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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

REPORTS
presented at the

EXPERT GROUP MEETING ON INDUSTRIAL ECOLOGICALLY CLEAN CROP PRODUCTION SYSTEMS IN ARTIFICIAL CLIMATE

Moscow, USSR, 12 - 19 September 1990

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XP/GLO/90/091

CONTENTS

PREFACE

The Expert Group Meeting on Industrial Ecologically Clean Crop Production Systems in Artificial Climate, held in Moscow and Leningrad, Union of Soviet Socialist Republics, from 12 to 19 September, was organized by the United Nations Industrial Development Organization (UNIDO) and the Scientific Research and Manufacturing Enterprise of Agricultural Engineering (NPO Viskhom) of Automobile and Agricultural Machine Building of the USSR.

UNIDO has been looking at the issue from at least three different view points, namely: the impact industrial crop production sestems in an artificial climate may have on the environment; the contribution such systems could make to the traditional production of food crops and plants in selected areas (e.g. overpopulated cities) and in developing countries; and the research and development work that should be carried out, particularly applied research directed towards the selection of relevant technologies and their adaptation. The purpose of the Meeting was to discuss these issues as well as conditions under which the ecologically clean production of crops and plants become economically feasible, to review the current state of development and to make recomendations to UNIDO.

UNIDO is indebted to NPO VISKHOM for the assistance fnd co-operation received in the preparation, organization and implementation of the Meeting and to A. Nelyobov and Y. Lipov for their personal co-operation, which was instrumental in the success of the Meeting.

INTRODUCTION

In accordance with UNIDO projects XP/GLO/90/091 and UD/GLO/90/102 the Agro-based Industries Branch of the Department of Industrial Operations of UNIDO and NPO Viskhom (Scientific Research and Manufacturing Enterprise of Agricultural Engineering) of the Ministry of Automobile and Agricultural Machine Building of the USSR held an Expert Group Meeting on Industrial Ecologically Clean Crop Production Systems in Artificial Climate in Moscow and Leningrad, from 12 to 19 September 1990.

The following experts participated in the Meeting: Dr. E.F. Winter (USA), Prof. C. Zabeltitz (FRG), Mr. J. Groiss (Austria), Dr. W.L. Bauerle (USA), Dr. A. Dlugy (USA) and the Soviet experts Dr. A.I. Nelyoubov, Dr. Y.N. Lipov, Dr. V.P. Doronin, Mr. M.A. Galkin, Dr. E.S. Sysoev, Mr. A.Y. Lipov, Dr. Y.F Sviridenko, Dr. B.A. Schulzhenko and Dr. A.V. Khromov. The Senior Industrial Development Officer and Industrial Development Officer as backstopping officers of the project from the Agro-based Industries Branch and the Industrial Development Officer of the Industrial Technology Promotion Division also participated in the Meeting. In addition, the following representatives of developing countries, Mr. Chuluunbaatar from Mongolia and Mr. Fapohunda from Nigeria, as well as a number of specialists from the Soviet Union took part in the Meeting. The list of papers presented at the Meeting is attached.

Mr. G.S. Kirichenko, Deputy Minister of the Ministry of Automobile and Agricultural Machine Building of the USSR, addressed the Meeting. The experts from UNIDO made a tour to the "Selkhoztechnika-90" International Exhibition and acquainted themselves with the organization of work and technologies of growing vegetables and champignons in the greenhouse farm "Moskovsky" in Moscow and firm "Leto" in Leningrad.

The reports of the experts were discussed as well as such topics as the intensification of the production of ecologically clean crops on sheltered soil and the introduction of modern industrial technologies in developing countries.

CONCLUSIONS AND RECOMMENDATIONS

The participants of the Meeting made the following recommendations, which were discussed at the Expert Group Meeting on 18 September 1990:

1. In order to develop on a comprehensive basis ecologically clean system for sheltered soil, utilizing advanced technologies of developed countries, and in order to introduce as soon as possible these system in developing and other interested countries it is advisable to establish an international scientific and technical centre on ecologically clean technologies and technical means of growing agricultural crops on sheltered soils at NPO Viskhom, with experimental pilot plants at the greenhouse firm "Leto" in Leningrad and in other areas with specific climate.
2. Complex projects should be prepared by UNIDO in cooperation with NPO Viskhom, USSR, which are to contain the recommendations made for the introduction of ecologically clean technologies and corresponding equipment for sheltered soil by the group of experts headed in the USSR by Dr. Y. Lipov, in the USA by Dr. F. Winter and Dr. W. Bauerle and in other countries.
3. The recommendations for technological processes made by Prof. D. Zabeltitz (FRG) and for drop irrigation made by Mr. J. Groiss (Austria) should be used for the preparation of corresponnding projects in developing countries upon Government request, taking into account the complex mechanization of operations.
4. It is rekommended that in the UNIDO Newsletter reference should be made to the Expert Group Meeting.
5. NPO Viskhom should publish a book which contains the reports of the UNIDO experts (two hundred copies in English and one hundred copies in Russian) and forward all the copies to UNIDO before the end of 1990 for distribution to developing countries and to organizations interested in this technology.
6. The results of the Expert Group Meeting should be discussed in Vienna from 8 to 12 October 1990 with the participation of specialists from NPO Viskhom and UNIDO.
7. The actuality of the issues discussed, the effectiveness of the Meeting as well as its good organization by NPO Viskhom should be noted.

THE PRESENT STATE AND PERSPECTIVE OF DEVELOPMENT OF ECOLOGYCALLY CLEAN TECHNOLOGIES FOR INDUSTRIAL CROP PRODUCTION.

A.I. Nelyoubov *

Prediction estimation of long-term development of agricultural production indicates the necessity to solve a whole variety of qualitatively new tasks in the nearest decade which are resulting from increasing scarcity of labour and material resources and from ecological restrictions.

Included into these tasks is a necessity to considerably reduce labour consumption, to preserve and to increase soil fertility, maximum invironment protection from contamination with chemicals and cattle breeding waste.

Large amount of work is being carried out in this direction in order to create new technologies and equipment for them. As far as grain is concerned - the work includes mass usage of industrial technologies which permit considerable crop increase in the country.

Industrial technology is characterized by strict sequence of carrying out agricultural technology measures taking into consideration peculiarities of a cultivation, soil character, complex of agricultural vehicles and tractors being used, forms of labour organization and payment.

This includes a complex of major organizational, economical, technological and other measures directed at soil fertility improvement, soil protection against wind and water erosion, reduction of negative influence of agricultural vehicles connected with overcompression of soil.

This includes creation, industrial organization and full satisfaction of requirements of the agriculture in vehicle complexes ing grain and other agricultural crops.

Results of large-scale experience gave a confirmation that usage of intensive technologies is not only the most real but also the most effective way of achieving high results in cultivation.

In the machine building sphere the main task of putting this programme into life is setting up of the scientific and production potential that could guarantee in full provision of the agriculture with the equipment of the most up-to-date level.

For intensive technologies of grain crop cultivation (winter and summer wheat and other cereal crops, rice, soybeans and coarse-ground.wheat) it will be necessary to make use of 204 items of agricultural facilities in all regions of the country. Out of this quantity 108 items (53.0 percent) are intended for soil preparation and planting and 75 items (36.7 percent) are intended for performing other technological operations (harvesting, grain processing after harvesting is completed, straw stacking, etc.).

Along with that it may be stated that there exists an increasing gap between the mentioned tasks and potential possibilities of the traditional types of agricultural equipment whose technological and technical capabilities are approaching their extreme values.

Thus, for example, the reserves of increasing productivity of the vehicle and tractor units of the traditional types by increasing their operating speeds are practically exhausted due to the fact that beyond the limits of definite values of the latter deteriorated is the quality of

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* General Director, NPO Viskhom (Scientific Research and Manufacturing Enterprise of Agricultural Engineering), USSR

carrying out tecnological processes and operations of soil preparation, planting, harvesting of crops, etc. which are performed by operating and transportation parts of agricultural facilities.

Working width of the traditional agricultural vehicles is also approaching its ultimate values due to an increase of the "gap" between the rates of their finished and operational output at simaltaneous increase of such negative features as overcompression of soil because of increment of mass of the vehicles, complexity of mating adjacent passages of the machine while performing the operations of soil preparation and cultivation of crops, difficulties of copying the relief of soil and accurate adherence to inter-row spacing while harvesting row crops.

Experience of the agricultural vehicles operation shows that soil is influenced by the engines of the vehicles which are used for mechanization of operations being carried out and it causes re- duction of crops by 10 to 18 percent. That is why the problem of soil dispersion is extremely urgent.

At present, mechanical loosening of soil is the only effective method of soil dispersion. Special vehicles are developed for loosening the plowing horizon. The most effective of them are combination vehicles which combine the operations similar to each other in output and power capacity: pimary and additional processing accompanied with several operations of preplanting soil preparation.

Certain reserves of increasing the output and improving the quality of operation of the traditional agricultural facilities may be put into life by optimizing the operation modes of agricultural facilities and by automatizing control processes. However, if the existing technologies and technical facilities are preserved, this method will require designing of relatively complicated and expensive automation systems and this will lead to reduction of profitableness of their usage.

Preservation of soil fertility is by now a very acute problem.

At present, soil preparation includes 40 percent of power and 25 percent of labour expenditures out of the whole volume of the field work in cultivating and harvesting agricultural crops.

Thus, the number of drag machines for tractors, type T-150 and K-701 is now more than 100 items.

Production association "Odessapochvomash", produces 6- , 7- , 8- -body general purpose plows provided with an increased (up to 40 cm) width of the plow bodies and ensuring reduction of fuel consumption down to 10 to 15 percent, mounted 7-body plow used for stony soil and equipped with hydraulic safety device, fixtures for 5- , 6- , 7- and 8-body plows which ensure breaking the soil down and its levelling.

Effective for soil protection technologies which are carried out with the purpose of preserving soil fertility and prevention of water and wind erosion are the furrow cutting mould boardless plows, appliances used for preserving moisture, subsurface cultivators and deep cultivators as well as the plows, slotting machines and soil loosening appliances which are used for processing alkali soil, etc. Mould boardless chisel plow ПЧ-4,5 (Fig. 1) ensures loosening of soil down to depth of 40 cm, high productivity along with a lesser fuel consumption as compared with a mouldboard plow and permits to prevent overcompression of the plow and subplow layers.

Minimization of soil preparation may be achieved by usage of combination machines which permit to reduce the number of passing of the machine-tractor units through the field, to reduce the cost and to load efficiently the powerful tractors. Rotary tilling planting unit КФС-3,6 (Fig. 2) during one passing through the field ensures soil preparation, mineral fertilizing, planting and rolling the soil down. Combination units КА-3,6, РВК-5,4 and КФГ-3,6 whose working width is equal to 3.6 and 5.4 m

Figure 1. Chisel plow PTch-4,5 fitted with soil loosening fixture.

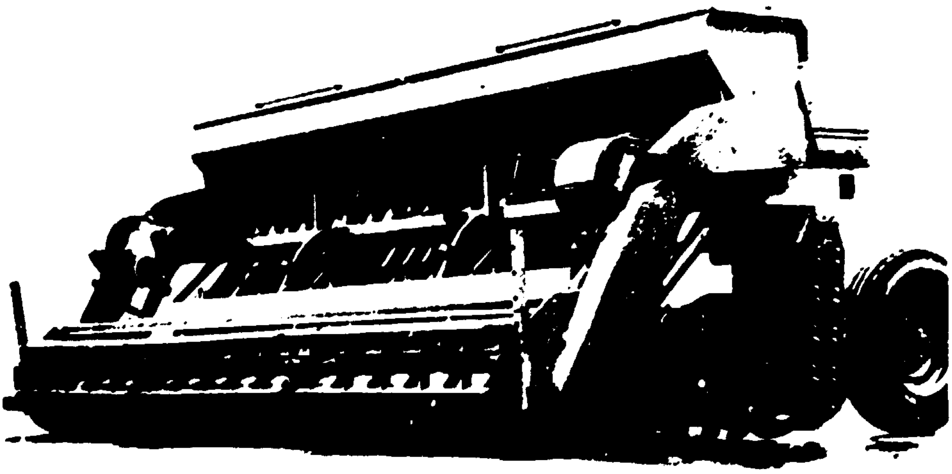


Figure 2. Rotary planting unit KFS-3,6

are used for primary and preplanting soil preparation and for putting mineral fertilizers into the soil.

Mastering and manufacture of a new generation of appliances for soil protection technologies is characterized with an increased working width and linkless type of structure which permits to considerably (by 5 to 7 times) reduce labour consumption when transferring the vehicles into transport position. Thus, linkless cultivators КПУ-12 and КПУ-18 whose working width is equal to 12 and 18 m and which came to replace previously used cultivator of 4 m working width ensure an increase of output by 20 to 30 percent.

Linkless wide-row sowing machines - grain fertilizer drill СЗШП-14.4 and stubble field drill СЗС-12 furnished with means of hydraulic control over the tools, planting control facilities and warning indication if the process is deviated from the established procedure, devices for transferring the drills into transportation position by means of one person - permit to reduce labour expenditures by 1.5 to 2.0 times and to increase the output up to 40 percent.

Primary attention of the industry is directed at mechanization of the grain economy of the country.

At present created are high-output grain harvesting combines "Don-12002" and "Don-1500" (Fig. 3) whose output is 1.5 times more as compared to the machines being produced. The technical level of these combines is higher than that of the best analogues existing in the world.

Fundamentally new combine CK-10 that is being developed now is equipped with a rotor threshing device which is exceeding the output of the series vehicles. Combine operation is characterized with a considerably less losses and grain damage.

Since an increase in power and mass of the mobile agricultural units, grew more acute the contradictions between the necessity of the agricultural technology of intensive mechanical preparation and its negative influence on fertility.

Looking from the positions of tomorrow, the problems of usage of mineral fertilizers and chemical means of protection of crops can not be considered to be solved.

As it is known, maximum share of expenditures in the intensive agricultural production lies with the fertilizers, including more than 30 percent of all energy consumption (according to foreign calculations). Considerable share of cost of fertilizers lies with the of mineral fertilizers whose major part includes transportation expenses from the places of their production and processing to the places of usage.

The modern integrated systems of crop protection combine the chemical, mechanical and biological methods and the tendency is preserved to expand utilization of chemical methods, herbicides in particular, whose standard dosages become non-effective with elapse of time and the necessity arises for systematic replacement of one type of herbicide with another. Evidently, under specific conditions of operation the reduction of efficiency of a herbicide of a definite type will first of all lead to an increase of the norm of the herbicide placement which is very often in excess of ecologically permissible amounts and only after that the attempts might be taken to replace a herbicide with another type. Integrated system of crop protection includes agricultural technology methods of soil preparation, planting, placement of liquid and hard mineral fertilizers, granular pesticides and grouth regulators as well as physical, mechanical and biological methods and manners of protection of crops. In this case, of primary importance is development of ecologically pure grain and row crops.

Experience and practice of last years accumulated by Scientific and Production Association VISKHOM (All-Union Institute of Agriculture) permit

Figure 3. Grain harvesting combine "Don-1500"

to determine basic trends for realization of the proposed programme.

It is proved by science and practice that at least half of the growth of agricultural crops is received due to usage of fertilizers and up to 30 percent of biological crop - due to usage of crops protection means. The effect of usage of chemization means may be increased by putting into production a set of machines and appliances for intrasoil, layer-wise and differential placement of chemization means. Thus, intrasoil placement permits not only to ensure the environmental protection and to reduce the volume of placing expensive compounds as well as to reduce labour expenditures. The intrasoil placement (Fig. 4) permits to ensure unanimous young growth of agricultural crops.

Usage of equipment for row and field cultivators (Fig. 5) meant for intrasoil placement of pesticides and contact application of growth stimulants permits to ensure an increase of harvest up to 20 percent.

The sprayers which are used for processing the crops by use of contact-wetting method (Fig. 6) permit to use herbicides and growth stimulants due to their partial wetting at the moment of intermediate contact of the tool with the plant. This is used to cut down expenses for expensive compounds, decreases contamination of the environment, increases the output of the vehicles by 1.6 times (due to usage of decreased number of fueling and eliminating the sprayers which are very often clogged).

All these measures ensure high technical and technological level of the machines which are capable to compete at the world market.

Fertilizer spreaders which are used for fractional placement of fertilizers contribute to putting into production the set of vehicles and appliances intended for intrasoil, layer-wise and differential placement of fertilizers.

This ensures a reduction of the norm of the fertilizer placement, an increase of efficiency of their action, a reduction of contamination of the environment and soil with an excess of the compounds, unanimous young growth and, as a result, an increase of the crop up to 25 percent. In this case, the labour expenditures are reduced by 1.3 times.

Combination units are used for volume placement of microbiological compounds onto the bottom side of leaves and that permits to fight against certain types of illnesses and parasites of agricultural crops without using pesticides. Developed for fighting against comroot rot, down mildew and plant louse are the microbiological pounds on the basis of lively bacteria and fungus. Due to the fact that parasites and illnesses are mainly located on the bottom side of the leave the efficiency of influence is determined by a place of treatment. The unit for microbiological compounds may be installed both on the cultivators and on the sprayers. Used in the unit may be perspective double-sided centrifugal sprayers which are patented in Hungarian People's Republic and France. In this case, the output of the machines is increased by 1.3 times and efficiency of utilization is increased by 1.6 times as compared to the traditional methods.

One of the trends of the biological method of protecting the crops may be dispersal of useful insects in the lively stage.

As compared with the fixed stage dispersal of insects (for example, eggs of sitotroga)the lively stage insects are more active in searching the eggs and parasites proper and eliminate the latter. In this case, their productivity and efficiency of influence against insect pests is abruptly increased. They are not so much influenced by weather variations (temperature, humidity fluctuations) and because of this efficiency of their operation is much higher than the fixed stage dispersal.

The biological method is mainly used in the protected soil. In the Soviet Union it is used manually for 11.5 thousand hectars. By the year of

Figure 4. Tool for primary soil processing with simultaneous placement of liquid fertilizers

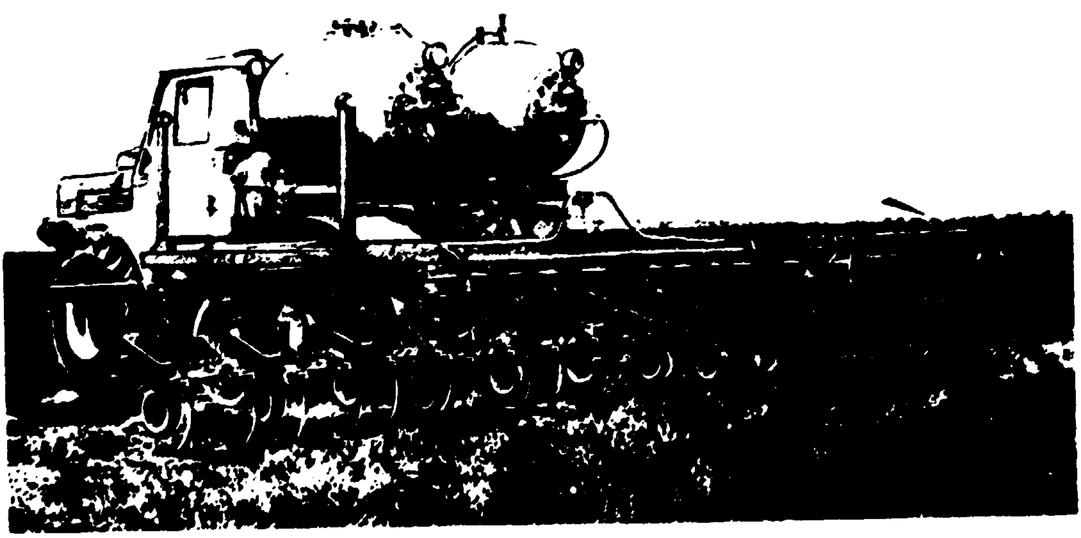


Figure 5. Row cultivator fitted with a fixture for placement of liquid fertilizers to determine basic trends for realization of the proposed programme.

Figure 6. Equipment used for application of fluid compounds using contact method.

2000 it is planned to expand the areas at the rate of 1 sq.m per a person. Besides, the practice of using the biological method in open soil is being expanded. For that reason, development of a set of machines used for dispersal of insects in lively stage appears to be a pressing scientific and technical task. This will permit to considerably reduce usage of pesticides and to obtain an ecogically pure product.

At present no analogues of fighting insect pests according to this method exist in the world. But works in this direction are started to be performed in Hungarian People's Republic, France, USA and Italy.

For planting grain crops along with simaltaneous or separate placement of fertilizers and soil cultivation use is made of combination planting machines of several unified modifications for tractors of classes 3 and 5 for operation on stubble and non-stubble soils.

Combination machines comprise the grain fertilizer autonomous pneumatic planting system and agricultural appliances fitted with replaceable tools intended for cultivation, planting and placement of fertilizers. Composite parts of the combination machines may be used separately for fulfilling more simple operations Modifications for different tractors and for operations under various conditions will differ by the volume of the hopper, number of elements being planted, working width and row of soil processing tools.

Usage of a new family of combination machines on the basis of pneumatic planting systems ensures planting within compressed agricultural technology terms, contributes to preservation of moisture in the soil, protection of soil from erosion economy of fertilizers. Versatility of the machines causes the reduction of their nomenclature by 1.5 times, increases their output by 1 5 times reduced power capacity and materials consumption by 30 percent.

At present, when cultivating agricultural crops use is often made of mulching polymeric films which create prerequisites for increasing productivity, reduction of terms and labour consumption of field operations due to setting up of the hot-house effect and most favourable conditions for development of plants. The results of field experience obtained in our country and abroad show high efficiency of such a technology of cultivating agricultural crops. According to information of the All-Union Scientific Research Institute of corn in the Dnepropetrovsk region and Central Association "Selkhozpolimer" (Aricultural Polymer) in the Moscow region increment of corn crop comes to 15 to 20 percent and green mass - up to 25 to 30 percent. Usage of the film technology permits to cultivate agricultural crops in the regions with unfavourable climate conditions guaranteed harvests when doing so.

When using mulching films the fertilizers and herbicides are placed into the zone that is protected with film. This reduces the rate of usage of compounds and invironment contamination.

At present, the procedure of harvesting primary agricultural crops is based upon utilization of complicated vehicles (combines) which are mainly self-propelled and which are capable to carry out under conditions of the field a complex of technological procedures, including such as separation of biological mass that is delivered into a combine to fractions in this case the tendency is preserved for increasing power and mass of the harvesting equipment while retaining a relatively low coefficient of usage of the materials and power potential incorporated in it.

It can not be but mentioned that one of the most important advantages of complicated harvesting equipment is its versatility which permits to harvest different crops with the help of various appliances and by changing the mode of operation.

However, if a specific regulation of usage of crops being harvested could be accomplished under particular economical conditions (for example, grain for forage, grain for feed etc) it will be possible to considerably simplify the procedure of harvesting and technical equipment being used.

For instance, during last years work is being carried out abroad and in our country in an intensive manner to design equipment which could be used for harvesting cereal crops by a method of thrashing the plants while standing Work regarding this problem is most widely performed in England. Created there is a pull type combine of a high output and it is possible to design a mounted or self- propelled vehicle on the basis of it.

At one time the Scientific and Production Association BHCXOM (All-Union Institute of Agricaltural Machine-building) was a pioneer of these developments and at present it completes the first stage of development and research of the field vehicle intended tor thashing growing cereal crops.

Economic checking and first tests have indicated that the scratching off fixture permits to assemble the whole scratched off thrashed heap when mounted onto a mobile power vehicle (Fig. 7). In this case, achieved are high quantitative and qualitative characteristics of the scratching off device operation:

-output (at vehicle speed of from 1.5 to 2.5 m/s)	- up to 20.0 tons/h
- content of free grain in thrashed heap	- up to 80 percent
- content of straw particles	- up to 20 percent
- low level of mechanical damage (crushing, demolition)	- up to 0.3 percent
- total loss, less than	- 2.0 persent

It has been determined that maximum economical effect from usage of a new technological method of harvesting cereal crops may become possible if available will be the whole set of the machines which ensure all technological operations starting from thrashing growing crops up to the time of obtaining seeds and reprocessing the forage portion of the harvest into full-scale forage. That means that the ultimate purpose lies in obtaining the plant growth products (grain, forage) in the industrial specialized agricultural technology enterprises using primary principles of high productive industrial production (all-weather operation, waste-free operation, line production, automation).

At present, efficient process lines and complexes cf technical appliances are being worked out which permit to do the following:

- to harvest cereal crops by thrashing growing plants accompanied with simultaneous mow down of the scratched off stems and their placement in windrows;
- to perform preliminaly cleaning cf a heap at a grain and forage yerd accompanied with separation of spikelets and their additional thrashing;
- to accumulate and ventilate the grain prior to drying with subsequent keeping in the hoppers of active ventilation;
- to carry out initial grain cleaning prior to placing the grain for storage;
- to prepare full-scale mixed food made of grain and forage of the farm and of purchased additives;
- to prepare feeding granules made of mixed feed and chaff that was received during preliminary cleaning;
- to prepare the seeds up to required conditions during the period of storage.

Lately, in our count work is beln carried out to expand the team-ture and family ture labour organization. This caused to review the conceptions of technical re-equipment of the people's economy with respect to the agricultural production.Along with the preserved tendency to increase the

Figure 7. Device for harvesting cereal crops using scratching off method

output of the agricultural equipment one can not but notice an increase of requirements in cheap, maneuverable, safe, simple-to-maintain machines which are convenient in service.

Modern machines which were designed for industrial production of vegetables and a number of other crops were planned in their majority for specialized farms and are not fully fit for operation at minor-contour earth areas under conditions of a family contract. First of all it conserns the harvesting mashines: usage of self-propelled vehicles is not proved to be economically correct and the trailers are not maneuverable and require an additional operator.

New possibilities of a compromise combination of advantages of the machines used together with the tractor and mounted upon self-propelled chassis are opened by a module principle of configuration of the vehicles which is used by the All-Union Institute of Agricultural Machine-building (ВИСХОМ) in a company with the plant producing the tractor self-propelled chassis in the city of Kharkov, Scientific and Research Institute of Agricultural Economy and Machines (УНИИМЭСХ) and other agencies while creating machine complexes for the resource-saving production technology of plant growing and cattle breeding products under conditions of a family contract. Basis of the complexes - is a module power vehicle (MPV) of class 0.6 made on the basis of a self-propelled chassis T-16МГ (Fig. 8). The module power vehicle incorporates a power plant of chassis T-16МГ that is equipped with a device for rigid forward and aft coupling. Used together with a dumping trolley it forms an agricultural tractor unit (agricultural "automobile") that is furnished with a comfortable two-seat cabin.

МЭС-0,6 vehicle fitted with drag appliances is intended for operation in the following spheres:

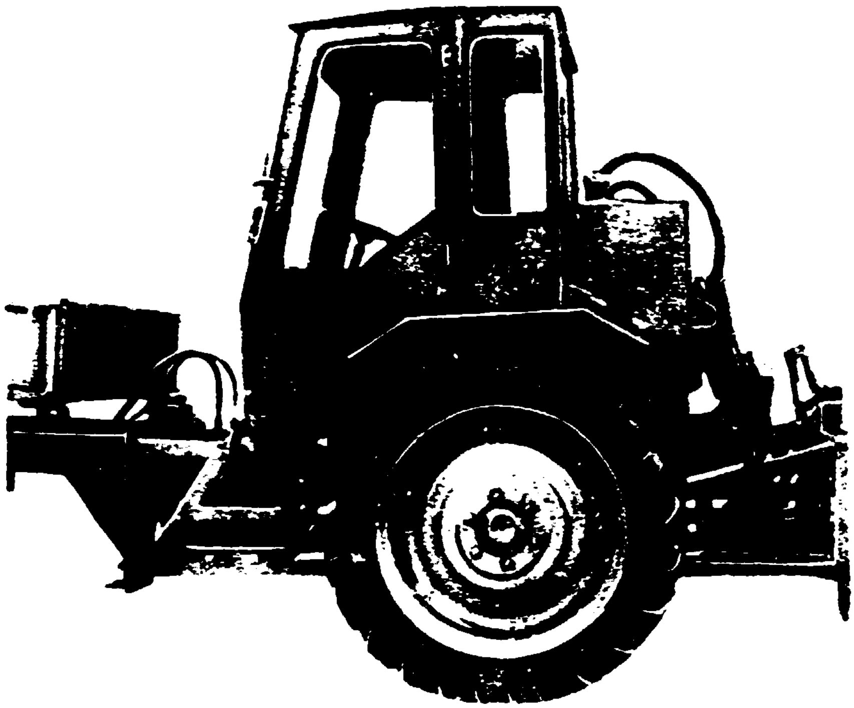
- vegetable growing;
- flax growing;
- feed production;
- mechanization of operations at minor .arms;
- general-purpose work.

As differed from the appliances which are mounted onto usual self-propelled chassis, the vehicles which are assembled on the basis of a module power vehicle (MPV) possess the following advantages.

- minimum operation labour consumption for making up a unit (one machine operator makes up a machine during 5 to 15 minutes not using hoisting devices);
- minimum rational configuration of a technological diagram of harvesting machines;
- reduction of nomenclature of the machines, differed from special machines (planters, cultivators, etc.), mounted onto the self-propelled chssis only. Used may be the machines which are made use of with the row-crop tractor.

As compared to the machine-and-tractor units made on the basis of the row-crop tractor, class 1.4, the machines on the basis of a module power vehicle МЭС ensure the following:

- high maneuverability and relative cheapness which permit to replace manual labour at small-contour earth sections and under conditions of a family contract. Increase of labour productivity by tens of times;
- reduction of labour expenditures by 2 times for maintenance due to making the machine operator free;
- reduction of power capacity by 1.5 to 2 times and reduction of specific consumption of materials by 10 to 15 percent:
- fitness into inter-row spacing of 0.45 to 0.7 m wide;
- increace of ecological cleanliness due to the reduction of soil



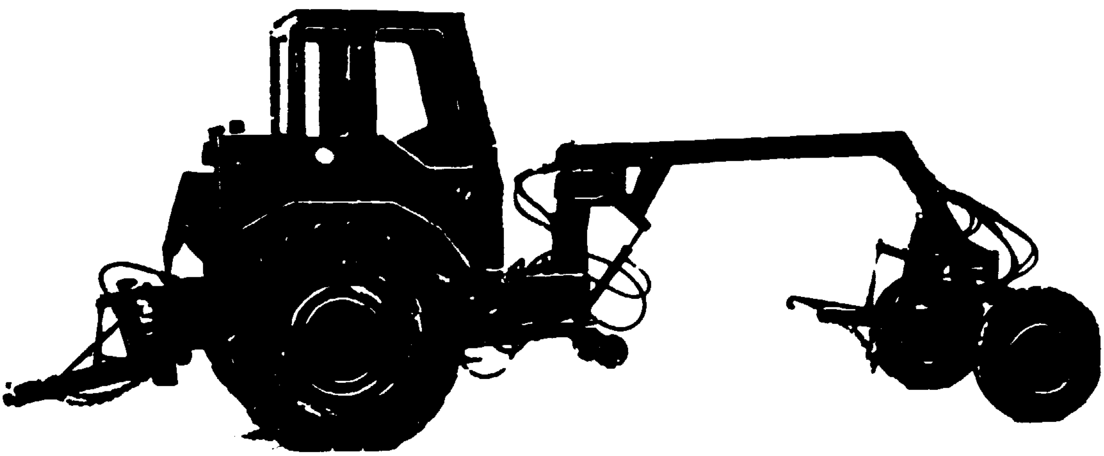


Figure 8. Single-axle module power vehicle МЭС-0,6
(a) power module
(b) power module in a unit with
a single-rod chassis

compression with passage systems.

As compared with the self-propelled machines achieved is a multiple reduction of mass and cost.

1. Complex of the machines intended for mechanization of work in the vegetable growing sphere ensures mechanized perfor mance of all operations starting from soil preparition and planting up to harvesting. Unit and module usage of the harvesting power- -technological units permits to create combination units which are capable for simultaneous accomplishment of several operations in cultivating the crops as well as to create optimum construction of the harvesting machines possessing low power consumption and minimal maintenance personnel for cabbage, tomatoes, root crops onions and garlic.

Optimum area of cultivating vegetable crops (cabbage, tomatoes, root crops) comprises 15 to 30 hectars.

A complex consists of 28 machines.

2. Set of machines for harvesting long-stemmed flax. At present, the world practice knows two methods of harvesting the long-stemmed flax combine and separate.

In our country the mechanized harvesting of flax is mostly widely incorporated using a combine method with simaltaneous scratching off the seed boxes - up to 70 - 80 percent of sowing areas. As it is known, the output of high-quality fibres is obtained when flax is harvested at the period of early yellow ripeness and the output of high-quality seeds - at the period of yellow ripeness. That is why flax harvesting accompanied with simultaneous thrashing of the seeds will inevitably lead to deterioration (loss) of quality of the seeds.

At a present situation it is advisable along with the improvement of the traditional technology to introduce new forms of labour organization, new technologies and sets of the machines directed at increasing the quality of seeds and flax heap and as a consequence, to the increase of productivity.

The task in hand also requires creation of non-complicated, mobile, non-expensive machines for a divided technology and that will ensure a higher energy of seed growth - by 10 to 11 percent, their productivity - by 12 percent. In this case, germinating capa—city of the seeds achieves 92 percent as compared against 66 percent during combine harvesting.

Preliminary calculations indicate the possibility to create the complexes of machines intended for divided technology of the flax harvesting using the unit-and-module principle on the basis of a small-scale power vehicle (МЭС) which will permit to considerably improve the technical and economical characteristics of the machines 7 items are part of the complex. They ensure pulling and its placement, collection of stems and their scratching off by use of a fundamentally new rotor-and-plank apparatus, turning over and stirring flax, rolls formation and their loading.

Introduction of a two-stage harvesting with the help of a complex of the machines on the basis of small-scale power vehicle will permit to ensure loss reduction of the seeds and increase of their quality by 1.5 to 2 times, to increase productivity by 50 percent, to increase reliability of the technological process and quality of products due to a better field of vision, controllability, manueverability with the front unit-and-modular tion per a unit of a product by at least 20 percent and to reduce specific fuel consumption by 40 percent.

Optimum area of cultivation of long-stemmed flax comprises 75 hectars.

3. Complex of machins for preparation of feeds. At present, there are 20 thousand of cattle breeding farms in the country with a livestock of up to 100 animals The amount of minor dairies counting up to 200 animals (including the farms counting up to 100 animals) comprises 54 percent from the total quantity of the dairies in the country. Many of these farms are transferred for family and team contracts where the operations of preparing and distributing the feeds should be performed with minimum labour expenditures.

These requirements may be met by a set of the machines made on the basis of the МЭС-0.6 which is provided with a forvard and aft mounts and with the power take-off shafts For preparation of coarse feeds it will be advisable to possess two sets of the machines for preparing the feeds in a loose and pressed manner.

A complex of the machines used for preparation of feeds con-sits of 6 machines. Optimum area of cultivating feed crops comprises 100 to 150 hectars.

Great hopes for improvement of agricultural products supply for our population are connected with developed intro-duction of vegetables and mushrooms in the rotected soil.

Every year about 500 hectars of hothouses are put into service in the USSR. As a rule, during last years large hothouse complexes are being constructed where the technological process of vegetable production could be mechanized. At present created is a complex of the machines for general-purpose hothouse operations which includes equipment meant for preparation of bedrocks and planting mixtures, machines for processing and formation of soil as well as means for soil sterilization, producing pots growing and planting seedlings, spraying the crops, appliaces used for harvesting purposes machines intended for loading and inter-hothouse transportation operations.

Developed is a complex of machines for cultivating green onion and a complex of machines for cultivating meadow mushrooms.

However, inspite of the fact that possibility exists to fully mechanize the processes of cultivating and harvesting vegetables - - the products grown in the hothouses are extremely labour consnming because the technological methods which are being used are intensive and require a considerable amount of manual labour.

To say more than that, relative stability of temperature con-ditions accompanied with high air hnmidity creates favourable conditions for growth of pests and their control specifies extremely harmful conditions of work in the hothouse.

An important factor that influences the productivity of a hothouse is a problem of soil compression. Multiple passages of machine and tractor units, deterioration of soil during plowing and subsequent processing, intensive fertilizing with organic and mineral substances deteriorate its water-and-air conditions and feeding of the plants and that in the long run reduces efficiency of its utilization.

Thus, the main factors which determine ecological environment conditions of protected soil are the following: practically constant presence of agricultural personnel under difficult conditions. The conditions is saturated with toxic chemicals and the necessity of soil desinfection accompanied with its mandatory loosening.

The existing tecnology and mechanization means of chemical protection of plants by spraying them in the protected soil are designed for usage of large dosages of operating fluid flow - up to 500 to 10000 lit/hectar and are involving considerable manual labour consumption and adverse sanitary and hygeine conditions for the operator who is manipulating a hand hose nozzle in the immediate vicinity of the plant roots.

Difficult conditions of work during spraying operations are practically excluded with usage of sprayer ATOC-0.5 which is intended for processing espalier cultivations of cucumbers and tomatoes with solutions of toxic chemicals in the block hothouses.

Used in the sprayer are hydraulic diffusers and hand-operated hose nozzles which are located on the vertically installed balanced rod. They ensure a required dispersity of drops (250 to 350μm) and a required norm of toxic chemicals flow rate. The drops are carried to the leaves and to the top of plants with the help of an air stream that is created by a fan that is furnished with a nozzle with a deflector-type slotted diffuser.

The fan is used to create an air-and-drop stream that is direction from bottom upwards along the stem of the plant in order to make qualitative treatment of leaves from the lower side.

Treatment of the top side of the leaves is ensured by use of hydraulic sprayers which are located on the vertical rod.

Qualitative performance of the tecnological process that is free from intermediate contact of a person with the medium being sprayed on is ensured by the sprayer control system (according to the preset programme) which from the concrete passage-way controls the movement and stop of the sprayer at any location at the register of the above-soil heating as well as ensures return into initial position, stop, disengagement of working tools protection of electric motors from overload and short-circuits and protection of personnel from injury with electric current.

The operating mode of the sprayer permits to perform one and two-fold treatment of each side of the inter-row spacing while moving along the register of the above-soil heating. In this case, the hose with toxic chemicals is coiled in automatic manner.

Operation of the sprayer includes the following. The operator brings the sprayer along the central concrete passage-way and stops it at an inter-row spacing from which the treatment begins. The operator places the sprayer upon the register of the above-soil heating that is used as a rail guide and connects the hose of the spra- yer to the valve of the pipeline of the stationary system of preparation and supply of toxic chemicals and connects the power supply cable to the hothouse mains. Having installed the mode of operation in the automatic control unit, the operator makes use of a remote control panel and puts the sprayer into operation.

The sprayer is moving inside the inter-row spacing and processes the plants with a help of a combination working tool (hose and fan nozzle fitted with a diffuser) in case the plants are in fruit bearing stage and processes the plants with the help of a vertical rod only that is furnished with the hydraulic diffusers in case the plants are in the stage of growth.

