OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

This document has been produced without formal United Nations editing. The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization (UNIDO) concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. Designations such as "developed", "industrialized" and "developing" are intended for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. Mention of firm names or commercial products does not constitute an endorsement by UNIDO.

FAIR USE POLICY

Any part of this publication may be quoted and referenced for educational and research purposes without additional permission from UNIDO. However, those who make use of quoting and referencing this publication are requested to follow the Fair Use Policy of giving due credit to UNIDO.

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

United Nations Industrial Development Organization

16821

Distr.
LIMITED

ID/WG.473/2(SPEC.)
22 April 1988

ENGLISH

International Symposium on the Continuous Industrial Hydroponic Crop Production System in Artificial Climate

Moscow, USSR, 17-19 May 1988

BLOCK-MODULAR COMPLEX:

LAYOUT, SYSTEMS AND CONTROL *

Prepared by

Yu. Lipov **

R. Wick ***

M. Galkin ****

E. Sisoyev *****

* The views expressed in this paper are those of the authors and do not necessarily reflect the views of the UNIDO Secretariat. This document has been reproduced without formal editing.

** Chief of Department, NPO Viskhom (Scientific Industrial Association of Agricultural Engineering), USSR

*** Manager, Andritz AG, Austria

**** Researcher, NPO Viskhom (Scientific Industrial Association of Agricultural Engineering), USSR

***** Researcher, NPO Viskhom (Scientific Industrial Association of Agricultural Engineering), USSR

489

V.88-24183

BLOCK-MODULAR COMPLEX: LAYOUT, SYSTEMS AND CONTROL

Yu.Lipov, NPO VISKHOM
R.Wick, "Andritz", Austria
M.Galkin, NPO VISKHOM
E.Sisoyev, NPO VISKHOM

Depending on the conditions in which the complex is used its components and equipment layout may be different and adapted to the local terrain, adjacent energy sources and other facilities. Block-Modular Complex (BMC) given here is designed for the specific conditions of the Moscow region.

Fig. 1 shows a principle scheme of the BMC layout which comprises: module (item 1) for fruit and vegetables growing; module for leaf vegetables or green forage from cereals (item 2); container (item 3) equipped for seedlings growing for module (item 1); container (item 4) for crop collection from the module (item 1); two containers (item 5) with electric equipment, control and measuring instruments and automatic devices; container (item 6) with laboratory equipment; block (item 7) of the air conditioning system of the vegetation section; container (item 8) with the emergency power source; block (item 9) for the control board and operator seat; container (item 10) with the sanitary equipment; entrance gate (item 11).

The containers (items 3-6, 8 and 10) are standard 20-feet containers. The modules and containers with technological equipment are mounted on a solid foundation. The mounting space of the modules and containers is limited by the upper edge of the foundation sole.

1. Description of the modules and containers design structures with technological equipment.

1.1. Module for fruit and vegetable growing.

The module has the following dimensions: width 8.50 m,

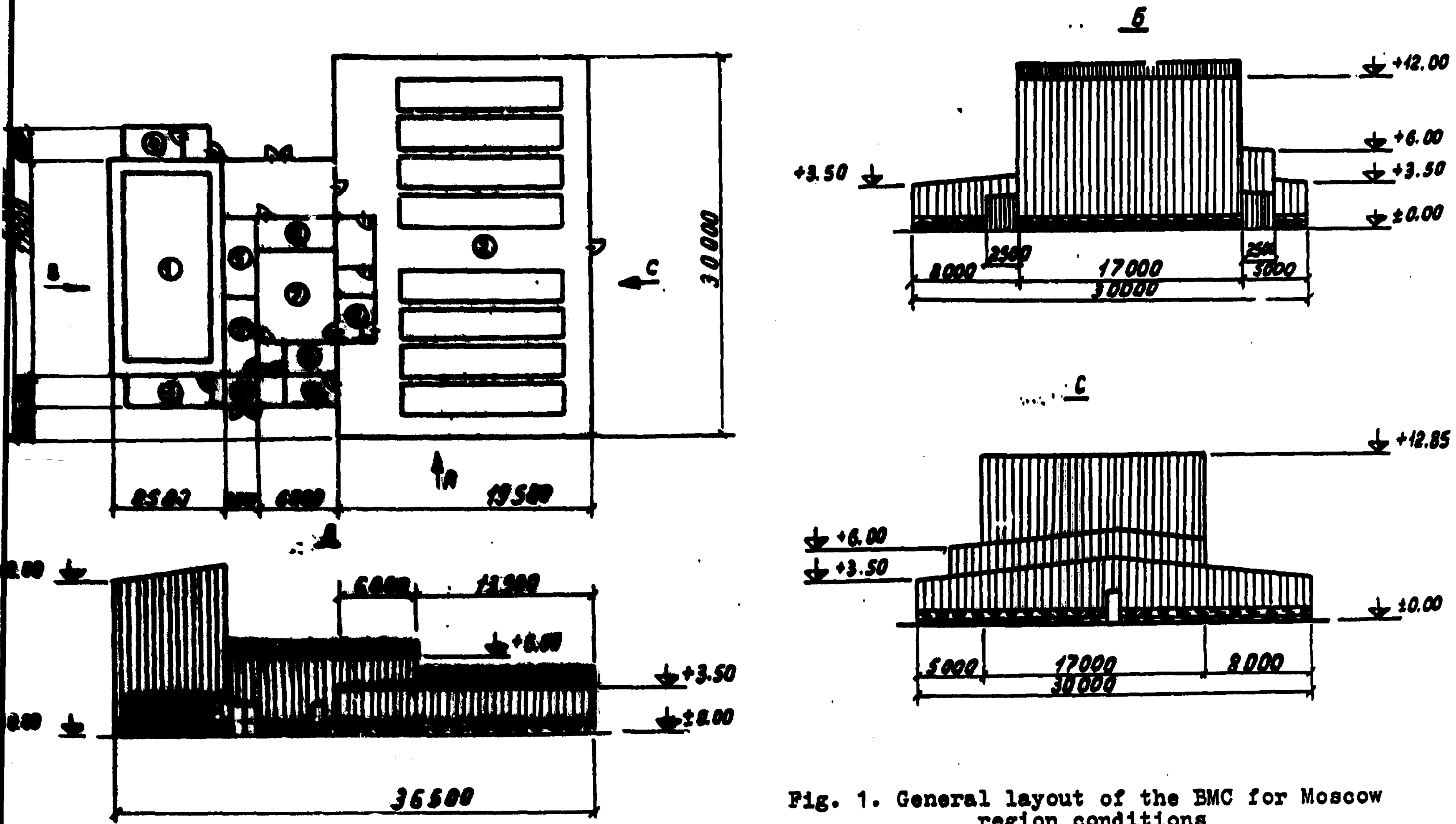

Fig. 1. General layout of the BMC for Moscow region conditions

length 17.00 m,height 12.85 m. A carrier steel structure is composed of the non-split rectangular frames spaced at 4.00 m.

The steel structure is designed to withstand the loads of the mechanical part of the circular conveyor system as well as the atmospheric loads (wind, snow etc.).

The facade structure is formed by wall profiles installed in perimeter at intervals, approximately, 4.00 m.

The floor is made up of steel beams. The trapezoidal roof panels are laid down directly on the trusses of rectangular frames.

The metal structure is protected against corrosion by the following means:

- elimination of rust by sand blasting up to the A 2 1/2 degree;
- double ground coating with a material on artificial resins basis, each dry layer of coating is about 50 micron thick;
- single dry layer of finish coating with artificial resins material is about 50 micron thick.

Roof structure of the fruit and vegetable module

This module is provided with pent roof with a gradient of 10%. The roofing consists of double trapezoidal panels with heat insulation.

The roof carrier structure with a span of about 4.0 m consists of steel galvanized trapezoidal panels. The inner side of the panels is covered with a layer of synthetic material about 25μ thick and the outer side is protected with varnish.

The insulation fiberglass panels are of 120 mm thick.

The outer roofing consisting of steel galvanized trapezoidal panels is mounted on the intermediate, Z-shaped planks spaced at 2.50 m. The outer surface of the panels is covered with synthetic material of 25 mm thick. The roofing has two longitudinal ridges. All joints of the trapezoidal panels are sealed with packing tape.

In order to ensure a good heat insulation the intermediate, Z-shaped planks are provided with heat insulating packings on both sides.

Coefficient of heat transmission of the roof is:

$$K = 0.35\ w(m^2 \cdot K).$$

Under the roof structure a horizontal metallic, groin-type ceiling is mounted with perforated area up to 12% and holes size of 3 mm. This ceiling encloses the upper section of the room and forms an integral part of the air conditioning system.

The surface of the metallic groin ceiling is covered with easily washable synthetic material.

Facade structure of the fruit and vegetables module

The front walls are made up of sandwich-type elements consisting of steel panels, 0.55 mm thick, galvanized on both sides, plastic coated of 25 mm and a foam polyurethane packing of 70 mm thick.

The wall elements are attached vertically on to the wall posts spaced at 4.00 m. The structural width of the wall elements is, approximately, 915 mm.

Coefficient of heat transmission by the facade structure is:

$$K = 0.30\ w(m^2 \cdot K).$$

Floor structure

Depending on the climatic conditions, a so-called doublefloor structure is used in the module.

At a height of about 0.50 m above the hydraulic insulation cover a structure of steel beams is mounted on which the trapezoidal steel sheets are mounted. These sheets are covered with a layer of concrete. The trapezoidal casing steel sheets are included in the steel structure supply. The upper surface of the concrete is thoroughly finished by rubbing, smoothed and prepared as a clean floor for technological purposes. The hollow space between the floor steel structure and foundation may be filled with foam concrete or used for mounting purposes.

1.2. Module for leaf vegetables or forage cereals crops.

The module has the following dimensions: width 19.50 m, length 30.00 m, height 3,50 m.

The module is a structure of steel frames with a set of pillars. The pillars arranged inside the module support the conveyor with the driving and tension mechanisms as well as the loads of the roof structure.

