures, such as urgent orders, change in quantities ordered and to have items reserved for the plant's requirements. At least once per month the programme package supplies different summaries in which unusual circumstances are identified.



3.3 Extension module 2

While basic module WARTAS-10T and the first extension module WARTAS-10S can be operated independent of each other, extension module 2 will function only when joined with the preceding modules.

This extension module is made up of the following 4 programme groups:

a) Spare-parts availability check

All individual service orders covering up to 2 months are stored in the service order files.

Each service order will be provided with an index being the reference to the corresponding spare-part in the spare-parts file. This index is used for allocating to each service order all spare-parts numbers and the required quantities.

The inventory available without any restriction is checked in compliance with the requirements included in the service orders

b) Material withdrawing cards

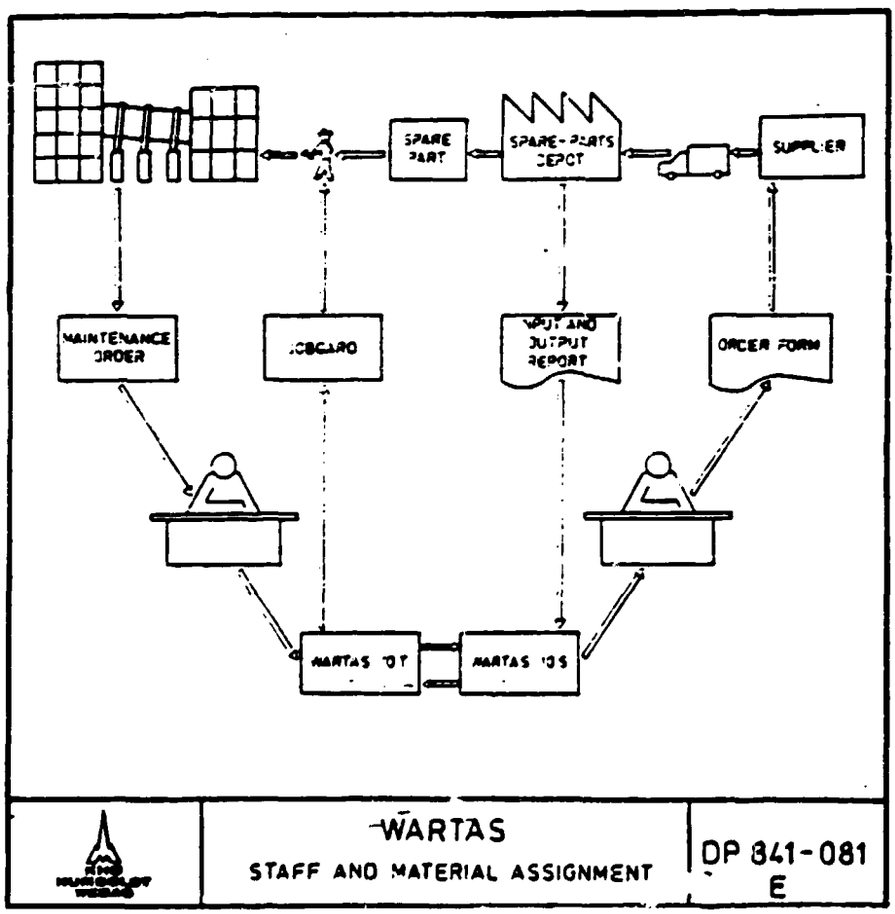
Material withdrawing cards are issued for each service order for which spare-parts are needed. These cards serve for inventory monitoring and for recording the material issues, i.e. deduct them from the stock reserves.