When the sprayer reaches the end of the inter-row spacing it starts to move back in automatic manner, besides, in this case processing of plants may be continued or stopped. When the sprayer is returned in the initial position it stops and ceases its operation. Time of processing of one inter-row spacing takes 3 minutes.

Thanks to usage of sprayer ATOC-0,5 the operator finds himself to be out of the zone of intermediate toxic chemicals spraying and that serves to improve labour conditions, increases output of spraying along with simultaneous improvement of quality of plants treatment.

However, a biological method proved to be a more radical method of fighting the pests of the plants under conditions of the hothouses.

At present, approaching its final stage is creatior of equipment for mechanization of the production of a biological method means where the primary attention is paid to the biological basis of cultivating and usage of useful insects, microorganisms and ticks.

Approaching final stages are the lines intended for mechanized production of aphid lion, phytocelluse tick, encarsia, gall gnats. These Arthropoda distruct white flies, plant louse and spiderweb ticks. To fight against the root rots, downy mildew and plant louse developed are microbiological compounds on the basis of lively bacteria and fungus.

The All-Union Institute of Agricultural machine-building (BHCXOM) carries out operations for creating mechanizms for dispersal of predaceous ticks and aphid lion in the protected soil. Ready for production is a machine intended for dispersal of useful insect Trichogramma. Its manufacture is planned for the year of 1991 in the plant "Lvovselmach" (agricultural machine-building plant in the city of Lvov).

For protecting the plants it will also be necessary to replace or desinfect soil in the hothouse. Due to the fact that soil replacement procedure - is an extremely complicated, labour consuming and expensive operation, in the majority of cases they try to desinfect it but not to replace. During this operation steam is supplied under the tent made of thermal-resistant film that is attached to the soil and the layer of soil down to 30 to 40 cm deep is heated up to 80 percent during 10 to 12 hours.

The whole of the operation is performed manually. Works were carried out by the All-Union Institute of Agricultural machine-building (BHCXOM) to mechanize the soil desinfection. A simple method is developed of mechanical placement of perforated hoses into the soil along which steam is supplied into the soil The proposed method reduces the time of soil desinfection by several times reduces steam flow rate and makes the job of operators easier However it can not eliminate one of the defects that is typical for all open-type and protected-type soils - fertile layer compression.

Everything stated above is related to mechanization of works in the hothoses based on traditional types of equipment.

At the same time, the analysis of technological operations performed for producing hothouse products indicates that usage of robotics may fully change the work chracter accompanied with a complete sanitation of adverse conditions of environment and its influence on the personnel.

As a perspective, a possibility is envisaged to use robotics for all technological processes provided there is an operator in the system of the technological processes control In this case, all operations are carried out in compliance with his command.

However, complete robotization may be accomplished when the whole technological process is performed without participation of a man starting from planting the crops up to the moment of harvesting. Fulfillment of technological operations is checked by means of a control system on the basis of data received from the sensors which are fixing condition of plants.

To improve ecologhcal environment when carrying out operations in protected soil, it will be necessary to do the following:

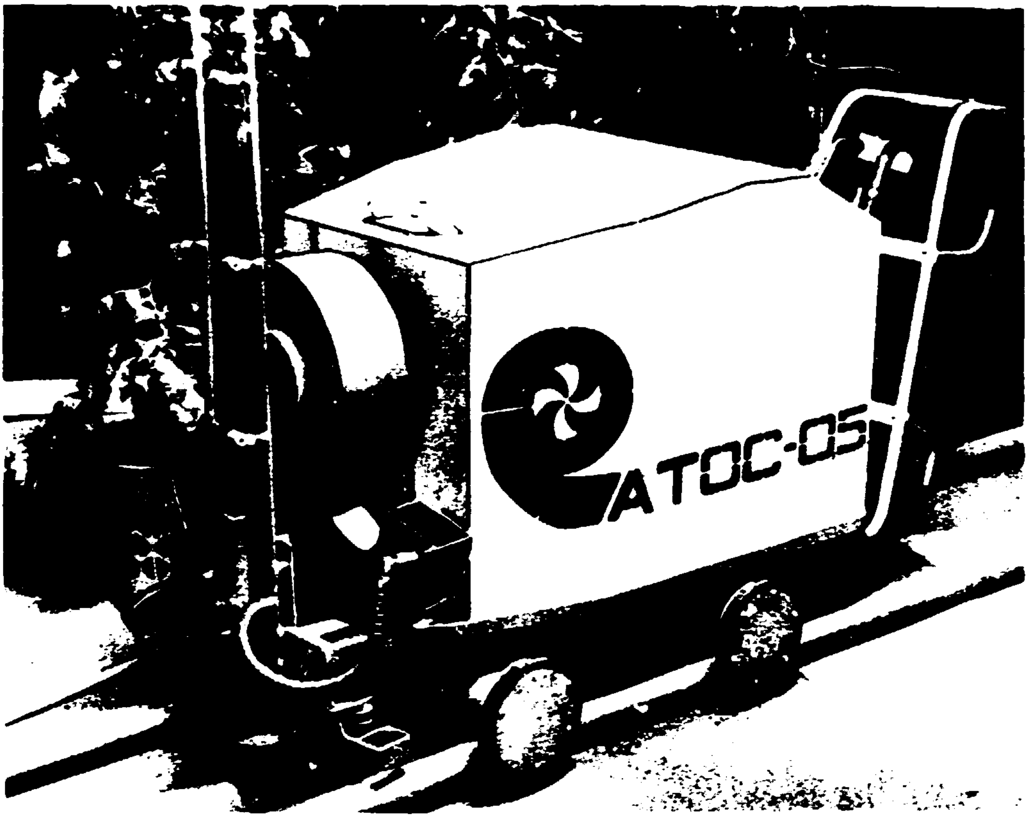


Figure 9. Automatic self-propelled sprayer ATOS-0,5 for hothouses

- in existing hothouses. To introduce everywhere a complex mechanization of general hothouse works and machines which are used for cultivating vegetables (cucumbers and tomatoes) equipment developed for these purposes is versatile as a rule and may be used in the majority of hothouses available in the country.

- in new hothouses. There is an objective possibility to create a complex of robotics for the purpose of automating the technological operations practically at all stages of cultivating the plants. It is advisable to refuse from chemical methods of protecting the plants from agricutural pests and to switch over to the biological methods usage which give better results and ensure required labour conditions for the personnel.

Under these conditions cultivation of vegetables in the protected soil will give a considerable economic and social effect.

The analysis of prospects of the agricultural production development permits to determine general interconnected trends of for the development of its technologies:

- reduction down to a required minimum of a number of production operations for preparation of soil planting and cultivation of agricultural crops (without an effect on the productivity growth);

- reduction of production operations quantity while harvesting the plants which are carried out by use of mobile field machines by transferring maximum possible operations to the stationary conditons;

- economically substantiated automation of the production processes;

- considerable reduction of usage of chemicals;

- full utilization of non-marketable portion of the agricultural products for producing feeds fertilizers organic fuel and creating in this manner waste-free systems of production.

To put the mentioned trends into life it will be necessary to perform an intensive search of fundamentally new technological and technical solutions which are based on modern achievements of scientific and technical revolution and which will satisfy the social economical requirements of tomorrow.

Included among perspective trends - are the technologies and technical means which are based on electrophysical methods of influence on soil, plants, seeds and agricultural products which permit to carry out the so-called "contactless" treatment of them. These methods are ecologically pure, practically non-inertial and are easily automatically controlled.

For displacement and driving the field mobile operating machines and appliances in the future industrial agricultural enterprises usage of a bridge-type robotics seems to be mostly perspective which are also "contactless" with regard to the fertile surface of the field. Equipment of bridge-type chassis with working tools and machines of a "contactless" type permits to create automatic widespan units having a relatively small specific consumption of materials and operating round o'clock.

At present, work is being carried out in the USSR and abroad connected with usage of electrophysical methods of influence on the seeds of the plants and on agricultural products. For instance, the weeds are eliminated with the help of the energy of ultra high frequency or by passing electric current along the stems of the plants, drying grain seeds and green mass with electromagnetic irradiation of ultra high frequency, etc. Operations on various types of bridge systems are also carried out.

A characteristic peculiarity of the works which are being carried out in this direction is a local approach to the problem of replacing traditional technical means with fundamentally new means. Majority of operations are performed within the frames of one technological process or one technical means. As a result, economical efficiency of a number of fundamentally new technical means appears to be not to the benefit of the latter.

Along with that, the analysis of a combination of questions connected with creation of agricultural equipment of the future permits to formulate two primary positions which detemine an approach to the solution of this problem:

- in the agricultural production the most effective way of realization of new technological principles is not a creation of individual technical means but a development on their basis of a system of machines and equipment intended for specialized waste-free agricultural enterprises of the industrial type with a full coordination of all production processes. Such an approach permits to increase trustworthiness of economic efficiency evaluations of new technologies and to take into consideration the strategic factors, ecological and social, for example, which are not as a rule considered during usual comperative technical and economical calculations;

- it is advisable to start practical realization of the new trends indicated above with a specific object that is of a great importance for national economy and for which a certain potential of scientific ideas and studies is already available.

An example of practical realization of the conceptions which are above indicated is the reseach work that is being carried out in the Scientific and Production Association of the All-Union Institute of Agricultural Machine-building (ВИСХОМ) which are connected with searching for new technologies and technical means for the agricultural technology complexes of the future of the grain and forage and cattle breeding trend.

CREATION OF PERSPECTIVE ECOLOGICALY PURE TECHNOLOGIES AND TECNICAL MEANS INIMITATION OF A SPECIALIZED AGRICULTURAL COMPLEX OF THE GRAIN, FORAGE AND CATTLE BREEDING TREND

The following new technologies are envisaged in the agricultural complex:

- cultivation of cereal crops excluding influence of the moving systems of the tractors and mechanical working tools of the machines on the soil during several years;

- harvesting all biological yield of cereal crops along with pressing the whole cut-off lucrative mass and its storage in a special store-premises;

- reprocessing of lucrative mass into primary feed by using grain to grow full-ration hydroponical greed feed using the straw

- anaerobic reprocessing of organic waste of plant growing and cattle breeding and getting desinfected high-quality organic fertilizers and fuel gas which can be used in the agricultural complexes;

- feeding and keeping milk cattle with automation of primary production processes;

Technological diagram of an agricultural complex is depicted in Table 1.

The technology of "contactless" cultivation of the plants envisages the following:

- preparation of incrusted seeds (covered with water and airtight shell);

- periodical preparation of the fields (once every 3 to 5 years) - loosening and processing the soil along with elimination of weeds with the help of the ultra high frequency energy and placement of the main dosage of organic fertilizers;

- planting of a to 5-year norm of incrusted seeds which is accomplished simaltaneously with the field preparation;

- usage of high-frequency currents for selective distruction of the incrusted shell of the seeds which are intended for growing at the present vegetation period;

- placement fluid components only (water, fertilizers, etc.) into the soil during the process of growth of the plants;

- multiplication of all field technical means on the basis of the automated bridge-type chassis.

A peculiarity of the proposed "contactless" technology of cultivating cereal crops lies in the fact that water and air-tight shell of the seeds which are being cultivated at a certain field during crop rotation which is made inertial and resistant to the influence of the soil medium possesses definite electrical characteristics. The technology envisages availability of several types of the shells and that permits to selectively distruct them at a definite agricultural time period with the help of high-frequency currents produced by the induction coil.

The inductor with the generator as well as technical aids used for placement of liquid components are mounted onto the mobile transportation vehicle of the bridge-type which during its movement is free from contact with the cultivated surface of the field.

During harvesting season mounted on the same chassis are the reaping machine, crop collector and pressing appliance.

Peculiarities of the procedure of harvesting, storage and re-processing of lucrative mass are the following:

- pressing the stacks of lucrative mass in the field;

- drying the stacks under stationary conditions, including the energy of electromagnetic field of ultra-high frequency;

- growth of hydroponic green feed from the forage grain that is stored in stacks under conditions of controlled micro-climate and plant feeding during the whole of the year.

There is also a number of fundamental peculiarities in other parts of the agricultural complex - in cattle-breeding part in particular.

The primary components of the technical and economic efficiency of the proposed system are the following:

1. An increase of productivity and stable increase of fertility of the soil by way of the following measures:

- full liquidation of compression and soil damage by use of machines and appliances;

- usage of mainly fermented organic desinfected fertilizers;

- preventive (for several years ahead) demolition of weeds and their seeds.

2. Reduction of labour consumption for cultivation and harvesting by way of the following measures:

- liquidation of mechanical processing of soil that is carried out every year;

- fundamental simplification of the process of harvesting;

- complex-type automation of technological processes.

3. Lack of losses of the crop and full utilization of the agricultural production waste for the purpose of obtaining highly effective

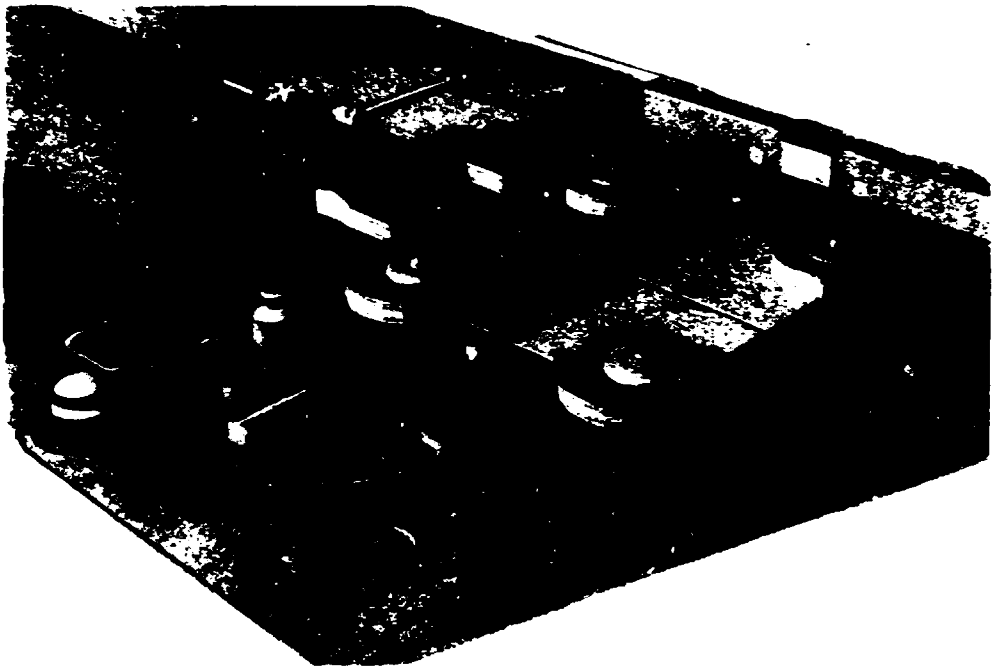


Figure 10. Agricultural complex.

1 - bridge-type chassis; 2 - transportation platform; 3 - block of lucrative mass storage and processing; 4 - agricutural block; 5 - control and maintenance block; 6 - power supply block; 7 - gas-holder; 8 - - biological mass storehouse; 9 - biological mass transfer station

organic fertilizers and fuel gas.

4. Absence of a negative influence on the environment due to the waste-free system of production and nearly full exception of usage of chemicals and soil damage.

5. Reduction of consumption of mineral natural as a result of using biological gas that is obtained from organic waste.

Advantages of the technology that is described above also include a complex usage of technical aids based on utilization of currents of high and ultra-high frequencies which will permit to increase coefficient of usage of primary unite and assemblies of this equipment and to considerably improve technical and economical cha- racteristics of the system.

Evidently, new technological principles described above may be used for producing a number of other agricultural crops and further development of new trends of the agricultural machine building will pemit to obtain a positive effect that is difficult to be forseen now.

As a result of the study of agricultural and biological aspects of the problem and a complex of perfored laboratory investigations of the main components of the proposed system, substantiated was the possibility of its practical realization and the following was worked out: system of the machines, process charts of the production procedures, technical and operation design and feasibility study of the agricultural complex whose area is equal to 800 to 1000 hec- tars and which contains 800 cows.

The agricultural complex is intended to annually produce:

- grain of barley	2 to 3 thousand tone
- grain of beans	700 to 800 tons
- milk	5 thousand tons
- meat	40 tons
- fermented organic fertilizers (dry substance)	1170 tons
including:	
- nitrogen	47 tons
- potassium	54 tons
- phosphorus	7 tons
- biological gas, heat value from 5 to 5.5 thousand ccal/m^3	1 million of cu.m

Agricultural complex (Fig. 10) comprises field part (1) whose area is equal to 1000 hectars and industrial sector) whose area is equal to about 4 to 5 hectars.

The field part incorporates the rows of cultivated strips and the width of each of them is equal to 30 m. Located between them are the guiding ribs which serve for movement of the propelling de- vices of bridge-type chassis (1) of transportation platform (2).

Located on the territory of an industrial sector are the following buildings: unit for storage and processing lucrative mass (3), four two-storey agricultural units (4), agricultural complex control unit, building of technical maintenance and storage of field equipment (5), power unit (electric power station using biological gas for fuel, compressor plant used for compressing biological gas, transformer sub-station) (6), gas-holder (7), storehouse of fermented biological mass (8), station for transferring biological mass (9).

The block for storage and processing of lucrative mass (Fig.11) comprises two ventilated stores (1) and two-storey shop intended for processing lucrative mass (2) located between them. The following appliances are installed in them: transportation robot for supply of stacks

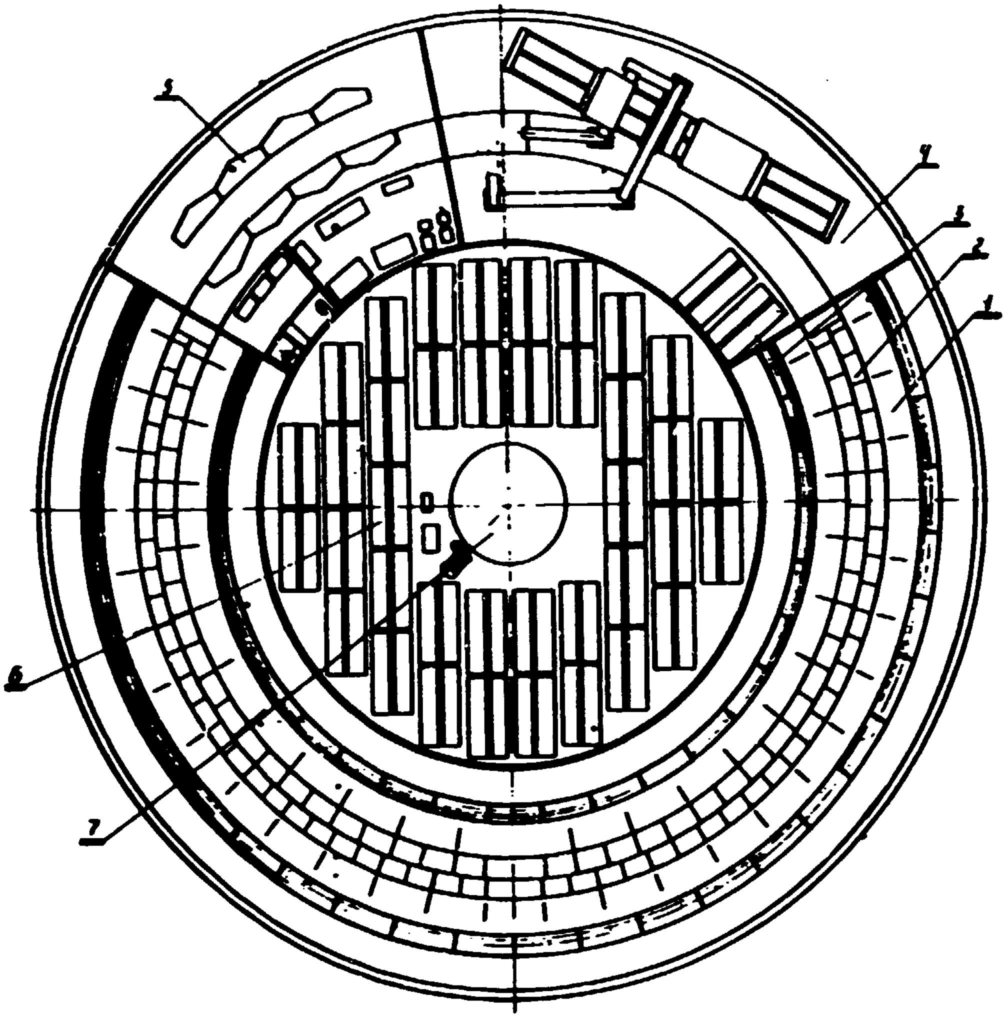


Figure 12. Agricultural block: 1 - stalls; 2 - feed-distributing device; 4 - feed preparation section; 5 - milking block; 6 - germinator; 7 - biological power reactor.

Development of primary technologies for the industrial production of agricultural plants that is described above envisages relation of methods and modes which are used in integral system of protecting the plants (Fig. 13).

Tactics of the integrated system of protecting the plants combines to a possible and advisable extent all methods and means of the control capable to keep the quantity of harmful organisms at the level that is not exceeding economical threshold of harmfulness. In this case, considerable attention is paid to strengthening and preserving the mechanisms of natural regulation of harmful organisms quantity.

The service of rediction and economic study carries out rational planning and assists to determine the volume of works with regard to protection of agricultural crops; it accomplishes coordination of usage of all other methods and modes of control.

Usage of forecasts permits to reduce expenses for protection of plants by at least 25 to 30 percent and to increase efficiency of measures at the same time.

Quarantine and preventive measures include protection of definite territories, states or materials from ingress of dangerous pests, illnesses and weeds, prevent probable outbursts of aborigine phytophagan, stimulants of illnesses and weeds.

Primary measures which are taken by the quarantine service are the control over import and export of plant growing products, study and reveling the quarantine volumes and taking measures for their location and liquidation.

Agricultura technology methods also include incorporation of obligatory crop rotations which prevent accumulation of harmful organisms in the soil and establish optimum time terms and norms of planting, optimum systems of soil preparation and treatment of plants, etc.

For a long time the role of agricultural technology methods in protecting the plants was under-estimated but nowadays they are paid great attention.

Excluding the usual agricultural technology methods, regulation of environmental conditions for controlling the quantity of harmful and useful organisms includes special methods of plant growing and optimum structure of agricultural landscape (planting shelterbelts, planting the fields around with nectar-yielding plants, rational space location of the crops, etc.).

In other words, this method is called agrocenotic because it contributes to the self-regulation of the organisms at the agricultural farming lands and reduces the volume of usage of chemical means of plant protection.

Creation of agricultural crops resistant to harmful organisms is one of the most efficient methods of controlling a whole number of stimulants of illnesses and pests.

This is one of the primary tasks in the plant protection designs which are being accomplished under the aegis of FAO. The work is being carried out by mutual efforts of breeders, entomologists, phytopathologists and geneticists. In these cases, created are the types of high-productive plants with the immunity to the most dangerous stimulants of illnesses or slightly damaged by insects (plants bearing repellent smell, special strength of outer shell, misalignment of development of the damaged phase of plants with the dangerous phase of pests, etc.).

Physical and mechanical methods and modes are used in the agriculture and are mostly effective, as a rule, in combination with other methods, with the biological method especially.

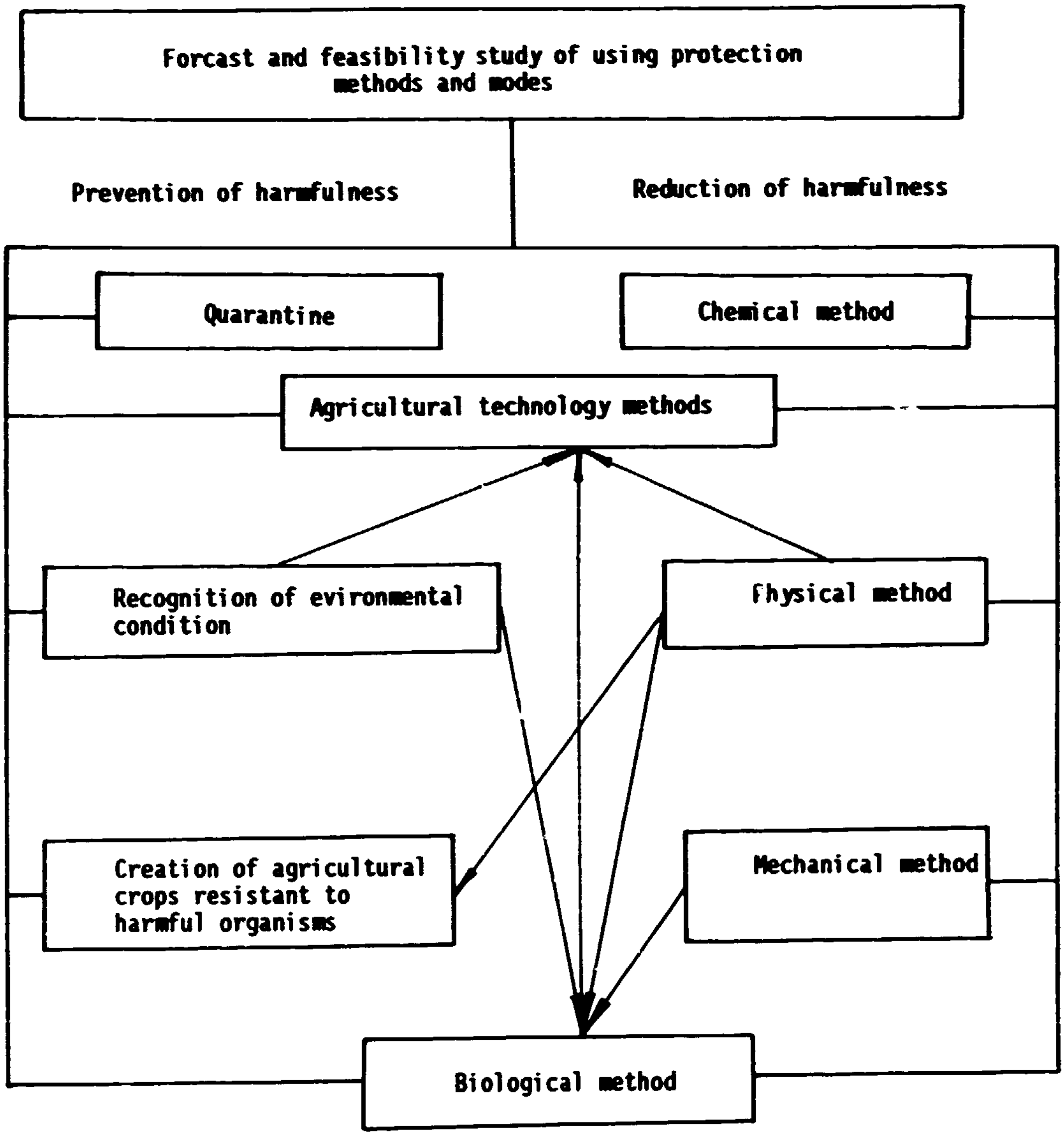


Figure 13. Primary principles and methods used in integrated system of plants protection.

The mechanical aids include different devices and mechanisms for collection and distruction of insects, insect-trapping bands which are arranged in the tree trunks and the grooves made around the fields which are being protected.

The physical method includes various methods of treatment with heat, radiant energy (ultra-violet and infra-red light, gamma and -rays, etc.), ultrasound, electrical fields of different types (electrostatical, corona and pulse discharge, ultra-high frequency, microwave frequency and industrial frequency) and the magnetic fields. These methods are mainly in different stages of research now but in the nearest future they may be effectively used in the agriculture.

Chemical method - treatment of seeds and plants with chemical substances (pesticides) - at present continues to play a leading role in the agricultural production. Its advantages lie in simple usage, accessibility, high effectiveness, quick action and efficiency.

Production of pesticides is well mastered by the industry and the agriculture is experienced enough and possesses the fleet of vehicles for placement of pesticides. The pesticides proper, technologies and vehicles for their usage are being continuously developed. This is especially important because pesticides represent a serious factor of invironment contamination.

Due to the fact that the chemical method has big and serious drawbacks along with advantaged, in the integrated system of plant protection it is given a role of a "fire-brigade method". Usage of chemical method is advisable in those cases only when there is no possibility to eliminate losses of harvent with the help of other methods and modes.

Biological method represents the most real way for reduction of volumes of the chemical method usage and its damage to plants because the biological method has a strictly selective action and practically does not cause any harm to the environment.

In compliance with the regulations of the International organization of biological control which were approved by General Assembly in 1971, understood by the biological control is utilization of lively organisms and products of their active life with the purpose of preventing or reducing damage caused by harmful organisms.

The biological method for plant protection is comperatively young both in scientific development and in practical usage. It reflects in the most full manner the principles of integrated system of controlling harmful Organisms in the agriculture, that is the reason why such great attention is paid to it at present. Some of the authors consider the biological and integrated protection of plants to be one and the same method and call it to be a complex biological protection against harmful organisms. This underlines close connection of the biological method with other methods and modes of plant protection.

Microbiological means of plant protection against harmful insects possess a number of advantages as compared with the chemical means: high biological efficiency with aspect to susceptible types of phytophagans which causes demolition of pests at subsequent phases of their development; selectivity of action and absence of noticeable influence on entomophags and pollinator insects; minor probability of appearance of pests resistance to the products of microbiological synthesis; lack of harm for warm-blooded animals and for a man, absence of phyto-toxicity and influence on palatability of vegetable products; short time of waiting; possibility of using microbiological compounds at any phase of plant vegetation; absence o danger of accumulation of toxic substances in the environment and agricultural products.

The indicated advantages of biological control against harmful insects predetermines the volumes of production and usage of microbiological compounds. In our country by the efforts of the specialists of various scientific institutions proposed are several types of such compounds for the purpose of industrial production and practical usage: bacteriological, virus, fungus.

The volumes of usage of the microbiological means of plant protection are restrained first of all by insufficient production of bacterial compounds and absence of production of the protection means on the basis of fungus producers.

Creation of the compounds on the basis of fungus producers - - entomo-fluorine fungi, verticillium, ashersoni, etc. is delayed by technical difficulties of their industrial manufacture because the existing technical means do not give the possibility to obtain an effective fungus with the help of deep cultivation.

Thus, the essence of the integrated system of plant protection lies in the fact that thanks to skilful utilization and combination of other methods and modes to bring the losses of agricultural production to the economically permissible level. When doing so, it will be necessary to minimuze usage of chemical method. However, inspite of its noble purpose and rather serious theoretical study, the integrated system of plant protection is considerably weakly introduced into the agriculture of our country and abroad and that is explained by a whole number of objective and subjective reasons. That is the reason why the majority of scientists consider that the chemical method of plant protection will preserve its leading role up to the end of the twentieth century, as a minimum.

SOME NOVEL AGRO-INDUSTRIAL CLEAN TECHNOLOGIES FOR AN ECOLOGICALLY INTEGRATIVE AND COMMERCIALLY INTENSIVE MEGA FOOD PRODUCTION SYSTEM

E. F. Winter *

Part I: The approach of Regenerative Agriculture
Part II: A modular growing-medium container system

PART I
The approach of Regenerative Agriculture

A. Introductory

As the title suggest , this paper aims to share some informations on innovative technologies and their conceptual frame-work for large-scale food production.The approach is akin to that of system's analysis.The system's approach centers around "regenerative agriculture".

It is now fifty years ago that I stumbled as a student of the novel field of soil biology within the traditional soil science discipline, on King's Farmers of Forty Centuries. (14) It opened the world of sustainable agriculture, without that term being known or used at that time. This classic of sustainability is very worth reading still today.

Study, laboratory work and practical farm management experiences introduced me already in the 1940's to "organic agriculture". Over 20 years of consultancy activities to field projects in developing countries confirm to me the great promises of "ecological agriculture", as I began to call it, as well as its current practicability.

From the perspective of the agrarian situation in the US three aspects strike the observer. Firstly, the open and free society helps promote a large number of experiments by individuals and small groups wishing to invent solutions to their specific problems. In farming and in environment we can observe numerous timely innovations. Secondly, society at large does not take cognizance of these. In fact, the world's breadbasket is slipping into a fatal environmental crisis, including farming and economics. Thirdly, the past measures to tackle the crisis revolved around cheap and plentiful articles from the petro-chemical realm. That continued supply is gravely challenged once more at this very moment.

How long can any society continue with the following problems? Every day 17,000 akres of farmland are destroyed in the US, primarily due to erisions, but also from all kinds of constructions---houses til roads. US industries generate 88 billion pounds of toxic waste every year. 90% of toxic waste is disposed of improperly. Hazardous farm chemicals are now prezent in groundwater supplies, rain, fish, poultry, meat, grain, and in blood and fat tissue of nearly every man, woman and child in US---possibly to a larger degree then in any other populace, includind the peoples in the polluted lands of the East.

Economically, corporate debt is now 40% of the GNP. Personal debt, including home equity loans, has reached record levels and is at its saturation point. Total consumer debt, which was 18% of the Gross National Product in 1970 is now 70% of the GNP in 1989. Total consumer, business, and government debt is $10.3 trillion, more than double the GNP. This does not take into account the large trade deficit.

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B. Regenerativ Agriculture

It is against this very sketchy background that "regenerative agriculture" holds out hope,because it challenges this downward spiral. It holds out a social solution for USA. I am convinced that it does equally do so for all other countries.

What is "regenerative agricalture" The term has been coined only recently. Much credit goes to a pioneer in "orga- nic farming" for this Robert Rodale. (23,24,25) He has incidentally formed a joint venture in the Soviet Union,na——mely, to publish a practice oriented and innovative monthly,the "НОВЫЙ ФЕРМЕР". The antecedents are concepts like "organic agricalture,"bio-organic",and "alternative" (20,p.27).

"DEFINITION OF ALTERNATIVE AGRICUL TURE

Alternative agriculture is any system of food or fiber production that systematically pursues the following goals:

- More thorough incorporation of natural processes such as nutrien cycles nitrogen fixation, and pest-predator relationships into the agricaltural process;
-Reduction in the use of off-farm inputs with the greatest potential to harm the environment or the health of farmers and consumers;
- Greater productive use of biological and genetic potential of plant and animal species;
- Improvement of the match between cropping patterns and the productive potential and physical limitations of agricultural lands to ensure long-term sustainability of current production levels;
- Profitable and efficient production with emphasis on improved farm management and conservation of soil, water, energy, and b'ological resources."

Advocates and practitioners of alternative farming systems developed many, response potentials (20,p.136 and 137).

"ADVOCATES AND PRACTI ONERS OF ALTERNATIVE FARMING SYSTEMS.

-Individuas why adhere to philosophies that advocate nonconventional farming practices.Some farmers never changed to the chemically intensive, specialized approach to crop and animal poduction that currently dominates U.S.agricultural. These farmers include followers of traditional organic farming movements, such as biodinamic agriculture and systems advocated by Albert Howard and Eve Balfoyr (Balfoyr, 1976; Howard, 1943). These individuals also includ farmers who farm organically because of religios beliefs such as some Amish and Mennonite farmer of Pennsylvania and the Midwest.Others have practiced a generic form of organic farming not associated with any of the established organic movements (Harwood, 1983).

- Farmers looking for new ways to reduce production costs. Throughout the United States,individual farmers have recognized that heavy purchases of off-farm inputs can put them in a less competivite economic position.These farmers have modified their farming practices, often in innovative ways to reduce production costs.Examples include a wide variety of conservation tillage systems; the use of lequme-fixed nitrogen through rotations; interplanting;the substitution of manures,sewage sludges,or other organic waste materials for purchased inorganic fertilizers;and the use of IPM system and biological pest control.

- Farmers responding to consumer interest in chemical-free organic produce. Many enterprising farmers producing agronomi and hoticultural crops,milk, eggs, poultry, beef,and pork without synthetic chemical inputs have teken advantage of the fact that many consumers and businesses are willing to pay higher prices for these sorts of products. In response to marked demand, several commercial supermarket chains have recently begun to market produce grown with no or very low levels of certain synthetic chemical pesticides at prices roughly comparable to those of conventionally grown produce.

- Farmers responding to concerns about the adverse impact of many conventional farming practices on the environment. Environmental groups and soil conservation organizations have raised public awareness of the environmental hazards of conventional agricultural practices. As a result of these hazards and personal concern of the environment, some farmers have adopted alternative farming practices that are helping to reduce the deterional of our nation's soil and water resources.

- University research scientists. Critics have attacked the colleges and schools of agriculture in the land-grant universities and the U.S.Department of Agricalture (USDA) for not researching farming systems that protect the environment and reduce on synthetic chemical inputs. But many individuals at these institutions have been investigating for years practices and systems that have alternative agricaltural applications. Examples include integrated pest management (IPM) biological controls of pest,rotations, nitrogen fixation,timing of fertilizer applications,disease- and stress-resistant plant cultivars, conservation tillage, and use of green manure crops. These research efforts have fostered some important changes in U.S.agriculture. As greater effort is made toward implementing the results of this research, more progress can be expected in the future.Much of the scientific knowledge of alternative practices summarized below is the result of research at the land-grant universities and the USDA.

- Alternative agricalture organizations. Groups such as Practical Farmers of Iowa, the Land Stewardship Project,the Institute for Alternative Agricilture, the Regenerative Agriculture Association, the Center for Rural Affairs, the Land Institute,and many others have worked to provide farmers with information on alternatives. They have organized research and demonstration projects, lobbied state legislature and Congress for research and demonstration support, and produced numerous technical publications and reports with information designed to help and reports with imformation designed to help and encourage farmers to adopt alternatives."

Recently, it appeared, a unifying concept was accepted,"sustainable agriculture".It emerged in the last 10 years as the most agreed-upon term to describe the varied field of agricultural practices that began to differ and even challenge more and more conventional concepts of modern agricultural production.So said the World Bank 1981. Gips gave it a pithy phrase in 1987:"Ecologically sound, economically viable, socially just and humane".

Modern agriculture is a very recent development;not even a hundred years old.Engeneering for input-intensive agriculture versus engineering for sustainability is now however being challenged. Conventional agricutural systems have been able to sustain growth rates of 2-4% per annum over 2-3 decades, because of chemical fertilizer dependence.Agricultural production itself uses a modest 1% of the US total annual energy consumption of 75 Q, Q being a quadrillion BTU or 252 trillioh KCAL. With world energy consumption at 300 Q, global agricultural energy consumption is probably no more than 3 Q.(6) However, the supply relationship for energy use in agriculture depends upon non-agricutural consuption of energy. Here comes the input of petroleum. In 1987 petroleum reserves were estimated at 700 billion barrels. Undiscovered there might still be an additional 450 billion. At a world consumption rate of 20-25 billion barrels per annum, the supply of 1.2 trillion will last 50 years, ceteris paribus. Since, however, most countries strive to emulate the high living standard of the US, which is being sustained with an annual per capita oil consumption of 24 barrels, another formula is appearing. It the current population of 5 billion were to obtain half the US consuption levels, the global use would be 60 billion and the world supply would last only another 18 years. Conclusion: energy-intensive, high-tech, and petro-chemical based agriculture has no future. It can, at best, last for several decades. Alternative energy technologies can not provide substitues.