The steel structure is designed to withstand the loads of the technological equipment and the atmospheric loads: winds, snow etc.

The wall profiles are installed between the socle and roof overhang. The trapezoidal roofing sheets are laid down directly on the steel trusses.

The anticorrosion protection is the same as for the fruit and vegetables module.

Roof structure

The roof is ridge-type with a gradient of 10%. The roofing is made up of trapezoidal panels with thermic insulator between them.

The roof carrier structure with 3.00 m wide spans is composed of steel galvanized trapezoidal panels. The inner surface of the panels is covered with synthetic material of 25μ thick and the external surface is protected with varnish.

For the thermal insulation the fiberglass plates of 120 mm thick are used.

The outer roofing casing is mounted on the intermediate, Z-shaped profiles spaced at 2.50 m and consists of steel galvanized trapezoidal panels. The external surfaces of the panels are covered with a layer of synthetic material of 25μ thick. The roof has two longitudinal ridges.

All the joints of the trapezoidal panels are sealed with packing tape. To ensure the thermal insulation the intermediate, Z-shaped planks are also provided with heat insulating packings.

Coefficient of heat transmission of the roof structure is:

$$K = 0.35 \ w(m^2 \cdot K).$$

Under the roof structure a horizontal, metallic, groin ceiling is mounted with perforated area of 12% and hole sizes of 3 mm. This ceiling encloses the upper section of the room and forms an integral part of the air conditioning system.

The surface of the metallic groin ceiling is covered with washable synthetic material.

Facade structure

The front walls are made up of sandwich elements consisting of steel panels, galvanized on both sides, 0,55 mm thick, with plastic coating of 25 μ thick and foam polyurethane packing of 70 mm thick. These elements are attached vertically on to the posts spaced, approximately, at 3.50 m. The structural width of the wall elements is 915 mm.

Heat transmission coefficient of the facade structure is:

$$K = 0.30 \ w(m^2 \cdot K).$$

Floor structure

The projected foundation depth is, approximately, 1.20 m. A layer of frost resistant material of 0.50 m thick is laid down and fixed on the previously mounted hydraulic insulation which, in its turn, is covered with a layer of concrete 0.20 m thick.

The surface of the concrete layer is thoroughly rubbed, smoothed and finished as floor for technological room.

The outer sides of the foundations are provided with heat insulators of 10 cm thick.

1.3. Air conditioning system for the vegetation sections of the modules.

The block of the air conditioning system (item 7, fig 1) for vegetation sections is located between the modules.

It is designed in such a way that all the adjacent containers for the electrotechnical equipment, control and measuring instruments, laboratories etc. are housed under roof and look like an architectural ensemble of modern design.

The dimensions of the air conditioning block together with the containers (item 5, 6, 8, 10 and 11) are the following: width 15.00 m, length 8.50 m, height 6.00 m.

The metallic structure is formed by steel frames spaced at 3.00 m. The free space between the containers and the roof is used for conditioning pipings mounting. The trusses are supported by the containers. The anticorrosion protection is similar to that of the modules structures.

Roof structure

The ridge type roof has a gradient of 10%. The roofing is made up of trapezoidal panels with heat insulation between them.

The carrier roof structure with spans about 3.00 m is composed of steel galvanized panels. The inner surface of the panels is covered with a layer of synthetic material about 25μ thick and the external surface is protected with varnish.

The fiberglass plates of 12 cm thick are used for heat insulation.

The outer casing of the roof is mounted on the intermediate Z-shaped planks spaced at 2.50 m and consits of steel galvanized trapezoidal panels. The exte nal surfaces of the panels are covered with a layer of synthetic material of 25μ thick. The roof has two longitudinal ridges.

All the joints of the trapezoidal panels are sealed with packing tape.

The intermediate, Z-shaped planks are sealed on both sides with heat insulating packings.

Heat transmission coefficient of the roof structure is:

$$K_1 = 0.35 \text{ w}(m^2 \cdot K).$$

Facade structure of the block

The front wall elements of sandwich type consist of steel panels, 0.55 mm thick, galvanized on both sides, with plastic coating of 25μ thick and foam polyurethane packings of 70 mm thick. The wall elements are attached vertically on the posts spaced at 3.50 m; their structural width is 915 mm.

Heat transmission coefficient of the facade structure is:

$$K = 0.30\ w(m^2 \cdot K).$$

The structure of the block is the same as of the vegetation modules.

1.4. Technological containers.

The electrotechnical equipment, control and measuring instruments, laboratory etc. are previously mounted inside the containers and then delivered to the assembly site ready for mounting.

The standard 20 feet containers have the following dimensions: 6055/2435/2590 mm.

This complex comprises the following containers:

1 container - for crop collection;

1 container - for seedlings growing;

2 containers - for electrotechnical equipment and control and measuring instruments;

1 container - for the emergency power source

1 container - for laboratory;

1 container - for sanitary equipment.

Containers structure

The supporting frame is a self-carrier frame of rolled and hollow profiles welded with the aid of shielded gas welding, with cross reinforcement members. The steel container angles and fastening parts correspond to the ISO Standards.

Floor is made of PVC sheets of 27 mm thick stuck with a waterproof glue to a three layer plate. After the sheets a steamproof layer of PVC film follows (0.3 mm thick). Under the latter a sandwich element, galvanized on both sides is laid, with foam polyurethane insulator of 70 mm thick. The lower surface is protected with rubber coating.

Heat transmission coefficient is:

$$K = 0.29 \ w(m^2 \cdot K).$$

Walls are made of the sandwich elements with two-sided galvanization and foam polyurethane packing of 70 mm thick, profiled outside and plain inside. The walls are attached to the supporting frame with the aid of self-tapping screws.

Roof of the containers is made of steel sheet 0.75 mm thick mounted on the pressed sawdust panels, of 22 mm and sealed by means of a waterproof material. A cotton - wool layer of 100 mm thick is used for insulation.

The inner side of the roof is made of sawdust panels of 12 mm plastic covered on both sides for easy washing. Steamproof insulation is of 0.3 mm thick PVC film.

Heat transmission coefficient is:

$$K = 0.35 \ w(m^2 \cdot K).$$

The anticorrosion protection of the metallic structures is similar to that of the vegetation modules.

All containers are provided with a set of electrotechnical equipment comprising: 4 luminiscent lamps, 1 switch, 1 socket for 200 v, 1 automatic overload switch.

2. Fruit and vegetables module arrangement and equipment.

2.1. Principal mechanisms.

A conveyor for the transportation of the trays with plants within the vegetation section is secured to the principal steel frame structure, as mentioned in para. 1.2.

The conveyor (fig. 2) comprises two circuit chains with guiding pins on which special suspensions are fastened and which, in their turn, serve to attach the trays with plants. The overall length of each chain is about 176 m and the intervals between the guiding pins, and consequently, between the trays is 1120 mm.

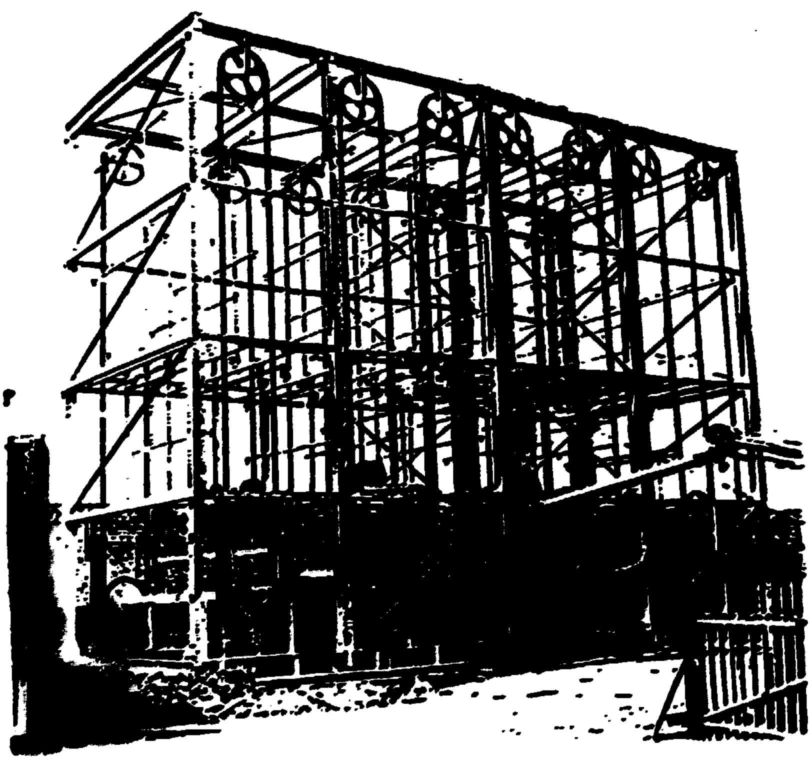

Fig. 2. General view of the conveyor for the vegetables growing module

The conveyor chains are supported by two shafts - driving and guiding mounted in the lower part. In the upper part of the vegetation section the chains are sucured on the steel frame beams. In the lower part of the vegetation section the chains are also fastened to the tandem hinged wheels fixed on special tension axles.

A necessary tension of the chains is controlled by measuring the slack of the tension axles.

The driving unit of the conveyor comprises a chain transmission ($i = 3$) from a special motor/gear box to the driving shaft of the conveyor.

The motor/gear box unit is provided with a regulator of acceleration, rotation frequency and braking (its power consumption is 2.2 kw, rotation frequency in working regime is 0.6 min^{-1}, and acceleration time is about 15 s).

There are 156 trays suspended to the conveyor chains and one special suspension is provided for transportation of an operator within the vegetation section for technical maintenance and repairs.

The vegetation tray is a channel manufactured of foam polystyrene (fig. 3) with holes for plants. A special tank attached on one side of the tray is designed to catch the nutrient solution and direct it along the channel and another tank, fixed on the other side of the tray serves to collect the used nutrient solution and to pour it down into the collecting bath of the central system for the preparation of the nutrient solution.