c) Availability list with checked tool status

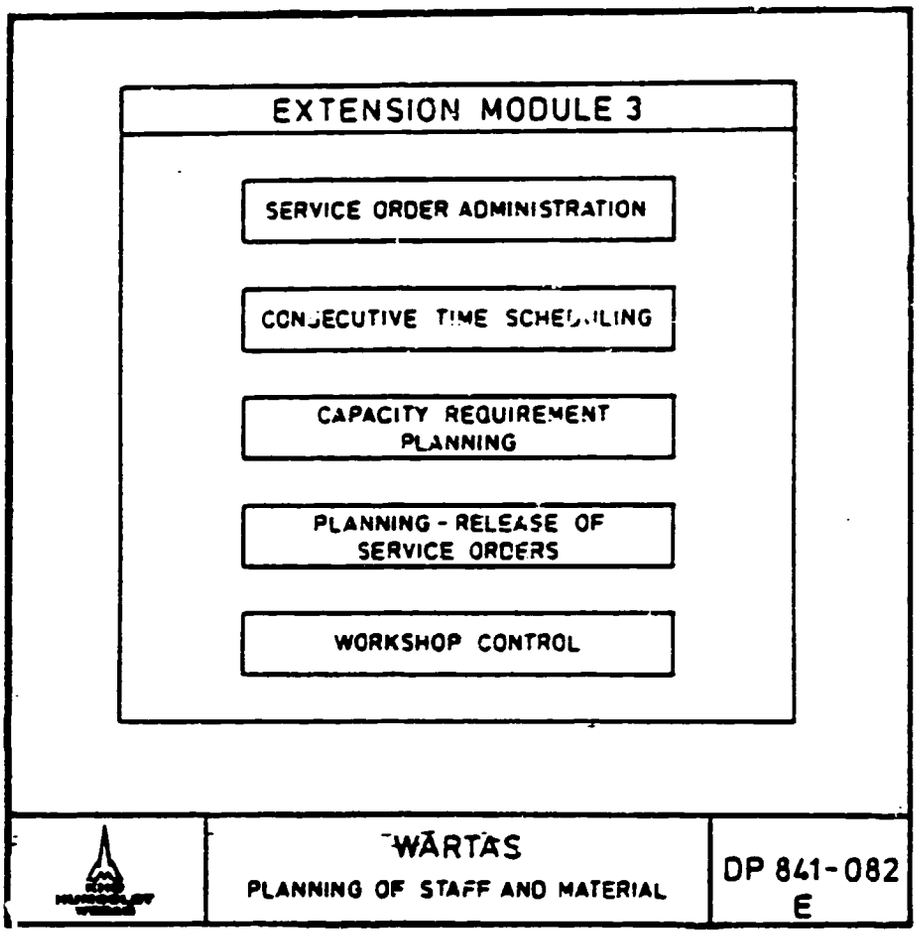
The service orders once again pass the same programme operations as for spare-parts availability checking with simultaneous access to the master tool file. The tool list has previously been chained to the service order set.

d) Planning the inventory of spare-parts that are subject to demands

Controlling of spare-part inventories dependent on demand is derived from planned service orders. The spare-parts that shall be subject to this demand control are identified in the programme "parts classification" of extension module 1 WARTAS-10S. The planned service orders are keyed into the programme and the demand of spare-parts is ascertained on the basis of these data.



Managing the spare-part inventories by demand requires the material managing clerk to monitor the stocks (additions and withdrawals) and, moreover, to anticipate the service orders that will be issued.



3.4 Extension module 3

The programmes included in extension module 3 tackle the problem of allocating a limited capacity of service personnel to a large number of service jobs with due consideration of the time schedule set. On the basis of a defined number of service orders for production machines and machine groups, characterized by given service intervals and operating periods, the programme calculates the desired assignment of the personnel capacity and the material needed. Subsequently, the service orders are balanced with the personnel capacity available.

Excess capacities and shortages are recorded for defined periods of varying duration. This permits deriving management decisions as to whether overtime will have to be ordered for future service activities or whether the time schedule should be changed.

The programme system has been split into the following blocks:

a) Service order administration

The function of service order administration includes a service order list.
This service order list is updated and covers several periods of the near future so that the service order file contains a service order list for several months.

The service order data are processed for the subsequent programmes.

b) Consecutive time scheduling

This function calculates the time required for completing a service order out of a preset value made by experience.
In addition, the assignment of the service personnel is determined and time schedules issued for the service orders.

Service orders for which delays are anticipated, are particularly identified.

c) Planning required capacities

This function provides for service order planning in accordance with specific intervals.

A partial order list for a shorter, future period is generated out of the overall service order list which is based on a longer planning horizon with respect to time scheduling and capacities available.
The material cards are issued for this partial order list.

d) Planning service order releasing

The partial service order list is transferred to the function that plans service order releasing which latter duly considers short-term changes in capacity.

It determines the required overtime, realisable starting dates and the order completion date.
The programme provides for output of a service order summary which includes all service orders that have been released.

e) Workshop controlling

This function takes over the released service orders and

- checks these as to starting dates
- checks availability of materials and tools
- reserves service material
- generates material and tool requirement sheets
- establishes the service order documents.

It is advisable to have material and tool availibility checking, earmarking of material and generating of material requirement sheets carried out shortly before commencement of the job.

This will avoid the reserved stocks becoming excessive in case of a changed sequence of the service orders and issue of material withdrawing cards for material not being required at all.

4. Concluding remark

The statements made above reveal that all extension modules of WARTAS result in a very complex and far-reaching system. That's why WARTAS is made out of different, modules, one on top of the other.
WARTAS handles within his data base a large quantity of information needed for effective maintenance using reasonably the possibilities of electronic data processing. It is not only meant to be a decission aid for the maintenance people but also to be their powerful organizing tool.
According to our philosophie and experience it will be advisable to start with basic module WARTAS-10T for introducing this system in an existing plant or works to be set up. This will guarantee that all known service and inspection works will be included and be advised and specified for extension at the time required.
The remaining modules should be added stepwise, i.e. to the extent the operators in charge have been thoroughly familiarized with organisation of the systems installed previously.

This is the KHD HUMBOLDT WEDAG AG contribution to aiming at and maintaining trouble-free operation of the plant for a better return of investment.