Lower inputs of fossil fuel-based chemicals into agriculture requires vastly increased knowledge about and management of ecological processes. It is, moreover, a multidisciplinary task. Where are the teams that can fathom the data- base of whole-farm analysis; incorporete price effects and government programs impacting on micro- and macro agriculture? Some major regions of Asia, to mention only one area, have benefitted very little, if at all, from the petro- chemically based Green Revolution. In the heavy populated rice-dependent areas of East India and Bangladesh, rice yields have remained at 1.5 tons/ha over the past three decades.

Donald L.Plucknett summerizes the hope and promise of "sustaina-bility" in the light of the above sketched variables. (6.pp.35ff)

"This goal statement specifies and focuses on:

-Developing, not developed countries.

-Research-related activities, not developmeht or technical assistance.

-International research, not national or regioal.

-Food and feed, not industrial commodities.

-Technologies for long-term sustainable production, not those that sacrifice ecological stability fo short

- term gains in productivity.

-Improved nutrition and economic well-being of low-income people, not only through increased food production, but also through imroved food quality, more equitable distribution, more stable food supplies, and increased purchasing power.

Eight objectives under the complex CGIAR goal provide a framework for the work of the centers in collaboration with national agricultural research systems and other partners in the global system:

-Managing natural resources for sustainable agriculture.

-Increasing productivity of essential food crops within improved production systems.

-Improving productivity and ecological of livestock production systems.

-Improving post-harvest technologies to utilize agricultural products more fully in rural and urban areas.

- Promoting better human health and economic well-being through improved nutritional quality of foods, more equitable access to foods, expanded economic opportunities, and better management of overall family resources.

-Ensurihg the formulation of rational agricultural and food policies that favor increases in food production and commodity productivity.

-Strengthening national agricultural research capacities in developing countries to generate, adapt, and use enhanced technologies faster.

-Integrating efforts within and among centers of CGIAR and its partners in the global system.

These biological consideration will be important for future sustainability:

-Conservation of genetic resours must be continued and strengthened.

-Yields per unit of area and per unit of time must be substantially increased to meet the needs of rapidly increasing populations.

-Long-term pest control must be developed through intedrated pest management and built-in resistance because intensified production will tend to encourage build-up of pests and break down the effctiveness of pesticides and host-plant resistance.

-Impoved methods for disease and parasite control will also be important to sustain animal production.

-A balanced production system invoving both crops and livestock will be needed to enhance productivity and avoid overgrazing.

These physical factors and constraints are deemed most important:

-Soil is the most important resource for ensuring sustainability;loss of topsoil through ersion and a reduction in soil fertility by not replacing nutrients both turn a rehewable resource into a nonrenewable one.

-Agriculture is the principal user of water globally; inefficiently using fossil water and overdrafting rechargeable aquifers can result in another renewable resource being eroded

-Poor soil and water management in reinfed agriculture can cause severe land degradation.

-Misuse of agricultural and indastrial chemicals can contribute to the accumulation of toxic substances in soil and water.

-Atmospheric changes brought about by human activities will adversely affect agricultural production.

-Energy consuption required by high- yielding production systems will probably be justified in the foreseeable future as using a nonrenewable resource,oil,to protect soil from being reduced to a nonrenewable resource."

Unfortunately,"sustainability" is not an operational reality. Firstly, there is enough food right now in the world.Convectional agriculture produces mountains of it. Can we keep this up, even with gene-technology, bio-technology, bio-engineering etc? Are the current high levels sustainable? Secondly,without adequate and low-cost long-term supplies of oil, gas, phosphates etc our convetional a riculture can make no long-term plans.Thirdly the high levels of production today are taking a toll on the farm environment.Soil erosion, deforestation, desertification and other degradations are widespread, especially in the Third World.Millions are trading soil for food there. Fourthly,escalation of pollution,is it sustainable? Agriculture contributes to it.This listing can be continued.

It was Rodale who stated bluntly: "Sustainability is the problem.Something else is the solution".Do people wish conventional agriculture with all the above imlied problems to really continue? With population growth we'll need much m o r e production of food and fibre in the future---not just sustaining current amounts.Do people with to maintain the deterriorating quality of the agricultural resource base? On the contrary, people want the air cleaner, the water safer, the land healthier.

Sustainability is only one of the right question to ask. Far more important is an analysis of resource renewability.Regeneration is the people's desire! An increasing number of farmers and researchers talk very little about sustainability. They focus instead on the regenerative nature of all living systems! Many of us are looking at ways and means to mobilize the regenerative tendecies inherent in land and the land-based environment.Renewable resource just dun't renew themselves.Everything regenerates within a very complex environment of many living systems for which scientific man is responsible.

When agricultural land is allowed to rest and regenerate seven specific things can be observed by layperson:

1.There is an increase in the diversity of plant species;

2.The surfase of the soil become covered with plants, ending erosion and increasing beneficial microbial populations near the earth's surfase ;

3.Without chemical fertilizer and pesticide use, a great mass of plants and other life begins to exist once in the soil;

4.More perennials and other plants with vigorous root systems begin to emerge and grow prolific;

5.Past patterns of weed and pest interference with growing system are disrupted;

6.Nutrients tend either to move upward in the soil profile or to accumulate near the surface, there by becoming more available for use by plants;

7.Overall soil structure improves, increasing water-retention capacity.

Through a regenerative agricultural system man can help this natural development. When farmers near cities become sustainable and regenerative, so also becomes the city environment cities! Those who are practicing regeneration are obliged to at suggest to policy makers a way around the growth-no-growth stalemete (Julian Simon vs.Dennis Meadows) by educating them about obvious fact and value of the permanence of the internal resources of Nature.The following tables illustrate this state of affairs. (6.John M.Lunna and Garfield J.House, p.204 and 222)

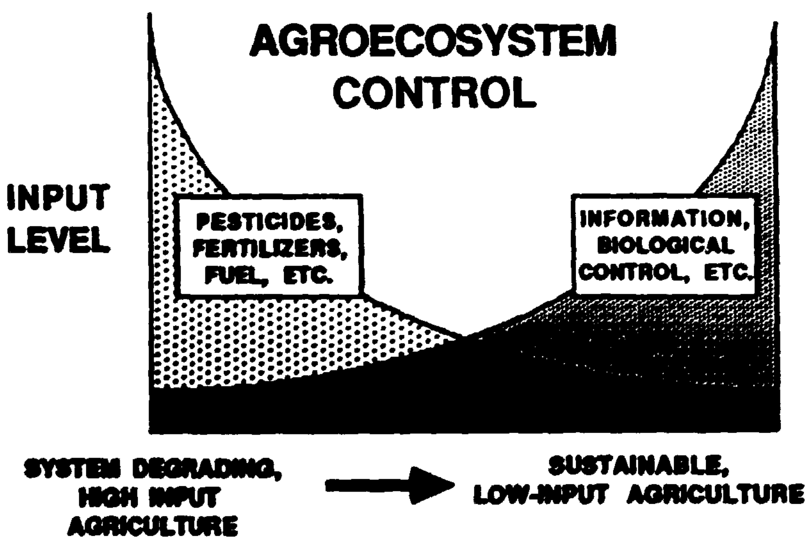


Figure 1.

Sustainable agricultural systems are conceptualized here as being low in material input-pesticides, inorganic fertilizer, ect.-and high in information input-applied ecological knowledge of the system.High chemical input practices conceal and depreciate the importance of ecological processes occurring in agricultural systems.However, as pesticides, fetilizers, and other inputs are reduced, greater knowledge of the interactions occurring in agroecosystems is required for success (Stinner and House,1988).

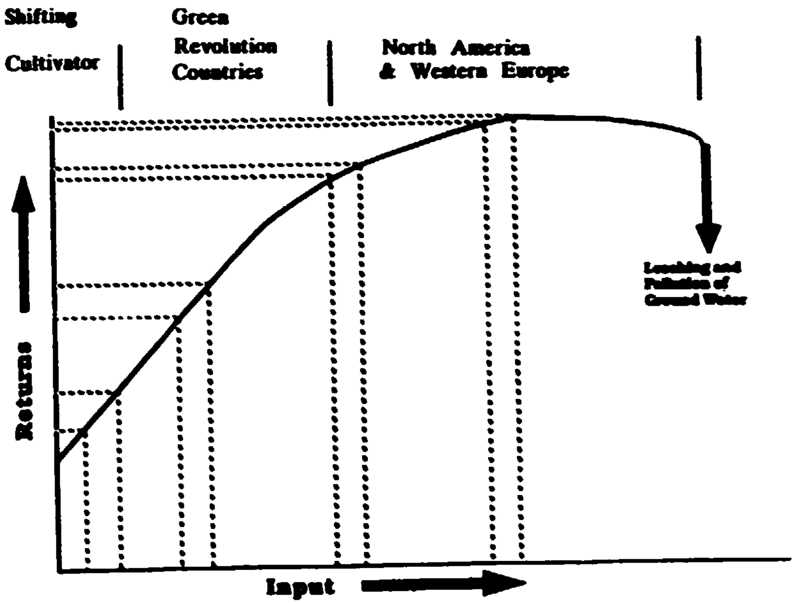


Figure 2.

A generalized response curve depicting output-input ratio for farming systems ranging from subsistence shifting cultivator to large-scale commercial agriculture.

"Regenerative agriculture is not organic farming. Unlike organic farmers, regenerative farmers use some herbicides, synthetic pesticides, and artificial fertilizers. However, regencrative farmers are not conventional either. They strive to use low levels of off-farm inputs, and substitute for them the internal, regenerative resources that are available within their farming systems. That idea---the linking of farming to natural land-restoring systems---is at the heart of regenerative methods". (25) Rodale draws the following table of it.

RESOURCE SYSTEMS FOR AGRICULTURAL PRODUCTION	
INTERNAL	*EXTERNAL*
SOIL	HYDROPONIC MEDIUM
SUN—main source of energy	SUN—energy used as "catalyst" for conversion of fossil energy
WATER—mainly rain and small irrigation schemes	WATER—increased use of large dams and centralized water-distribution systems
NITROGEN—collected from air and recycled	NITROGEN—primarily from synthetic fertilizer
MINERALS—released from soil reserves and recycled	MINERALS—mined, processed, and imported
WEED & PEST CONTROL—biological and mechanical	WEED & PEST CONTROL—with pesticides
ENERGY—some generated and collected on farm	ENERGY—dependence on fossil fuel
SEED—some produced on farm	SEED—all purchased
MANAGEMENT DECISIONS—by farmer and community	MANAGEMENT DECISIONS—some provided by suppliers of inputs
ANIMALS—produced synergistically on farm	ANIMALS—feed-lot production at separate location
CROPPING SYSTEM—rotations and diversity enhance value of all of above components	CROPPING SYSTEM—monocropping
VARIETIES OF PLANTS—thrive with lower moisture and fertility	VARIETIES OF PLANTS—need high input levels to thrive
LABOR—most work done by the family living on the farm	LABOR—most work done by hired labor
CAPITAL—initial source is family and community; any accumulation of wealth is reinvested locally	CAPITAL—initial source is external indebtedness or equity, and any accumulation flows mainly to outside investments

C. Some Priority Components of a Regenerative Agriculture System.

A somewhat simple example illustrates the complexity. Take conservation tillage (37,38,39,41,43,44). Some form can always be applied on a wide range of soils under varied ecological conditions by adopting the system approach. There is a holistic approach considering a l l factors that affect the issue. That is a evidently a close interrelationship between coservation tillage and cultural practices. This reqires a high level of management skills and a high level of precise inputs. (6, R. Lal, D. J. Eckert, N. R. Fausy and W. M. Edwards, p. 222).

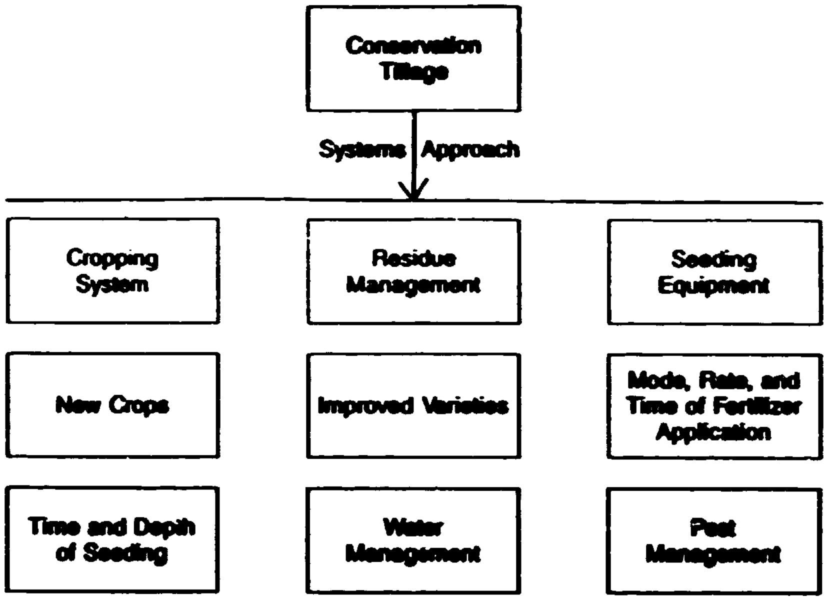


Figure 3. Cultural practices needed for successful adoption of conservation tillage.

The systems approach can also be expressed verbally in a holistic fashion (6, p.255,256).

"In addition, the use of insecticides can be minimized or replaced by other technques that invole:

-Minimal use of insecticides based on methods of forecasting pest incidence.

-Better insecticide placement and formulations, there by using smaller amounts with improved effectiveness.

-More crop rotations to avoid carryover of pests from one season to the next and gradual build up of population.

-Appropriate cultivations that minimize pest attack. The from these cultivars should take depends upon the pest involved.

-Timing of crop sowing to avoid pest attack.

-Adoption of controlled weed growth practices as compared with total weed suppression so as to encouragr natural enemies of pests.

-Use of biologocal insecticides based on insect pathogens that are effective without environmental impacts.

-Use of nematodes that attack insects to control them. Many nematode varieties have considerable potential but are not yet available on an extensive commercial basis.

-Release of parasites and predators of pest.

-Use of pheromones, other allelochemicals, or repellents to keep pest away from crops.

-Release of sterile male insects to abort reproduction of pests where appropriate.

-Use of crop varieties resistant to pest attack.

-Use of crop varieties with toxing implanted into their tissues by genetic engineering.

-Encouragement of natural predators by maintaining biological diversity among plants and in soil systems.

-Use of trap crops that promote pest emergence when the main crop is not available.

-Innovative cultural techniques, such as stripcropping, intercropping, etc., that increase diversity of habitat, flora, and fauna.

Fungicide use can be minimized by:

-Use of crop minimal amounts of fungiside based on disease forecasting methods.

-Use of rotations to minimize disease attack.

-Better application tehniques for fungicides using small amounts and better placement.

-Timing of crop sowing to avoid the disease incidence period or climatic periods favorable to the disease.

-Use of disease antagonists. A number of microorganisms inhibit the growth of plant pathogens.

-Use of crop varieties that are tolerant or resistant to disease.

Herbicide applications can be replaced by:

-Use of mechanical weed control. This can be associated with row spacing to fasilitate such cultivations.

-Use of rotations to avoid volunteer of seedlings from previous crops.

-Cover cropping to minimize weed seed germination.

-Use of live mulches to provide soil cover and in hibit seed germination.

-Use of mycoherbicides. These have been identified and can be prodused by genetic engineering techiques.

-Release of pests of weeds. These have been used successfully against a number of weed species.

Cultivations. Traditionally, land in developed countries has been cultivated annually to a depth of 9 to 12 inches (22.5-30 cm) with the surface soil completely inverted by moldboard plows. This involves a high consumption of energy to pull the plow, particulariy in difficult and compacted soils. For the last 30 years there has been a progressive trend toward fewer cultivations with corresponding reductions in energy inputs. This has culminated into a complete absence of cultivation and seeding into the previous crop using special tillage implements, usually after a herbicide application.

Techniques that reduce the number of cultivations required, compared to deep-plowing, include:

-Shallow prowing to a depth of 6 inches (15 cm) or less.

-Chisel prowing, which does not invert the soil.

-Deep subsoiling, which lifts the soil but does not invert it.

-Ridge tillage.

-Shallow-tine, soil loosening.

-Harrowing to create a seed bed.

-No-till (direct-rrilling).

All of these techniques tend to create conditions that reduce soil erosion and create a more natudal soil structure, which improves both drainage and water retention and favors biological and natural techniques of pest and disease control because there is less disturbance of the soil ecosystem.

Other components of this systems approach could be holistic considerations concerning "rotations", "innovative cultural techniques", "innovative machinery inputs", "organic matter inputs", "crop breeding" and the like to some this paper returns to later. Regenerative agricultural systems depend upon suitable manipulation of these components. How do components interact? Lower input agriculture is more system-oriented and, consequently, management-intensive. The farmer of the future will have to be intellectually alert! The fertilizer interaction diagram attempts to display some of this challenge. (6, pp. 260, 261).

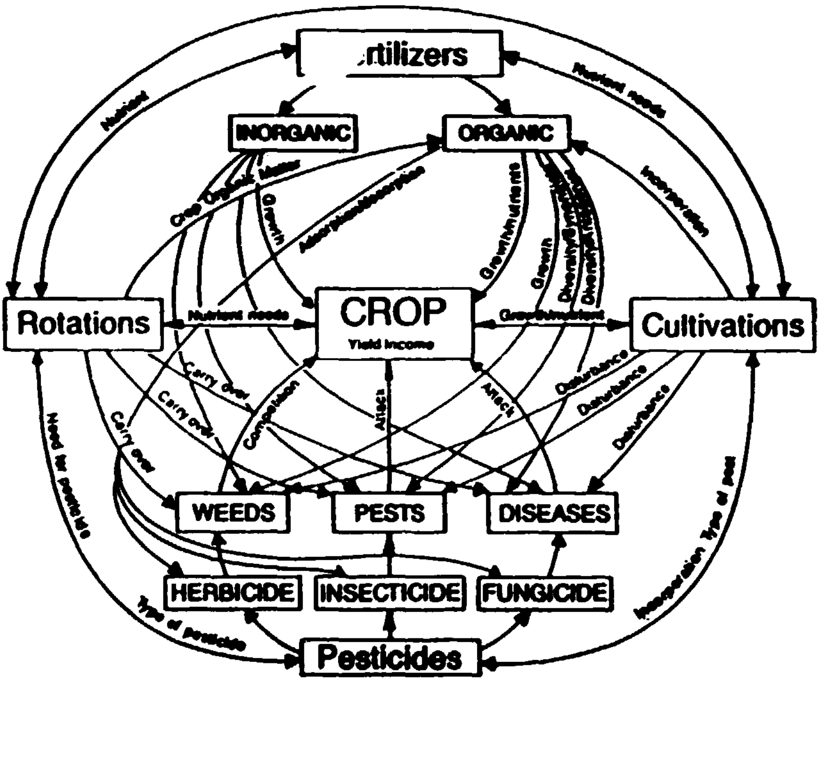


Figure 4.
Interactions between inputs (Edwards, 1987).

"These interaction and others that are more speculative include:

-fertilizers influence the growtn of weeds as well as crops (Moomaw, 1987).

-Fertilizers can increase dicsease incidence, for example, general leaf discase (Jenkyn, 1976, Jenkyn and Finney, 1981) aphids on wheat (Kowalski and Viser, 1979).

-Fertilizer can increase pest attack, for example, aphids on wheat (Kowalski and Visser, 1979).

-Organic matter can adsorb and inactivate pestisides (Edwards, 1966).

-Organic matter can promote populations of fungi thet control nematoes (Kerry, 1988).

-Organic matter can provide alternative feed for marginal pests or diseases (Edwards, 1975).

-Cultivations affect the incidence of weeds either mechanically or by burying weed seeds (Klein et al., 1987).

-Cultivations incorporate organic matter into soil where it decomposes more rapidly (Follett et al., 1981)

-Cultivations bring pesticides into contact with the pest, thereby increasing their effectiveness (Edwards, 1966)

-Cultivations incorporate organic matter into soil where it decomposes more rapidly (Follett et al., 1987)

-Herbicides can influence the severity of pest and disease attack by removing alternative weed hosts or by reducing the availability of natural enemies (Alteiri, 1987).

-Pesticides can affect soil organisms that break down organic matter and release nutrients (Edwards, 1983).

-Insecticides can reduce the incidence of viruses and diseases by killing the vectors of these organisms (Eedvards and Heath, 1964)

-Insecticides can increase weed populations by killing the natural enemies of weeds (Smith, 1982).

-Infecticides kill natural enemies of pests and thereby increase pest incidence or create new pests (Edwards, 1973).

-Fungicides can kill soil fungi that exert considerable natural control over insect or nematode populations (Kerry, 1988).

-Fungicides can reduce populations of beneficial soil microorganisms (decompesers and antagonists) as well as those of pathogens (Thomson and Edwards, 1974).

-Pecticides can deplete earthworm populations and, hence, lower soil fertility (Edwards and Lofty, 1977).

-Rotations reduce the incidence of most pests and dseases dramatically by interrupting the carryover of organisms from crop to crop (Dabbert and Madden, 1986).

-Rotations provide crop nutrients, particularly when they include legumes (Follett et al., 1981).

This list of interactions is far from complete. Indeed, there is little doubt that some are still unknown, and many others have not yet been fully documented."

D. Some Innovative Technologies that Help meet this Challenge

Four characteristic examples will be presented: a comruterized soil analusis laboratory, two approaches to mobilize the regenerative powers in the soil, and a hubrid solution between hydroponics (the classic continuation of conventional agriculture) and future possibilities of a new intensive agriculture (not yet completely regenerative). These examples are also applicable to protected soil.

1. ANVIL's LAB

Anvil Mineral Mining Corporation (36, 52) was the first in the world to assemble a computerized emission laboratory for the "mass" analysis of soils, plants, water and fertilizers. Anvil's lab is still leading with its modern base in Eqypt. The mining company was selling a trace mineral soil amendment called MICRO- MIN. One of the most difficult problems in maintaining the micronutrient balance in soils has been the lack of suitable measuirements and safe means of application. The first laboratory built was on wheels. All samples can be taken and analyzed on the spot by this mobile lab. Analysis are realized by a computerized testing system based on state-of-the-art software which is able to make a parts per billion analysis and to pass these test results to a second on-line computer which then summarizes these data in the form of analysis with 'recomendations' for the 'right kind' and 'amount' of fertilizer. Furthemore, this total farm information is 'held' in memory for future use. With the inputting of additional data, such a post-harvest production amounts and actual fertilizer usage, the laboratory represents the most effective tool the farmer has to maintain and improve his soil to the highest and most efficient levels of agricultural production at the lowest possible cost.

The laboratory has over 100 major pieces. These are assembled around an atomic specroscopy system, a laboratory computer, ultravioleted/visible Lambda 3A and 3B spectrophotometers, a data station and terminals.

Early in the lab's career an entire state of Mexico, namely Tlaxcala, was tested. The mobile unith drove to the peasant homesteads and recorded each one'slayout, soil tupes, crops and usages. The peasant could obtain on screen or as a print-out the sophisticated information about his operation. The agricultural university which collaborated in the project obtained a detailed overview of the actual state and the potenytial of its farming. The state and federalgoverments could have plugged in at any time. In fact, the advantage of the system with its softwares is that on the one hand it gives direct personal information to the land- user, while on the other hand, the system could be employed by some central agrarian authorities to plan agricultural production, save on fertilizers, subsidize and guide. No agrarian system has ever succeeded to do all this to everyone's satisfaction.

I had the privelege of having been involved personally in some of the field work and saw the happiness on the weathered faces of old Indians. In fact, regenerative agriculture will need this sophisticated service, in order to grasp the interrelationship of all ecological factors, as well as economic and political ones.

2. MICRO-MIN

Such a soil analysis can maintain the micronutrient balance and promotes healthy growth. The base material for MICRO-MIN (52) is in the Bucatunna Clay Fomation, an ansient marine volcanic ash deposit that (1) is exceedingly rich in micronutrient elements, chiefly in sulfide form, and (2) has a remarkably high ion exchange capasity that absorbs these elements and holds them until the plants are ready to use them. This montmorillonite agricultural clay is oxidized under controlled conditions, which mobilize the micronutrients as soluble sulfates. Then the material is dried at low temperatures, ground and blended with other micronutrient salts to bring the elements into a recommended balance. Unlike many other systems, the micronutriens are absorbed by the clay minerals in the product and released only as the plants call for their use in the different stages of development.

It has the following analysis: boron trioxide (B) 0.08% soluble, cobalt carbonate (Co) 0.014%, copper sulfate (Cu) 0.2, ferrous sulfate (Fe) 3.25%, manganese sulfate (Mn) 0.4, sodium molobdate (Mo) 0.002, zinc sulfate (sulphur (S) 6.2 and zinc (Zn) 4.0), montmorillonite (Al Si O (OH)).

The strong base exchange capacity of MIKRO-MIN illustrates the much neglected and only resently recognized importance of that capacity. The soil's colloidal energy is provided by the negative charge contained by clay mineral, and humic (organic) colloids. They attract and hold positive charged ions (cations) on their surfaces. Colloidal energy is measured by the ANVIL LAB directry. It is measured as milli-equivalents per 100 grams of soil, or total base exchange capasity. In the upper 15cm of soil, each one milliequivalent of exchange capasity means that the soil will absorb and hold 400 lbs/acre calcium, 240 lbs/acre magnesium, 460 lbs/acre sodium, 780 lbc/acre potassium, and 20 lbs/acre hydrogen.

The base exchange capasity of a soil reflects its content of negatively charged clay rich soil may have 40, or an organic muck soil up to 100.

It is necessary to know a soil's capasity in order to make recommendations for cation firtilizers. If more fertilizer is applied than the soil's base exchange capasity will hold, the exess will be quickly leached out and get lost. Similarly, if the capasity is not approached, soil imbalances may result. Hudrogen ions, always available in water, will find the extra exchange sites, causing soil asidity. When cations are absorbed by soil colloids, they become available to the plant root, as follows:

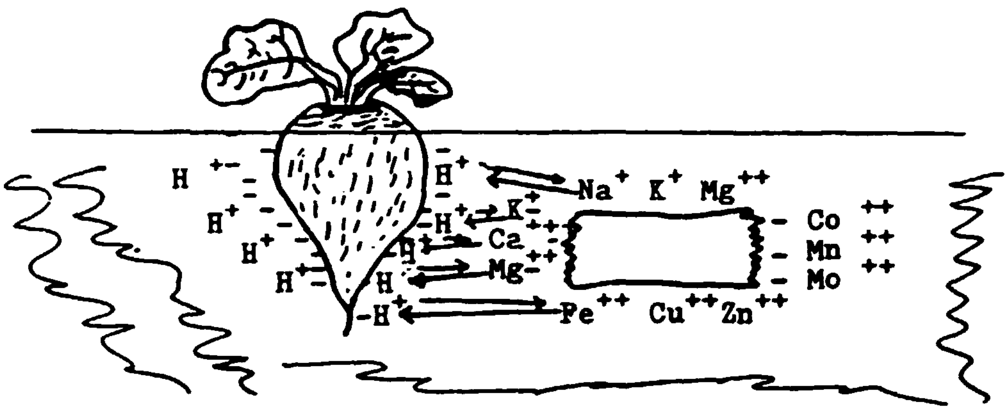


Figure 5.
A plant's hair-roots will allow the exchange of hudrogen ions for more necessary cations from soil colloids.

This process allows a plant which may require, for example, a positively charged potassium ion, to trade or "exchange" a hudrogen ion for it.

Since plants require more than one kind of nutrient, it is necessary to know how the soil's colloidal energy absorbs and holds cations in general. Their amounts are reported on an individual basis by the ANVIL LAB. The following base saturation ranges may be considered the ideal balance of the cation elements for the majority of commercial crops:

0-15% Hydrogen (H^+)

5-7 % Potassium (K^+)
15-20% Magnesium (Mg^{+2})
60-75% Calcium (Ca^{+2})
5% total of (Co^{+2})(Cu^{+2})(Fe^{+2})(Mn^{+2}, Mn^{+3})
(Mo^{+3})(Na^+)(Zn^{+2})

Macronutrient cations are Calcium, Magnesium, Potassium. Micronutrient cations are Copper, Iron, Manganese, Sodium, Zinc.

Unlike cations, anions are negatively charged ions and not directly related to the base exchange capacity of the soil. Macronutrient anions are Nitrogen, Phosphorus, Sulfur. Micronutrient anions are Boron and Molybdenum.

Results with MICRO-MIN have been in desert regions.

3. PETRIK LAB

Vaclav Petrik (48,50) has developed some of most efficient "bacterization" formulas.

BTR-CC/BTR Plus/BTR-E are compost starters. HXM/BTR 363 are also compost starters, but prepared for particular tasks, like BTR 464 for bagasse, BTR 565 for macadamia nut shells FX2 is a foliar plant energizer (see Appendix One).

Omega is a microbial fermentation material for use as a starter fertilizer Evergreen is designed to improve grasslands, pastures, golf courses, forage crops and like. STL maximizes seed germination and plant growth SLX/SBX is an advanced soil metabolizer for reclamation of severly saline soils (see Appendix two).

N-FEX/N-FEX Plus is both a foliar spray and soil conditioner, HOP is for treatment of raw manure, BIOLATES are amino acid chelated minerals, BB2000 is a microbial fermentation liquid designed for use as a root dip for transplants.

These materials are designed with the soil in mind. The soil must get into optimum condition. Therefore, micro-organisms are used in making the Petrik materials. A partial list includes:

Arthrobacter terregens	Enterobacter aerogens
Aspergillus sp.	Enterobacter agglomerans
Bacillus megaterium	Lactobacillus sp.
Bacillus subtilis	Penecillium sp.
Brettanomyces sp.	Pichia
Clostridium beijerinckii	Rhizopus sp.
Clostridium butyricum	Saccharomyces sp.
Clostridium pasteurianl	Torula sp.

Petrik's understanding of the soil processes is shortly to be published. Excerpts he showed me August 9 at his laboratory looked very promising. He is filling a real need for a holistic summary of soil biology.

4. LIVING WALL GARDENS.

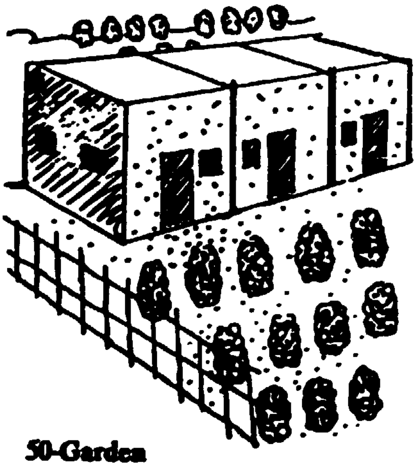
The best introduction to LIVING WALL GARDENS (40) are the spectacular looking gardens in action. They are a completely novel idea of growing in plastic containers, filled with a certain rock-wool and fertilized with slow-release NPK 10-20 tumes as much, as on the best open or covered soils.

The patented LWG growing medium is composed of mineral wool of certain basalt rock types with high cation exchange, vermiculite and

How the hungry can learn to feed themselves

Every $750 contributed will buy ten Living Wall Gardens

that will produce...



1200 lbs of tomatoes

or

2,000lbs of cucumbers

or

480 lbs spinach

or

540 lbs of peppers

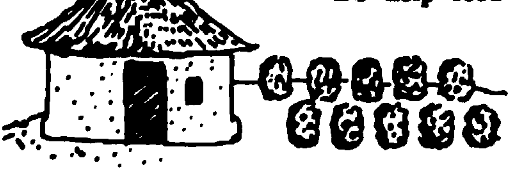
50-Garden
Community Garden

100-Unit Plot
at the Missio

every year for at least 10 years!

These crops grown on non-arable land in tropical climates and sold to hotels, restaurants and supermarkets (or for export) can provide the poor with an income to buy food, clothes and other basic necessities through their own efforts.

Do help feed the hungry, with dignity!



10-Garden Plot byt a Hut

Fig 5.

phenolic resin, with a Hydrogen Ion concentration of 6.2 - 6.5. It comprises a composite function. Unless wasted, it should last forever. The oldest units extant are 12 years without dimenshed vitality. It holds more water than any other growing medium, but can never be overwatered to damage plants, because of saturation run-off. While holding the optimum amount of water, contemporaneously, it holds the optimum amount of air for roots. It acts as a sponge for nitrogen, because it has a cation exchange capacity. Thus it can absosb from the fertilizer and release nitrogen as the plants demand. Any soluble fertilizer will work. Recommended trace elements have been developed to work synergistically with the LWG growing medium.

Floating LWG have been used very successfilly, growing an abundance of vegetables in subtropical climates.

In this connection no fertilizers are being used, except the natural nutrients in the lagoons and sweet-water streams.

Our company A.E.G.I.S. is about to start a series of desert experiments in Kenya and Baja California. The fertilizers will be a composite of BIOVIN (50) and ACADIAN (50) in the drip irrigation and a

Figure 6.

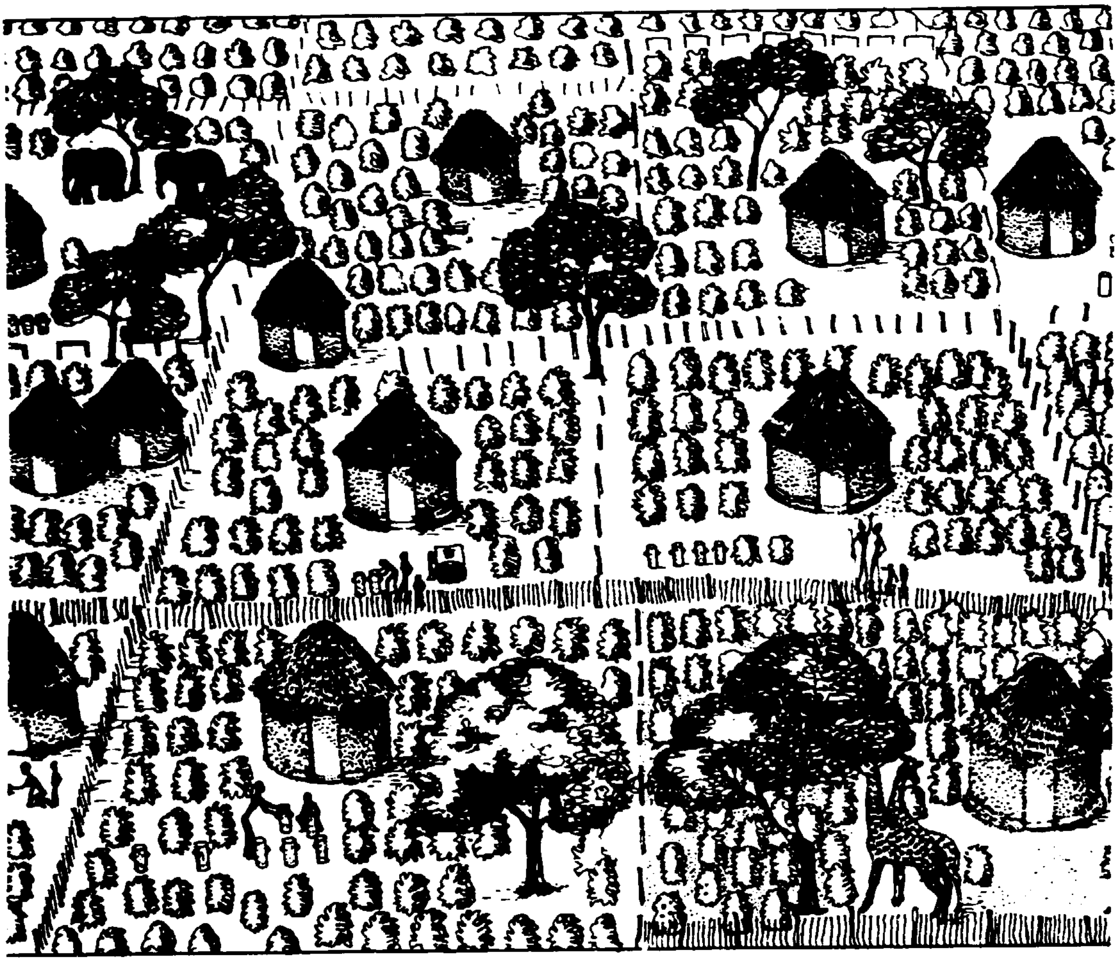


Figure 7.

E.Conclusion

major foliar feeding program with PETRIK's (48,50). ICI Great Britain produceda spray instrument, "elecrtodyne" which allows for fine misting to stay suspended around the leaves.With SONIC BLOOM (51) the stomata are observer to open and the major nutrients would enter via the leaves. New possibilities arise for fertilizing plants growing in LWG without a soil environment. Root and soil insects have difficulties to exist and survive. Biological fertilizers and ecological foliar sprayes can be utilized to a maximum. For example, fungi, as a key to future sources of safe chemicals, find wide application. So do the entire realm of enzymes. The benefits of companion planting are very evident and easily manipulated. While most LWG operators still work heavily with chemical fertilizers, sprays and controls, the approaches of regenerative agriculture are becoming recognized as commercially and quality production-wise valid. Finally, it becomes feasible to root sensor plant requirements on a large and automated base, allowing maximum feeding with minimum inputs.

Cash-flow projections (see APPENDIX THREE) have not taken into account these potential expenses. LWG is a very intriguing model for green-house enterpreises; perhaps even in conjunction with hydroponics. Regenerative agriculture will modify LWG, hower in another direction.

The key to an appreciation of regenerative agriculture lies in a new understanding of soil biology.

European achievements in regenerative agriculture and new technologies were omitted on purpose. It would have burst the interdisciplinary integration of American components.

Nevertheless, it should be mentioned that European low technology equipment is making its way to American farms. Europeans perfected flameweeding. The Dutch LELY spring-toothed cultivator, the BERG model pushpowered wheel hoe made by Gschwind in Switzerland, the Germen made tool-carrier SCHMOTZER,the IMANIS tractor- drown rotary spader of the Netherlands, the GOLDONI Italian walking tractor, the pedal-operated "rackomobil" by the Austrian Gottfried Pessl, the Dutch VISSER soil-block maker are only a few of the fertile inventions very much needed by regenerative agriculture.

To have an ecologically and economically healthy world, we have to make changes in man's oldest occupation, agriculture. This new agriculture system will be complex. Work related to it should include many aspects beyond the agrarian ones: the consumers' perspective, the total food and health system from production to consumption, the social implications of land, the role of women and children in agriculture.

No matter where six postulates will need serios consideration:

1. Equitable access by all who wish to farm to fertile land, credit, and agricultural information;

2. The maintenance and support of independent agriculture over which those farmers who work, both men and women, have personal control;

3. The development of cultivation, food processing and food storage methods that ease the horrendeous demands on women's labor;

4. A high dergee of diversification on each farm and in all rural areas for ecological survival reasons;

5. The regeneration of all soil;

6. A stewardship use of the rarest resource in the future, water and fuel.

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G. Some Novel Agrcultural Technologie

36. ANVIL's LAB. 5111 Pebble Springs. Houston. TX 77066. FAX:713.537.9573. Robert A.Kalish. Director. Laboratory Services (advansed and computerized emission laboratory for the 'mass' analysis of soils. plants. water and fertilizers) See also no. 66 below.