The design of the vegetation tray allows to create necessary optimal conditions for the vital functions of the plants root system.

2.2. Lughting system for the plants.

The lighting system is designed in such a way that it accomplishes two functions simultaneously: it ensures the lighting of the plants and heating of the vegetation section. For this purpose the light sources, high pressure natrium lamps (type SON-T or SON-H of "Phillips" make or DNaT and DRI of Soviet manufacturing) for 400 w each are placed in

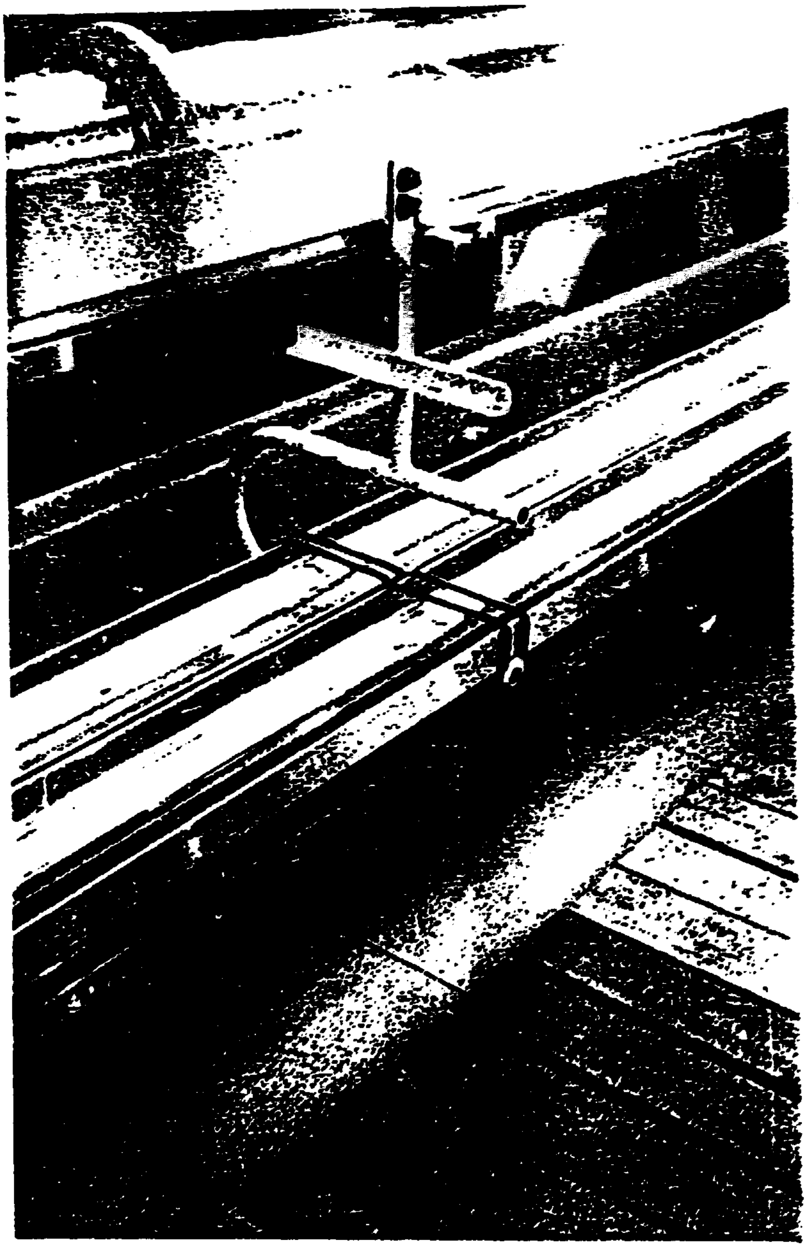

Fig. 3. Vegetation tray of the vegetables growing module

special light-transparent ventilated tubes. The whole lighting system comprises 90 tubes, distributed in 15 planes in each conveyor branch. Each tube contains 7 light sources. In the upper end of each tube there is a fixing ring for fastening it to the module roof. Between the light sources of each tube a flexible plastic cylindrical bushing is inserted capable to keep its form at the temperatures of up to 100 °C and which may be raised to give an access to the lamps for their maintenance or replacement.

The starting and regulating devices of the lamps are mounted in one of the BMC technological containers and are connected with them by means of cables.

The temperature of the external bulbs of the lamps rises up to 250 °C and for their cooling an air stream of constant temperature is delivered to the light-transparent tubes from the air ducts mounted in the lower part of the vegetation section. Thus, the cooling air moves up the tubes and, in their upper ends the heated air passes to other air ducts and to the common collectors. Both ends of each tube are provided with a flap gate which may be closed if it is necessary to repair a tube or replace a lamp.

Each of the 15 planes of the tubes is provided with one automatic valve common for these tubes which may work, for example, with the switch-off of the lamps to eliminate the danger of cooling the vegetation section.

The cooling air for the lamps of light-transparent tubes is prepared in a special mixing chamber in which the ambient air is mixed with the heated air coming from the light-transparent tubes to such a degree that at the inlet in the lower end of the tube its temperature is +25 °C. Previously, this air passes through a room in which the throttle valves, starting and regulating devices of the lamps are located and takes away a part of heat produced by these throttles.

While the air is moving up the light-transparent tubes it is heated up to +60 °C: part of this air is used to heat the ambient air supplied to the tubes and other part is used to heat the vegetation section of the second module. If there is no need for such use, especially in warm seasons, the heated air passes to the heat accumulator and from there returns to the tubes ventilation circuit. The heat from the accumulator may be consumed for different technological purposes.

2.3. Seedlings growing block.

The seedlings for the module conveyor are grown in the container 3 of the BMC (fig. 1). The technological equipment for growing seedlings comprises a thermostat (fig. 4) in which the substrate cubes with sown seeds are kept for a certain time until the sprouts emerge, table (fig. 5) with the block-growers on which the substrate cubes with seedlings are placed, light sources (fig. 6), tank for the nutrient solution (fig. 7).

2.4. Equipment for the nutrient solution preparation.

The equipment for the nutrient solution preparation used in both modules, is arranged in one container and the description of both systems is given below.

In fig. 8 a scheme of preparation of the nutrient solution is shown: its left hand part represents the system of the nutrient solution destined for the green vegetables and the right hand part represents the system for the fruits and vegetables module and in the centre a water supply unit common for both systems is shown.

2.4.1. System for the preparation of the nutrient solution for the fruit and vegetables module.

This system comprises: a plastic tank of 1000 lit capacity for the working solution; 6 plastic tanks of 100 lit for mother solutions (A, B, C, D, E) and acids; automatic agitators for all the tanks, except for the "Acids"; magnetic pump-meters for the tanks with mother solutions and acid; two circulation pumps, one of which is for the fresh water supply to the working solution tank and the other is for pumping the working solution into the vegetation trays; level regulator of the working solution in the tank; electromagnetic valve in the fresh water supply line; pulse meter