37. BEZZERIDES BROS. Inc. P.O.Box 211. Oresi. CA (designer and builder of weeding technologies which make herbicides obsolete. like spring-hoe weeder for $75. rotary brush rake for
$348.bug-zapper for $10.000 for orchards. wineries etc). 38. BUFFALO FARM EQUIPMENT. Nebraska (cultivator for
ridge-till planting)

39. HOLLAND EQUIPMENT. PA (AER-WAY prepares seedbeds and opens compacted soils. prepares stubble for decay etc. SEEDMATIC saver on chemicals and cultivation).

40. LIVING WALL GARDENS. F.Wesley Moffet Jr..President. 2044 Chili Ave.. Rochester. New York 14624 (the building block LWG system was now developed to feed the Thirg World. With its advent. farms can now be anywhere. removing many of the climatological. economic and agrarian risks which have surrounded farming thougrount history).

41. SIMCORP Inc. Rt.1. Box 202. Canyon. TX 79015. Tel.:(806) 655-4515 (Fletcher Sims developed the SCAVENGER for windrow composting of steer manure at his own large composting operation).

42. THOMAS QEUIPMENT. New Brunswick. Canada (SALAD VACs. sweeping out the bugs. See below under Vacvum).

43. THRUSTON MANUFACTURING Co. Nebrasca (subtillers. plows etc.) PLOW Examples: Cf.Agricultural Research. Febuary 1988. vol 36. no 2. p.12: Lloyd N.Mielke and colleagues at the Universaty of Nebraska have developed the "sweep plow" which undercuts emerging weeds and loosens the soil layer above the blade. Sweer-tilled soils store more water for crop growth. The water is thapped in subterranean reservoirs. a series of troughlike corrugations that the shanks create just below the tilled zone. Porous soil helps foster microbial activity that unlocks extra nutrients for crops. Three sweep plows are aligned and pulled abreast.

Cf. New Scientist. 27 August 1987. vol. 115. no 1575: EEC's herds number about 81 million heads. Their manure disposal is becoming a particular problem. Yet its high nitrogen content makes the manure also desirable as valuable fertilizer. Scintists at Britan's Cranfield Institute of Technology have developed an injector-disc that can be pulled over pastures or fields. Up to 140 cubic meter of slurry can be desposited in a hectare of land by a winged tine digging in to a fepth of 13 centimeters. Injecting in the autumn causes no negative change in yields and the pasture. for exemple. can be used again in three weeks. otherwise spreading slurry keeps a six mouths waiting period. Volatile ammonia can the air. where it contributes to acid rain.

Cf. JOURNAL OF SOIL AND WATER COSERVATION. May/Jun Water infiltretion rates in soils tilled with a paraplow werc greater throughout the growing

Underground Plow

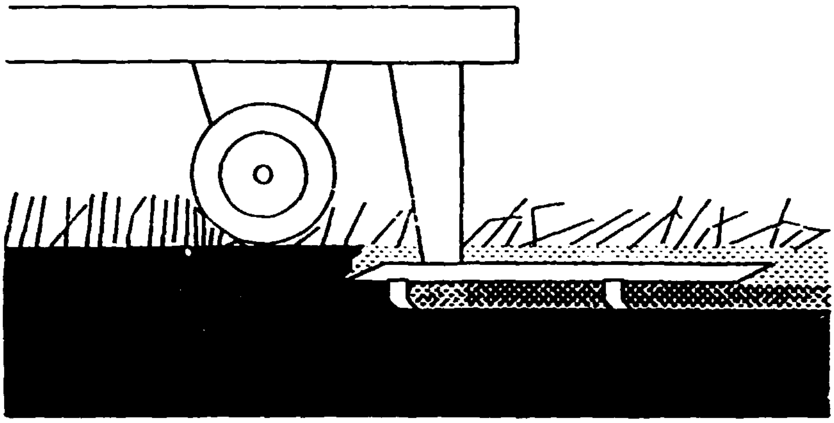


Figure 8.
Modified from existing sweep plows, the underground plow loosens soil and increases water-holding capacity, yet leaves crop resident on the surface to cut erosion. (Not to scale.)

season compared with no-till, moldboard plowing, or chisel plowing at three experimental sites in Iowa. Iowa State University researchers found that the paraplow, a new tool to North American farmers, lifts the soil an inch or less and drops it back in pleace as it pulls a winf-shaped blade through the soil. A moldboard plow turns the soil over. The paraplow does not disturb the residue cover which helps keeps soil from sealing and crusting.

44. TRACTOR Example: Cf. Farm Journal, Mid-March 1985, vol 109, no 6, p.16-D and Cf. Science, July/August 1986, vol 7, no 6, p.8 on the tractor of the future. It is easy on the earth, because its widely spaced wheels roll along permanent paths, leaving at least a 15-footwide center strip untouched. An automatic steering system borrowed from the lunar land rover makes maneuvering the giant tractor easy. This high-riding tractor was developed by Granot Technologies Ltd and Technion. The "Merhav" is a 10-ton Israeli tractor for controlled field traffic. Roots need loose and moist soil. Wheels need dry and firm soil. Yields have climbed dramatically and enegy savings are remarkable.

45. VACUUM SWEEPERS: Cf. California Farmer, May 20, 1989, "Sucking up Salad Pests" and "Blueprints for Bug Vacs"; and Cf. American Vegetable Grower, March 1990, "Sweeping Fields Controls Some Pests": IAP Manufacturing of Phillips, WI constructed insect vacuums which worked twice a week appeared to suffice. Adult Lygus bugs on strawberries also succumb. Green peach aphid, however, so far defines being vacuumed off. Tests in greenhouses turned out very satisfactory. In Florida vacuums are being tested on timatoes and squash for white fly control. The following are some of the active firms:

AGRI-VAC, 234 Kearney St., Watsonville, CA 95076; (408) 722-1908

BUGS UNLIMITED, P.O. Box 371, Florence, MA 01060; (413) 586-5040

IAP Inc., P.O. 56, Phillips, WI 54555; (715)339-3024 Mike McCluerey Manufacturing, 28 Morehouse Dr., La Selva Beach, CA 95076; (408) 722-2194

Sukup Manufacturing Co., Sheffield, IA 50475; (515) 892-4222.

H. SOME SOURCE MATERIAL ADDRESSES

46. BIOLOGICAL PEST CONTROL; Beneficient Insectary, 14751 Oak Run Rd, Oak Run, CA 96069; (916) '72-3715 (fly parasites, trichogramma, lacewing, predatory mites, ladybugs etc)

47. CARBON, useable: Ridzon Farms, 47810 St. Rt. 14, New Waterford, OH 44445 (Nutri-Carb provides necessary usable carbon)

48. FOLIAR SPRAY: The Bioneering Corporation, 1233 E. Beamer, P.O. Box 176, Woodland, CA 95695; FAX: 916.666.2694 (Lloyd Franklin Anderson manages the varios PETRIC sprays, among the most successful in the world).

Liatinie Fish Inc., Rt 2, Box 84, Bonduel, WI 54107; (715) 758-2280 (liquid ocean fish and sea-weed for foliar feeting)

Skow nterprise, Route 2, Box 233 B, Fairmont, Minn. 56031; (507)235-6909 (offers an instruction course on how to build your own foliar spray)

Sunrise Internstional, Capital Plaza, 1000 E. William St., Suite 100, Carson City, Nevada 89701; FAX 702.883.4874 (Foliar spray for sees, seedlings, transplants, trees; and soil inoculation)

49. REMINERALIZATION: Canton Mills Inc., P.O.Box 97, Minnesota City, MN 55959; (507) 689-2131 (CALPHOS is a natural soft phosphate rich in fast acting phosphorus, calcium and essential trace elements)

Hugh L. Paddock Co, Dpt. A, 811 North Bluff Rd, Greenwood, Indiana 46142; (317) 881-6143 (provides Lonfosco colloidal soft phosphate)

Peak Minerals, 101 N. Tejon, suite 2001, Colorado Springs, Co 80903; FAX: 719. 635.8938 (Azomite)

Soil Balancing Service, Gay Weber, R 3, Tomah, WI 54660; (608) 427-3534 (reactive rick phosphate: 30.5% P O ,48% Calcium oxide, 1.2% sulphur)

"Soil Remineralizatoin, a network newsletter", Joanna Campe, 152 South Street, Northampton, MA 01060 (sources; grinders; remineralization groups worldwiJe; international gravel and rock dust sources)

50. SOIL ACTIVATORS: Acadian Seaplants Ltd, 202 Brownlow Ave, Tower D, suite 304, Dartmouth, Niva Scotia, Canada B3B 1T5; FAX:902.468.3474 (North America's largest manufadturer of seaweed products for agriculture)

(see also 48) (Petrik is leading in enzyme and bactaria amendments, inocculants, besides foliar sprays) Bioneering.

Biovin-Austria, Trever Ges.m.b.H.,A-2340 Modling, (02236) 85 1 68 (complete organic-biological fertilizer characterized by a high content of humus and microbial charge. The fertilizer is produced from organic substances - grape sees, skins and stems - by way of a microbiological process of aerobic putrefaction)

McDaniel Inc., HCR 1, Box 2B, Felt, OK 73937; (405)426-2481 (HU-MAC, a combination of humic acids and varies organic catelists builds soil hums levels by increasing biological activity in the presence of suitable, non-fat, organic matter. MAC-T-VATOR, an organic catylist, is a biologically formed substance which speeds up the rate of chemical and energy exchangee reactions in living cells. Organic catylists are called enzymes. They are proteins specifically related to individual trace elements, such as manganese, iron copper, zinc, boron etc. without which they can't operate).

Minnehaha Ag. Service, Wayne Bjerdahl, 102 E 7 St.,Dell Rapids, SD 57022; (605) 428-3657 (AER.WAY revitalizes the soil and increases yields by using liquid humate blends like carbo-cal, carbo-trace min; elemite; leonardite, colloidal phosphate clay etc)

Nature's Way, Inc., RR 1, Box 114, Horton, KS 66439; (913) 486-3302 (Nature's "Solid Bio's" use molasses, seaweed, humates and liquid fish concentrates as carriers for its enzymes, soil microbes and bacterias)

United Agri Services Inc., 9201 Penn Ave South no. 10, Minneapolis, MN 55431; (612) 881-1915 (WASTE_X is a biological activator for lagoons, pits and holding tanks. The enzymes in WASTE-X speed up the biochemical reaction in waste elimination processes. It neutralizes foul odors from feedlots, dairy barns, hog and chicken houses)

Wamco Inc., P.O. Box 60, Lawai Kauai, Hawaii 96765; FAX:808.488.4219 (producting bio-catalitic kelp based systems as soil flocculator, fertilizer, insecticides; ridding well water of chemical pollutants such as nitrates, insecticides; ridding well water of chemical pollutants such as nitrates, arsenics etc; cleaning up septic tanks and sewer treatment plants)

51. SONIC BLOOM: Dan Carlson, Scientific Enterprises Inc., 708-119 Lane N.E., Blaine, MN 55434; (612) 757-8274 (combines enzymatic nutrient solutions with certain music types. The music opens the stomata. Foliar spray is taken up in large quantities)

52. TRACE MINERALS: Anvil Micronutrients Corporation, M. Manny Kalish, President, P.O. Box Q, Bay Springs, Mississippi 39422 (plant facility) See for address no. 36 above.

Pro-Minerals Co, Box 193a, Fairbrank, Iowa 50629; (319) 635-2539 (the merits and results of PRO-MIN mineral fertilizers in providing plant nutrients, improving soil structure and acting as a catalyst for other nutrients in the soil assist the farmer to begin a careful transition to a less sostly energy and resource farming operation, that inputs of petro-chemical fertilizers, herbicides and insecticides).

APPENDIX ONE

FX2

FX2 is a non-polluting, non-toxic and ecologically sound foliar plant energizer. Meets the California Health and Safety Code Section 26569.11 for use by farmers who label their crop "organically grown."

This biological material containins a complex of enzyme systems and other plant growth factors, produced naturally by a fermentation process.

FX2 AND "PHYTAMINS"

Phytamins are natural growth factors created by the soil life (microbes) for the use of the plant's system of higher plants; and thus, are a necessary part of the soil solution. They control plant growth and vigor and have a similar effect as hormones and vitamins in animal and man.

Phytamins are not a substitute for soil nutrition derived from fertilizers. But man-made chemicals cannot perform their function, nor can we manufacture these naturally produced biological factors; they cannot even be identified by chemical analysis in the plant or root system.

Our energizer material, FX2, merely stimulates the natural production of phytamins in the plant and root zone .

The following results have been noticed, when using this foliar energizer:

1. Better crop stand
2. More plant resistance to stress
3. Improved and balanced plant vigor
4. Increase in number of flowers
5. Improved fruit setting

DIRECTIONS FOR USE

1. FX2 is a plant foliar spray which may be applied by any spray equipment ranging from the small hand sprayer to powered pumps.

2. Material are completely miscible and mix readily with water.
3. For field application, FX2 materials should be diluted at a minimum rate of 1:30 (one part to 30 parts of water), or up to any total water volume requirement of spraying equipment or method. It is recommended to avoid chlorinated water.

4. Once diluted, the material should be applied immediately for maximum results. But in any event, it must be applied within 2 days after dilution.

RATE OF APPLICATION

Most crops including orchards: 945 - 1890ml/ha (13 - 25 fl.oz/acre) per application.

On mature trees: Rate may be increased up to 3785ml/ha (50 fl.oz/acre) per application.

FIELD APPLICATIONS

Similar to micronutrients foliar fertilizers, it is recommended to apply FX2 before the plant enters into a major stress such as blossoming, tasseling, booting, squaring, tuberization, etc. For maximum results, the material must be applied at the right time during the growing season.

If spraying young row-crops does not cover all of the field area do not include the non-sprayed area in calculation of coverage.

SUGGESTIONS FOR SOME CROPS

Alfalfa: One treatment 6-8 weeks after planting, up to one treatment 8 days after each cutting.

Almonds, apples, apricots, cherries, peaches, pears, prunes and pecans: One treatment in the spring as soon as sufficient foliage has emerged. FX2 may also be applied prior to blossoming (i.e. on buds with no foliage) to increase the number of opening flowers.

Artichokes: One treatment 6-8 weeks after planting. May be repeated 4 weeks later.

Asparagus, cabbage, brussel sprouts, carrots, cauliflower, celery, endive, escarole, lettuce, spinach, zucchini: One treatment approximately 4-6 weeks after planting.

Avocadoes, citrus (oranges, lemons, nectarines, tangerines, grapefruits), **grapes, olives, palms**: One treatment before blossoming. May be repeated after fruit setting if needed.

Bananas: One treatment during early growth. May be repeated 4 weeks later if needed.

Beans, peas: One treatment approximately 10 days before flowering.

Broccoli: One treatment at 4-5 leaf stage.

Cantaloupe, melon, watermelon: One treatment when first flowering commences. May be repeated 3-4 weeks later.

Corn: One treatment 21-42 days after emergence.

Cotton: One treatment before squaring.

Cucumber, squash: One treatment approximately 6 weeks after planting. May be repeated 3-4 weeks later.

Eggplants, peppers, tomatoes: One treatment approximately at 4-5 leaf stage. May be repeated 3-4 weeks if needed.

Maize, sorghum: One treatment approximately 10 days before tasseling commences.

Onion, garlic: One treatment approximately 6 weeks after planting (or shortly after thinning).

Potatoes: One treatment when plants are approximately 15-20cm before tuberization. May be repeated 3-4 weeks later.

Rice: One treatment approximately 10 days before booting.

Strawberries and all varieties of berries: First treatment after leaves have matured. Second treatment 6 weeks later.

Sugar beets: One treatment immediately after thinning. Second treatment 6-8 weeks before harvest to increase sugar content.

Walnuts, figs: One treatment after foliage has matured.

Wheat, milo, barley, rye, oats: One treatment 14-20 days after plant emergence.

TECHNICAL DATA SHEET

Material	FX2
Applied to	Foliar
Physical Appearance	Brownish condensed fermentation liquid
Specific Gravity	> 1g/ml (8.32lb/US gallon)
pH	3
Solubility	Completely miscible in water
Flammability	Non-flammable
Temperature Stability	268K to 323K (23°F to 122°F)
Storage Conditions	275K to 300K (35°F to 81°F)
Shelf Life	5 years in original container.
Safety	Non-toxic fermentation material and does not represent a hazard to humans or plants. **However it is not intended for human or animal consumption.**
Compatibility	Only non-chlorinated water
Application rate	As foliar 945 - 1890ml/ha (13 - 25 fl.oz/acre) per application.

Typical Analysis:

1.Total Aerobic count	<3.0 x 10^3/ml
2.Total Anaerobic count	<2.0 x 10^3/ml
3.Total Yeast count	<1000/ml
4.Total Mould count	<1000/ml
5.Total Actinomycetes	<1000/ml

6.Minerals

N	0.3%
P	0.2
K	0.5
Ca	0.7
S	0.15
Mg	0.004
Fe	300.ppm
Mn	10.
Zn	10.
Cu	2.

7.Enzymes
Hydrolase group, Desmolase group

14.Traces of Organic Acids
Aspartic acid, Deoxycholic Acid, Thioctic Acid, Malic Acid, Butylic Acid

15.Traces of Vitamins
Thiamine, Riboflavin, Niacin, Choline, Cryptoxanthin

16.Growth Factors
Adenine, Tripeptid glutation, Cytokinins, Guadinine, Purine, Puridinine

APPENDIX TWO

SLX / SBX

SLX/SBX is an advanced soil metabolizer produced by Petrik Laboratories, Inc. for the reclamation of severely saline soils.

Meets the California Health and Safety Code Section 26569.11 for use by farmers who label their crop "organically grown."

This biological fermentation material contains special groups of natural enzyme systems, highly effective in causing biological transformations of soil salinity.

In addition, SLX/SBX contains all the basic soil metabolizer and biofertilizer from Petrik Laboratories, Inc. which improve the soil structure and assures a balance in soil metabolism, with the production of stable humus.

MODE OF ACTION

While the beneficial results of using SLX/SBX in the field have been proven, the exact and precise "Mode of Action" has not been determined yet by science. What is known now to us is that SLX/SBX, when used as directed, is non-toxic, non-polluting and ecologically sound, while working with other native soil microflora to reduce soil salinity, to improve soil structure and to transform non-productive or poorly productive soils into fertile soils that produce healthy crops with consistent high yields.

Our research is aimed at being useful to farmers by providing information and experience in practical microbiology. Practical microbiology today requires a re-evaluation of many of our previously held theories regarding microbial interactions and agricultural applications.

Soil Scientists have greatly modified their theories concerning the relative importance of strictly physical and chemical processes, and microbial activities, in soil formation. Once regarded as being of negligible significance, the complex interactions between the bacteria, fungi, actinomycetes and yeasts, as well as the soil protozoa and insects, are now believed to be the primary "driving force" of soil genesis and formation.

In the case of SLX/SBX, we cannot claim that any branch of science has yet fully explored every detail relative to its "Mode of Action". But we know that SLX/SBX reduces soil salinity; and we have reasons to believe that it causes changes within the sodium nucleus and not just chemical transformations of sodium compounds. By analyzing the total levels of sodium, potassium, magnesium and calcium in treated saline soils, before and after the application of SLX/SBX, we have observed a decrease in the levels of sodium and an increase in the levels of potassium, magnesium and sometimes calcium; and the most observed was the direct link between sodium and potassium levels.

A more plausible explanation of the mode of action in SLX and SBX has been supported by the most recent studies conducted in the middle east on sodium reduction in closed and open controlled environments.

It seems that methylization of some sort is taking place in the soil and the sodium is being evaporated into the atmosphere. More studies are being conducted to provide us with details of total sodium evolved into the atmosphere and to determine the exact methyl compounds.

This may be the whole explanation of mode of action, but more probably there is a complex solution to this and more than one process is taking place. We do not claim that we know the precise mechanism of these changes. But since the exchanges are taking place between the total levels of these elements in the soil, we believe that we have good merit in describing SLX/SBX as a biological transmuter of soil salinity. In addition, and as always, the consistent improvement in the soil fertility and the health of plants in treated soils will be our preferred yardstick for measuring success.

We believe that if mankind is to meet its future needs for agricultural production, it is imperative that we utilize the dynamic benefits of our microbial allies.

DIRECTIONS FOR USE

SLX/SBX directions should be followed carefully.

1 SLX/SBX may be sprayed with any equipment, from a small hand sprayer to powered pumps, or injected into irrigation systems.

2 All application equipment, to be used for spraying SLX/SBX, must be thoroughly cleaned-. To clean equipment, after the regular cleaning with soap and water, use baking soda (sodium bicarbonate). Dilute in water at the rate of 50 grams soda in a 20 liter tank capacity (1oz for 3USgallons). Spray to flush the whole system including pump, hoses and nozzles if present. Let the system stand overnight soaking with soda. Next day, flush the whole system twice with clean water. Note: Rubber hoses are very difficult to clean from chemicals. Therefore, we recommend using new hoses whenever possible.

3 Dilute properly the necessary amount of SLX powder in water (1kg SLX in 8 liters [1lb in 1USgallon], preferably luke warm water) and keep for 12 to 24hours before adding to the main tank. SBX may be added to main tank just prior to use (no activation needed).

4 It is preferable if you do not use spray nozzles or filters smaller than 80 mesh size.

5 Do not mix SLX/SBX with fertilizers, pesticides, herbicides or any chemicals. Allow at least 96 hours before or after applying SLX/SBX before using any of these chemicals. If soil fumigation is done, wait at least 1 week and properly aerate the soil before applying SLX/SBX.

6 Mix SLX/SBX only with water as a carrier.

7 Diluted SLX/SBX should be used within 48 hours.

8 Sand filters should be removed if SLX/SBX is injected into irrigation system.

9 If drip irrigation is used, apply SLX/SBX by injecting into the drip system for best results.

10 SLX/SBX must be disked in the soil or followed by irrigation or rain, within 24 hours after application.

11 SLX/SBX should not be disked in more than 10-15cm (4-6in).

DIFFERENT PRACTICAL USES

SLX/SBX is designed for the reclamation of non-productive soils with severe salinity problems, and for improving the fertility of poorly productive soils with relatively lower salinity levels. SLX/SBX is used in such soils on a temporary basis until the salinity drops to a normal level that is even tolerated by sensitive crops.

1 If the salinity problem exists in the irrigation water itself, or because of a high water table, SLX/SBX may have to be used regularly for every crop season or once a year, if necessary, to prevent the accumulation of the water salinity in the soil.

2 In saline and partially productive sands or soils, SLX/SBX is applied, before planting, once per crop season. For perennial crops, orchards and fruit trees, SLX/SBX is used at least once a year in the fall or early winter.

3 In severely saline non-productive soils, SLX/SBX may be applied at any time of the year provided moisture is available via irrigation or by rain. Although SLX/SBX is highly effective even if used alone, it is, however, recommended to try planting some resistant crops; we believe that if any plant growth is possible, it will be significant in enhancing the beneficial effects of SLX/SBX due to the dynamic relationship between soil microbes and plant roots.

   a First, treat a representative sample of the seeds to be planted with a small moist quantity of the saline soil itself. If the treated seeds cannot germinate, then there is no sense in trying to plant. But if the seeds can germinate, then this treatment will give them more resistance to salinity before planting. In this case, apply SLX/SBX in the soil following carefully the directions of use, treat the total quantity of seeds in the aforesaid manner and plant them immediately after treatment.

   b It is a must that no chemical fertilizers are to be used if SLX/SBX is used in severely saline soils.

   c Representative soil samples from the area to be treated with SLX/SBX, should be collected before treatment, 2-3 weeks after germination and then after harvest. These soil samples should be analyzed mainly for Organic Matter level, pH, E.C. and the -total- levels of sodium, potassium, magnesium and calcium; results will be evaluated accordingly in addition to field observations on the soil and crop.

> In the biological sciences, we learn how to move nature, with natural means at our disposal, to accomplish certain goals which we cannot achieve systematically. Even when we do not understand nature's precise "Mode of Action", we are often successful in moving nature toward the desired objective of long-term fertility in a biologically active soil.

TECHNICAL DATA SHEET

Material	**SLX**
Physical Appearance	Light brownish, fine powder
Specific Gravity	0.8g/cm³
Particle Size	80 mesh
Solubility	Dispersible powder - 92% soluble in water

Temperature Stability	268K to 322K (23°F to 120°F)
Storage Conditions	275K to 300K (35°F to 81°F)
Shelf Life	Under normal storage conditions and with no contamination, the material will remain stable for 3 years.
Safety	This is a non-toxic fermentation material and does not represent a hazard to humans or plants. **However it is not intended for human or animal consumption.**
Compatibility	Only non-chlorinated water
Application rate	Soil 3 - 4 kg/ha (2.5 - 3.5lb/acre)

Typical Analysis:

1.Total Aerobic count $<2.0 \times 10^{10}$/ml
2.Total Anaerobic count $<2.0 \times 10^{5}$/ml
3.Total Yeast count <100000/ml
4.Total Mould count <100000/ml
5.Protein 2.00%
6.Crude Fat 0.04%
7.Crude Fibre 0.04%
8.Lactic Acid 5.45%
9.Minerals

N	0.5%
P	0.2
K	0.5
Ca	0.7
S	0.15
Mg	0.004
Fe	300.ppm
Mn	15.
Zn	10.
B	8.
Cu	2.

10.Enzymes
Hydrolase group, Desmolase group, Transferase group
11.Traces of Organic Acids
Aspartic acid, Deoxycholic Acid, Cholic Acid, Malic Acid, Butylic Acid
12.Traces of Vitamins
Thiamine, Riboflavin, Niacin, Choline, Cryptoxanthin, Ergocalciferol
13.Growth Factors -
Adenine, Tripeptid glutation, 3-adenylic Acid
14.Biocatalysts
Bios I, Bios IIA, Bios IIB

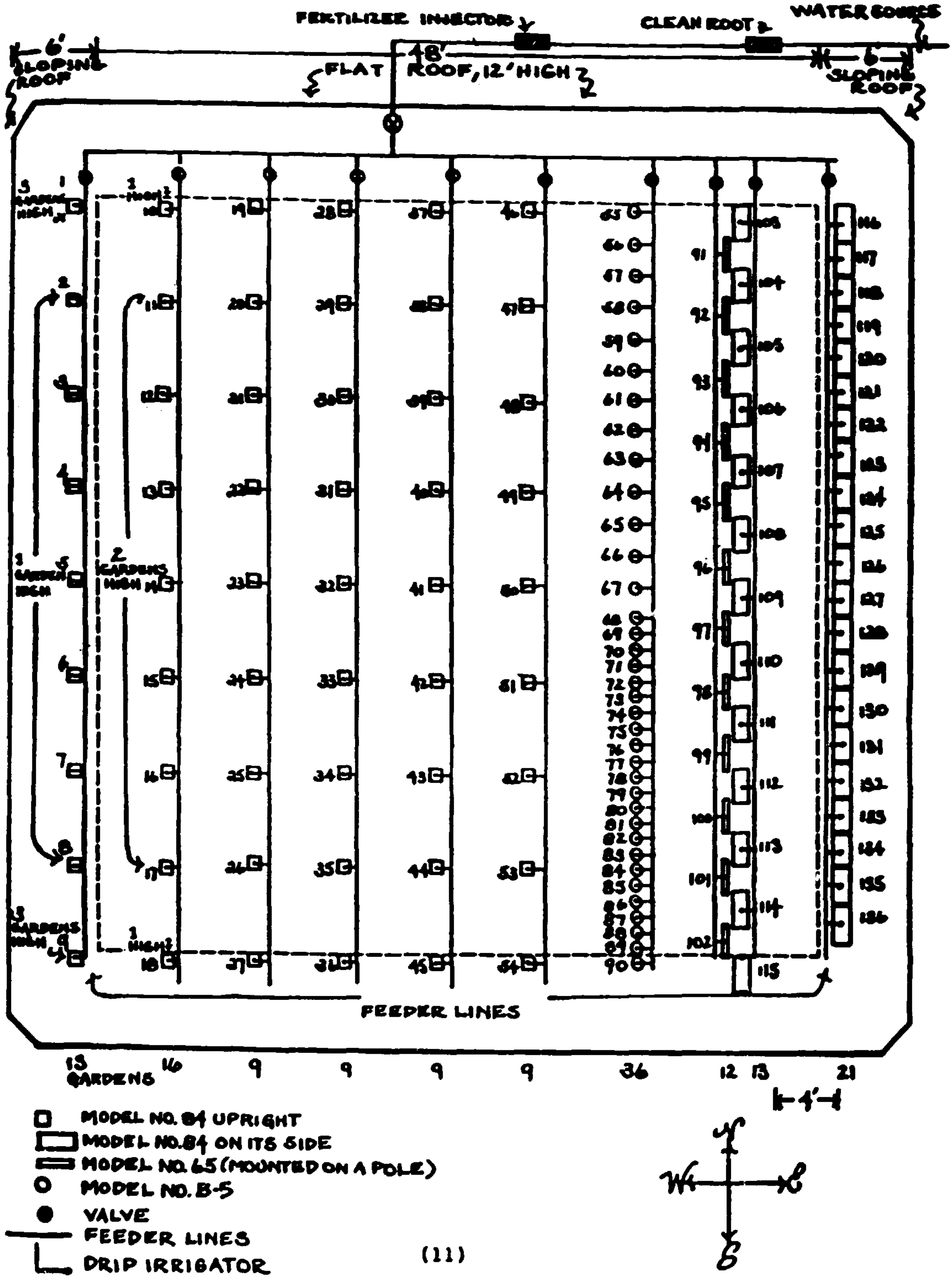
Material	SBX
Description	Biological regulator of the rhizospheric microbial population in saline soils
Physical Appearance	Buff colored slightly pink fermentation liquid
Specific Gravity	> 1.07g/ml (8.93lb/US gallon)
pH	3
Solubility	Completely miscible in water
Flammability	Non-flammable
Temperature Stability	268K to 322K (23°F to 120°F)
Storage Conditions	275K to 300K (35°F to 81°F)
Shelf Life	5 years in original container
Safety	This is a non-toxic fermentation material and does not represent a hazard to humans or plants. **However it is not intended for human or animal consumption.**
Compatibility	Only non-chlorinated water
Application rate	Soil 3785 - 5000 ml/ha (50 - 66 fl.oz/acre)

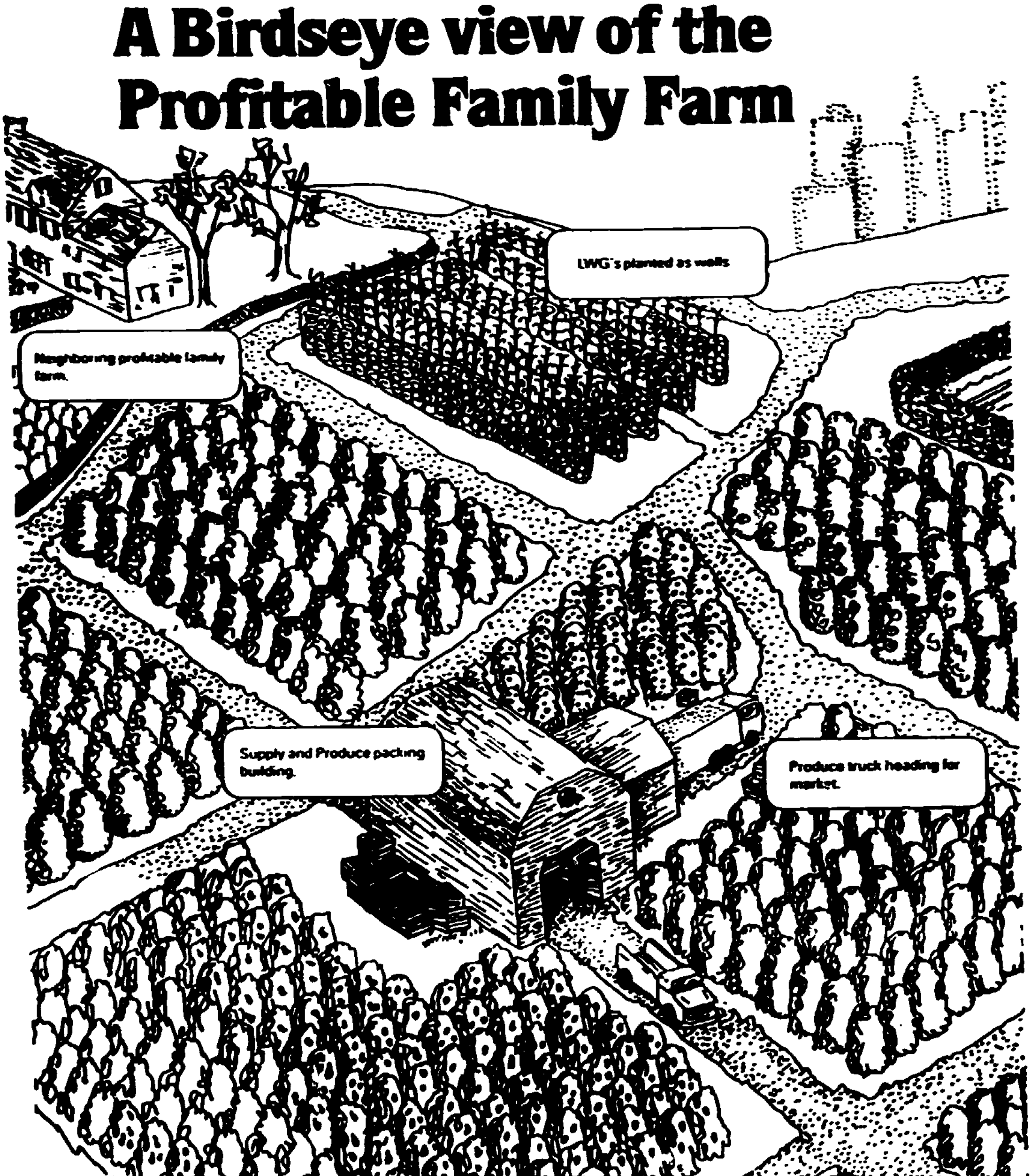
Typical Analysis:

1.Total Aerobic count	<2.0 x 10^9/ml
2.Total Anaerobic count	<2.0 x 10^5/ml
3.Total Yeast count	<100000/ml
4.Total Mould count	<100000/ml
5.Protein	2.00%
6.Crude Fat	0.04%
7.Crude Fibre	0.04%
8.Lactic Acid	6.00%
9.Total Solids	15.00%
10.Minerals	
N	0.5%
P	0.2
K	0.5
Ca	0.7
S	0.18
Mg	0.036
Fe	300.ppm
Mn	25.
Zn	25.
B	8.
Cu	2.

11.Fusel Oils
   Isoamylanol
12.Enzymes
   Hydrolase group, Desmolase group, Transferase group, Trypsin
13.Traces of Organic Acids
   Aspartic acid, Deoxycholic Acid, Cholic Acid, Malic Acid, Butylic Acid, Formic Acid, Gallic Acid
14.Traces of Vitamins
   Thiamine, Riboflavin, Biocytin, Choline, Cryptoxanthin, Ergocalciferol
15.Growth Factors
   Adenine, Tripeptid glutation, 3-adenylic Acid, Triacontanol, Gibberellins
16.Biocatalysts
   Bios I, Bios IIA, Bios IIB, Terregens

THE "STARTER MODULE" LAYOUT




A Birdseye view of the Profitable Family Farm
LWG's planted as walls
Neighboring profitable family farm.
Supply and Produce packing building.
Produce truck heading for market.

PART II

A.Introductory

As the title suggests, this partion of the paper aims to share some information on a specific innovative technology and its conceptual framework for large-scale food production.

Part I conserved itself with the approach of "regenerative agriculture". (1) In this Part II a modular growing-medium container system is being introduced, commercially available under LIVING-WALL-GARDENS TM (LWG). (2) LWG is one of several intensive food production systems needing no lang and no soil.

Its inventor and also current sole manufacturer, Mr.F.Wesley Moffett Jr and I visited Moscow and Leningrad during October 1989. We offered the LWG system as an intensive vegetable production technology to help alleviate within one year of its instalation substantially food shortages in urban areas.

We could point to its succesesses as a basic food supplier in the Carribean (especially in Puerto Rico, the Dominican Republic and Haiti, and St.Thomas, US Virgin Islands), in sertain Latin American countries (especially Ecuador), in the Middle East (especially Saudi Arabia, Jordan, Abu Dhabi and Oman), in Ethiopia, India, China and especially in Japan. In all cases the LWG were mainly acquired and installed, because they could produce cheaper, better and fresher food locally under adverse agricultural conditions.

The development of LWG began 13 years ago. Some instalations are 10 years old. Up til now, the marketing of LWG has hardly been commercialized. Instalations are custom-made pilot projects, because of the necessary adjustments to concrete environments and the ongoing research to overcome various problems.

I visited the headquarters office, the greenhouses there, the laboratories, displays and factory in preparation of this paper.

B. A brief report on the present tecnology and uses of LWG

LWG can be defined as the first three-dimensional food production system invented. Thus, it holds the promise of becoming a large source of basic vegetable production in the world, especially in developing countries and urban regions, basically inhospitable environments to conventional gardening and farming.

The LWG system depends on various sizen of containers made of polyethelene which is non-biodegradeable and of long-life sturdyness. It has lasted now over 13 years ever sinse its introduction into use. It is an item which can be recycled, (3) giving a resource for new containers.

They are filled with a patented inorganic and steril growing medium comprised of a mixture of silica in mainly two forms, i.e. mineneral wool and vermiculite with admixture of phenolic resin.

Historically, artificial growing mediums contain sphagnum moss which grows mainly in Norther zones and shipping costs to Southern lands adds to the exprense of the system. Silica exists on 98% of the earth's surfase. Eventually, LWG could and should be manufactured anywheres in the world. Certain types of silica rocks and combinations are preferable over others, but all can be made into mineral wool.

Vermiculite (i.e. expanded mica) is another form of silica generally available and currently used in horticulture.

Neither of these forms of silica will deteriorate. They are simply changed forms of rock. A word of caution, however. Mineral wool for insulation, sometimes called rock wool, is often made out of slag which is a by-product or residue of making steel in blast furnaces. This "rock wool" is not satisfactory as a growing medium. The best rock for agricultural and horticultural use so far iden tified is a certain basalt, a volcanic rock widely available.

Mineral wool generally has a high pH of about 8.5. Vermiculite is neutral. The desired pH would be between 6.2 and 6.5. Therefore, a third ingredient, expanded phenolic resin, is mixed in it has a pH of about 3 to 3.5. With the proper proportion mixed a resulting 6.3 pH can be obtained. The vermiculite, moreover, provides a cation axchange sponge.

As the mineral wool furnishes an ideal growing place for the root system to take hold in, it also has a high water retention capasity. Air and water are more readily and more evenly available due to the immense amount of surfase in proportion to the amount of substance than any type of soil under any cultivation form can supply. When expanded phenolic resin is available in addition, its helps absorb even more water. It becomes obvious, why even the best composted gardening soil is not used in the containers. It eventually packs itself down, leaving insufficient air spaces in the soil to allow the plant roots to beathe and flourish in the edaphon. Also, regular soil does not hold much water, thus necessitating frequent watering.

There are a number of imitaions of this growing medium on the market, especially in Great Britain and in the Netherlands. These are, however, not as perfected as LWG's.

The container system comes in several models, in order to facilitate modular assembly to meet land contours, urban environments and any other enveronment, including greenhouses, where LWG may be installed (4).

1. The Started Module

The system's versatility and practicability can best be illustrated by observing carefully the accomplishments of the socalled started module. It can be used in the open air, under shadehouses or in greenhouses.

An area of 5,000 square feet overall is needed. (5) The layout will accomodate growing of all vegetables, some fruits and herbs, experting potatoes, beets, carrots and other root crops which can be grown best in LWG Model 4-33. Root crops are not included in this layout. The mobile is land out so that simultaneously the following can be grown in several modes. There can also, of course, be a decision to specialize in one crop or to a number of crops such as:

Tomatoes	Lettuc	Cabbage	Egg Plant
Cucumbers	Herbs	Strawberries	Watermelon
Broccoli	Hot Peppers	Sweet Ppeppers	Flowers
Dill	Thyme	Rosemary	Chives
Majoram	Purple Basil	French Tarragon	Mint
Melons	Abergines	Okra	Spinach
Beans	Oregano	Squash	Peas

It is recommented to consider three aspects for a start. A different crop can be planted in each unit, in order to observe the productivity in a given latitude and climate. Secondly, the distanse between gardens varies with the latitude and season, in order to maximize available sunlight or to minimize it. Thirdly, a companion planting combination should be decided on for maximum productivity.

The typical started module equipment list contains the following:
Gardens: 102 Model 84
35 Model B5

12 Model 65
12 Model 65 ground posts
15 extra 30 lbs boxes growing medium
14 support posts (set of 4)

Irrigation accessories:
40 hose clamps
800 feet of feeder hose
200 irrigators
30 valves
26 ends
22 T's
10 Els
1 proportioner
1 clean root device
1 tank
4 couplers
15 screens

Other: 44 concrete reinforcing mesh to support tomatoes and cucumbers (400 sq.ft plastic cloth, if shadehouse is contemplated)
(1 10'6'' high shadehouse, 47'x 47' with sloping sides; 68'x 68' overall, equalling 4,624 sq.ft.)

The following full service installation of the starter module costs in the U.S. $50.000. This figure includes:
a) an on-site field survey by a qualified LWG technician, in order to determine a specific equipment listing and to trovide advice regarding terrain, water supply, climatic conditions, garden lavout, greenhouse application etc;
b) all the equipment listed above, including freight to the site;
c) the 'superspan' (of Australia) 50% white knitted Weathashade shadecloth, including custom engineering drawings, freight and installation by factory technician;
d) the tools, pesticides, seeds, seed starting supplies recuired to begin the operation;
e) a one-week installation trip by a qualified LWG technician to teach the client/customer how to lay out the units, hook up the irrigation equipment, plant the gardens etc;
f) a one-month training period by a qualified LWG technician to train personnel and to insure that the program gets off to a good start.

Obviously, there is flexibility in this offer by the Curious Research Corporation.

Naturally, it is very important to assess not only the costs, but above all the potential yeilds and profits. The folloving figures are provided by the experience of the St.Thomas (U.S. Virgin Islands) production facility and can not be taken as a firm universal statistic. These estimates seem to be on the conservative side.

Tomatoes are grown 2 plants to each model #84, lying horizontally in a continuous row with 5' high road mesh for support. Each plant produces about 20 lbs. of tomatoes, so each 50' run of 22 gardens (2 plants to a garden) produces some 880 lbs. per crop with 3 crops produced annually for a yearly total per row of approximately 2,640 lbs.

If tomatoes sold at $0.75/lb., annual income=$1,980/row.
If tomatoes sold at $1.00/lb., annual income=$2,640/row.
If tomatoes sold at $1.25/lb., annual income=$3,300/row.

If all 9 rows of the Starter Module grew tomatoes sold at $1.00/lb., gross income would be $23,760/year.

Cucumbers are grown 3 plants to each Model #84, lying horizontally in a row alternating on each side of 5'high road mesh for support. Each plant produces about 10 lbs. of cucumbers, so each 50'row of 22 gardens (3 plants to a garden) produces some 660 lbs. per crop with a minimum of 5 crops per year expected for a yearly total per row of approximately 3,300 lbs.

If cukes sold at $0.50/lb., annual income=$1,650/row.
If cukes sold at $0.75/lb., annual income=$2,475/row.
If cukes sold at $1.00/lb., annual inkome=$3,300/row.

If all 9 rows of the Starter Module grow cucumbers that sold at $0.75/lb., gross income would be $22,275/year.

Spinach is grown on Model #84's stacked vertically 2 hight on 5' centers (11 stacks per 50'row). Each stack of 2 gardens produces approximately 8 lbs. of spinach with the row therefore producing some 88 lbs. per month (the plant remains growing for about two years with montchly harvesting with shears). Annual yield per row can approximate 1,100 lbs. per row.

If spinach sold at $1.25/lb., annual income=$1,375/row.
If spinach sold at $1.50/lb., annual income=$1,650/row.
If spinach sold at $1.75/lb., annual income=$1,925/row.

If all 9 rows of the Starter Module grew spinach that sold at $1.50/lb., gross income would be $19,800/year.

Basil is grown with 9 plants on the top of each Model #84, lying horizontally with 18 LWG's per 50' row. Yield estimate is some 15 bunches per garden , per monthly harvest which totals 270/month or 3,240 bunches/year.

If basil sold at $0.75/ea., annual income=$2,430/row.
If basil sold at $1.00/ea., annual income=$3,240/row.
If basil sold at $1.25/ea., annual income=$4,050/row.

If all 9 rows of the Starter Module grew basil that sold at $1.00/bunch, gross income would be $29,160/year.

Any cash-flow analysis will have to take into account the climate, water conditions, sunshine, humidity, rainfall, temperatures, crop management, wages, local prevailing wholesale prices etc. If it is a greenhouse operations, the parameters applying to it, will be taken into account. However, the initial investment of $50,000 or less can be depreciated easily over a ten-year period, because the equipment will last at least that long. Based on the St. Thomas production, gross annual revenue of the starter module can reach easily the $20,000 to $30,000 range annually.

Other production installation sizes can be computed by headquarters of LWG. Suffice it to say that a full production installation frequently asked for is for 40,000 su.ft. (i.e. 3,710 sq. meters or 0.9182 acres). It applias to shadehouse, greenhouse or tunnel house application. Approximate yields are computed for:

tomatoes 168.000 lbs
cucumbers 30.000 lbs
spinach 21.000 lbs
herbs 76.000 lbs 3 oz. bundles

Different crops will require different spacing between rows, different spacings in the rows, different assortments of LWG models and a different number of gardens. Once a certain number has been acquired, they can be shifted around within the season or in the growing year to meet many eventualities and planting plans. Using the average wholessale prices of St.Thomas, the full production insttallation would cost $200.000 and would generate approximately $250.000 per year already the first year.

Several additional items need to be thought of, not provided by LWG:
packing supplies
scales
record books
instructions
supply building
security fencing
security guard house
securit" dogs
assorted spare parts
working capital
and the like

Finally, there are several additional considerations.

2. The Shadehouse

In some lokations a double use of a growing area may offer itself during each season. During the warmer months, the greenhouse may wish to use regenerated soil for root crops and other intensive cultivars. In that case, the LWG units can be set outside on any infertile piece of ground, be it parking spase, waste land and so forth. In that location a shadehouse may have advantages for a number of reasons:

birds, locusts, many insects, monkeys and other small animals are preveted from damaging crops.

Driving rains, monsoons and other weather impacts as hail and storms passing through the mesh are reduced to fine droplets and winds are reduced to mere breezes. Where it becomes very hot at certain times of the year, a white shadehouse reduces the temperature 10 to 20 degrees so plants will do very well. In too great a heat many cultivars become poor producers.

In sub-tropical and tropical areas, a reduction in the amounth of the sun's rays that strike a plant will markedly improve the plants growth and production.

White shadehouses are recomended for their 50% shade factor, dipending on latitude. The shadecloth should totally enclose the area, including the top and sides so that none of the pests mentioned above can enter.

One of the best designed shadehouse structures is produced in Australia and is called 'Super Span'. The unit panel sizes for shadehouses are 47 ft. x 47ft:. so shadehouses are made up of multiples these paneks. An economic size is a shadehouse of 3 panels x 3 panels, for a total of nine panels. Each shadehouse is somewhat larger, because sloping sides are added on all sides.

3. The Water Requirements

Water and the condition of the water are paramouth to the growth of any plant. The availability of good water is decreasing world-wide. It is becoming essential that water be used in the most efficient way possible. Fortunately, LWG use only 1/20 as much water per plant as is required in normal irrigation. Water loss: Because the growing medium and the roots of the plants are totally enclosed, unless the gardens are overwatered, nearly 100% of the water is used dy the plants. Evaporation takes place through the leaves, in the main. With the use of foliar sprays this transpiration can be controlled, as well as additional nutrients be given to the plants.

Salts: All water contains some salts. Where irrigation occurs over a period of time, the salts will build-up in the soil eventually so harmful that plants will no longer respond. This salts' build-up will also occur in LWG. But, because it is recomended to over-water the gardens for half an hour after each second or third crop, the accumulated salts are washed out and the growing medium is again pristine. LWG growing medium should thus last foreever. If the salts are washed out inside a greenhouse, they can be planned into the fertilizer program of the regenerated soil. Sensor equipment can monitor any fertilization program and minimize salts.

pH: The hydrogen ion concentration know as pH of the water to be used needs to be determined and adjusted so that when the fertilizer solution is in the growing medium, the pH is about 6.2 to 6.5.

4. The Clean Root System

A novel techolodgy in water conditioning for horticultural purposes is part of all commercial installations of LWG. It is know as the "clean root" device.

Like water pipes which become corroded over a period of time where in the chemical deposits on the inside of the water pipes gradually become thicker and thicker, until eventually very little water can pass through the pire, the same thing happens to the roots of all plants.

The roots, fairly quickly, become partially coated with the "hardness" in the water so that the plant cannot absorb as much food, air and water, as it otherwise would. This is one of the causes slowig plant growth and requiring the use of more and more fertilizer, as would otherwise be needed.

The simple "clean root" device is a short lenght of pipe which is placed into the water line ahead of the injection of fertilizers. The patented pipe contains a labyrinth of rare metals. The water must pass through the pipe at a minimum rate of seven and a half feed per second. This is sufficient to cause an electrolytic action, if the root device is well grounded. The device neither takes anuthing out of the water nor adds anything to it. It simply changes the ionic structure of the water and chemicals so no deposit can occur on the plant roots.

Under such conditions, the roots can much more readily absorb water and fertilizer. This aids faster growth and savings in fertilizer applications. For example, cucumbers that normally take 63 days from the planting of seeds until first production now require only 41 days and produce more pounds. Many places have brackish water which plants cannot toletare. The device prevents salts of brackish water to afect plants. The device comes in various appropriate diameters to fit all needs. It pays for itself in a couple of months, when used by greenhouse operators and any operations using irrigation water that passes through pipes.

5. Fertilization

LWG recommends and furnishes for general use with each unit a 20 nitrogen, 10 phosphorus, 20 potassium quick-dissolve slowrelease fertilizer. It will grow almost everything. For maximum yields of specific crops, however, specially tailored fertilizers are being recommended. In the case of tomatoes, for example, 4-18-38 is recomended with calcium nitrate and magnesium sulfate to be added to the mixture. All of these chemicals cannot be mixed together in dry form, because they will solidify into a block. Therefore, they must be separately dissolved in water and only then be mixed together. Technologies for mixing and regulating, even automating, fertilizer water exist on the market. The proportion of the above mixture should be varied according to the stage of life of the plant. Early in its life, the tomatoe plant will be stressed for nitrogen. This will cause it to set many blossoms early. It should then be supplied with all the nitrogen it needs.

The fertilization methods of LWG offer the greatest potential to innovative uses of biological fertilizers. Root conditions and plant requirements can be sensored quite accurately in each container, if so desired, or in a sampling of containers. The information can be computerized and the nutrient feeding program can be automated. Whatever the plant calls for at a certain moment, can be responded to. This possibility is a key to successful and minimal uses of chemical fertilizers, but it also, for the first time, makes biological fertilizers highly effective.

6. Disease and Pest Control

Plants grown away regenerated agricultural conditions will be subject to various specific diseases and pests. Therefore, commercial vegetable operations rely heavily on the following:

-information systems dealing with the problems of growing each of the different cultivars;

-supplies of chemicals and equipment on hard to fight exprected diseases and pests for the local area and greenhouses;

-entymologists, plant pathologists and agronomists nearby and quickly accessible.

For commersial and chemical tomatoe production, for example, the following chemicals are recommended by LWG:

Diazanone
Manzate and copper sulfate
Wettable sulfur
Vendex
Malathion
Vydate
Pydrin
Neem tree extract
Dipel

However, it is exactly in the LWG enviroment that biological pest controls become highly effective. Together with vaccuming (45) pest, insect and disease control become relatively easy, economical and highly successful. I suggest the convening of several workshops in different regions of the world, in order to design guidelines and a handbook for use by developing countries of this simple, inexpensive and highly efficient system for food production.

LWG research has succeeded in introducing specific trace elements required for human nutrition adjustments into the fertilizer. The growing medium facilitates that the plants ingest these spesial trace elements. The use of these trace elements on two-dimensional ground agriculture is very difficult to control. In LWG it can be more precise.

Every plant or seed inserted in a LWG container is instantly protected within its own individual 'spase', therby eleminating the invasion of weed seeds and negating the use of many and potentially harmful herbicides. The intensive possibility of 66 plants covering lees than one cubic foel helps crowd out undiesereable growth.

In a shadehouse on St.Thomas spinach was planted three years ago in No.84 LWG two high with 50 containers in a row. The plants are not only 3 years old, but are harvested every 3-4 weeks with hedge clippers, 4 to 5 lbs of spinach a unit, 500 lbs/month, without weeds having appeared in the lush foliage.

In Ecuador, an exported of exotic fruits has converted 5 hestares to weedless production, because of the intensive cultivation possibilities in LWG.

Open air, shadehouse or greenhouse cultivation with LWG help, parlially, to solve the problems which arouse consern among environmentalists and health authorities with the indiscriminate use of chemicals as fertilizers, herbicides and pesticides in food produktion.

C. Some of the Unique Advantages of LWG

Mr. Moffett asks rhetorical questions, in order to "sell" his product. They summarize most of the advantages.

If you do not have enoung good arable land;

If you have some water, but not enough to grow well all the produce you need;

If you do not have, or do not have the money for tractors, farm equipment and all the gas and oil you need;

If you operate irrigated land, but the salts build-up resulting from years of irrigating with water containing some salts has poisoned the soil so it is producing less and less;

If you do not have the money to buy all the fertilizer conventional, two-dimensional farming requires;

If you do not have enough good roads to transport perishable food requlariy on a timely basis to remote areas;

If your currently conventional, productive arable land is not close to the market and you do not have enough refrigerated trucks, and some produce spoils because you cannot get the produce to the needy at all, or soon enough;

If you do not have the infrastructure to preserve foods, resulting in much spoilage;

If your government has a fixed price of produce law to keep the city dwellers content, but so low it does not pay the farmers to produce;

If land reform is demanded, wherein large estates would be broken up into two to five acre plots for the peasants, to the end that the large estates can no longer produce for export and foreign exchange;

If much of your rural population is migrating to your cities, creating
If you believe your transportation system would cease to function in the
large, poor ghettos with sewer, water, food and civil problems;
event of nuclear or other war, or for any other reason to the end food could not be transported to all, and you feel it desireable to have each

family carable of producing all its food needs no matter where it lives;
If everyone in your country does not have an assured supply of enough to eat, and thus there is a chance of unrest and revolution;
If there is any starvation;
If the handwriting is on wall that your population growth rate is going to outstrip your country's abilitly to produce food;
If you need a method to produce food that even the illiterate can operate as prolifically and abundantly as the educated;
If it would be advantageous for much of your urban, suburban and farm populations to each family's food needs--in small spaces, without needing to be horticulture experts.
"If any or more of the above 'IFS' "he concludes, "apply to you or your country, then making LWG easly available to all your citizens may help solve all your country's food problems and reduce the chance of unrest." (6)

A comparison of calories for some culturals, meats, grains and fats supports the claims for LWG. In the twelfth edition of Food Values of Portions Commonly Used by Bowes and Church, it is shown that:

					Calories per pound	Number of pounds for 2000 calories
100gms	totatoes	contain	22	calories	100	20
100 "	cabbage	"	24	"	109	18.3
100 "	yams	"	101	"	459	4.35
100 "	lettuce	"	14-18	"	63-82	24-32
100 "	lima beans	"	123	"	559	3.58
100 "	green beans	"	32	"	145	13.8
100 "	broccoli	"	32	"	145	13.8
100 "	wax beans	"	27	"	122.7	16.3
100 "	sweet potato	"	141	"	640.9	3.12
100 "	pumpkin	"	26	"	118.2	16.9
100 "	taro	"	98	"	445.5	4.49
100 "	sum. squash	"	19	"	8[illegible]	23.15
100 "	win. squash	"	50	"	227.3	8.8
100 "	watermelon	"	26	"	118.2	16.9
100 "	cantalope	"	30	"	136.4	14.7
100 "	figs	"	80	"	363.6	5.5
100 "	strawberry	"	37	"	168	11.9
100 "	okra	"	36	"	163.6	12.22
Averade of the above						13.1
100gms	milk	contain	62	calories	281.8	7.097
100 "	br. sugar	"	370	"	1681	1.19
100 "	cooking	"	885	"	4022	0.497
100 "	wheat	"	342	"	1554	1.29
100 "	br. rice	"	360	"	1636	1.22
100 "	been	"	262	"	1190	1.68
100 "	chicker	"	151	"	686.4	2.91
100 "	fin fich	"	87-168	"	395.5-763.6	5.05-2.62
100 "	cheese	"	398	"	1809	1.1

The economies of scale would be equally persuasive. For tomatoes 100 gms contain 22 calories; 1000 gms contain 220 calories; 1000 (1 kilogram)=2.2 lbs.; 1 lbs=100 calories; 2000 (100 calories per pound)=20 lbs. Probably no one could or would want to consume 20 lbs of tomatoes every 24 hours. However, if the 20 lbs were boiled down into a tomatoe paste at 82 calories per 100 grams, then there would be 372.7 valories per lb and only 5.36 pounds of tomatoe paste would need to be consumed for 2000 calories per day. Varuing the intake with wegetables and roots and using the same calculations, we arrive at investment cost per person of $280 to produce 2000 calories per day per year. That is 76 cents per day to enable one person to self-produce his/her food needs:

On a large scale the following costs would accumulate:

	Starter Module	Professional Module	Production Unit	Full Instalation
1) Shadehouse Modules	1	4	9	36
2) Sq. ft. Size	5.000	25.000	40.000	160.000
3) Annual Yield in Pounds	25.000	125.000	250.000	1.000.000
4) Approximate C.I.F. Cost	$50.000	$150.000	$250.000	$ 900.000
5) Cost/Module	$50.000	$ 37.000	$ 27.000	$ 25.000
6) Original Cost Annual Yield	$ 2.000	$ 1.20	$ 1.00	$ 0.90
7) Amortized 10 yr. Cost Anual Yield	$ 0.20	$ 0.12	$ 0.10	$ 0.09
8) Anual Gross Income	$18.750	$ 93.000	$187.500	$ 750.000
9) Monthly Gross Income	$ 1.562	$ 7.812	$ 15.625	$ 62.500
Monthly Expenses				
10) Wages	$ 430 (1)	$ 860 (2)	$ 1.290 (3)	$ 4.300 (10)
11) Mgr. Salary	-0-	-0-	-0-	$ 1.000 (1)
12) Utilities	$ 150	$ 250	$ 500	$ 2.000
13) Truck/Driver	$ 300	$ 500	$ 750	$ 2.000
14) P & I	$ 833	$ 2.500	$ 4.166	$ 15.000
15) Land Rental	$ 500	$ 1.500	$ 3.000	$ 10.000

16) Misc.	$ 300	$ 1.000	$ 3.000	$ 10.000
Total/Month	$ 2.513	$ 6.610	$ 12.706	$ 44.000
Gross Income/Mo	$ 1.562	$ 7.812	$ 15.625	$ 62.500
Profit (Loss)/Mo	($ 951)	$ 1.202	$ 2.919	$ 18.200

The explanation of numbered rows is as follows:

1) number of shadehouse sections
2) resulting sq. ft. required
3) based on the average yields per month described above
4) estimated landed costs, including training
5) breaking total cost down by shadehouse module cost
6) relating first year cost to annual yield
7) amortizing those costs over 10 years to show only a 9 cents cost per pound for the original set-up in the full installation
8) taking an average Caribbean wholesale price of 75 cents/lb times the annual yield (St. Thomas averages $1.00; St.Kitts-75 cents and St.Lucia-50 cents)
9) dividing by 12 for monthly antisipated income
10) based on $100/week, 4.3 weeks/month
11) based on $12,000/yea
12) averages of supplied
13) averages of supplied
14) prinsiple and interesr assuming 100% of cost boorowed, year payback, 10% per annum interest (actually cost doubled, divided by 10 year cost, then 12 for monthly budget)
15) guess !
16) seeds, planst, pesticides, tools etc.

Very important for comparison with conventional and/or hudroponic greenhouse operations would seem the following estimated crop yields per row. (7)

Crop	Plants Per LWG	Yeld/ LWG/Mo x	LWG's** Per Row =	Yield Per Row x	Crops/ Year =	Yield Per Row Per Yr.	Anual $Value Per Row
Broccoli	19	19 lbs	22	418 lbs	3	1254 lbs	______
Pascal Celery	27	40 lbs	22	880 lbs	3	2640 lbs	______
Cucumbers*	3	30 lbs	22	660 lbs	5	3300 lbs	______
Christophines*	3	30 lbs	22	660 lbs	5	3300 lbs	__
Sweet Peppers	9	18 lbs	22	396 lbs	3	1188 lbs	_
Leaf Lettuce	20	12 lbs	22	264 lbs	12	3168 lbs	______
Tomatoes*	2	40 lbs	22	880 lbs	3	2640 lbs	______
Cabbage	10	27 lbs	22	594 lbs	2-1/2	1485 lbs	______

Spinach	36	4 lbs (4-12 oz bags)	22	88 lbs	12	1056 lbs	______
Thyme	9	10 bunches	18	180 bunches	12	2160 bunches	______
Basil	9	15 bunches	18	270 bunches	12	3240 bunches	______

* means, can grow spinach, parsley ets on the sides of the container
** means, model No 84 LWG per started module
All the above figures are for 50' rows. There are 9 rows in the starter module.

Finally, the following figures were supplied for amortized costs over 10 years vs annual cost/yield pound

	Starter Module	Professional Module	Production Unit	Full Installation
Sq. ft. size	5.000	25.000	40.000	160.000
Shadehouse Modules	1	4	9	36
Anual Yield in Pounds*	25.000	125.000	250.000	1.000.000
Approximate C.I.F. Cost (inc. training) in U.S. $	$50.000	$150.000	$250.000	$ 900.000
Original Cost Annual Poundage	$ 2.00	$ 1.20	$ 1.00	$ 0.90
Amortized 10 yr. Cost Annual Poundage	$ 0.20	$ 0.12	$ 0.10	$ 0.09

* means, conservative estimate. Yields will vary by location and management.

Each Module cost in US $	50.000	37.000	27.000	25.000

Among additional advantages can be listed the improvement in working style to largely upright posture. This is very important for the women work force in horticulture.

There is very little pollution coused, if any.

Greenhouse cultivation witn LWG lends itself perfectly to a controlled environment, and owing a number of innovations to a controlled enironment, allow-ing a number of innovations to become highly effective. Companion planting isone of them. Use of beneficial insects is another. Utilization of fungi as a key source of safe chemicals and other biotechnology approaches are additional benefits.

My company is working on various non-chemical fertilizers and foliar feeding sprays of great promise. The likelihood that LWG used in greenhouses could yet in this century supply a 100% clean technology is highly probable.

In this connection it is interesting to note that in the Bukini Atol LWG supply some food, otherwise contaminated, when grown in soil. The potential of this for areas and populations affected by the Chernobyl disaster has not yet been studied. Planily, the disruption of wars, revolutions, nuclear disasters, disruption of oil supplies and various urban supply crisis moves LWG tehnology into center stage.

The enorm-ous potential of "sonic bloom", of enzyme application and halophytic agriculture could only need to be touched upon. For example, Dr.Gernon Graeffe (8) has contributed to greenhouse horticulture the cracking of grape seed as a resource of bio-vin, carbon and nutrients.

In the last analysis, it will be the further development of these innovations and concomitant clean technologies which will bing LWG into regenerative agriculture. Othwerwise it will remain another example of conventional agriculture with all its besetting problems. (9) This outlook worth discussing.

WHAT YOU GET

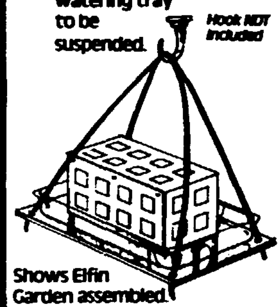
Living Wall™ Garden Co. Product Catalog

This catalog shows the various models and accessories available from the Living Wall™ Garden Company. The items are numbered to correspond with both the retail and wholesale price lists. All Living Wall™ Gardens are "ready to take me home and plant me," complete with the special Living Wall™ Garden growing medium and fertilizer. All you supply are seeds or plants, water, sunshine and love.

① Elfin Garden

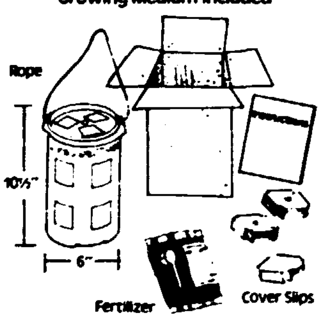
② Hanger Platform

Allows Elfin Garden and watering tray to be suspended.

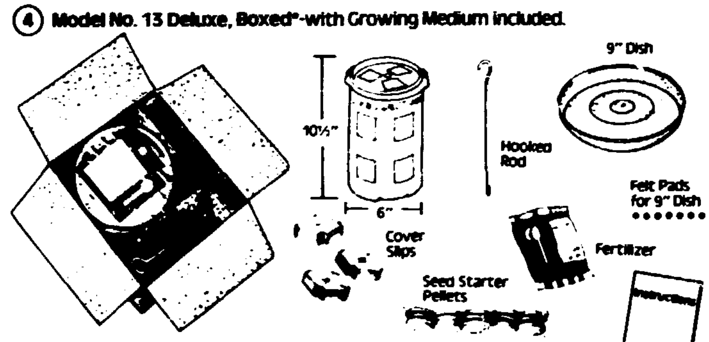


Shows Elfin Garden assembled.
(NOT included with Hanger Platform)

③ Model No. 13, Boxed-with Growing Medium included

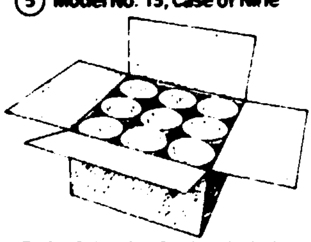


④ Model No. 13 Deluxe, Boxed*-with Growing Medium included.



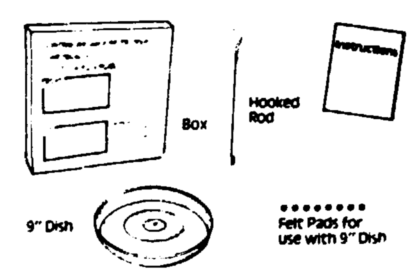
*Carton has slot, so that Dealer can insert seeds.

⑤ Model No. 13, Case of Nine

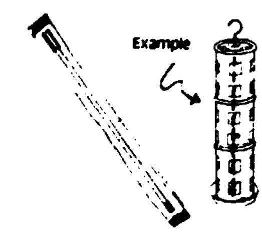


Each of the nine Gardens includes Instructions, Fertilizer, Cover Slips and Rope for hanging. Growing Medium is included.

⑥ Model No. 13 Accessory Package
(for use with item No. 3)

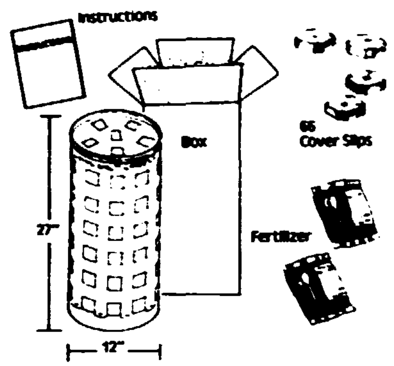


⑦ Model No. 13 Deluxe Rod Extension

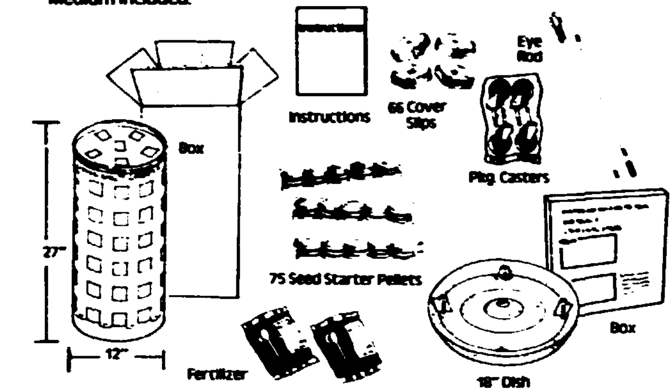


One needed for each Garden stacked on the first.

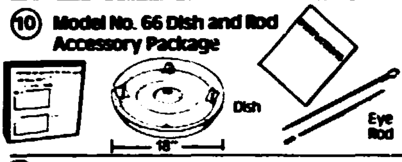
(8) Model No. 66, Boxed Growing Medium Included



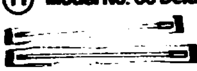
(9) Model No. 66 Deluxe, Boxed—with Growing Medium Included.



(10) Model No. 66 Dish and Rod Accessory Package

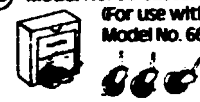


(11) Model No. 66 Deluxe Rod Extensions (For stacking one Model No. 66 Deluxe and one Model No. 66)



(12) Model No. 66 Replacement Eye and Extension Rod (For use with dish)

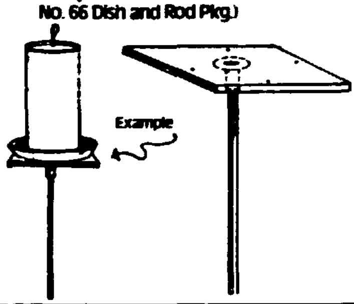
(13) Model No. 66 Casters (For use with Model No. 66 dish)



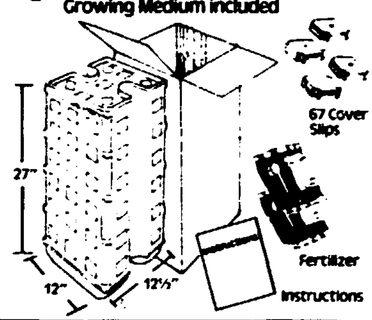
(14) Model No. 66 Support Brackets (For stacking two Model No. 66 Gardens)

(15) Model No. 66 Stabilizer Bars

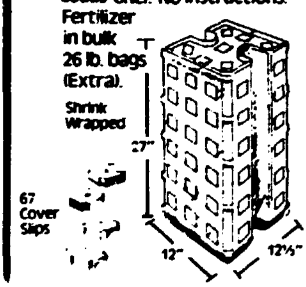
(16) Model No. 66 Raised Platform and pole (For use with Model No. 66 Dish and Rod Pkg.)



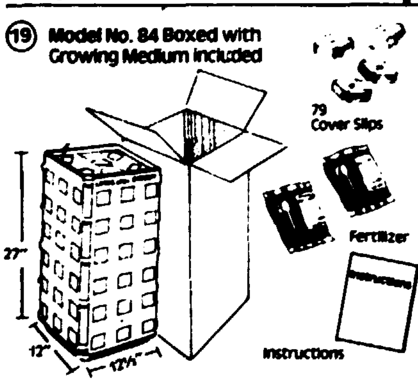
(17) Model No. 72 Boxed with Growing Medium included



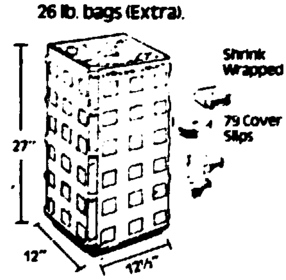
(18) Model No. 72 with Growing Medium sold in Full Container Loads ONLY. No instructions. Fertilizer in bulk 26 lb. bags (Extra).



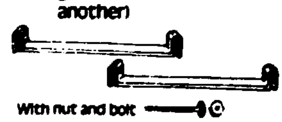
(19) Model No. 84 Boxed with Growing Medium included



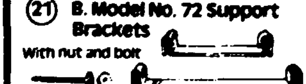
(20) Model No. 84, with Growing Medium, Sold in F Container Loads ONLY. No instructions. Fertilizer in bu 26 lb. bags (Extra).



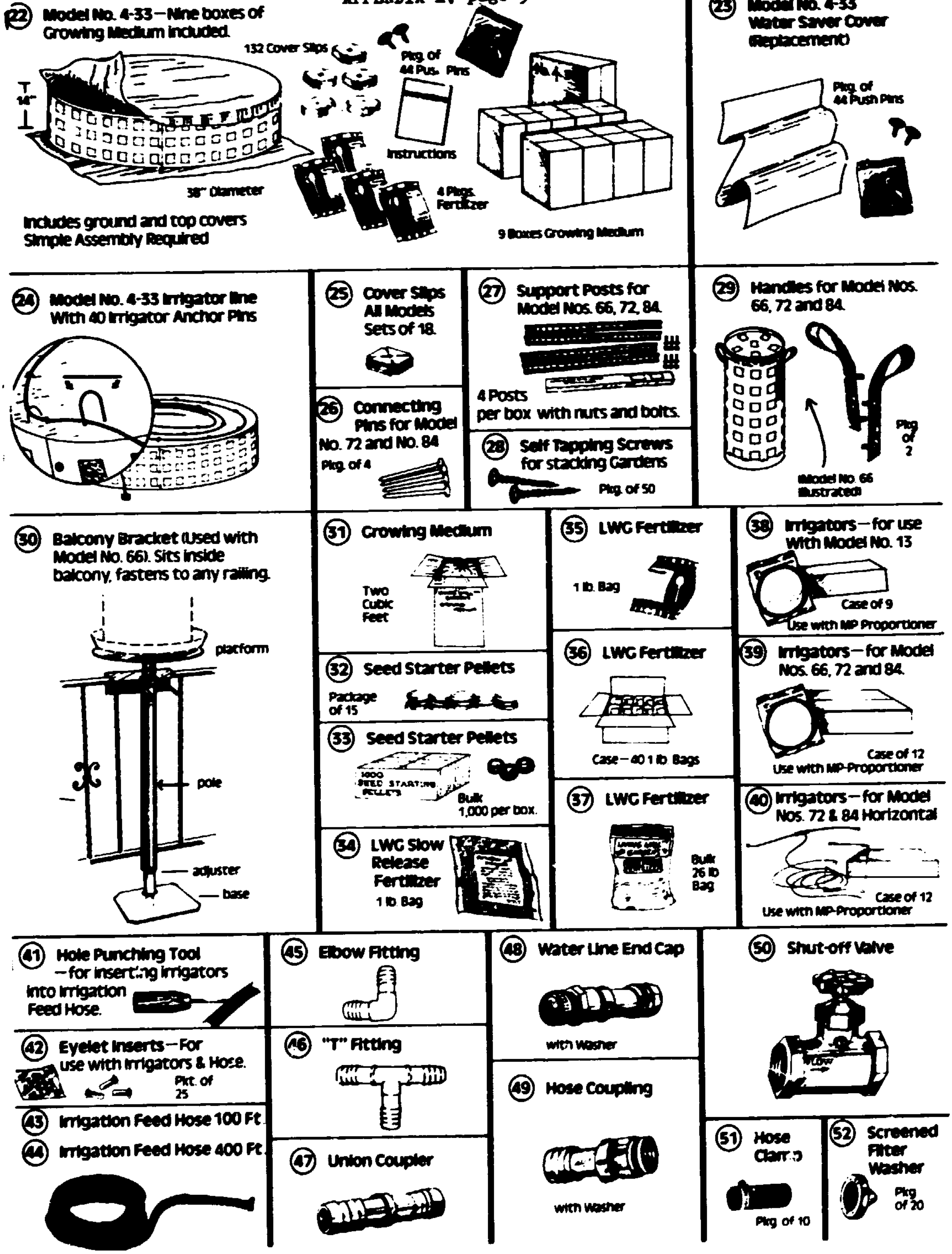
(21) A. Model No. 84 Support Brackets (For stacking two Model 84 Gardens. One set needed for each garden stacked on another)



(21) B. Model No. 72 Support Brackets



For use with Support Posts.

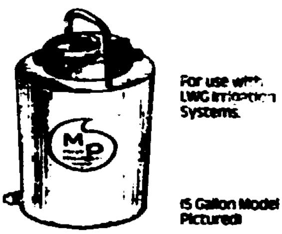

22 Model No. 4-33—Nine boxes of Growing Medium included.
14"
132 Cover Slips
Pkg. of 44 Push Pins
Instructions
38" Diameter
4 Pkgs. Fertilizer
Includes ground and top covers
Simple Assembly Required
9 Boxes Growing Medium
23 Model No. 4-33 Water Saver Cover (Replacement)
Pkg. of 44 Push Pins
24 Model No. 4-33 Irrigator line With 40 Irrigator Anchor Pins
25 Cover Slips All Models Sets of 18.
26 Connecting Pins for Model No. 72 and No. 84
Pkg. of 4
27 Support Posts for Model Nos. 66, 72, 84.
4 Posts per box with nuts and bolts.
28 Self Tapping Screws for stacking Gardens
Pkg. of 50
29 Handles for Model Nos. 66, 72 and 84.
Pkg of 2
(Model No. 66 Illustrated)
30 Balcony Bracket (Used with Model No. 66). Sits inside balcony, fastens to any railing.
platform
pole
adjuster
base
31 Growing Medium
Two Cubic Feet
32 Seed Starter Pellets
Package of 15
33 Seed Starter Pellets
Bulk 1,000 per box.
34 LWG Slow Release Fertilizer
1 lb Bag
35 LWG Fertilizer
1 lb. Bag
36 LWG Fertilizer
Case—40 1 lb. Bags
37 LWG Fertilizer
Bulk 26 lb Bag
38 Irrigators—for use With Model No. 13
Case of 9
Use with MP Proportioner
39 Irrigators—for Model Nos. 66, 72 and 84.
Case of 12
Use with MP-Proportioner
40 Irrigators—for Model Nos. 72 & 84 Horizontal
Case of 12
Use with MP-Proportioner
41 Hole Punching Tool —for inserting irrigators into Irrigation Feed Hose.
42 Eyelet Inserts—For use with Irrigators & Hose.
Pkt. of 25
43 Irrigation Feed Hose 100 Ft.
44 Irrigation Feed Hose 400 Ft.
45 Elbow Fitting
46 "T" Fitting
47 Union Coupler
48 Water Line End Cap
with Washer
49 Hose Coupling
with Washer
50 Shut-off Valve
51 Hose Clamp
Pkg. of 10
52 Screened Filter Washer
Pkg of 20

(53) MP Proportioner—1 Gallon

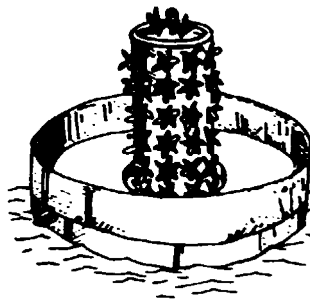
(54) MP Proportioner—2 Gallon

(55) MP Proportioner—5 Gallon

(56) MP Proportioner—15 Gallon

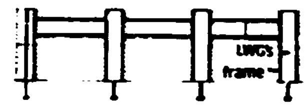


(57) Plans *(only)* for Model No. 66 Floating Garden.