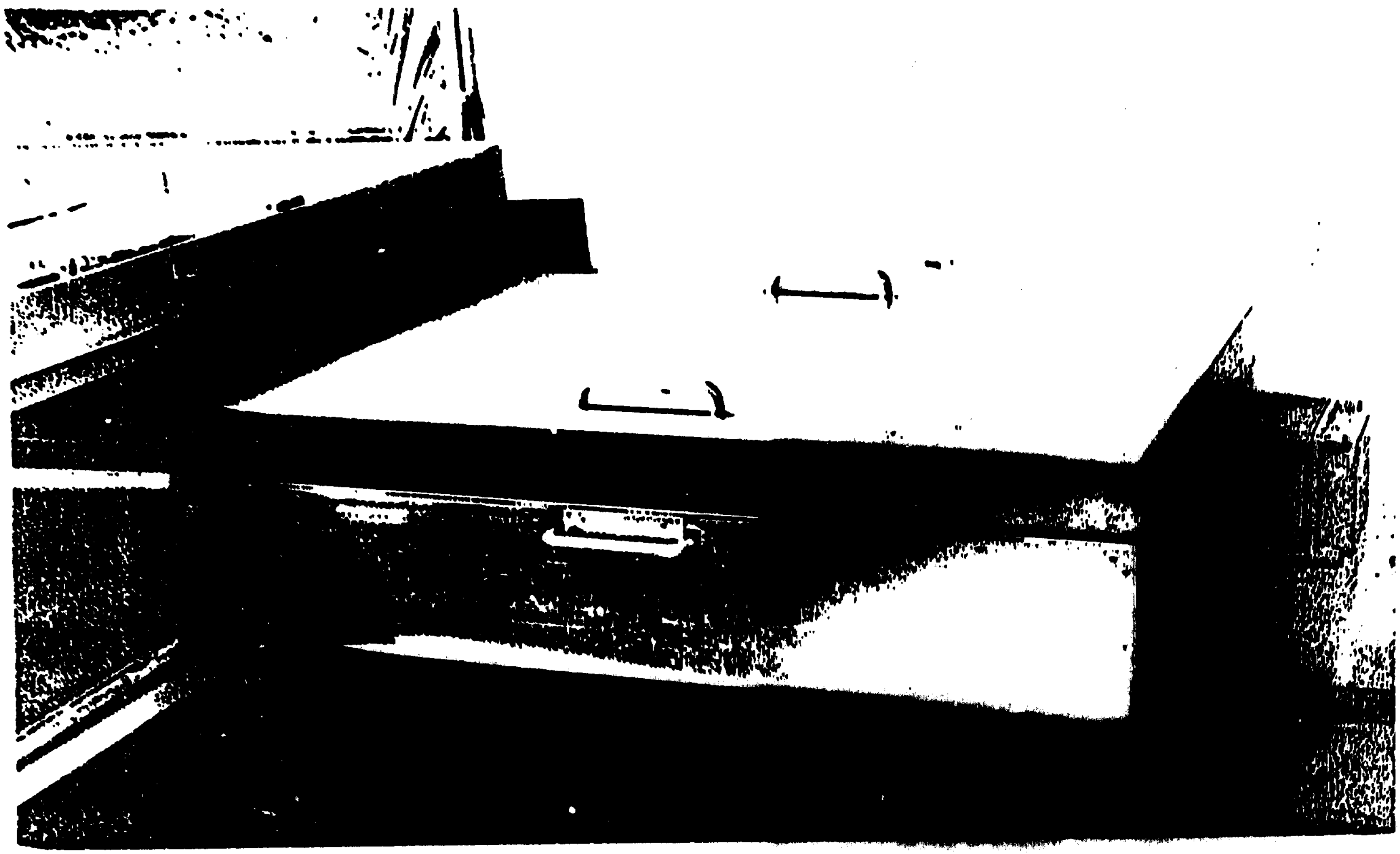

Fig. 4. Thermostat for germination of seeds

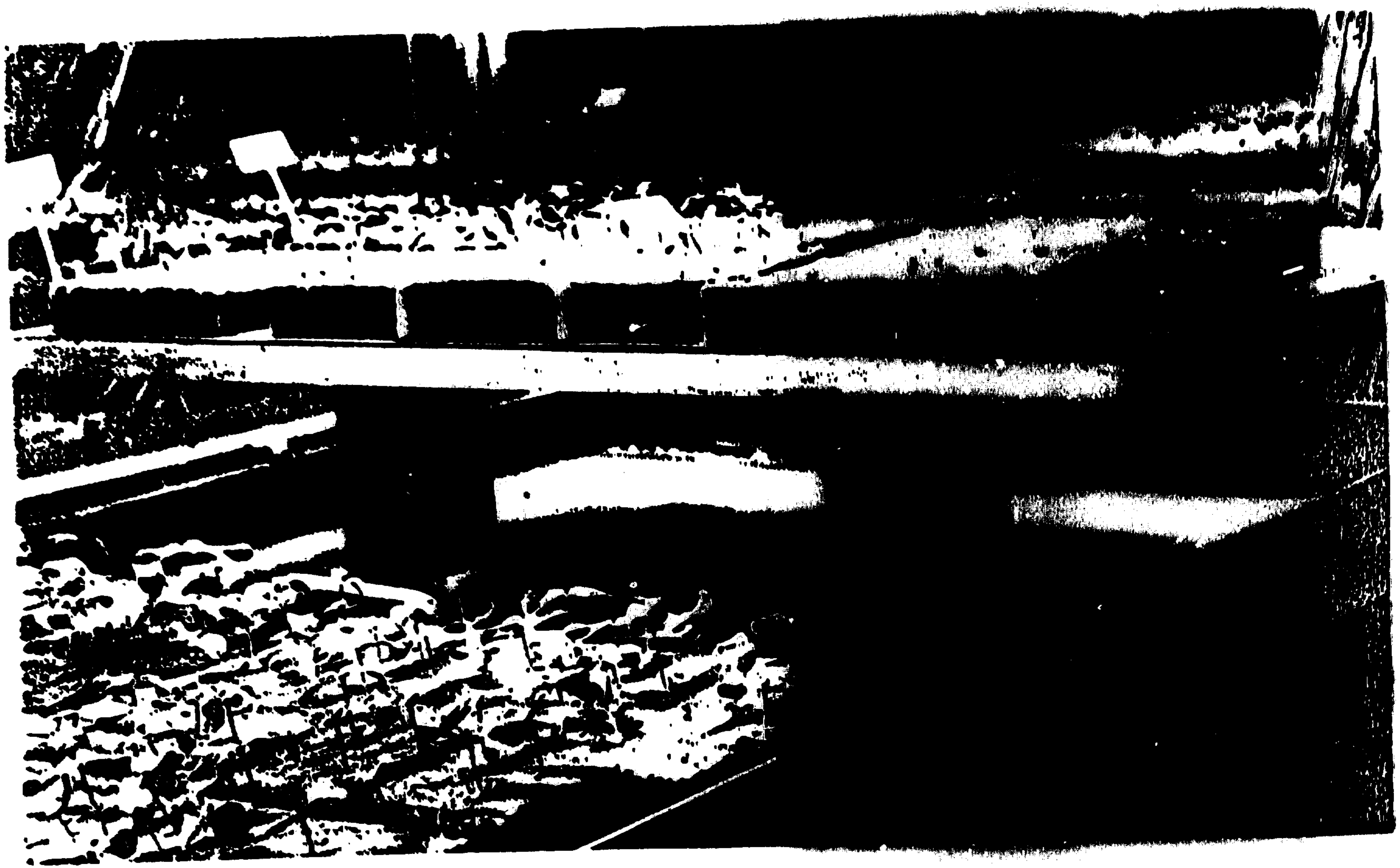

Fig. 5. Table of the seedling section with the grower cubes

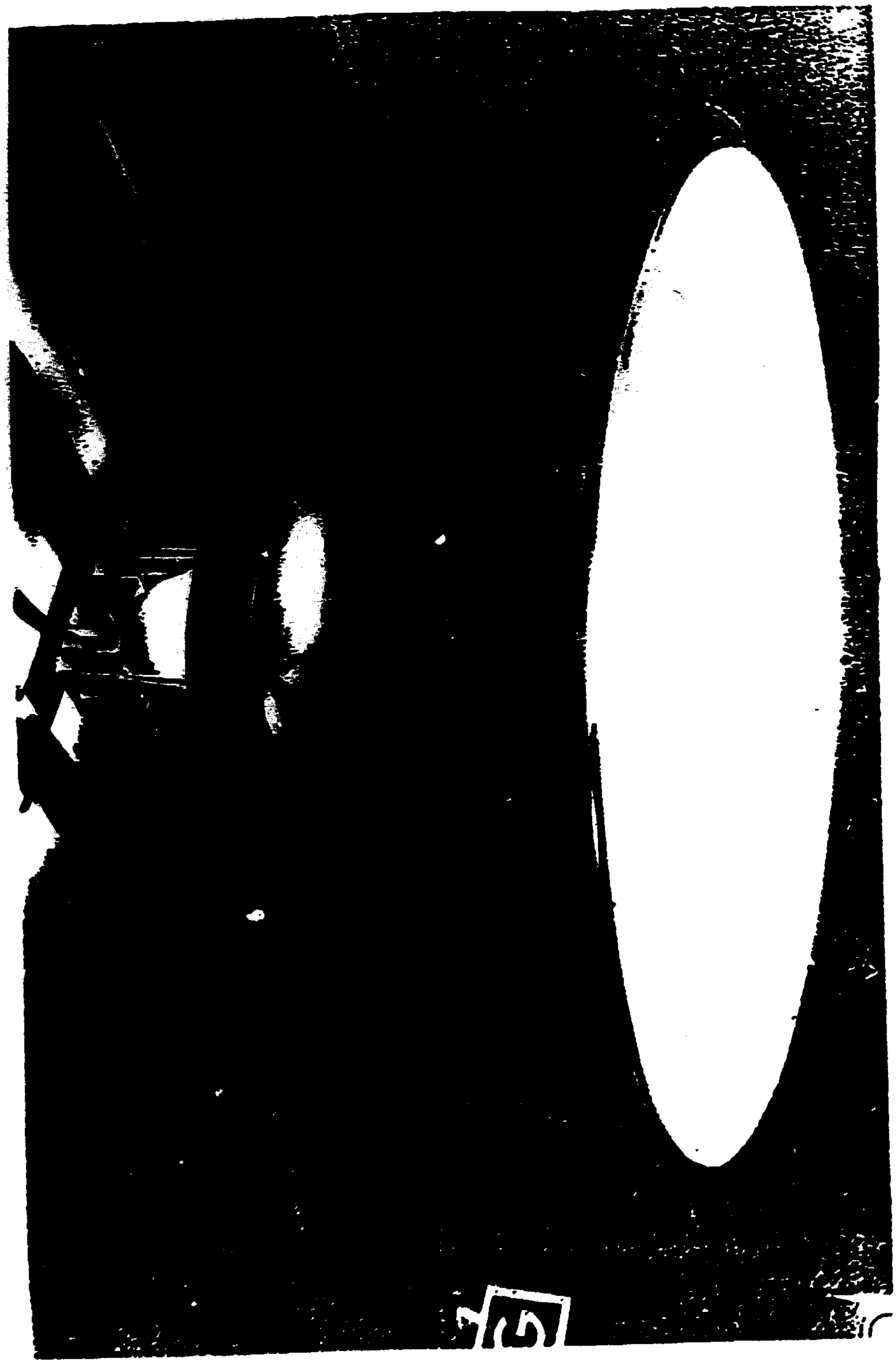

Fig. 6. Light source in the seedling section

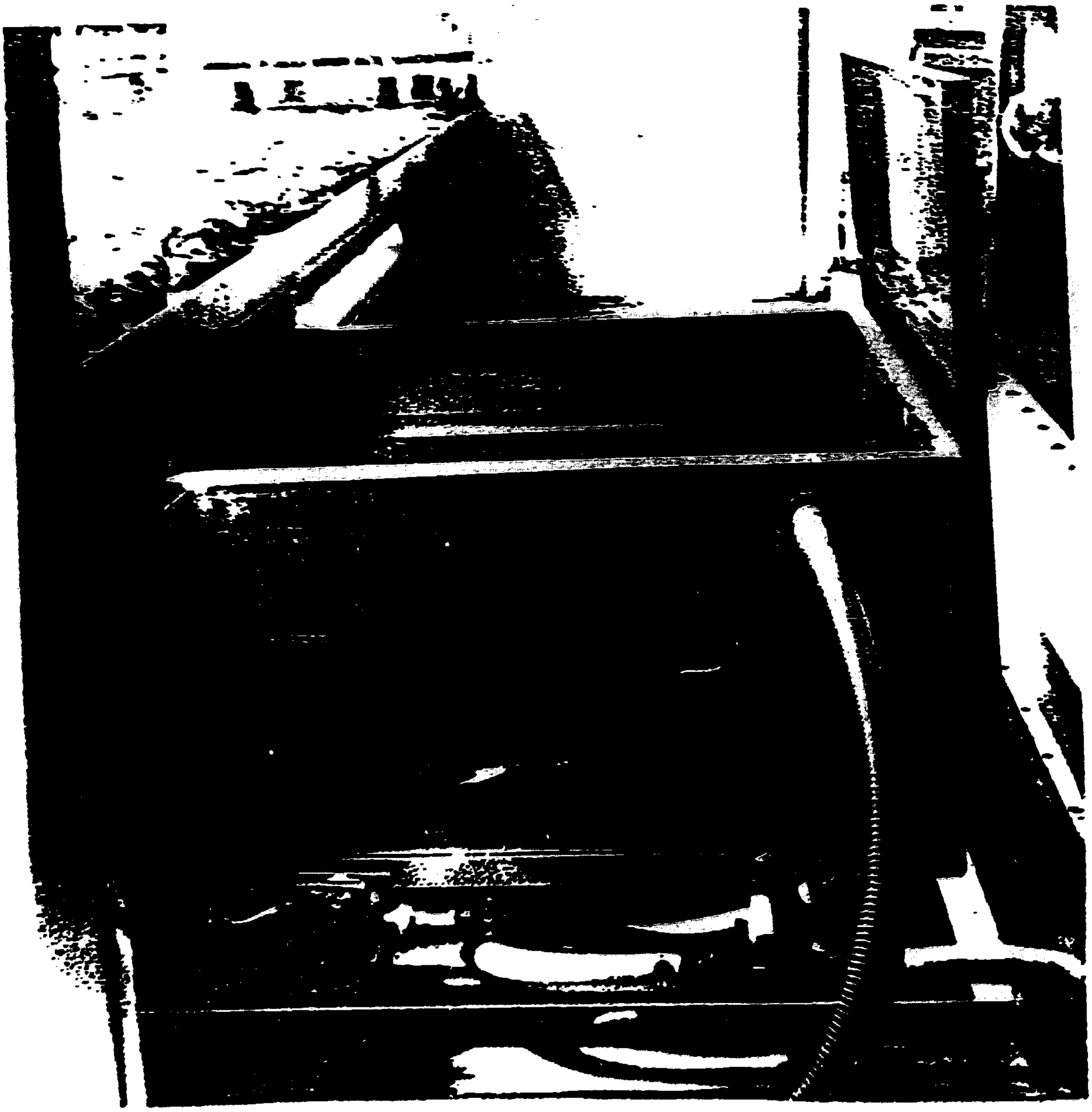

Fig. 7. Tank for the nutrient solution in the seedling section of the vegetables module

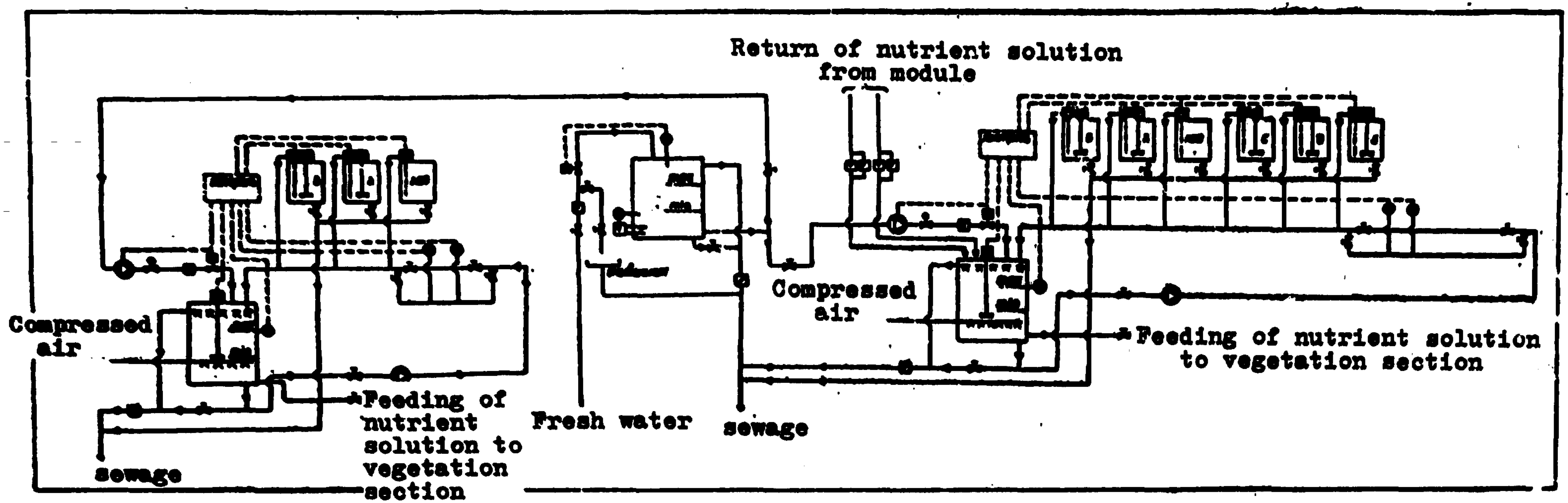

Fig. 8. System for the preparation of the nutrient solutions in the BMC

of fresh water supply; 4 filters in the return lines of the working solution from the vegetation trays; pH-meter with flowmeter attachment and automatic system of electrodes cleaning, single-rod metering circuit of pH, pH-transducer with LED digital display and measuring scale 0-14 pH, monitor of the magnetic pump-meter "Acid" with a series interface to transmit data to the central control board; conductivity meter and regulator (cF) provided with flowmeter accessories for the nutrient solution, a cell for conductivity measuring, meter-transducer for conductivity with LED digital display with measuring range 0-10 msm, monitor of the magnetic pump-meters "A" and "B" with a series interface for transmitting data to the central control board.

2.4.2. System for the preparation of the nutrient solution for the leaf vegetables module.