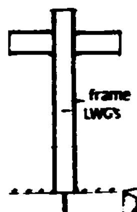
(58) Floating Garden Growing Medium

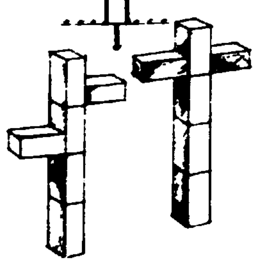
(59) Garden Fence, Frame *(only)*



(60) Garden Fence Complete—with Frame, 57 Model No. 72s, Irrigation System, Instructions

(61) Cross/Totem, Frame *(only)*

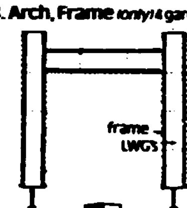


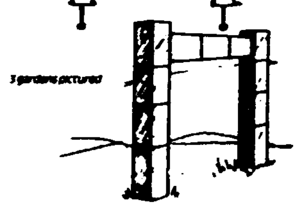


(62) Cross/Totem Complete—with Frame, 6 Model No. 72s, Irrigators, Instructions

(63) A. Arch, Frame *(only) 3 gardens wide*

(63) B. Arch, Frame *(only) 4 gardens wide*

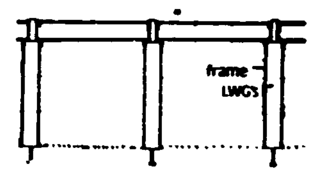


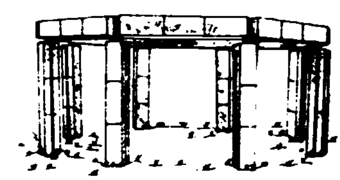


(64) A. Arch Complete - with Frame, 11 Model No. 72S, Irrigators, Instructions

(64) B. Arch Complete - with Frame, 12 Model No. 72S, Irrigators, Instructions

(65) Gazebo, Frame *(only)*





(66) Gazebo Complete—with Frame, 48 Model No. 72s Irrigation System and Instructions.

67. Slide Shows and Video Tapes
68. Landscape Design Service
69. Commercial Farm Plans
70. Water Analysis

LIVING WALL GARDEN CO. BROCHURES

71. It's Easy to Grow Me
72. Wow-Power
73. Community Garden
74. Handicapped
75. Worth of LWG
76. Why LWG?
77. Hunger Can Now Be...
78. Food Availability
79. Past Ways of Thinking
80. Seed & Bedding Bulletin
81. 28-page color book
82. How LWGs function
83. How to Plant, Water...
84. Factory Farming
85. Family Farm
86. Reducing Birthrate
87. 3rd World Food
88. What You Get/Catalog

LIVING WALL GARDEN CO. STRUCTURES

A. Parts Information—Illustration
B. Irrigation Instructions
C. Construction Instructions
89. Arch
90. Pyramid
91. Cross or Totem
92. Gazebo
93. Herb Garden Fence
94. 30 Foot Tower
95. Rose Garden Wall
96. Floral Display Wall
97. Giant Buttress Wall
98. Trellised Gazebo
99. Arbored Walkway
100. Reflecting Pool Wall
101. Floating Gardens
102. Hanging Gardens
103. Vertical Farm
104. Living Room—Square
105. Living Room—Curved
106. Trellised Arbor
107. Garden Stack
108. Shrub Toppers

Living Wall Garden Co.
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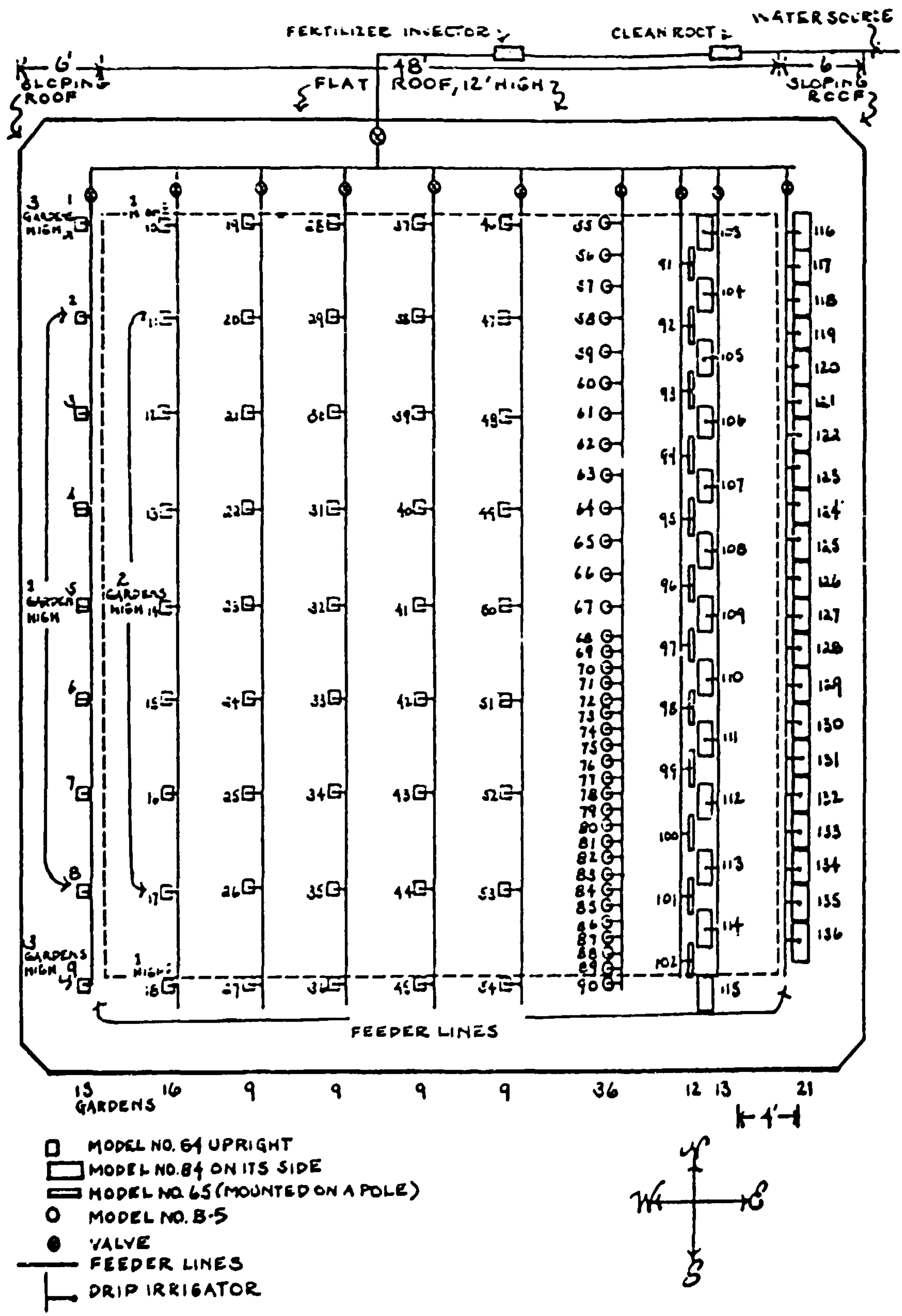
(716) 247-0070 • FAX (716) 247-1033
TELEX 978243 Living Wall Roc

THE "STARTER MODULE" LAYOUT



HOW DO LIVING WALL™ GARDENS FUNCTION?

With reference to how the Living Wall™ Gardens furnish water and fertilizer to the plants:

GROWING MEDIUM

The growing medium contains no nutrients.
The growing medium holds more water than most other growing mediums — but at the same time it provides optimum amounts of air to the roots of the plants.

FERTILIZING

Living Wall™ Garden fertilizer is specially designed to work synergistically with the growing medium. In other words, they are each designed to work with the other.

The instructions direct that the instantly soluble Living Wall™ Garden fertilizer be dissolved in the water in the proportion of one teaspoon of fertilzer per gallon of water. The teaspoon is furnished.

The fertilzer-water solution is applied at the top of each garden. Either it is poured on the top or it is dispersed through a drip irrigator emplaced on the top of the garden. Every seventh time of watering, plain water without fertilzer is used.

INJECTORS

Where more than four gardens are used in a single installation and where water in hoses with adequate pressure is available, a fertilzer injector can be employed. This permits large installations to be water-fertilized simply by turning on a valve.

WHEN TO WATER

How often to water varies over the life of the plants. It depends on the amount of foliage the plants have developed and the temperature of the season. The more leaves, the more water transpiration. The higher the temperature, the more the leaves grow and transpire.

About 2½ to 3 gallons of water per day are required for each garden in hot weather for Models 66, 72 and 84 when plants are full grown.

When to water is determined by sticking one's finger into planting holes at the top, middle and bottom of a garden. If the holes are not very moist, the garden needs water-fertilizer. Moisture meters work; however, nothing works better than a finger.

Whether the gardens are used singly or stacked into towers, the same watering procedure is followed. When operated as a tower, the procedure is the same as with one garden. Holes in the bottom of each garden permit the moisture to pass from a higher to a lower garden.

The hotter it is, the faster the plants grow. If the operator provides enough water, the plants automatically have the right amount of fertilizer.

Because the loss and use of water occurs essentially just through the leaves, there is no wastage of water unless the operator over waters. In this case the water runs out the bottom. It is impossible to over water because the growing medium will hold only the optimum amount of water. Because of this conservation of water, the Living Wall™ Gardens use only about 1/20 the amount of water per plant as is provided in normal desert irrigation.

SAVING FERTILIZER

In order for conventional farmers to be sure their plants get enough fertilizer, they customarily apply about seven times as much as their plants will use. This is so the roots can find the fertilizer they need. The rest washes away and is wasted. Thus, it is easy to understand why Living Wall™ Gardens do not waste fertilizer because they use only 1/7 the amount of conventional gardens.

SALTS — NEVER A PROBLEM

Wherever irrigation is performed, there is a salts build up which eventually will poison the soil, so not much will grow. Living Wall™ Gardens solve this problem very neatly. After every couple of crops, it is suggested the gardens be overwatered with plain water for ½ hour. This washes out all the accumulated salts and the growing medium is pristine again.

MANUFACTURING GROWING MEDIUM

The growing medium has a cation exchange capability built in. The growing medium is largely silica and should last forever, if it is not wasted. Silica exists on 95% of the earth's surface. Thus, when an adequate market is proven in any country, the gardens can be produced there or in a nearby country. Living Wall™ Garden Company is willing to discuss the manufacturing opportunities wherever and whenever it appears appropriate.

FOOD PRODUCTION

Because Living Wall™ Gardens are three-dimensional as compared with conventional two-dimensional farming, Living Wall™ Gardens can produce an average of 10 times as many plants per hectare as two-dimensional farm gardening.

ARABLE LAND NOT REQUIRED

Living Wall™ Gardens do not require arable land, so they will grow on deserts, rocky mountains, roof tops, paved areas, etc.

NO EROSION

Living Wall™ Gardens prevent erosion because there is no plowing or cultivating. Living Wall™ Gardens act as wind breakers — like snow fences — to prevent soil blowing away.

ILLITERATE CAN OPERATE

Because Living Wall™ Gardens are fool-proof and so simple to operate, they require no technical expertise. The illiterate can be taught quickly to be expert, very productive gardeners when using Living Wall™ Gardens.

HANDICAPPED AND AGING

Third World peoples have large families so their children can take care of them and feed them in there old age when they can no longer bend or stoop. Living Wall™ Gardens are ideal for the infirm, aged and handicapped because they can be operated without stooping — and of course no plowing or cultivating.

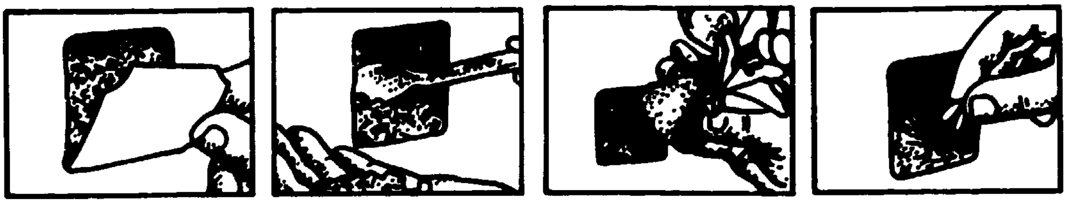
AS BUILDING BLOCKS

Each Model Living Wall™ Garden can be used by itself. In addition, each is a building block which can be stacked and attached to others to form towers for maximum production per square foot of ground space.
Living Wall™ Gardens can be hung or used as building blocks to form living arches, gazebos, long walls, fences, crosses, etc. Constructed as a wall against a house, Living Wall™ Gardens not only insulate the house against heat and cold, but also enable the resident to grow his/her food and flowers off the side of the house.

ACCESSORIES

A wide range of Living Wall™ Garden accessories are available, such as casters, irrigators, fertilzer injectors, frame works for building arches, gazebos, towers, etc., cages for climbing vine crops, etc., floats to allow your Living Wall™ Gardens to grow on lakes and ponds and be self-watering.

These are the planting instructions.



1. Snap off cover slip 2. Dig out growing medium 3. Insert plants 4. ...or seeds

For further information, please contact:

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CONTENTS

ADVANCED GREENHOUSE TECHNOLOGIES FOR INDUSTRIAL CROP PRODUCTION IN CLOSED SYSTEMS

Christian von Zabeltitz *

Introduction

The aim of the paper is to give some information on the latest status of technologies for clean crop production in greenhouses. Greenhouses are buildings which provide the necessary conditions for plant growth throughout the year. Greenhouses should be designed with more regard to general demands and climatic conditions in different regions and less in accordance with national traditions in the countries.

For an economical and ecological clean crop production greenhouses have to be designed and to be built for the following main criteria;

1. the economic market and price conditions of the crops for inland and export markets,
2. the demands for the different climatic regions in the world,
3. the materials for construction and production systems, which are available and low-priced in the country.
4. general design criteria.

Greenhouse types have been developed for the following different climates;

- grouses for temperate and cold climates,
- grouses for subtropical climates and highlands,
- grouses for tropical climates,
- grouses for dry and arid climates.

Grinhouses can also be classified according to the following characteristics:

1. plastic-film greenhouses with less technical equipments,
2. greenhouses with rigid covering materials and with technological systems for automatic climate control, irrigation and fertilization and with technical systems for crop handling and transport,
3. special closed system greenhouses for arid zones.
4. growing rooms and growth chambers with solely artifical lighting.

According to the country or climatic region greenhouses are dominating with glass or rigid plastic covering or, on the other hand, plastic film covering. The glass greenhouses are mainly built in Central and Northern Europe whereas most of the green- houses in warmer climates, Japan and the United States are covered with plastic film. Globally seen there are more plastic film greenhouses than glass greenhouses.

The control of the different climatic factors inside the greenhouse, the light, temperatures, humidity, CO_2- concentration and the control of irrigation and fertilization are very different in the different types of greenhouses. The method for environmental control are not described in this paper. Appropriate meaeures can be taken from the corresponding literature (1-6).

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2. General design criteria.

The purpose of a good greenhouse construction is to create the necessary climatic conditions for plant production for most time of the year and to control the climate factors as far as possible to the optimal setpoints by technical means. The growth factors light, temperature, humidity and air composition shall be delivered and maintained at the best possible amount.

As the daylight being the visible part of the global radiation is one of the essential growth factors in the greenhouse the greenhouses have to be planned and built with a light-transmis-sive covering so that especially in seasons with low sun posi tion enough light gets into the house. On the other hand some greenhouses containing special cultures need shading at high irradiation.

When the outside temperature falls below the desired inside temperature greenhouses have to be heated. The heat loss through the covering material has to be as low as possible. This means a demand for a maximum light incidence at a minimum heat requirement during the cold season.

When the outside temperature exceeds the desired inside temperature the surplus heat has to be dissipated by ventilation or, in case of a very high outside temperature, by cooling. In order to maintain the climate factors the demand is to adjust them to the setpoints as far as possible.

Temperate climate.

The main problems for crop production in greenhouses in the temperature climate are:

- Iperate climate ure in winter,
- wind and snow,
- little light in winter,
- occasionally hot summers.

Greenhouses for temperate climates should have the following characteristics:

1. sufficient stability against wind and snow loads under consideration of national etandards,
2. efficient heating system for winter,
3. high light transmiseivity,
4. efficient insulation against heat losses at low temperatures,
5. sufficient ventilation and shading in summer.

Subtropical climate.

The main problems for plant production in greenhouses in the subtropical (Mediterranean) regions are;

- low temperatures below biological optimum in winter nights, necessity of heating for one to three months,
- high temperatures during the day, even in spring,
- high humidity at night,
- wind,
- waster quality and water shortage,
- CO deficiency in closed greenhouses during the day.

Greenhouses for Mediterranean climates should have the following characteristics;

1. high light transmisieivity of construction and covering material at low

heat losses even in unheated greenhouses.
2. heating equipment to increase the temperature during the night.
3. highly efficient ventilation.
4. high stability to wind.
5. Greenhouses with gutters are recommended to collect rain water for irrigation.

Dry climate

In dry arid zones the following conditions have to be regarded futhermore:

- extrmely high temperatures during the day.
- heavy winds with dust and sand.
- low outside humidity.
- cold nights.
- Brackish or salt water is frequently available which has to be desalinated.

Greenhouses should have the following characteristics:

1. effective ventilation.
2. sufficient tightnese to sand, dust and losses of moisture.
3. wind-proof construction.
4. if necessary evaporative cooling.
5. avoiding of heat losses at night.
6. simple but efficient solar desalination systems.

Special closed system greenhouses have been developed for desert regions which are subject to the following demands:

1. water-saving operation and sufficient humidity level (closed atmosphere).
2. tightness to dust and sand.
3. solar water desalination.
4. low water and energy requirement for cooling.

Tropical regions

In some tropical region plant production in greenhouses is possible and advantageous. The production can take placeis throughout the year. Production in the open field, however, is affected by heavy rainfalls and wind.

The climatic conditions in humid tropical climates are;

- high monthly precipitation quantities and high average humidity throughout the year or during the rainy season.
- only little variation of temperature and solar radiation in the course of the year. During dry periods slightly higher temperatures.
- throughout the year day and night temperature are above the biological minimum for plant production.
- Irradiation can be too high.

The main demands for greenhouees and shelters in tropical regions are;

1. protection from extremely strong rainfall, high irradiation and wind.
2. high ventilation efficiency. Ventilators must not be closed. Constructions with open side-wall, gable and ridge ventilators.
3. durability of plastic film one year at least.
4. rain water collection for irrigation in dry seasons.
5. If necessary ventilation openings have to be equipped with disease-nets.

3. Greenhouse structures

3.1 Plasti film greenhouses

In many countries, especially in those with a warmed climate, much more plastic film greenhouses than glass greenhouses are used for cultivation. Most time plastic film greenhouses are, cheaper than those covered with glass. Plants can be cultivated well if the construction of the house comes up to certain conditions.

Several of the existing greenhouses have disadvantages. One should pay special attention to the following items:

1. working effort for assembly and exchange of the film.
2. reduction of film stability by global radiation and friction against construction parts.
3. fluttering of the film against the construction, sensitivity to storm.
4. falling of drops, due to condensation on the inner film surface.
5. inadequate ventilation in multi-span greenhouses with the result of poorer quality.

The following design criteria can be defined for plastic film greenhouee constructions;

1. avoidance of film destruction on the structure by flapping in the wind. Films must be stretched tightly by means of simple stretch devices.
2. simple methods to change the film which require little work.
3. insulation of those parts of the structure which are heated up by solar radiation and in contact with the film (mainly iron structures)
4. effective ventilation. The relation of ventilator opening area to greenhouse floor area should be 18 to 25%. Closeable ventilators are necessary.
5. minimizing heat losses even in unheated greenhouses by reducing the heat transfer through the covering material and by redusing the uncontrolled air exchange though leakages. That means cladding material opaque to long wave radiation and tight construction. It is better to ventilate the green- house if a temperature inversion occurs. Cheap thermal screens are recommendable.
6. avoidance of water condensation in drop-form on the inner surface of the covering material which causes a reduction of light transmission and drop-fall from the roof. Choice of sufficient roof slope, film treatment or anti-dew film.
7. greenhouse volume as large as possible.
8. greenhouses with gut'ers are recommended for collecting rain water for irrigation.
9. vertical side-walls to allow production of high crops near the walls as well as for utilization of machinery for cultivation.
10. sufficient wind resistance.
11. installations for increasing the temperature at night-time. Cheap fossil fuel heating systems, simple solar equipments or geothermal energy heating.

Structures or subtropical regions

A lagre number of plastic-film greenhouses have been developed world-wide. They range from simple constructions made of wood, covered with nailed-on plastic-film, to round arched tunnels and to superior conetructions.

A simple form of plastic-film greenhouse is the round arched tunnel greenhouse. This type can only be build single-span. Fig. 3.-1 shows a typical 8 m wide tunnel greenhouse. The film is 7 m wide. Openings are provided on each side at intervals of 7 m by parting the overlapping film sheets. The normal length of tunnel greenhouses is 40 to 60 a. In this case the ventilation efficiency is unsufficient.

In some cases the openings for ventilation are obtained by separating the overlapping film sheets on the whole round arched surface, Fig. 3.-2. The ventilation efficiency is better in this case but always sufficient. Recently developed round arched greenhouses have a rolling-up system for the ventilation openings at the side-wall, Fig. 3.-3.

The round arched tunnel greenhouses presently used in subtropical regions have the following disadvantages;

- The ventilation is not sufficient if only overlapping plastic films are "opened".
- When tall plants are grown (tomatoes, cucumbers) the arched design of the wall causes about 1 m of ground to be left unoccupied between the side-walls and the first row.
- The plants near the side-wall ventilation and gable grow less than those in the middle of the tunnels. This phenomenon is caused by low inside temperatures during cold nights, by low air humidity near the vents and the gables and by a wind effect.
- The greenhouse volume is small.
- The net greenhouse floor area fit for plant cultivation is small compared to the ground area occupied by the tunnels. The space left between two tunnels can be 2 to 3 m.

Multi-span greenhouses have advantages:

- The greenhouse volume is larger and the climatic conditions are better.
- The ventilation with side-wall ventilators can prove sufficiently efficient if the whole structure has a width of 16 to 22 m.
- The crop density is higher and the border effect is less important. Vertical side-walls avoid losses of space along the walls and allow machines to work inside the greenhouse.
- The usable greenhouee area per ground area is higher.

The width of individual spans in multi-span greenhouses is limited by the width of plastic-film available locally, if the film is stretched longitudinally.

Different tures of saddle-roof constructions with plastic-film coverings are built in the subtropical regions, Fig. 3.-4. Aim closeable rolling-up ventilation is situated at the side-wall and perhaps even at the gables. The stanchions are made of wood, steel or concrete; the roof construction is made of wood. The plastic-film is nailed on with lath wood which is unsatisfactory for the change of the films and their durability.

Steel tube constructions in round and pointed arch shape are built in many countries, Fig. 3.-5. Pointed arched or gothic arched greenhouse constructions have advantages over round arched constructions because condensation water can flow off better at the inner side of the film.

The constructions often have gutters to collect rain water and also for fastening the film. The film is fixed and stretched by rolling it on a pipe in the gutter.

The greenhouse shown in Fig. 3.-6 has sloped guy wires to stabilize the construction. The film is rolled up on the sloped rode for ventilation purposes. The ventilation opening is enlarged. Greenhouse constructions with ridge ventilation can also be equipped with rollable ventilations that can be closed over night, Fig. 3.-7. This construction is a little bit more expensive.

Another simple plastic-film greenhouse construction has been developed in Hannover suitable for subtropical climates. This construction is shown in Fig. 3.-8. It consists of two independent parts, the load bearing basis construction and the roof construction.

The basis construction is a guy-rope construction similar to a tent with sloped wire ropes or steel rode (a) connecting the gutter or upper end of the posts, respectively, with the foundation. Within the spane, the stanchions are connected crosswise at the upper ends by steel rods or wire ropes (b) Longitudinally, the stanchions are connected by gutters.

The stanchions only absorb pressure forces, the other parts only traction forces. Therefore, foundations are only necessary at the outside at the shaped rods. Under the vertical stanchions only supporting slabs and no deep foundations are necessary, or the stanchions are put into the soil.

In this way, the assembly is simplified considerably and the material costs are reduced.

The independent roof construction can be produced in various forms with different steel or wooden profiles and can be fixed at the gutter or the stanchions, respectively. Both parts must have sufficient resistance against wind forces.

Many plastic film greenhouses (also in the subtropical regions) are covered with double film in order to conserve energy or to reach higher temperature differences during the night in unheated greenhouses. The space between the films is inflated to a pressure of 40 or 60 Pascal which guarantees a good stability to withstand wind or snow load.

Double plastic-film constructions have been developed of which one half of the roof can be opened for ventilation (Fig. 3.-9).

Structure fo tropical regions

For tropical regions those measures are most important to improve the ventilation efficiency:

- Volume/ground floor ratio as large as possible, if local wind speed is not too high.
- Single-span constructions with open side-walls, gables and ridge ventilators.
- Nets on ventilators, if protection from insects and birds is necessary.

Ventilation openings should also be built at the ridge in tropical regions in order to obtain a sufficient ventilation efficiency. The ventilation openings remain open.

Fig. 3.-10 shows a simple single-span construction that can, for

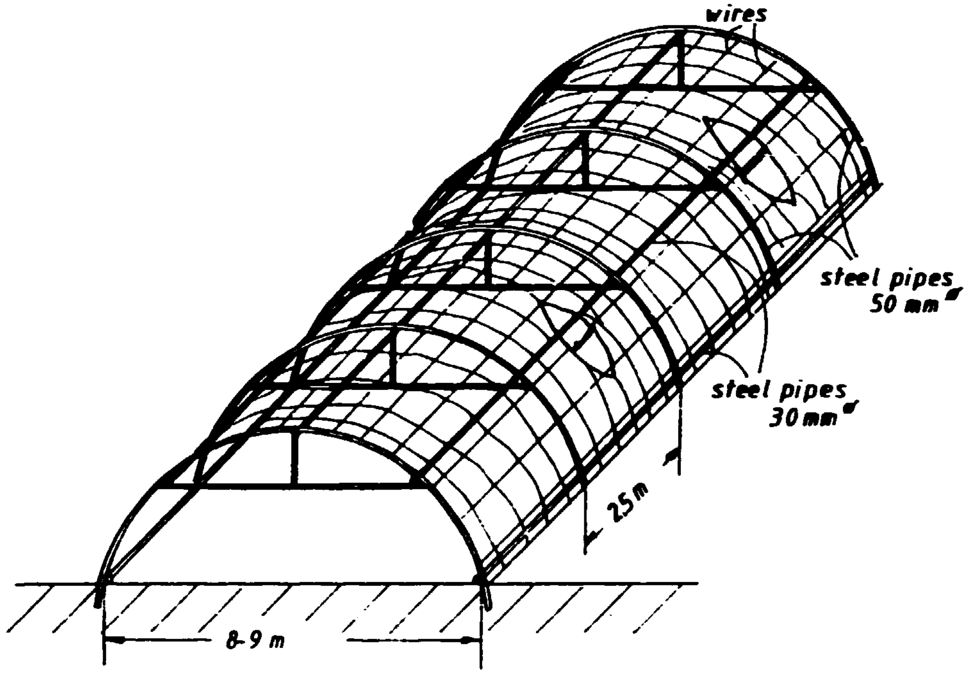

Fig. 3.-1 Tunnel greenhouse with conventional ventilation.

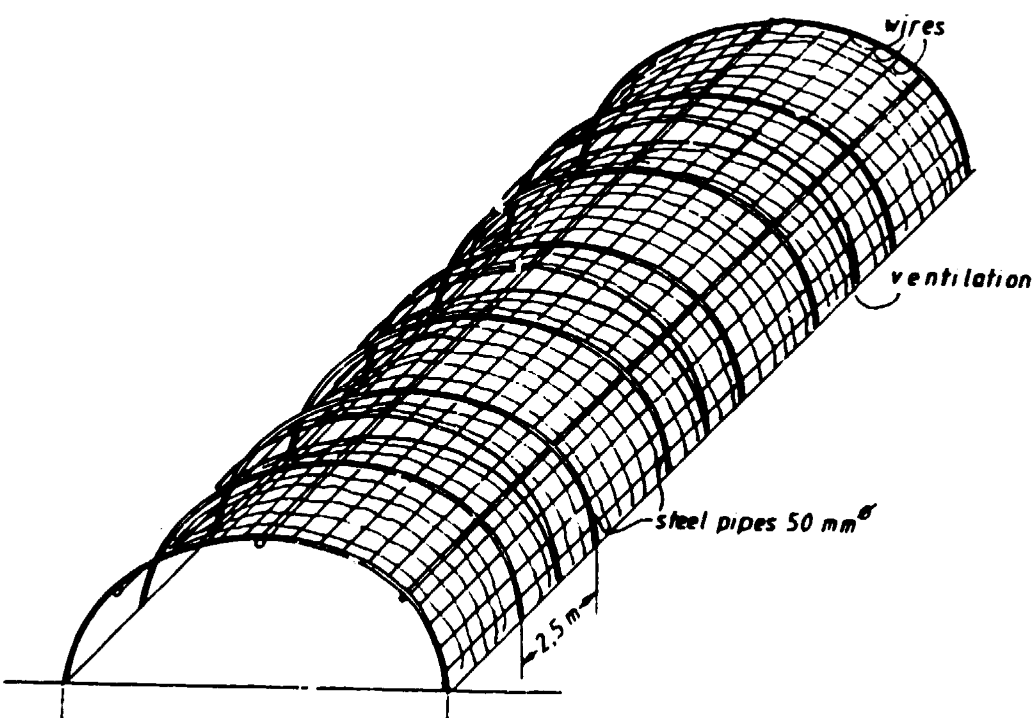

Fig. 3.-2 Tunnel greenhouse with improved ventilation

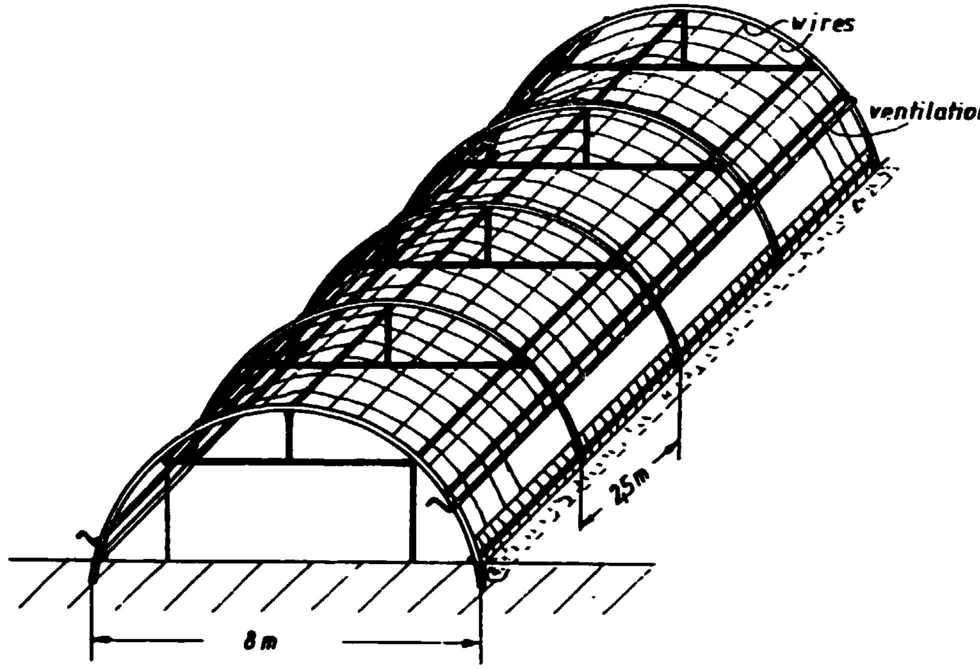

Fig. 3.-3 Tunnel greenhouse with rolling-up ventilation.

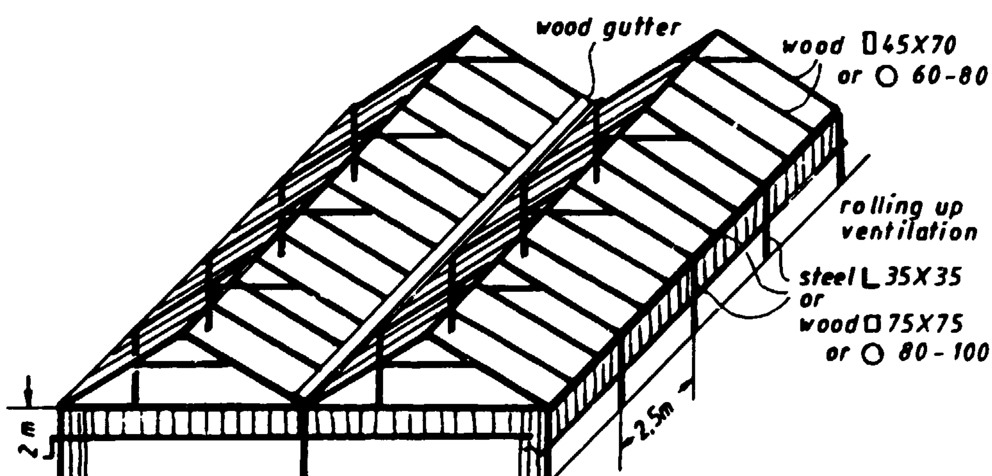

Fig. 3.-4 Saddle-roof greenhouse construction.

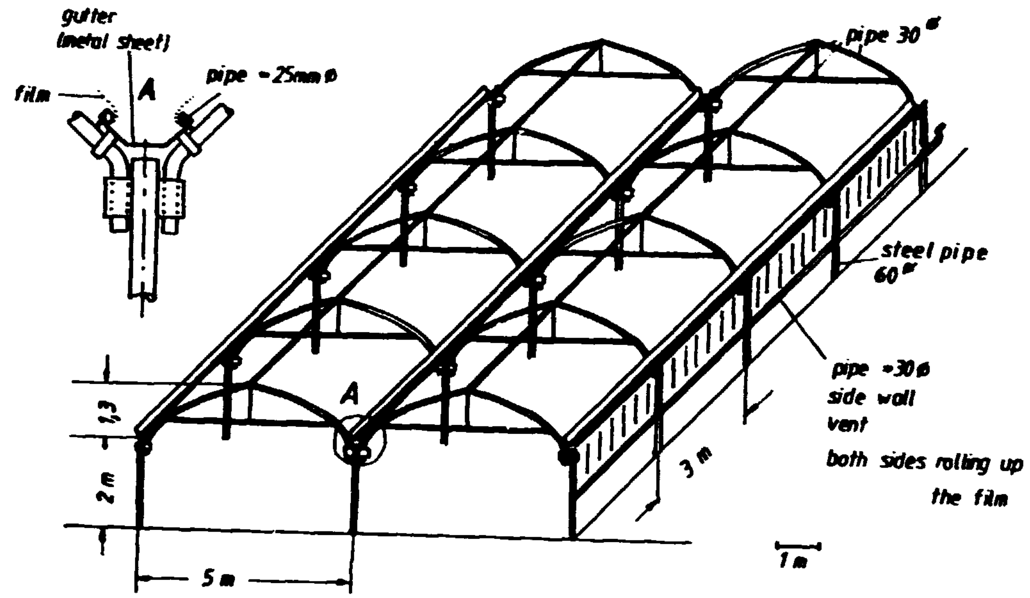

Fig. 3.-5 Steel tube construction with gotic arch.

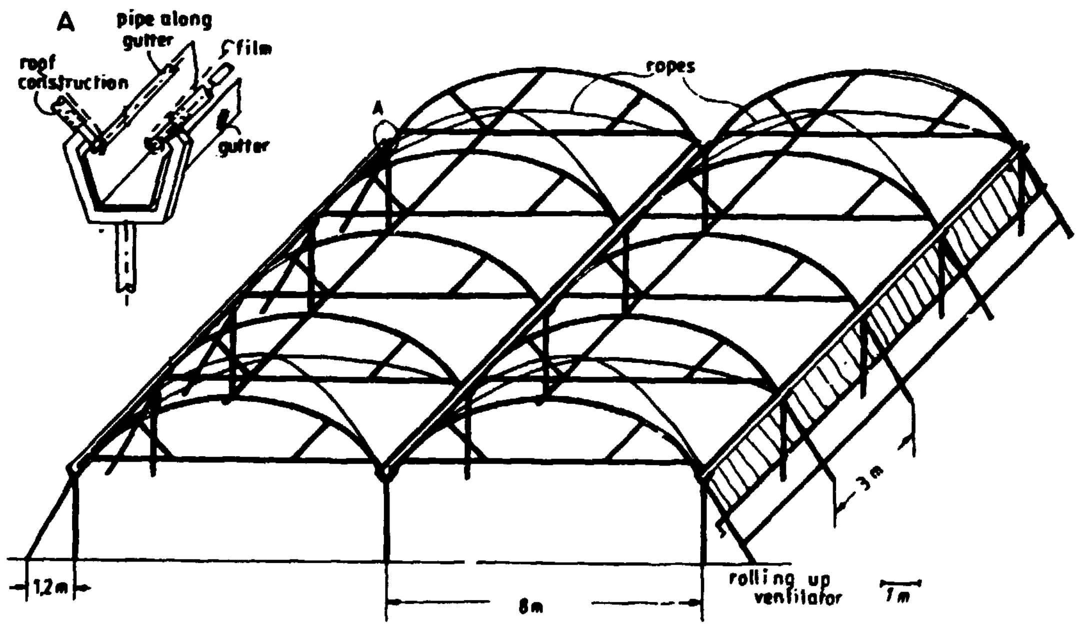

Fig. 3.-6 Greenhouse construction with sloped side-wall

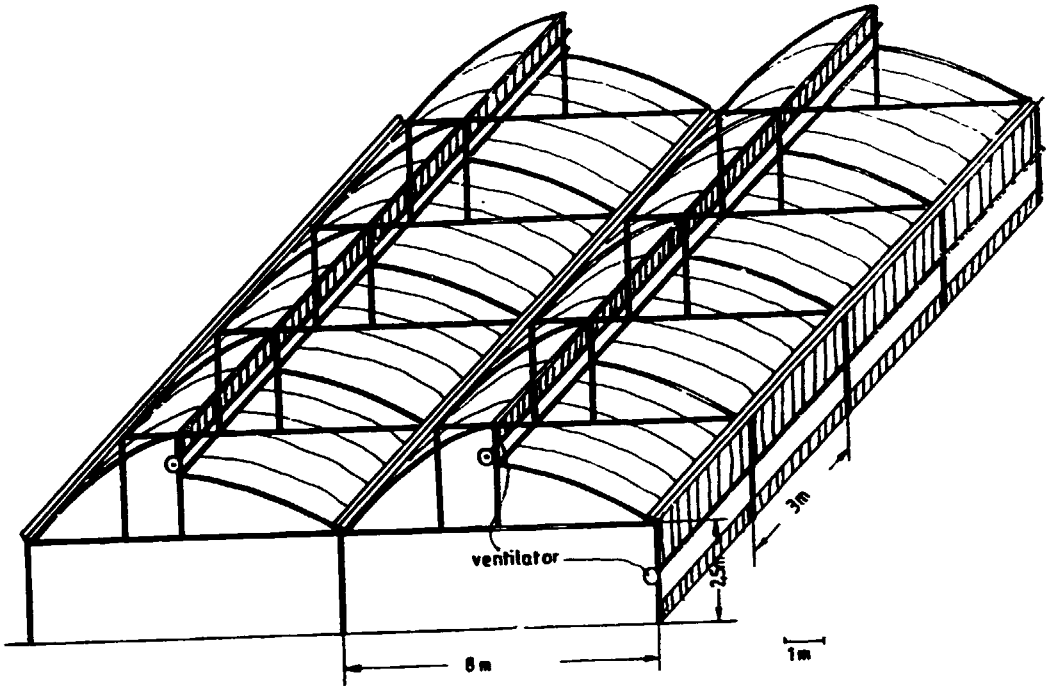

Fig. 3.-7 Greenhouse construction with ridge ventilation.