This system, like the described above, has similar units and equipment, escept for the tanks "C", "D", "E" which are not necessary in this system.

2.4.3. Water supply unit.

This unit comprises: a plastic tank of 1000 lit capacity, level regulator of water in the tank; electromagnetic valve in the fresh water supply pipe from the water mains on the site where the BMC is supposed to be mounted; filter and heating element (3 kW).

2.4.4. System for the nutrient solution oxygenation.

Fig. 9 shows the system for the nutrient solution oxygenation before it is pumped to the vegetation tray for creation of more favourable conditions for better root system development.

The system comprises: a receiving tank; pumping unit with two pumps for creating a necessary pressure; flowmeter with remote transducer; nitrogen filled pressure receiver of membrane type; tank with the devices for cooling or heating of the nutrient solution by the heat derived from the accumulator of the lamps cooling system; reactor of compressed air; reactor of hydrogen oxide; set of distribution pipeli-

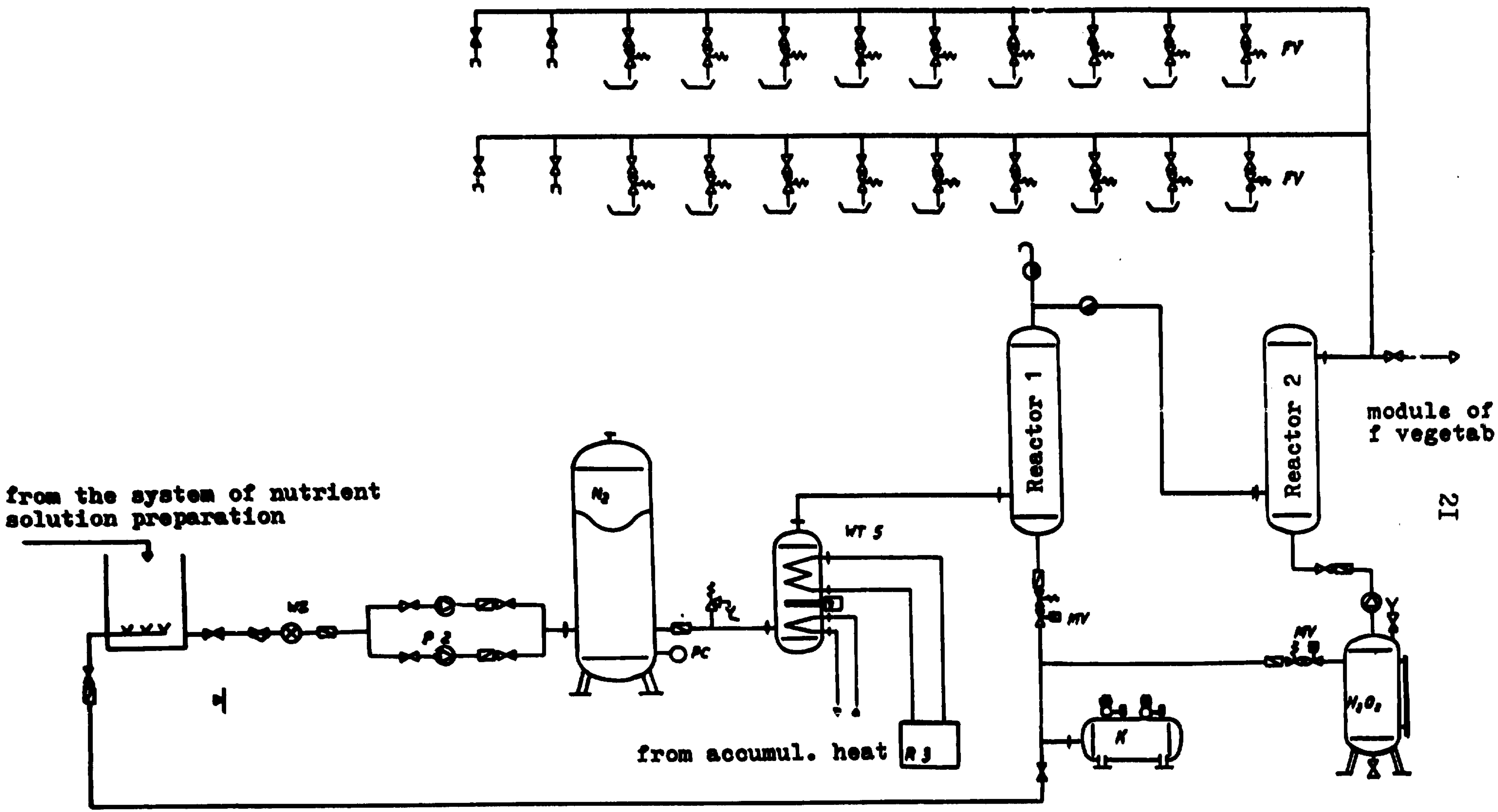

Fig. 9. System of oxygenation of the nutrient solution

nes for nutrient solution supply to the vegetation trays with all necessary accessories; refrigerator of compressor-condenser type.

2.5. CO_2 supply system for the vegetation section.

The equipment forming the CO_2 system is arranged in the same container where the equipment for the nutrient solution preparation is mounted.

The cylinderswith CO_2 which feed the system are storaged in a separate box. The set of equipment comprises a high pressure collector, pressure gauges, safety devices, high pressure valve for double switching of the gas flow, manometric switch for remote switch-over from one CO_2 cylinder to another, pressure reducer, working pressure regulator, flowmeter, analyzer CO_2 with necessary set of connectors, CO_2 transducers with airpipes.

3. Arrangement and equipment of the leaf vegetables module.

3.1. Principal mechanisms.

The equipments comprise the mechanisms and devices used for leaf vegetables as well as for growing of cereals green crops.

The common mechanisms for both systems are as follows: 8 technological belt conveyors with a set of necessary accessories; seed moistening and sowing devices, certain implements for crop collection, cleaning of the growing surface, device for the nutrient solution supply to the root system of the plants and irrigation of the vegetational mass of plants.

Each technological belt conveyor is 3-storeyed and each storey has unit for water spraying and nutrient solution supply, assembled in a common system travelling along the cultivation surface. Each storey is provided with a device for winding up the elastic tapes in rolls on which the plants are grown, if it is necessary to move the plants along the conveyor and to collect the crop. On the same travelling frame where the water and nutrient solution supply unit is mounted, there are also special devices for active ventilation of root systems and improvement of conditions for their development.

The device for seed moistening comprises a set of special cylinders with tapered bottom, travelling mechanism for filling the cylinders with seeds and a mechanism for unloading of the germinated seeds from the cylinders.

The device for planting of the germinated seeds on the cultivation surface of the belt conveyors comprises 4 sets of travelling tanks for germinated seeds, loading mechanisms and other accessories.

3.2. Lighting system for the plants.

There are two lighting systems: one is used for growing of leaf vegetables and the other - for green forage.

The lighting system used for leaf vegetables consists of the stationary sources of light installed between the belt conveyors. The lamps for this system are of the same type as for the vegetable module.

The lighting system used for the green forage comprises the luminiscent lamps fixed on the travelling frames of the irrigation and nutrient solution supply unit.

3.3. Water treatment system for the green forage irrigation and seed moistening.

Fig. 10 shows a scheme of functioning of the water treatment system for irrigation and seed moistening which comprises: a set of equipments consisting of a water softening device, tank for common salt, pump-meter, reverse and mixing accessories, consumption regulators, filters and pumps to increase pressure with stop and switch valves, tank for soft water with necessary hydraulic fittings, accumulator for water heating, 4 special tanks for grain moistening, device for grain ittigation, electromagnetic valves and unloaders of the germinated seeds, 4 metering mechanisms for adding of necessary components into the water for irrigation, set of pipes with fittings, adaptors, regulators, spraying nozzles, valves etc.

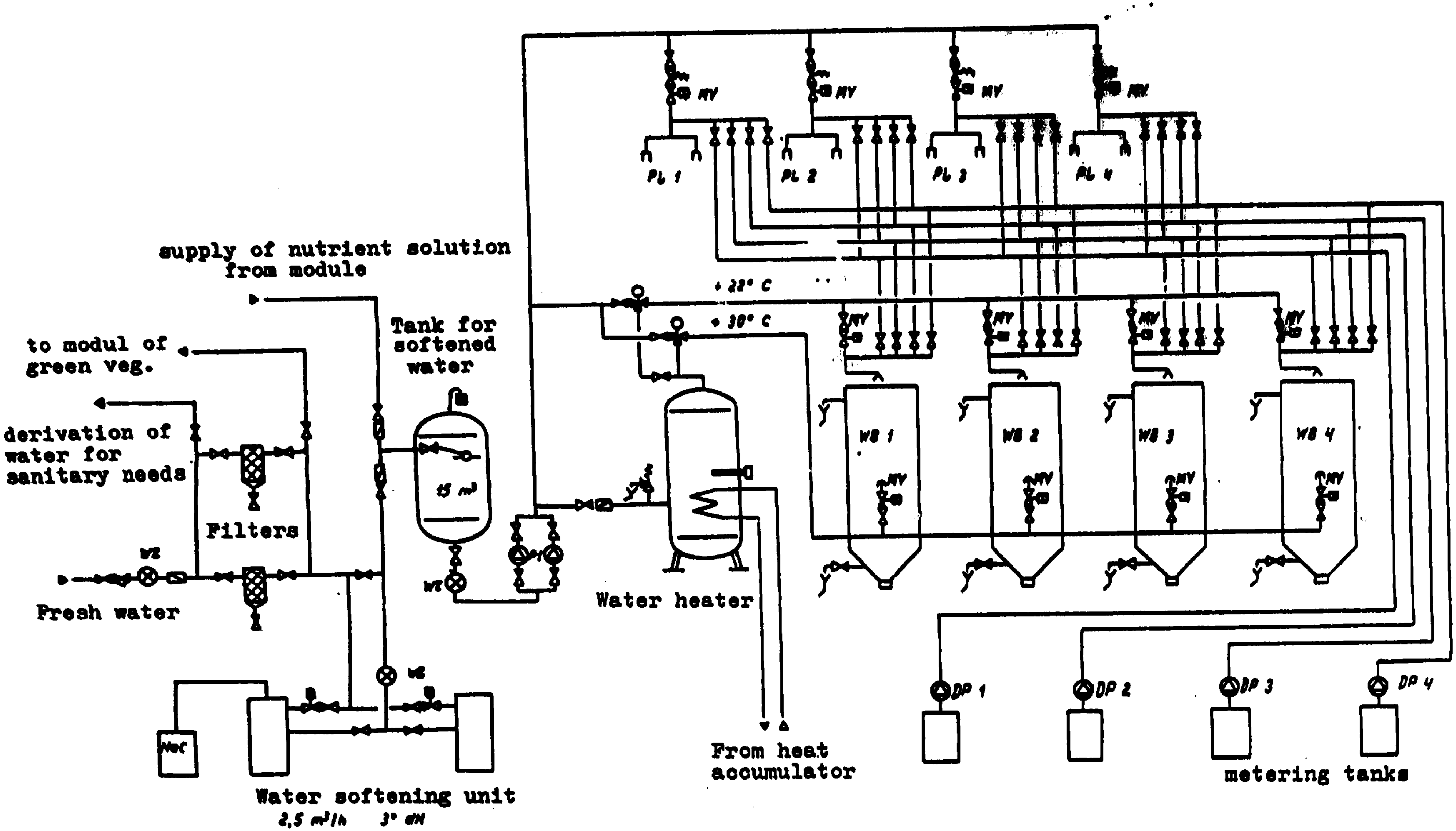

Fig. 10. Equipment for moistening the seeds and irrigation of the growing surface of the belt conveyors in the green fodder module

4. Air conditioning system for vegetation sections.

A scheme of the combined system for the microclimate parameters regulation of the BMC vegetation sections is given in fig. 11. It includes separate circuits for regulation of microclimate parameters in every module, which allow to use the excess of heat of one module in the other and system of heat accumulation for subsequent utilization.

As it is mentioned in para. 2.2, the principal source of heating of the vegetation sections is the lighting system for plants since more than 70% of the energy consumed by the light sources is further spent on heat radiation.

The advantage of the given conditioning system in combination with the lighting system of plants consists in its high degree of energy saving, as a result of utilization of all heat excess and of the ambient air for temperature regulation a feature which is very important for the zones with long cold seasons.

In the conditionig system a highly reliable equipment is used, including compressor-condenser units, highly efficient heat exchangers and accumulators, air ducts of light meterial and simple design filters, condensate collectors for further utilization of the condensate in the system of nutrient solution preparation, ventilators, desinfecting and other devices which allow to ensure an accurate regulation of the temperature and humidity parameters in the zones of growing.

The regulation complex of the air temperature and humidity in the modules which include the necessary measuring transducers, adjustment of the control boxes for ventilators, pumps, valves, remote control meters for each of the four zones of temperature measuring, air humidity in the modules, air temperature supplied to them and to the lamps ensures the control in three measuring points of the temperature at the outlet (when cooling the lamps), in three measuring points for heat accumulators, in two measuring points of the air for the modules and in one measuring point of the ambient air temperature. The regulation complex is provided with a programmed memory computer for transformation of the coming technological commands.