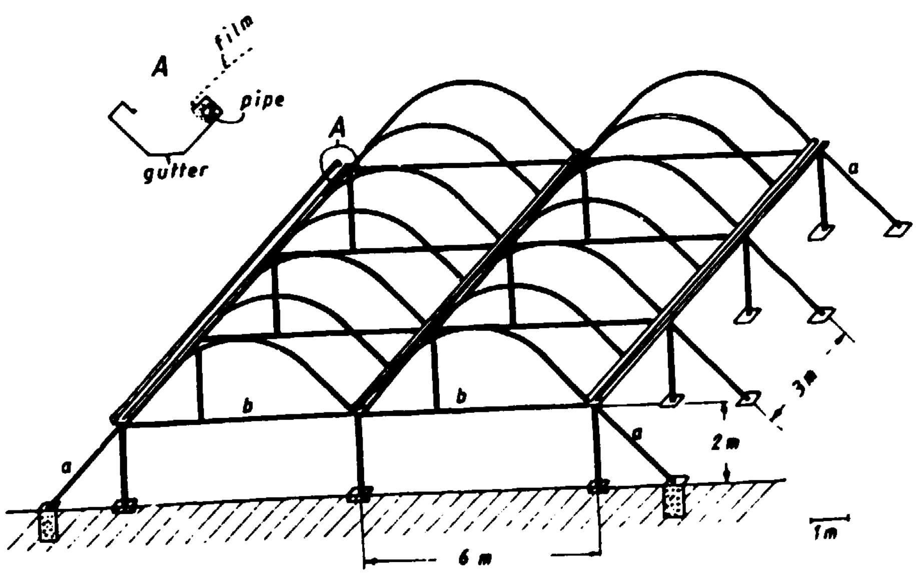

Fig. 3.-8 New construction with slopped side-wall.

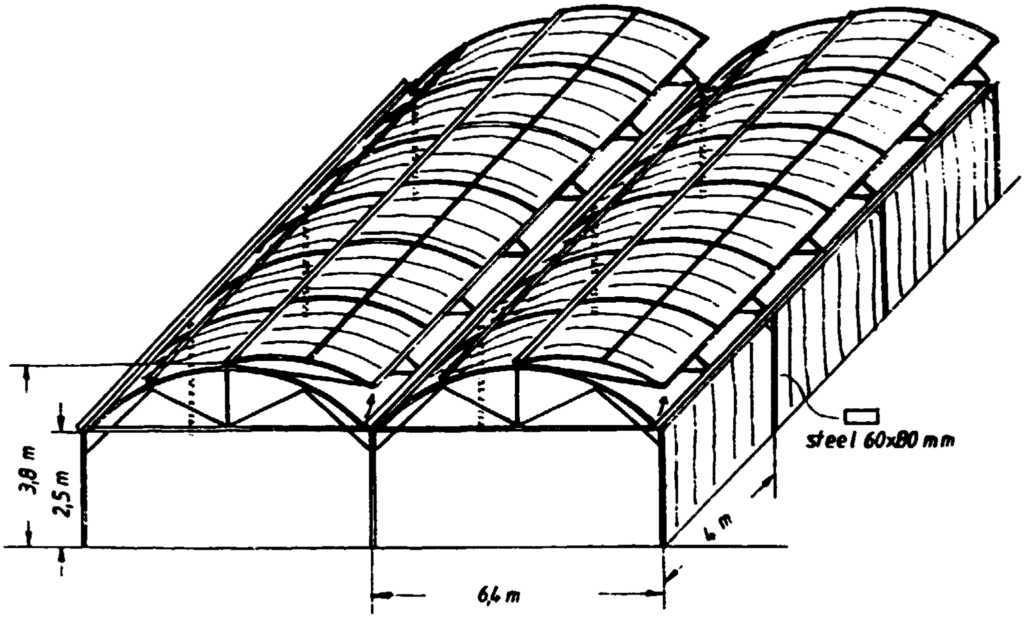

Fig. 3.-9 Double plastic-film construction with roof ventilation.

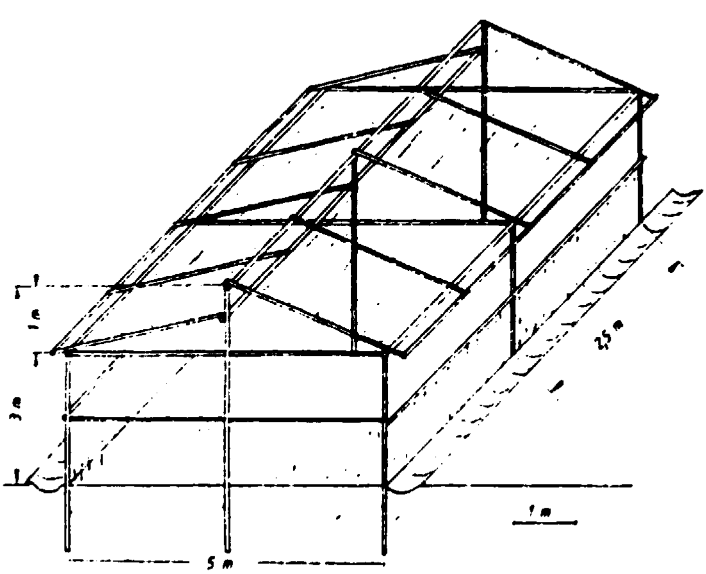

Fig. 3.-10 Single-span construction for tropics.

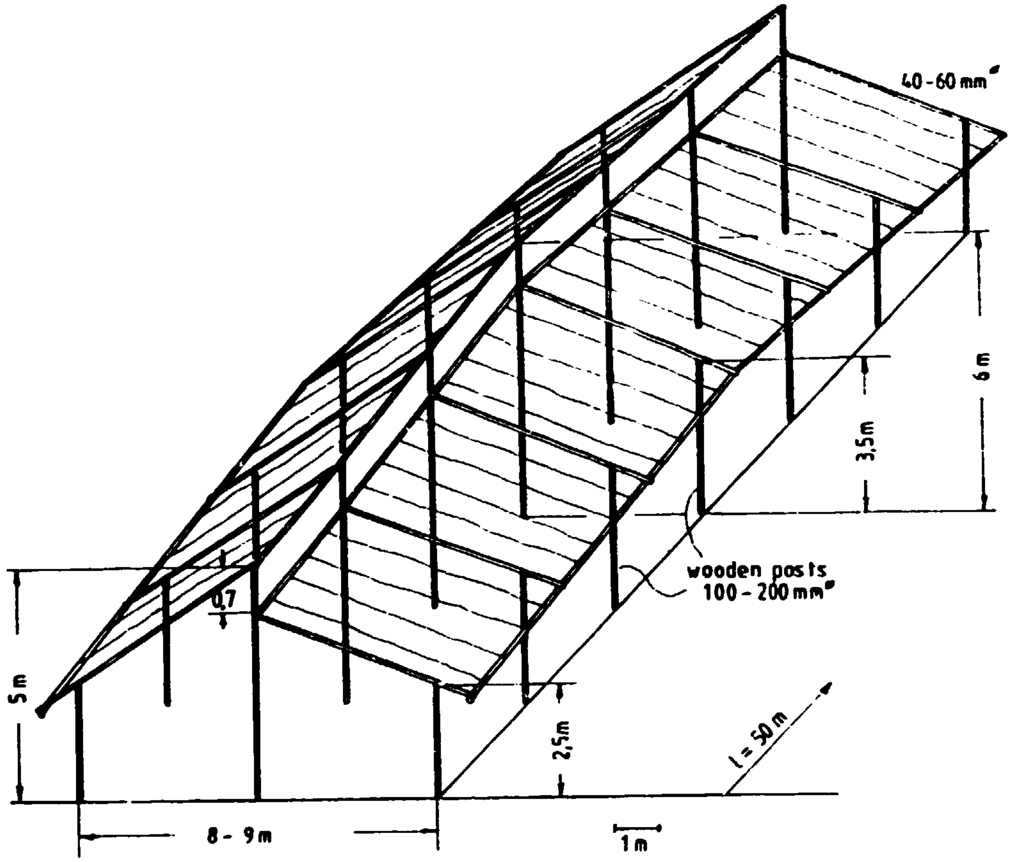

Fig. 3.-11 Construction with slopped ridge.

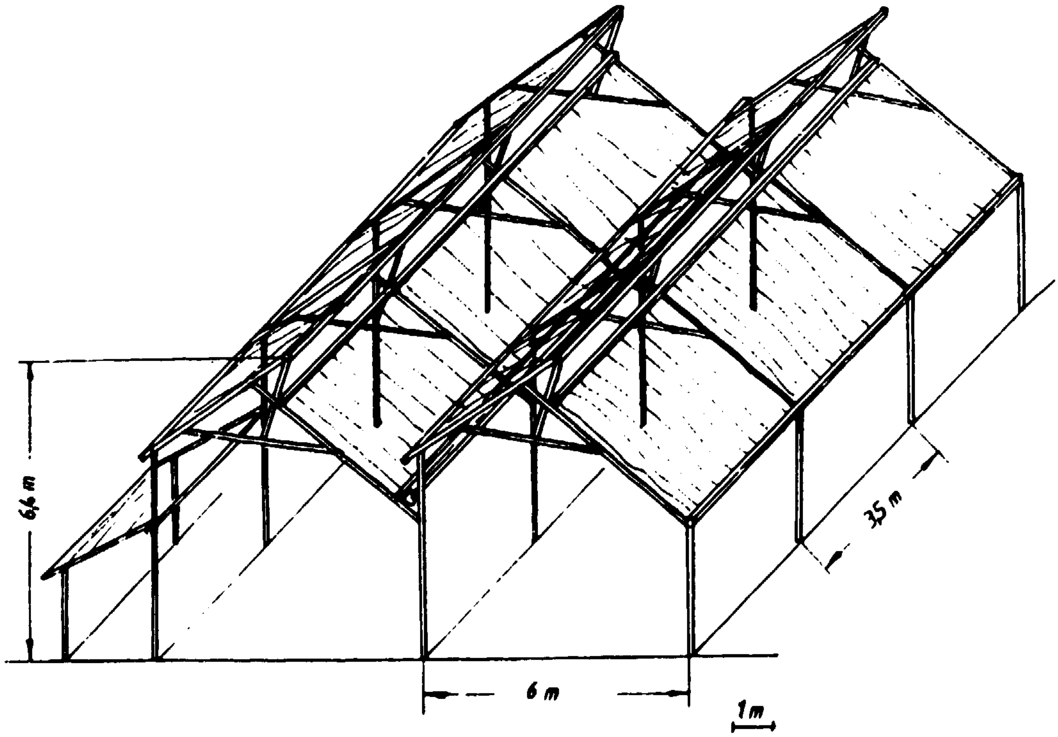

Fig. 3.-12 Wooden construction for tropics.

example. be need at the first introductory stage of vegetable production. The growers themselves can built them from wooden or steel parts. The construction must be so simple that the assembly is relatively easy to learn. A single-span mode of construction is easy to ventilate and is suitable for smaller holdings. As an alternative to the simple wooden construction steel pipes can also be need for the Stanchions and other connecting pieces. In this case, steel pipes would be driven approx. 1 to 1.5 m into the earth and the tubular stanchions would then be stuck into these steel pipes.

In some regions single-span and multi-span greenhouses are built with longitudinal angle of inclination of the ridge of 2 to 3°(Fig. 3.-11) The construction is highest in the middle and slopes down towards the gables to improve the draining of rainwater at heavy rainfall, especially in the case of multispan greenhouses. In the middle, the greenhouses are up to 6 m high. The ventilation at the ridge is 0.7 m wide. Due to the height and the wide ventilation, a good ventilation efficiency can be achieved. The roof sticks out at the side walls so that rain water can flow off without problems.

In some tropics very high wooden greenhouse constructions with ventilation openings at ridge and gutter are built for cut-flowers, Fig. 3.-12. The gable and side-wall surfaces are open. The height of the ridge is 6.4 m. The gutter is made of plastic film. Generally, plastic-film gutters have the disadvantage of forming water bags if the plastic-film is not stretched very tightly. At the sides facing the wind, a kind of porch or canopy is built as a mean of protection from wind and rain.

3.2 Glass grinhouses or grinhouses covered with rigin plastics can be classified as follows:

- wide-span greenhouses,
- Venlo-ture greenhouses

A characteristic feature of the wide-span greenhouse is the greater number of glass panes on the root between gutter and ridge. The Venlo-type greenhouse on the other hand has only one glass pane placed in glazing bars between gutter and ridge.

The gutters have several functions. The first is the drainage of rain water. Collecting rain water becomes more and more important because of the shortage of irrigation water. The second function is the melting of snow and the drainage of melting water to prevent snow from accumulating near the gutters. Finally, the gutter has a structural function namely in cooperation with stanchions and raftere and of fastening the plastic film.

Fig. 3-13 shows a wide-span greenhouse in its main dimensions width (b) , height of ridge (H) , height of side wall (he) and distance between stanchions (e) The greenhouse types can be built single-span or gutter-connected multi-span. They have automatically operated through ventilators at the ridge and if demanded at side-wall.

Fig. 3.-14 shows a Venlo-type construction with a standard width of 3.20 or 4 m. There are two possibilities; a stanchion under each gutter or a stanchion every second or third gutter with the gutter in between supported by a lattice girder. Venlo-type greenhouses should have also through ventilation openings for continental climate.

The advantage of glass is the long durability if it is not destroyed by storm or hail. The global radiation has no influence on the durability or transmissivity of glass.

The main rigid plastic materials are acrylic glass and polucarbonate, both mainly need for double covering. Double acrylic glass (Stegdoppelplatte) is available both in double and three-layer sheets, Fig. 3.-15. The thickness of the double sheets is 16 mm and of the three-layer sheets is 16 or 32 mm. The length of the sheets is 2 to 6 m. Today the sheets have additives against drop condensation (No Drop). Water condenses as a water film so that a better light transmissivity is achieved. The energy conservation in comparison to single glass is 40 to 45% in case of double web sheets. The light transmissivity at vertical light incidence is 86% . It decreases about 1%within 10 years.

Polycarbonate (PC) is also used mainly for double covering. The sheets have a thickness of 4 to 16 mm and a length of up to 6 m. PC sheets are remarkable hail-proof. The light transmissivity is less durable than that of acrylic glass. In order to improve the durability of light transmissivity PC sheets are coated with acrylic.

Water shortage appears to be a serious limiting factor for the agricultural and horticultural production in arid regions. In order to open up remote areas which are provided with little or no external support, an adequate greenhouse system must consist of several characteristics. Water purification by solar desalination seems to be an appropriate way of utilization reservoirs of brackish water or even seawater in the sphere of small communities because its application reduces the dependence on external energy and technology supply.

A most effective use of purified water must be required in order to harmonize water supply (solar still) and water demand (greenhouse crop).

The most important requirements for such greenhouse systems are the following:

- water saving operation by reduced evaporative water losses (closed atmosphere), water recollection by extraction of moisture from the enclosed air by condensation on parts of the greenhouse cover, reduced water demand of the crop compared to open air conditions in a closed atmosphere (high air humidity);
- simple, low technology structure which is based on the use of ordinary construction profiles used in common greenhouse design;
- low energy demand which includes the application of solar destillation and the avoiding of active cooling devices.

Some closed system greenhouse constructions have been developed in the recent years. Fig. 3-16 shows a closed system qreenhouse with salt water surface cooling (System Daunicht, West Germany) The outside surface of the roof is irrigated permanentry by salt water which evaporates and cools down the cover material. At the inside surface of the roof the inside air is cooled by convection at the inner surface. There is a sufficient cooling effect because the greenhouse surface is two times the area of the ground floor. The water produced by evapo- -ration from soil and plants condense at the cooler inner roof surface andm will be recollected by the inner gutters. The recollected water will be need to irrigate the plants again. This system saves water and has a low energy demand for pumping the salt water.

The fluid roof closed system greenhouse (Fig. 3-17) with separate water desalination has been developed in south France and in Israel. The covering material consists of rigid double plastic-material (acrylic or polycarbonate) through which a special fluid flows, which absorbs a high

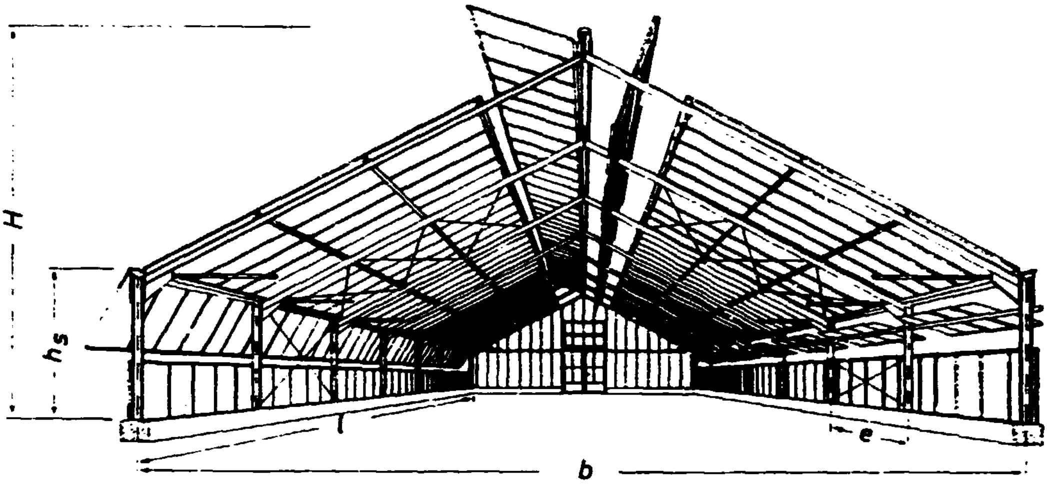

Fig. 3.-13 Wide-span glass greenhouse.

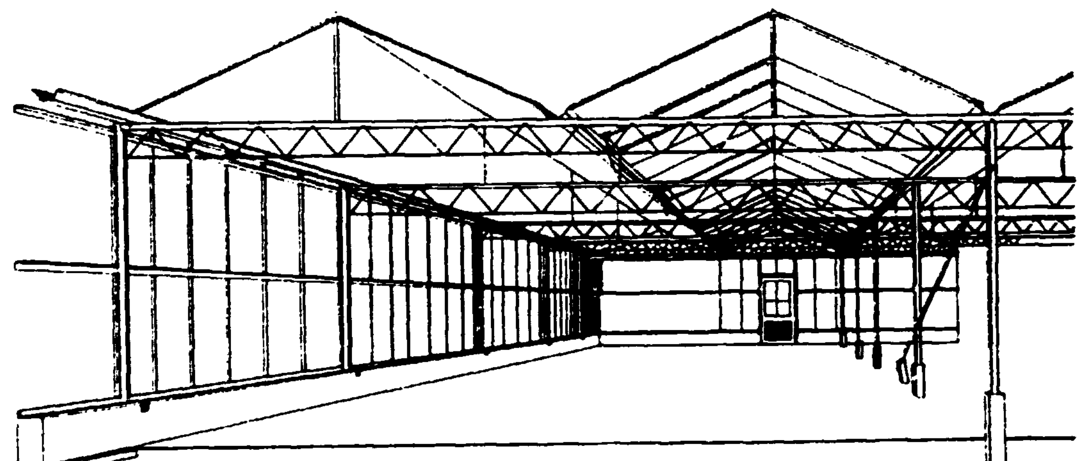

Fig. 3.-14 Venlo-type glass greenhouse.

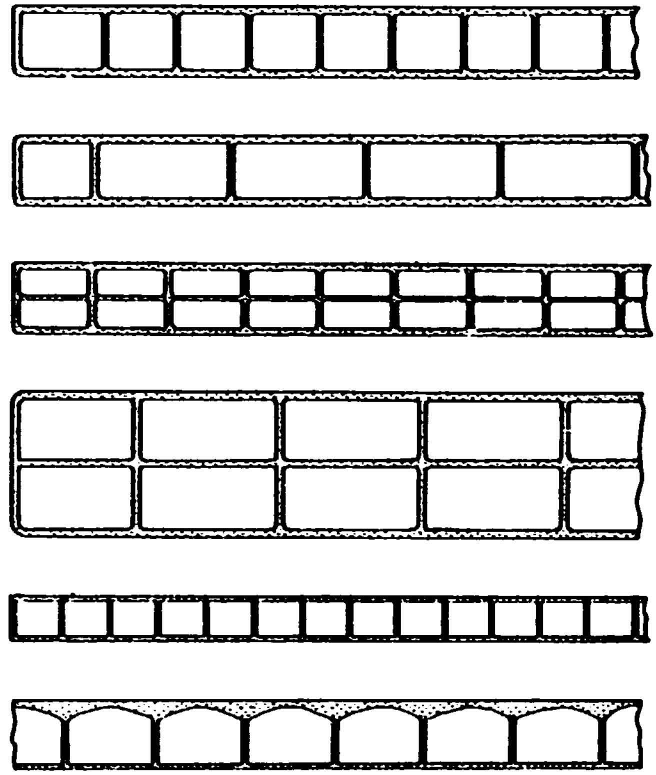

Fig. 3.-15 Double acrylic and PC covering materials.

amount of the near infrared radiation (NIR) from the global radiation. The fluid which is cooled down at night cools the greenhouse at day-time and heate it at night-time if necessary. Inside the greenhouse a simple solar desalination system ist installed to gain the irrigaton water for the plants.

Another closed system greenhouse with integrated water desalination shows Fig. 3-18 (System Bettaque, West Germany) The greenhousi consists of a double covered glass roof. The inner layer of the glass roof is covered with a shading material. Salt-water is flowing down over this shading material between the two layers. One part of the global radiation will be absorbed at the inner layer of the roof and the salt water evaporates. The water vapour condenses at the inner surface of the outer layer, runs down along the glass material and is collected by gutters for irrigating the plants. With this system the incoming light will be reduced.

In the Institute for Horticultural Engineering of the University of Hannover a closed system greenhouse with integrated water desalination has been developed (7-10).

The greenhouse has been designed to fulfil the following demands;

- plant production in arid regions in controlled environment (protection from wind, dust, and low air humidity),
- reducing humidity losses through air exchange by tightening the greenhouse,
- minimizing energy and water consumption by waiving artificial cooling and heating,
- recollection of condensed water from interior greenhouse surfaces,
- independent water supply by solar desalination,
- independent energy supply by solar cells,
- construction with common greenhouse elements to reduce investment costs.

The special shape, the use of selective absorbing glass and a movable outside shading system aim at an inside temperature which does not exceed suitable conditions for plants, even at high outside radiation and temperature. Fig. 3-19 shows a cross section of the construction. The shape of the northern roof is designed to reflect the main part of the global radiation during high positions of the sun. The movable outside shading system is closed to diminish the incoming solar radiation from the southern roof if the inside temperature is too high. The solar desalination system is installed at the southern side-wall.

In the north side-wall a security fan for a low capacity forced ventilation is installed (maximum air exchange rate 6 times the greenhouse volume/h) The fan can be need to circulate the inside air or to ventilate with outside air.

To reduce the necessary amount of desalinated water, the greenhouse is especially tightened and should be kept closed as long as possible. Thus the water which is evapotranspirated by plants and soil is not lost through leakages. Depending on the temperature of the glass and the moisture content of the air, condencation occurs at the interior surfaces of the greenhouse. This water is recollected for irrigation. The amount of recollected water depends on the tightness of the construction.

The deficit of irrigation water will be gained by the solar still. This water still consists of a water storage for salt or brackish water. From this storage the salt water will be pumped and distributed to a sloped absorber and evaporator surface. The salt water flows as a water film over the absorber and will be warmed up. One part of the water evaporates and condenses at the colder still cover consisting of glass. The excess salt water lows back to the water storage. The water in the water storage is warmed up at day-time. So it is possible to operate the

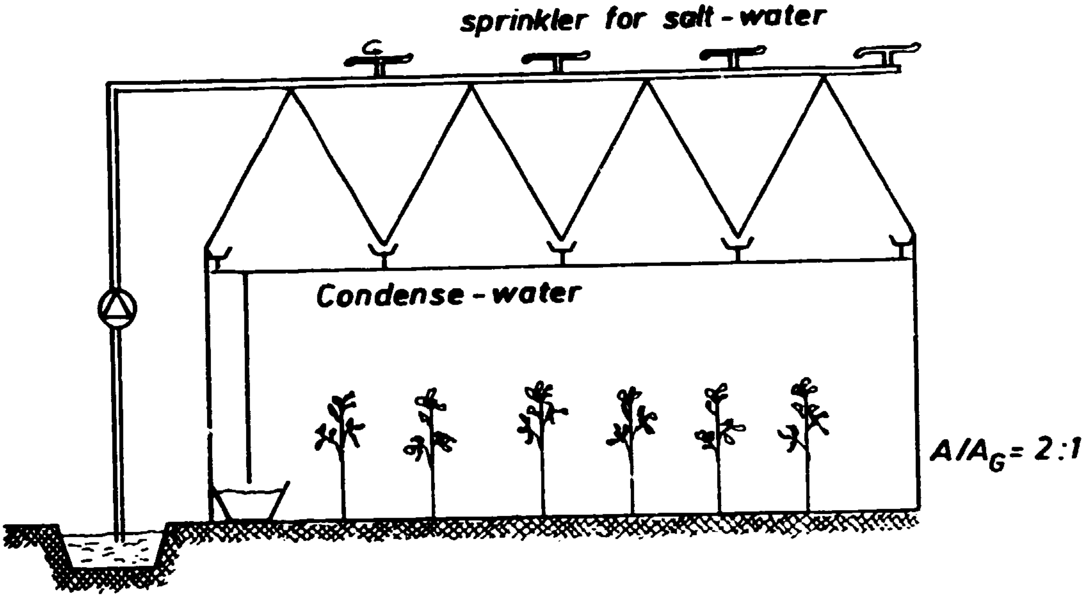

Fig. 3.-16 Closed system with salt water surface cooling.

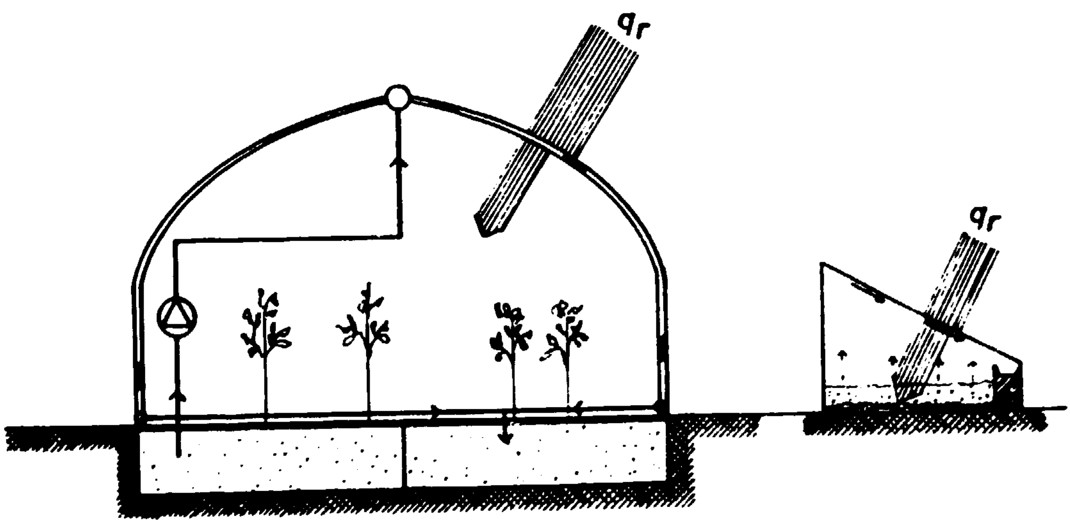

Fig. 3.-17 Fluid roof system greenhouse.

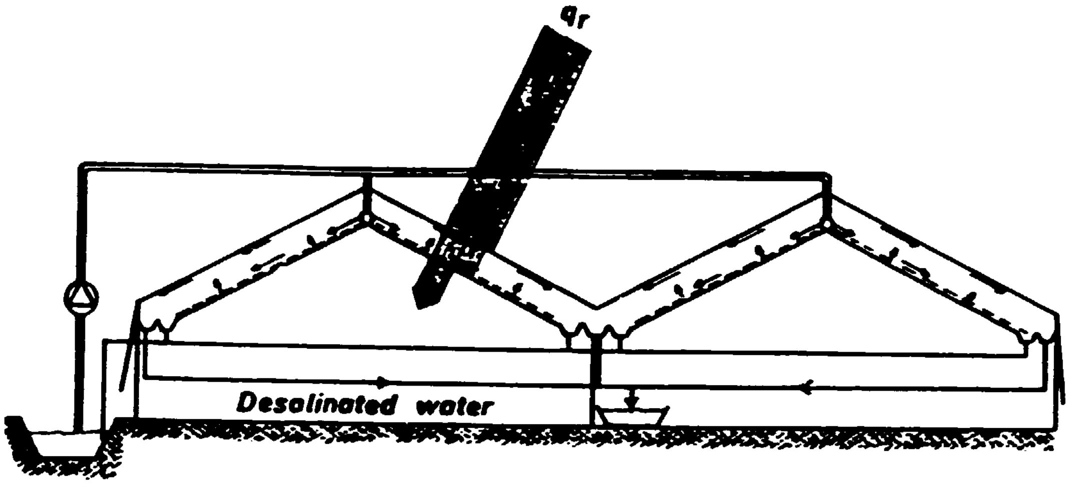

Fig. 3.-18 Closed system with integrated water desalination (System Bettaque).

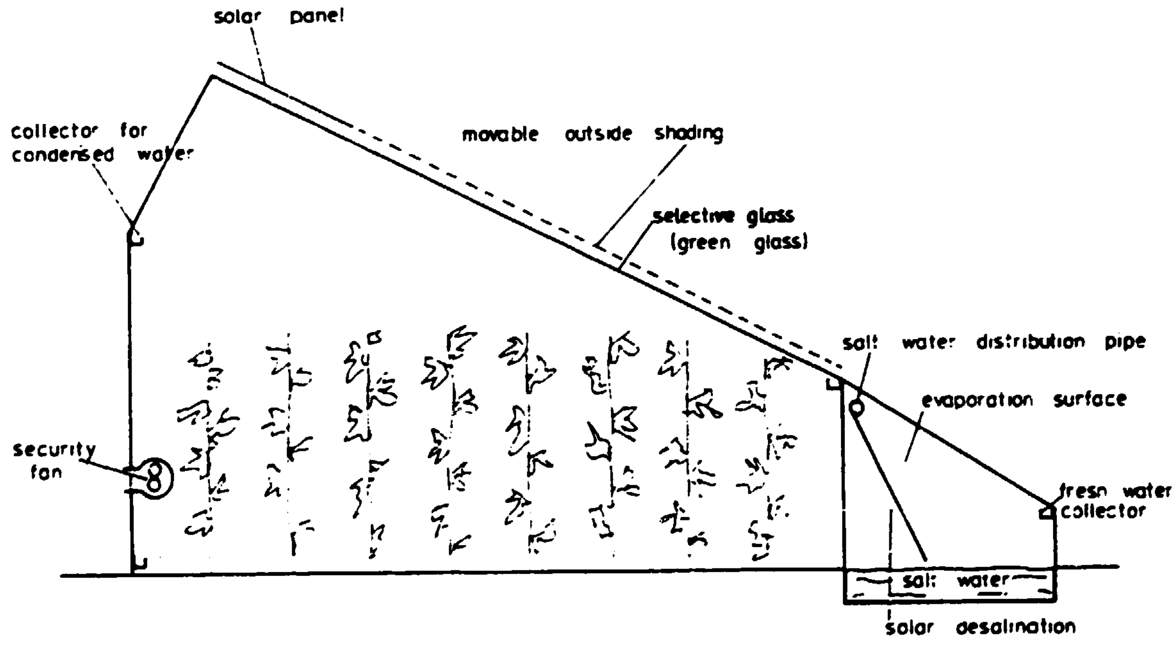

Fig. 3.-19 Closed system greenhouse with integrated water desalination (System ITG Hannover).

solar still also at night-time. The efficiency of the desalination unit running over 24 hours is very good. Results are given in the publications.

3.4 Growing rooms.

Growing rooms are enclosed climatic chambers which are solely lighted by artificial light. The difference to phytotrons is a simpler construction. It is not possible to control every climatic factor over a large range with cooling below outside temperature and humidity control. Therefore they are considerably cheaper than phytotrons. Temperature, light and CO_2concentration have to be controlled.

Growing rooms are used for seedl'~g production and certain crop production.

In winter, when the light conditions in greenhouses are bad, a growing room has the following advantages; short propagation period, better and more constant supply of growth factors, exact predictability of production, good and even quality and little demand of room as multi-layer production is possible.

Many types of growing rooms have been developed world-wide.

At the ITG of Hanover a growing room has been developed which is suitable for automatic operation and climate control and furthermore reduces the cost for lamp investment and electric supply. A supplementary heating is not necessary. This growing room is ehown in Fig. 3.-20.

The growing room has two walls and ceilings. The inside wall consists of aluminium and is completely closed. The outside wall consists of a double layer polyethylene sheet, leaving a space of 0.09 m to the inside wall. The inside temperature is, if necessary, controlled by blowing outside air through this space by a fan. Thus CO_2 enrichment and relative humidity are not directly influenced by cooling, except increasing leakage losses and dew on the inside walls while the fan is operating. In the middle of the room stands a column which carries on the opposite sides benches one above the other. In one half of the room 4 lamp rigs are installed so that the plants can be placed underneath. A curtain divides the room into a lighted and a dark part. When the plants are to be taken from the light the curtain goee up, the column turns round and the curtain goes down again.

The lamp rigs are closed upside and the warm air produced by the lamps is sucked out by a fan and blown as heating air into the dark part of the room. As the lamps are burning continuously, there is no need for supplementary heating. Irrigation takes place in the dark part of the room just before the plants are moved into the light. Day-night change and irrigation take place automatically.

Tubular fluorescent lamps are need for lighting. The intensity can be varied by the number of lamps up to 15000 lux at plant level.

The following climatic conditions can be reached and maintained in the growing room; an inside temperature of 20°C at an outside temperature of -15° to 15°C the temperature difference between the dark and the lighted part of the room is 2° to 3°C the relative humidity is 60 to 70% in the lighted and 80 to 85% in the dark half depending on the wall temperature. The vertical temperature and humidity distribution is very even. Both the time for plant nurse·y and the energy conservation can be considerably reduced in comparison to a glasshouse.

Another computer controlled growing room system is installed in an ISO-Container, Fig. 3.-21 (11) , which is insulated. Inside the container is a multi-layer system for plastic boxes, which can be moved automatically by a motor and drive-system from the upper level down to the lower level. The artificial lighting system and the fertigation system are

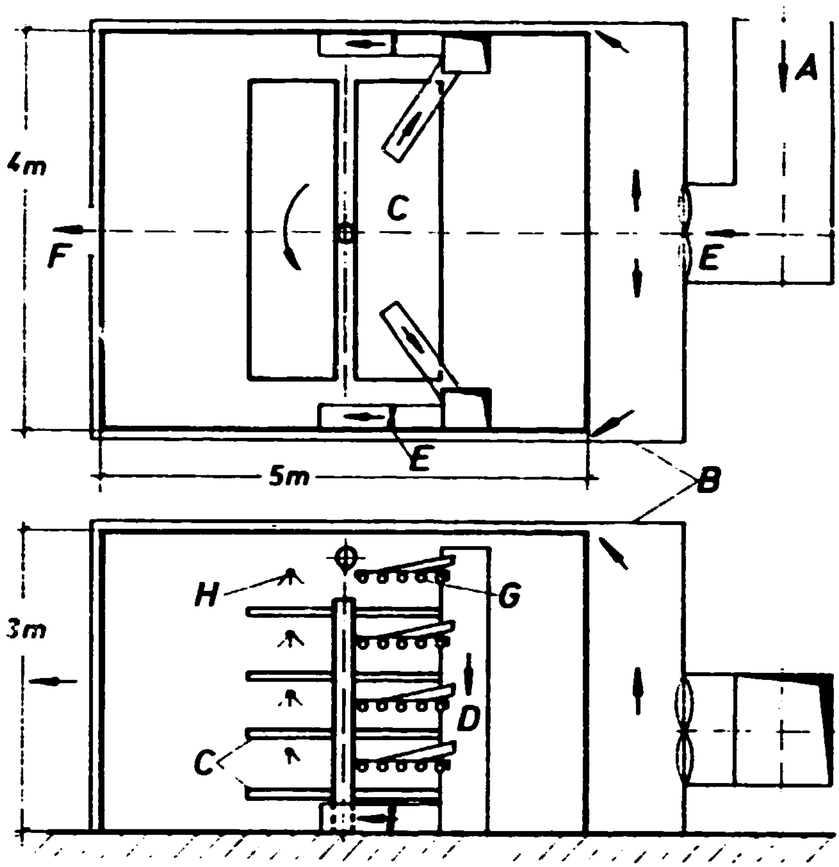

Fig. 3.-20 Growing room: (A) outside air channel; (B) jacket cooling; (C) bench; (D) circulation air; (E) fan; (F) cooling air outlet; (G) lamps; (H) irrigation.