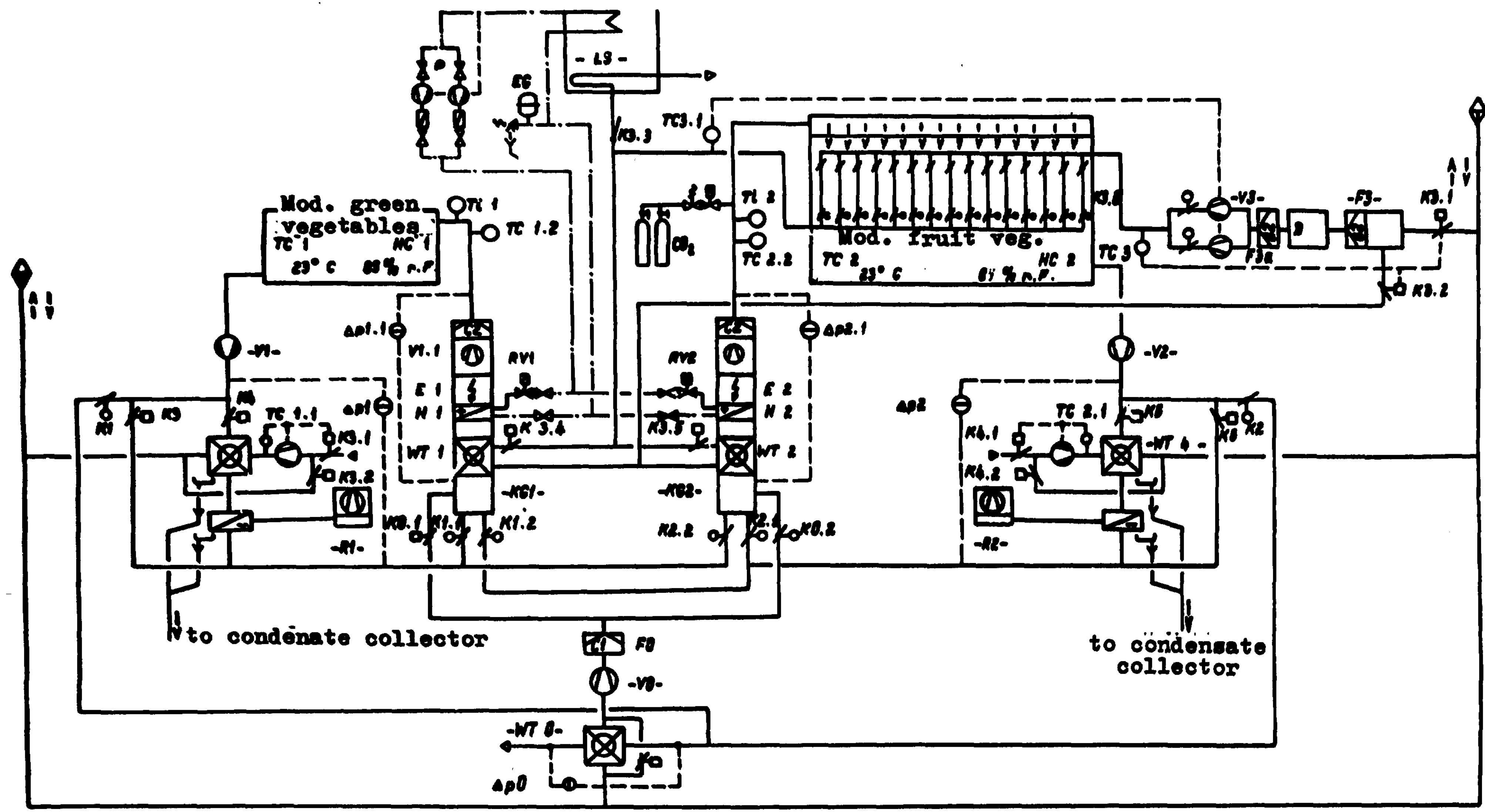

Fig. 11. Conditioning system of the vegetation sections of the BMC

5. Electrical equipment of the BMC.

5.1. Power supply.

The power for the whole complex is supplied from the central distribution board, of 380 V, 50 Hz with neutral zero; maximum power consumption is 360 kW.

The central distribution board is provided with an emergency switch-off in case of overloads, insulation failure or disconnection of the feeding tension. Besides, at customer's option, a device of remote programmed switch of the module may be mounted on the central distribution board. On the board the electric meters for the vegetables and green crops modules are mounted as well as lighting circuits with safety fuses, sockets and distribution panels for all technological lines. There is a separate distribution box for each technological line with protection, commutation and control devices and a monitor with software to ensure an automatic technological regime.

5.2. Automatic control system.

The automatic control system ensures the operation of three groups of devices mounted in the vegetables module, green crop module and artificial climate plants (fig. 12). All the parameters are controlled by means of the functional regulators consisting of a transducer of the controlled parameter, transducer-amplifier, proper regulator and an interface to connect an executive mechanism. Through a bus system the regulators are connected with the central computer and at a certain time intervals transmit to the latter the corresponding measured data. This computer is provided with a keyboard, monitor and printer. There is also a telephone modem, to transmit the measured data to the central control board. The board is also equipped with a computer with keyboard, monitor and printer.

Besides the functional regulator the system comprises:

- protection and commutation equipment;
- acoustical and optical indication system of the current processes;
- flexible programmed devices for control of technological processes;
- software;
- transducers of the executive mechanisms conditions.

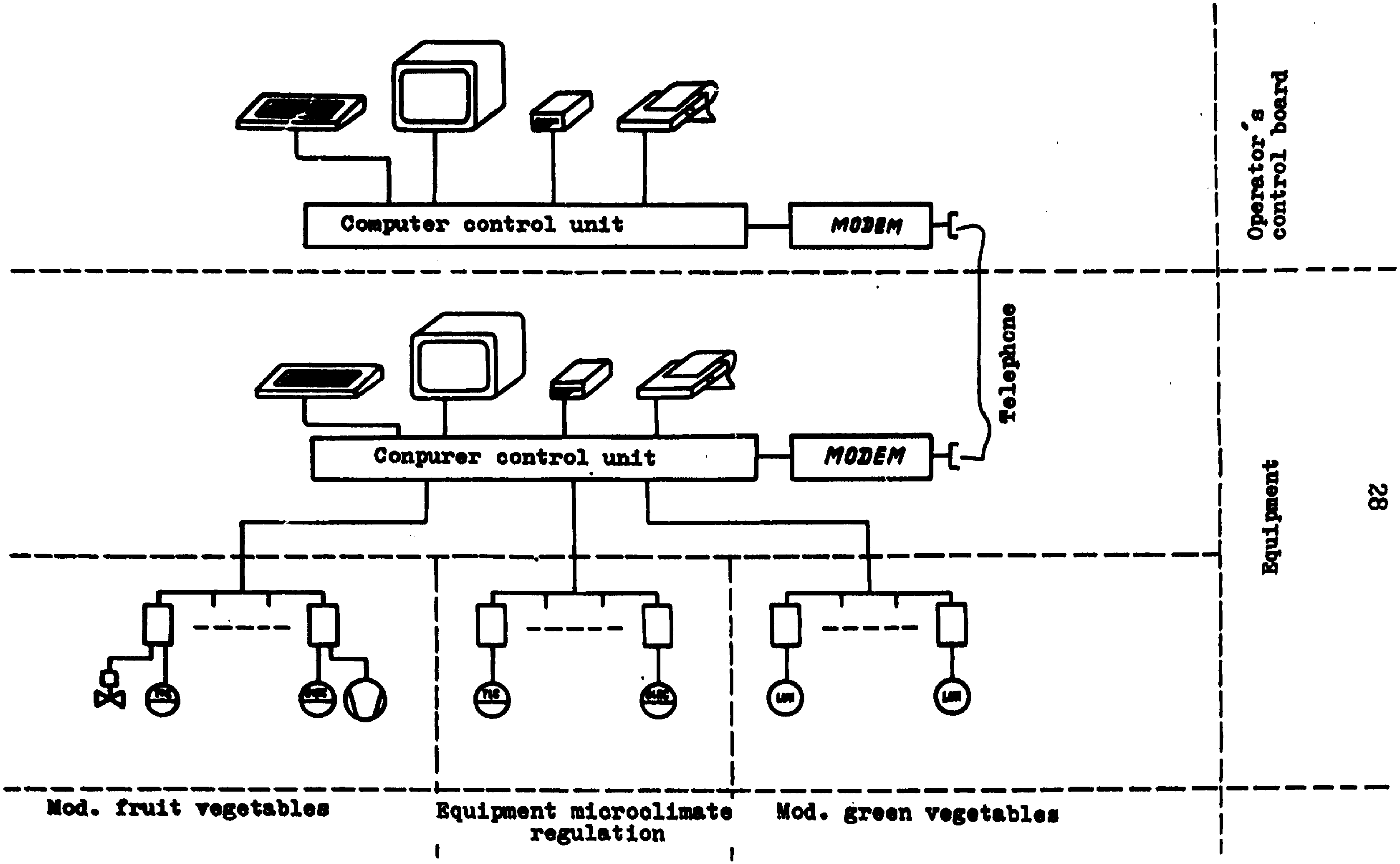

Fig. 12. Structural scheme of the decentralized control system of the BMC

Some regulators and receivers of the measured data accomplish the following functions:

- exercise control on the basis of the data determined directly by the regulator itself, or given by the central computer;
- collect and register the measured data;
- transmit the measured data through the bus system to the central computer.

By means of the computer programs certain regulators and data receivers are called, the data are collected into the random access memory block (RAM). The regulating parameters may be changed with the aid of the input keyboard or optimization characteristics registered in the memory.

Due to a special software three trends may be plotted for the temperature, humudity, pH, phosphorus, potassium, nitrogen, CO_2 content, lighting intensity etc. With the aid of other programs deviation reports are made up as well as eventual instructions are given for the maintenance personnel. The trends and deviation reports may be input into the monitor or registered by the printer.

The measured data to be transmitted to the central control board are deposited in RAM. These data may be later transmitted by the modem to the central board modem. The data transmitted through the telephone channels may be processed with the aid of a corresponding program.

In fig. 13 an example is given of the graphic report of principal parameters for one week for the analysis of the current processes and correction of the technology.

A graphic report may be also received for the analysis of 24 hours deviation of the controlled parameters in any day (fig. 14). The communication facilities for transmission of data to the central computer allow to simplify the service and consultation system for the customers of BMC.

One agronomical service centre may attend a net of BMC of a whole region. This cuts considerably the customer s agrobiological staff costs.

The safety communication equipment ensures that the executive mechanisms connect with the power mains by the

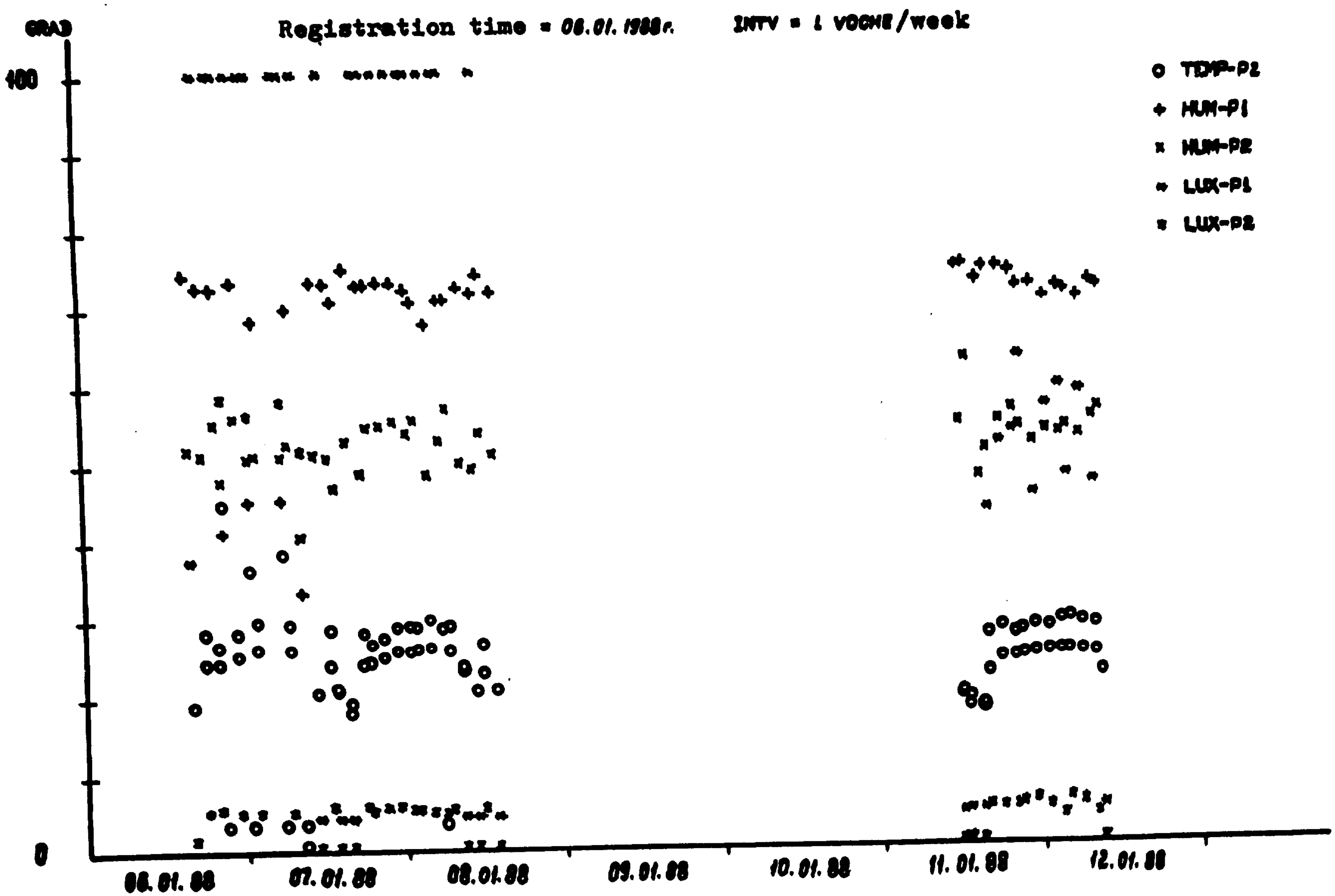

Fig. 13. Example of the graphic registration of the principal microclimate parameters for a week

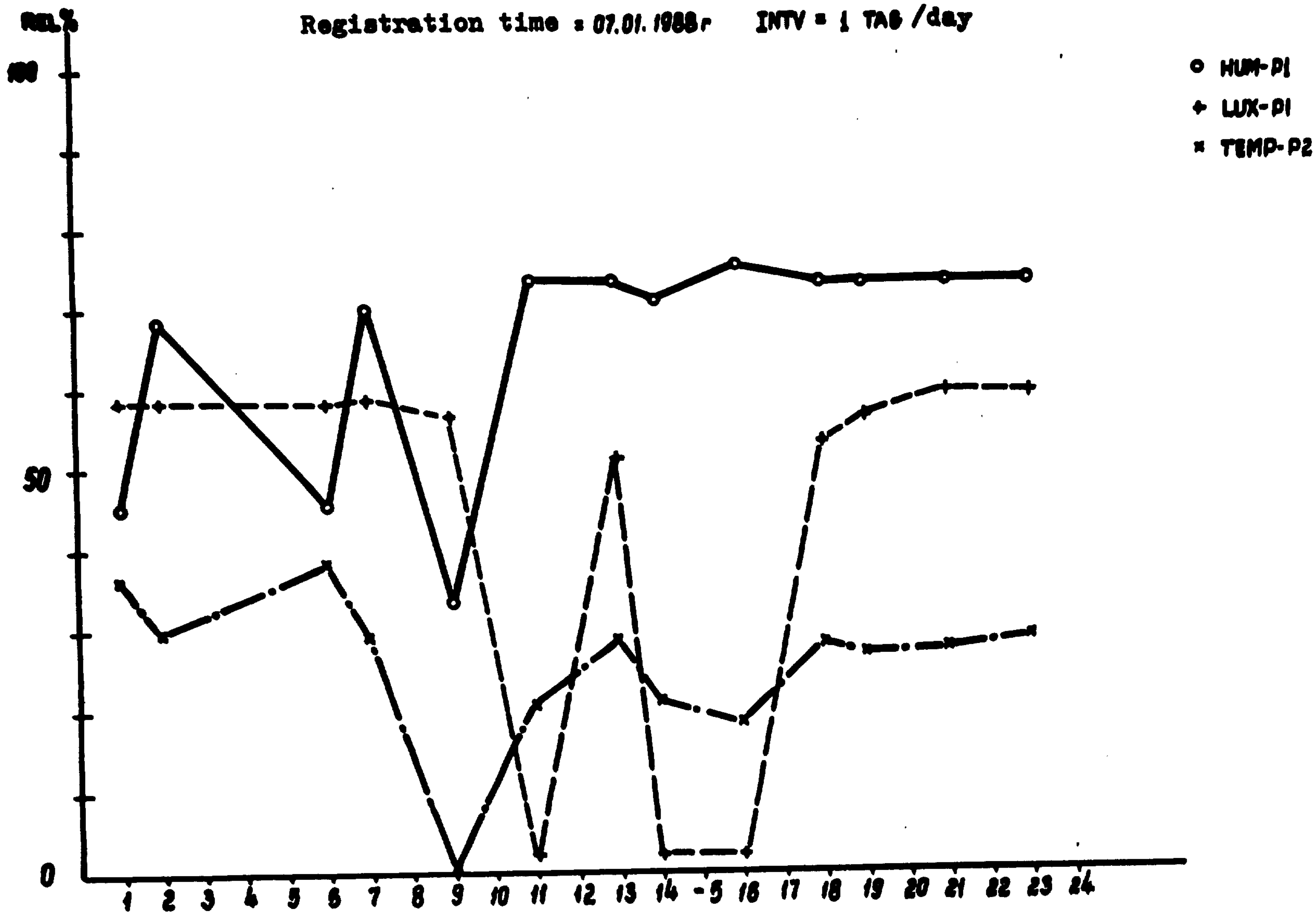

Fig. 14. Example of the plotting of principal microclimate parameters for 24 hours

automatic control signals and disconnect them in emergency cases.

The operation of all the systems is controlled with the aid of optical indicators "normal/failure" for all the parameters and conditions of the executive mechanisms; these indications are followed by the acoustic ones. If necessary an automatic telephone call may be used to inform the operator on duty about a failure.

The programmed control of each technological line is ensured by the flexible programming device. The sequence of the control commands and duration of the control operations are determined by the program and, if necessary, may be changed. All the principal regimes of the module work may be controlled with the aid of the controls mounted on the distribution panels.

The software of the control system allows to:

- change the regulation parameters of microclimate and feeding;
- change the regimes of switching on of all mechanisms;
- collect, process and storage the regulation data.

5.3. Control, measuring and regulating equipment.

For temperature and humidity regulation in the modules there is a set of equipments with necessary transducers of the parameters under control.

This equipment comprises:

- distribution boxes for ventilators, pumps and valves control;
- telemetric apparatus for two principal vegetation sections;
- set of transducers for measuring the temperature and humidity of the intake and exhaust air for the spotlights, heat collector and ambient air.

The plant for automatic temperature and humidity control has a programmable regulator with the memory block to process the technological commands coming from the central computer.

There is also a complex system to control the nutrient solution supply and its parameters consisting of functional regulators of pH, conductivity, temperature and O_2 concentration.

All the regulators have memory storage and accomplish their functions in accordance with the technological commands of the central computer. The solution and water parameters are shown on LED displays mounted on the control boards. This system includes also the equipment for CO_2 concentration measuring and control in the vegetables module. It comprises a transducer acting on the principle of absorption by CO_2 of the infrared radiation, hose for gas sampling, functional regulator, connected with the central computer. The executive device is a magnetic valve with reducer mounted on the compressed or liquefied CO_2 cylinders.

All the equipment of the system is arranged in distribution boxes. The commutation devices and indicators are mounted on the doors; the boxes are provided with relays and signal lamps.

6. Conclusions.

The described Block Modular Complex is a multi-purpose technological plant which allows to ensure an efficient and stable production of different vegetables all year round. With insignificant modifications of the cultivating facilities (trays) the BMC may be successfully used for flower, berries, melons and other crops growing.

One of the promising directions of BMC development is the growing of medicinal plants and extraction from them of raw material for deficit drugs production.

The BMC may give high efficiency and excellent results in the field of producing the rooted grafts of bush berries for their further planting in open ground.