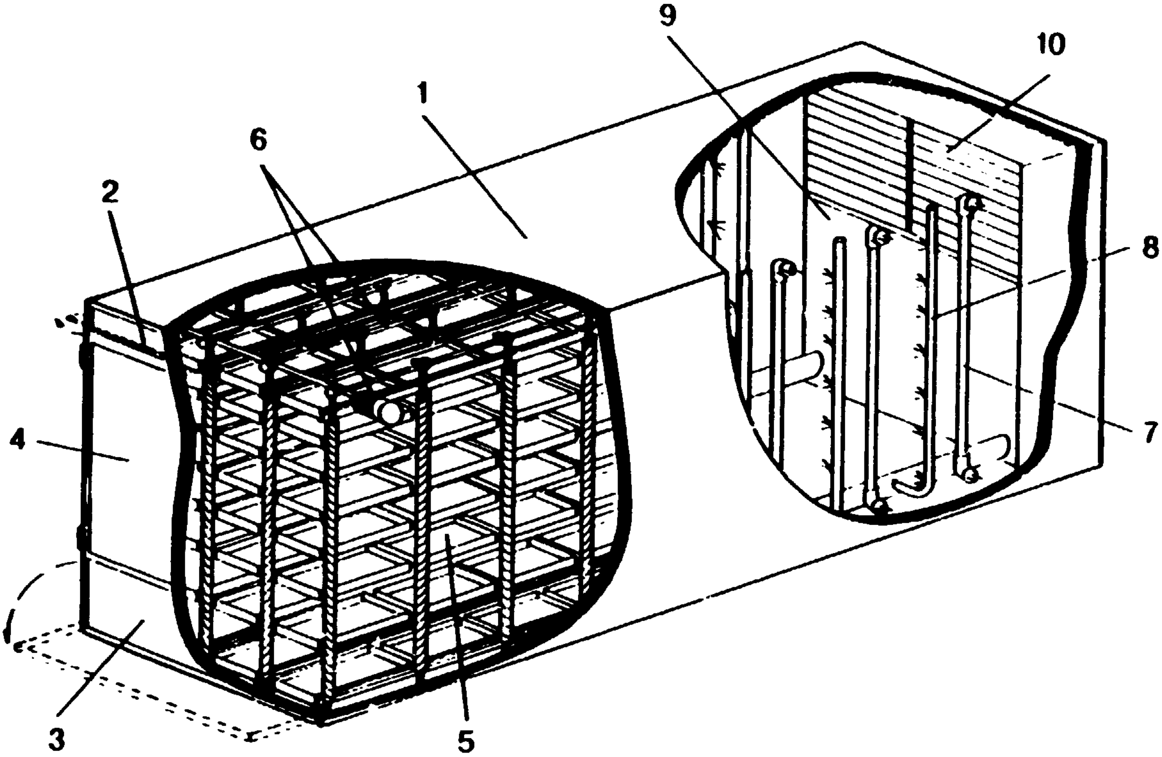

Fig. 3.-21 Growing system in ISO-Container: (1) ISO-Container; (2) Fill-in-opening; (3) outlet opening; (4) door; (5) multi-layer system; (6) motor and drive-system; (7) artifical light; (8) irrigation; (9) water tank; (10) climate control system.

installed at the sidewalls.

The plastic-boxes with substrate and seeds enter the system through the inlet-opening at the upper level. From one level to the other the distance of the levels increases according to the plant growth. At the lowest level the plants can be taken through the outlet-opening. In this way a continuous automatically controlled crop production takes place.

There are also continuous crop production systems installed with horizontal conveyer systems in greenhouses.

4 Equipment for crop handling and transport.

Plants greenhouses have to be cultured in a way that they are within reach for work. husbandry and harvest. Up to now in moste cases a worker has gone to the location of the plant for all husbandry work. The greenhouse area has to be splitted up so that the cultivation areas are within reach.

New developments mainly for crop plants and container crops tend to transport plants for the necessary work from their place in the greenhouse to a central work place by transport systems.

Dividing the greenhouse into paths, benches and beds has to happen under the consideration of the following factors:

- cultivation area as large as possible in relation to the ground area.
- shortest possible transport time, especially at manual transport.

The share of the cultivation area in the total floor area of the greenhouse depends on the widths of paths and benches. Up to now ground beds without permanent paths have been used for vegetable and cutflower production. If soilless culture is increasingly applied in future the greenhouse floors will be concreted to avoid losses of fertilizer and plant protection agents into soil and ground water.

The production of pot plants and container crops in greenhouses takes place:

a) in ground beds,
b) on benches,
c) on movable benches,
d) on movable pallets,
e) in multi-layer systems on horizontal rotor conveyers or on movable pallets in different levels.

Benches with permanent paths are produced in different forms out of wood, aluminum and concrete. Fig. 4.-1 shows as an example between the benches are 45 to 50 cm wide. The net cultivation area with non-movable benches amounts to 65 to 75% of the total greenhouse area.

In case of movable benches the bench top can be moved 50 to 60 cm sideways, see Fig. 4.-2 and 4.-3. Thus the path area can be reduced considerably. The net cultivation area can be increased to 83 to 88% by use of movable benches.

The construction of movable benches consists of subconstruction, roller tubes on which the benches are moved and the bench top. The subconstruction is made of concrete or steel, the bench tops are made of aluminum profiles with different tops. The benches are moved on two roller tubee installed in longitudinal direction which roll between bench top and subconstruction.

A space of about ten centimetres should be left between benches wich are moved together so that warm air from the heating system under the benches can rise up.

When planning greenhouses with movable benches the approximate labour amount of the different crops should be considered. If several paths are necessary in one house one non-movable bench should be installed every five to ten movable benches.

On movable pallets the pot plants are transported to a central working hall (Fig. 4.-3) The net cultivation area achieved with movable pallet system is slightly larger then that of movable benches. Theoretically the whole greenhouse area except the main path can be put to use. When movable pallet systems are installed, however, paths between the pallet rows are necessary to control the plants.

Movable pallet systems will be applied if as many working functions as possible are transferred to the workroom and if transport problems are solved.

A suitable dimension for movable pallets is 3 m*1.6 m. The pallets have rollers and are moved to the beds on tubes. They have to be as light as possible and therefore are made of aluminum profiles. They often have tops made of polystyrene. leys (Fig. 4.-4) on which they are rolled from the beds. The transport trolleys can be automatically directed to the workroom by built-in control systeme in concrete paths.

Moreover there are permanently installed transport systems for pallets on the paths, Fig. 4.-5. Holler tubes (2) which lie at right angles to the transport direction are lifted by means of pneumatic cylinders (1). The pallets are rolled on these tubes and lowered until they lie on the transport rolls (3) These rolls are driven via belts '4) by an electric motor (5) and transport the pallets to the workroom.

Another possibility is to install the transport system over the benches.

There are combinations of movable benches and movable pallets, Fig. 4.-6. The pallet has no rollers but rotating tubes which roll on tubes which are fixed on the subconstruction.

The usable cultivation area in greenhouses can be further increaeed by multi-layer production. Here the production takes place on two levels. One practicable method is the horizontal rotor conveyer, Fig. 4.-7, where pallets hang on a horizontal transport chain. The pallets loaden with pot plants are placed to the upper or lower level in turn. The lower level has to be lighted artificially. At one end of the rotor is a work place. The plants are automatically irrigated on their turn. This system is applicable only for relatively small plants. The cultivation area is increased by 1.6 to 1.8 times.

Another variation of the multi-layer system is the installation of movable pallets on two levels in the greenhouse. The lower pallets are lighted artificially. In order to move the pallets from one level to the other and to transport them to the work room special lifting and transporting equipment is required. Fig. 4.-8 shows a machine for automatical moving of the pallet from one level to the other. There is a machine on both sides of the pallet row.

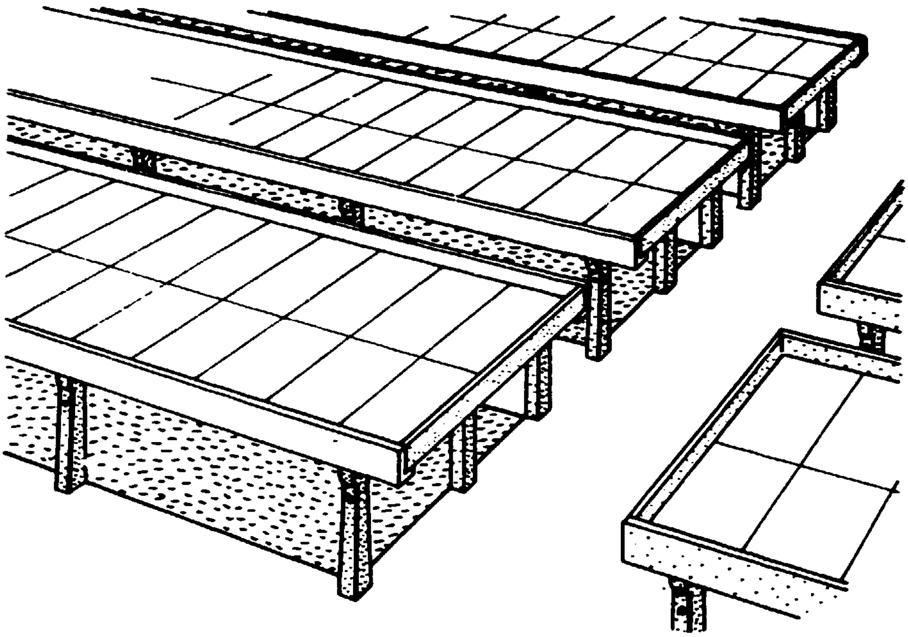

Fig. 4.-1 Benches wich permanent paths.

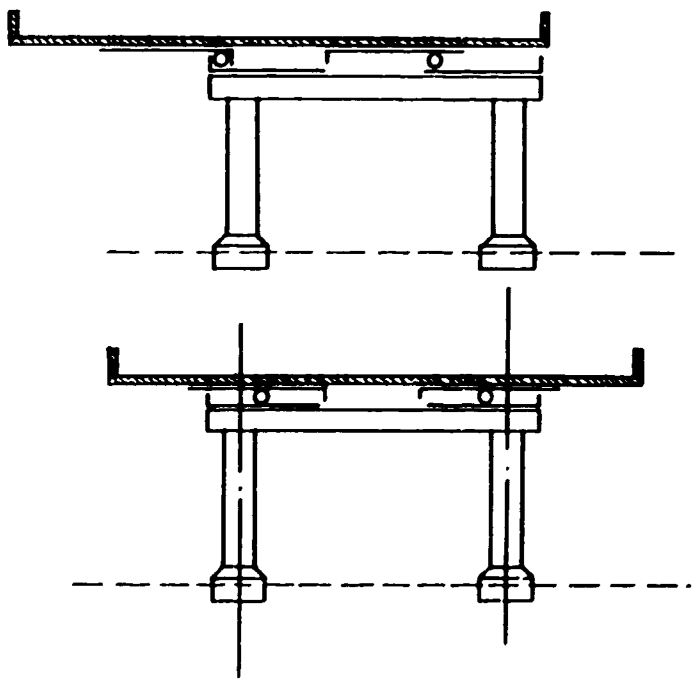

Fig. 4.-2 Movable bench.

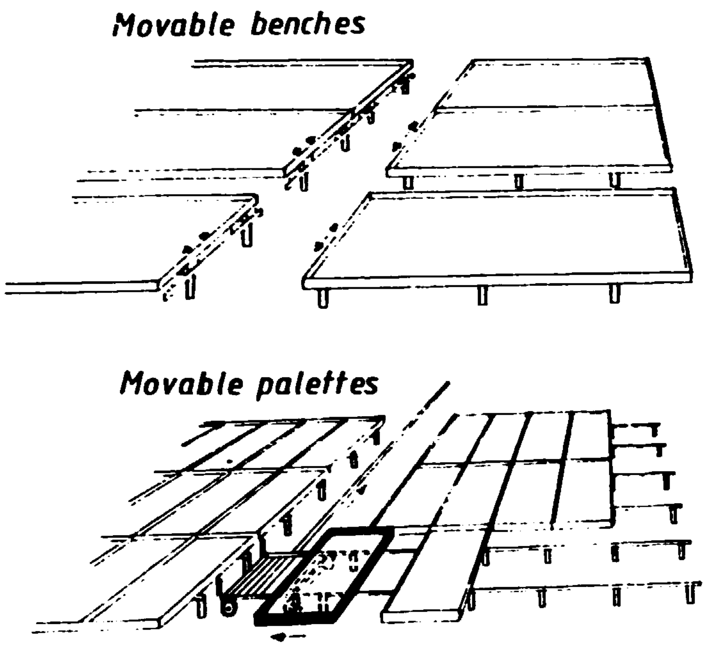

Fig. 4.-3 Movable benches and movable pallets.

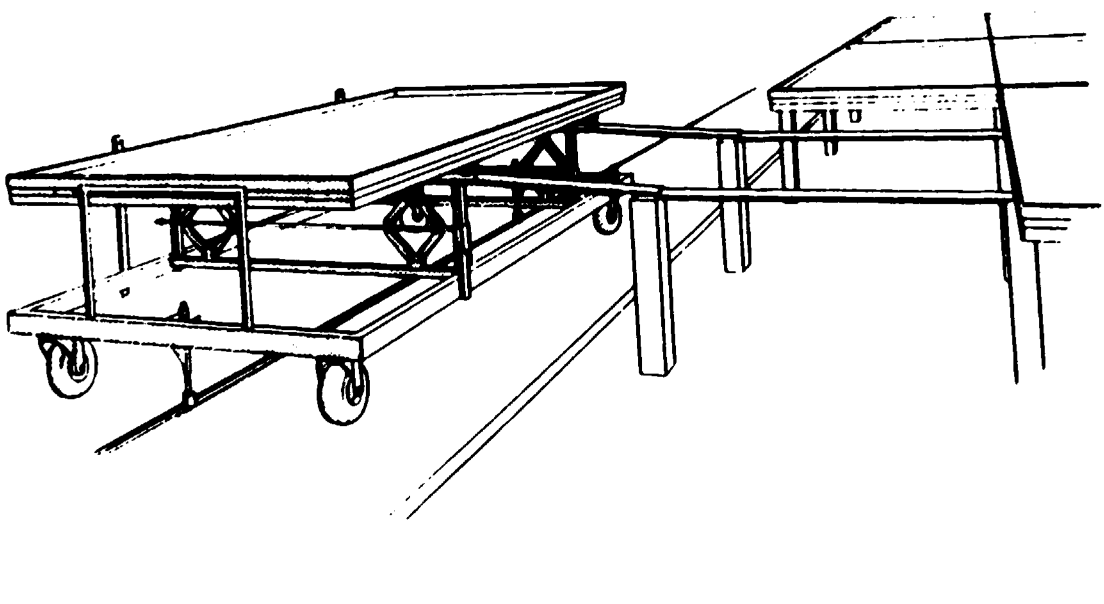

Fig. 4.-4 Transport trolley for movable benches.

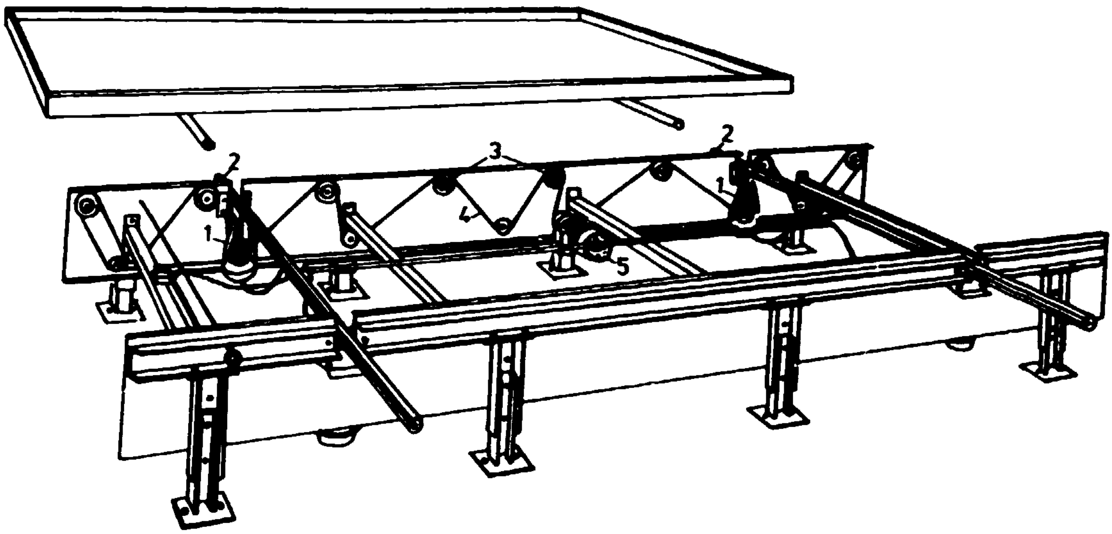

Fig. 4.-5 Transport system for movable pallets.

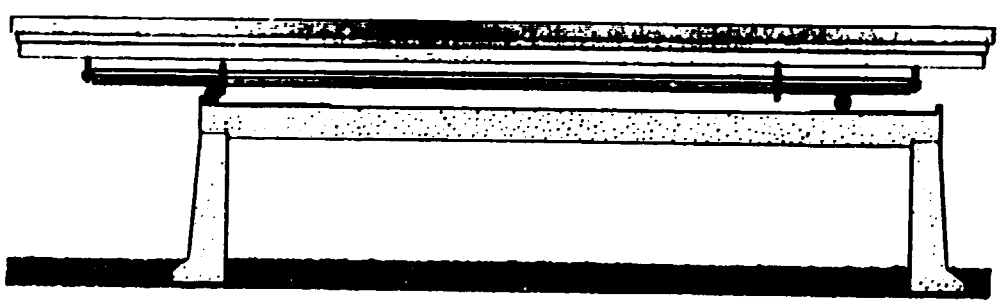

Fig. 4.-6 Combination of movable bench and movable pallet.

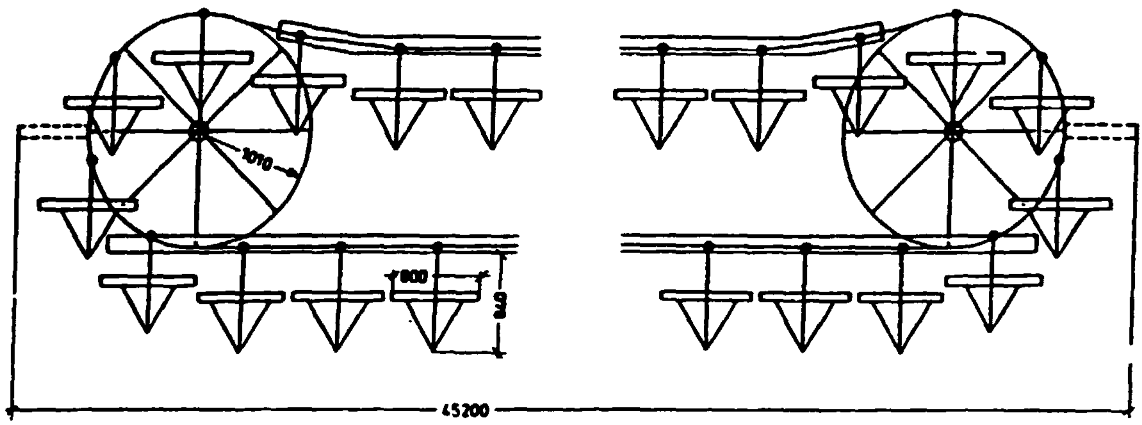

Fig. 4.-7 Horizontal rotor for multi-layer production.

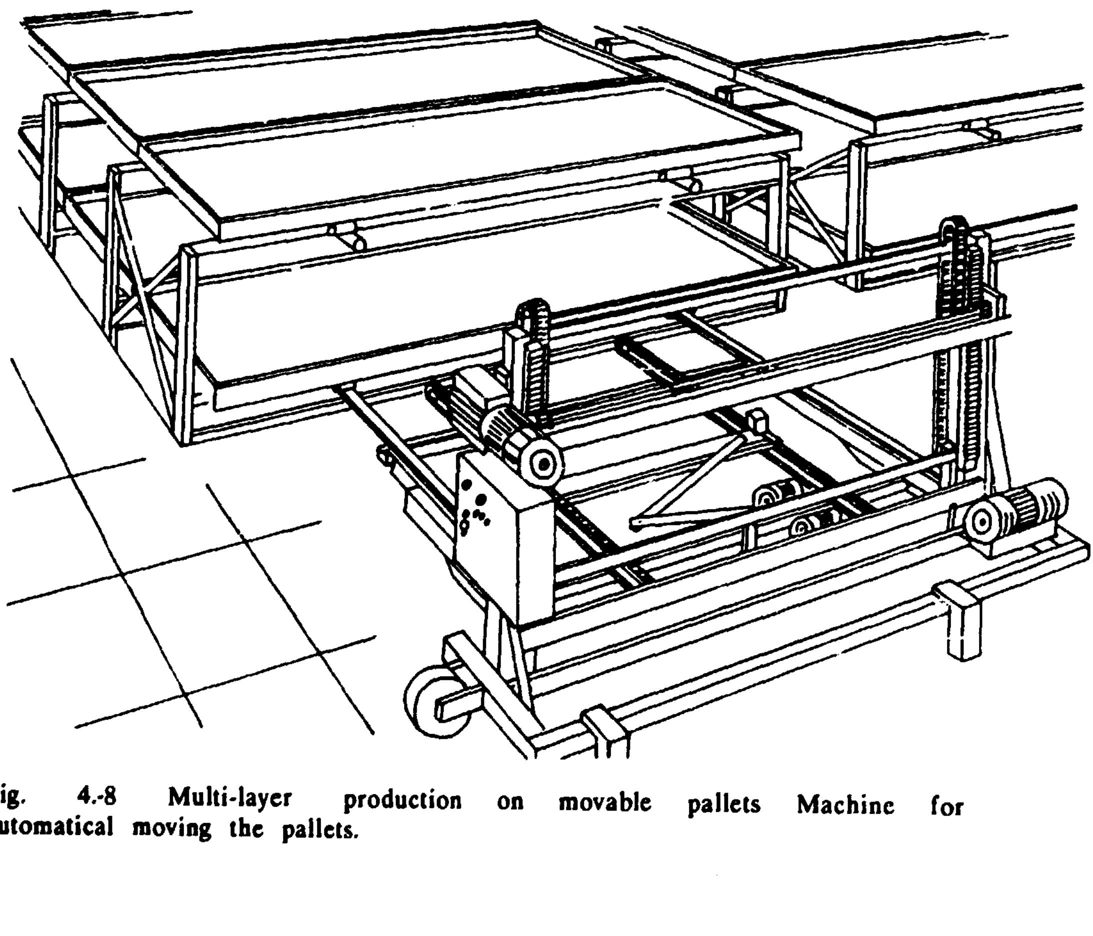

Fig. 4.-8 Multi-layer production on movable pallets Machine for automatical moving the pallets.

5. Technical equipment for soilless culture.

The application of soilless culture is constantly increasing in horticulture. The reasons are;

1. increasing of yield and improvement of quality by regular supply of mineral nutrients and better hygiene,
2. saving of peat and protection of natural resources for substrates,
3. protection of the environment; no contact of fertilizer and plant protection agents with the soil and the ground water.

Fertilizer and plant protecting measures have to be applied at intensive plant production in greenhouses with correspondence of the development of the plants. When cultivating plants in soil it cannot be avoided that surplus fertilizer and plant protection agents are transported to deeper soil horizons and to the ground water. Many countries will therefore enable laws for the protection of the ground water within the future and thus will permit only soilless cultivation and closed-loop irrigation syetems for plant production in greenhouses.

The following main groups of technical equipment belong to a soillese culture system (Fig. 5.-1) ;

A; processing of water and nutrients,
8; nutrient control,
C. space for plant growth.

Fig. 5.-1 shows the scheme of a complete device for nutrient film technique (NFT). This system basically corresponds to that of every other soilless culture. Certain simplifications are possible for several systems.

By means of a control system fertilizer are pumped into a catchment tank in dependence on the concentration. The irrigation and fertilizer solution is warmed up in the tank. The solution is then directed by pumps via supply tubes to trays and canals in which the plants are standing. The surplus water is tank via a catchment pipe. Here it is mixed with air to increase the oxygene concentration in the nutrient solution as a catchment sufficient oxygene concentration in the root space is essential for all soilless cultivation methods.

Very different systems with or without artificial substrates are available as a root space for plants which are either drenched with nutrient solution or through which the water flows. Fig. 5.-2 gives a schematic overview of different systems.

When using NFT culture the nutrient solution runs though the trays which have holes on the top and are tightened to avoide alga growth. The plante are held in mounts to that the roots grow in the nutrient solution without substrate. In case of other NFT methods seedlings are placed into the nutrient solution in absorbent cubes. As for the Aercponic system, the nutrient solution is sprayed from pipee with nozzles into the root space. The plant roots hang in an air space with tiny drops or fog.

Plant cultivation on rockwool is widely applied. Seedlings in cubes are placed on rockwool pads in which the roots grow into. The rockwool has to be provided with nutrient solution continuously by a drip irrigation system. Surplus solution runs off via trays. The rockwool pads are sometimes covered with plastic film to avoid evaporation. The disadvantage of rockwool is its limited suitability for frequent application. Moreover it is frequently problematic to remove the fertilizer-drenched rockwool pads after use in an ecologically harmlese way.

In several countries sand and other artificial substrates are filled into plastic bags. Seedlings in cubes are placed on the substrates through holes in the plastic and are irrigated by drip irrigation. In this case water and nutrient consumption have to be quite accurately adapted to plant consumption

The use of bloating clay for hydroponic culture has been known for for long time in floriculture. During the last few years bloating clay has also been applied in vegetable cultivation.n The advantage of bloating clay is that it can be recycled quite unlimitedly. The grain size of bloating clay should be between 8 and 16 mm.

Culture in bloating clay can take place in containers with drip irrigation, in hydro pots with stowing watering whereby the pots have to be 2 - 4 cm deep in the water, in hydro trays or in hydro beds with irrigation pipes. The plants in the bloating clay are continuously provided with nutrient solution. Normally the nutrient solution is not reducted. Therefore the concentration and the nutrient ratio has to be adapted to the plants' nutrient demand as accurate as possible. In case of a long cultivation period salts can accumulate at the surface due to evaporation and capillary action. It is favourable to supply the eubetrate with nutrient solution from above. If the trays or beds have a slight slope surplus nutrient solution can run off and be reconducted. Eloating clay is also applied as a mixture with other substrates.

As there is no or only little buffer action for nutrients or water in the substrate for soilless cultures an exact measuring and stable concentration of the nutrients is necessary. Moreover is of importance a sufficient oxygene supply to the roots. This makes necessary technical equipment with automatic control. These methods will gain more and more acceptance in order to protect the environment.

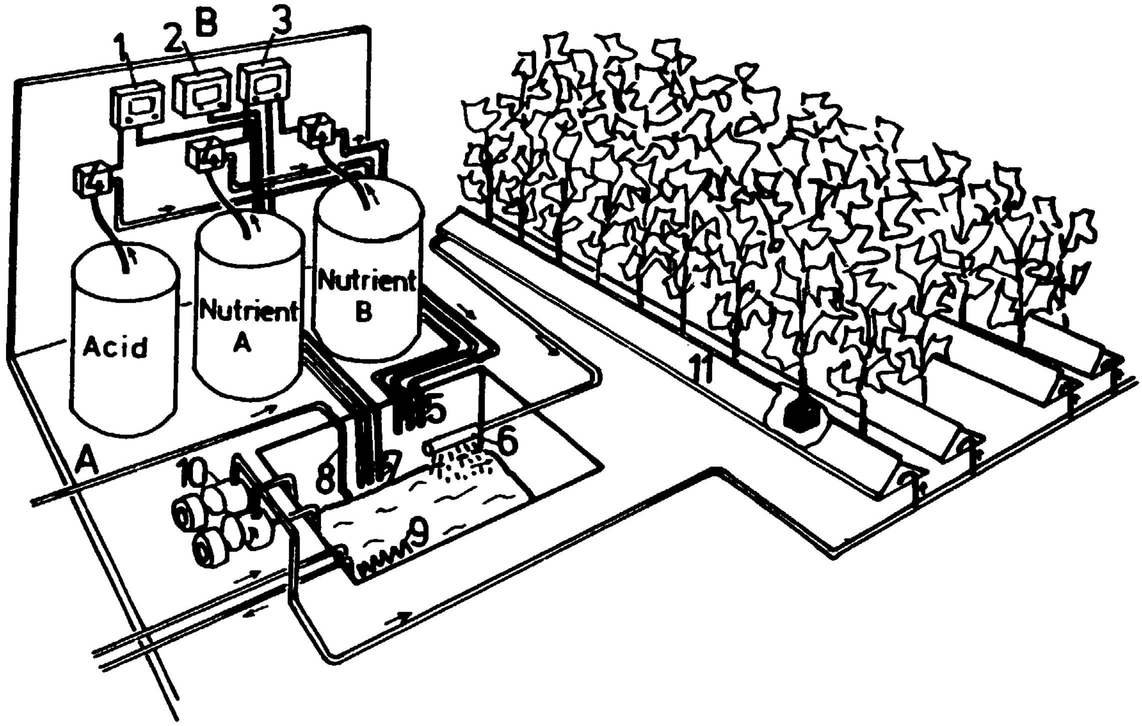

Fig. 5.-1 Scheme of nutrient-film-system: (1) pH-control; (2) temperature control; (3) salt-control; (4) pumps for nutrients; (5) nutrient supply; (6) aeration; (7) measurement of pH, temperature and salt concentration; (8) water supply; (9) heating; (10) circulation pumps; (11) NFT channel.

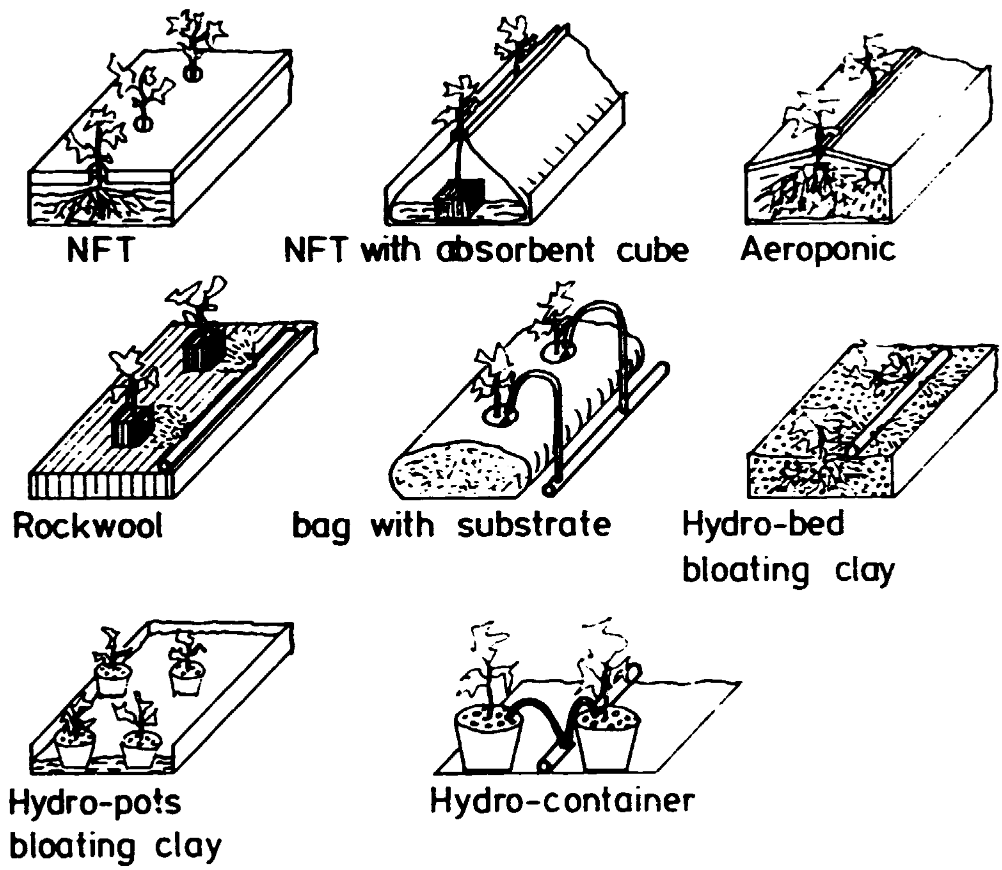

Fig. 5.-2 Different systems for soilless culture.

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MECHANIZATION OF GREENHOUSE OPERATIONS, AND AUTOMATION OF TECHNOLOGICAL PROCESSES ON SHELTERED SOIL.

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Independent of weather and climate conditions the possibility to programme the growing and development of plants as well as fulfilment of production processes in one technological flow makes the plant growing close to industrial way of production. The industrialization of protected ground operations may be achieved on the basis of continuous introduction of the up-to-date cultivation facilities, machine systems and intensive technologies.

Scientifically approved norms of man dietary envisage the equal consumption of vegetables all the year round. To achieve it the combination of open and protected ground vegetable production is necessary. The total volume of vegetables consumption per person according to the Dietary Institute of the Medical Sciences Academy of the USSR has to be about 125 kg annually, including cucumbers, tomatoes and green grocery which can not be preserved fresh for a long time (50 kg).

Recently this country has seen a transition from non- mechanized low scale hangar hothouses to integrated block hothouses suitable for machine treatment which considerably changed structure and size of cultivation facilities.

In the USSR the hothouse machine complexes are mainly designed by Scientific Research and Manufacturing Enterprise of Agricultural Engineering (VISKHOM), in particular by protected ground machine complexes department, established in 1973. Work is carried out in cooperation with the State Agricultural Design Bureau on protected ground macninery located in Leningrad. Within the VISKHOM department which presently has personnel of 55 there are scientific research and design and test laboratories for general purpose hothouse machines, seedling cultivation machines, hydroponic block modular systems and scientific and research group for testing and implementation of new machinery (in sovkhoz "Zarechie") , which is in fact a model farm for testing of new complexes.

In cooperation with the State Agricultural Design Bureau the department designed the hothouse machine complex suitable for mechanization of labour consuming processes on soil substrates and transplant mixtures preparation.

The most efficient machine complex may be elaborated on the basis of systematic researches.

The protected ground is a complicated technical system of high integration and uncertainty. That is why when creating machine complexes for hothouses the research covered not only technical system elements but intrrelations between them.

The hothouse machine complex as a system has a common purpose function, realized in a restricted number of technological operations. The complex integrity manifests itself, first, in the unity of restictions, and secondly, as a system in interrelation when machines are functioning

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in the entire technological process. Thirdly, the system integrity is determined by the common purpose of her components, revealing in the informational content of the ready product (weight, quality, cost price).

Introducing the hothouse machine system as a purpose oriented integrity we define it as complex of machines with their functions and connections, built on the common conception base, having the common aim of receiving the protected ground production and common restrictions, stipulated by hothouse conditions.

The system synthesis has been held on the basis of its structure and machine characteristics. The set of machines with extrs producing characteristics was defined by means of integral linear programming.

As a result the vegetable cultivation machine complex for block hothouses was optimized. The machine design work was carried out on the research basis according to the soil cultivation norms. That is how the first level of plant growing industrialization on protected ground has been achieved.

In cooperation with the State Agricultural Design Bureau the department developed the hothouse machine complex suitable for mechanization of the main labour consuming processes in soil substrates and transplant mixtures preparation, harvesting and transportation of hothouse crops, all sorts of weights transportation, tillage and rotavation of soil, plant protection against pests and deseases, cultivation of crops and other operations.

Preparation of soil substrates and transplant mixtures.

Artificial substrates (mixtures) containing two or more constituent components are most extensively used under greenhouse conditions. In fact the majority of greenhouse farms choose to depend on such substrates, their contents being exceedingly variable.

The recommended composition of a transplant mixture (kg per 1 cub.m. of peat) is as follows

- lime	1.7 - 5.2
- ammonium nitrate	0.5
- potassium nitrate	1.0
- double superphosphate	1.0
- magnesium sulfate	0.3
trace nutrients, g :	
- copper sulfate	3.0
- ammonium molybdate	6.0
- manganese sulfate	11.0
- zinc sulfate	3.0
- boric acid	3.0
- cobalt nitrate	3.0

The approximate composition of soil substrate is given below, %%:

High-bog or transitional peat	70
Cow dung	10
Sawdust	10
Earth	10
Lime (based on the assessment of peat acidity)	
or	
High-bog peat	50
Lowland peat	40

Cow dung	8
Sawdust	2
Lime (based on the assessment of peat acidity)	
or	
Transitional peat	50-60
Sawdust horse manure	20-30
Field earth	20
Lime (based on the assessment of peat acidity).	

The machinery used in this country to prepare earth peat substrate includes the following items:

- Model STM-8/20 plant for preparation of soil mixtures, peat composts and other peaty substances, equipped with dosing tanks.
- Production line for preparation of soil and transplant mixtures.
- Machine for preparation of soil mixtures and their loading into the IGT-10 model soil-block press.

The STM-8/20 plant (fig.1) is a ststionary installation which consists of several major units, viz. mixing chamber, roller screen, three dosing tanks, feed conveyer with fertilizer hoppers to apply mineral fertilizers, unloading conveyers, disposal transporter to remove waste from the rotary riddle, and operator's site.

The mixing chamber contains a cylinder with the blades ranged externally along the four-peatched screw thread. The working zone of the bladed rotor is protected by a cylindric case with the inlet neck and the outlet opening.

Cut through the case is a hole with the collapsible protecting lid to have access to the blades whenever their inspection or dismantling is deemed necessary. Between the blades and over the cylinder, in the working zone, there are angle knives (intensifiers) fixed on the shaft admitted from the outside.

The roller screen contains shafts fixed in bearings between the rigidly bolted lower and upper parts of the framework.

The dosing tanks are made of two parts each, i.e. a collecting box with outlet port opened by means of a lever mechanism and a conveying chain belt that forms the movable bottom of the tank. The plumb-walled collecting box is installed on the supporting frame above the conveyer. The conveying belt (the movable bottom of the tank) is manufactured either of a plain rubbered cloth (for peat, sawdust and soil mixtures) or of corrugated rubber (if the tank is being filled up with manure).

The belt is locked into the endless chain conveyer set round the driving and the driven cylinders. Between them, there are supporting star wheels attached to the frame. The drive from a geared motor is situated on the plate welded to the supporting frame under the conveyer.

The feed conveyer is mounted on a framework that ensures its motion in hirizontal and inclined planes. The driving shaft is placed where the horizontal plane passes to the inclined one. All along the frame there are supporting pinions that guide a scraping belt locked into the endless chain transporter.

The fertilizer hoppers, model ATD-2, are used as the sources of mineral fertilizers to obtain enriched soil mixtures.

The unloading conveyer is similar to the feed one in terms of construction but it is higher and have no fertilizer hoppers.

The disposal transporter is mounted on a welded tube frame. It consists of a plain belt placed horizontally on two motor driven drums.

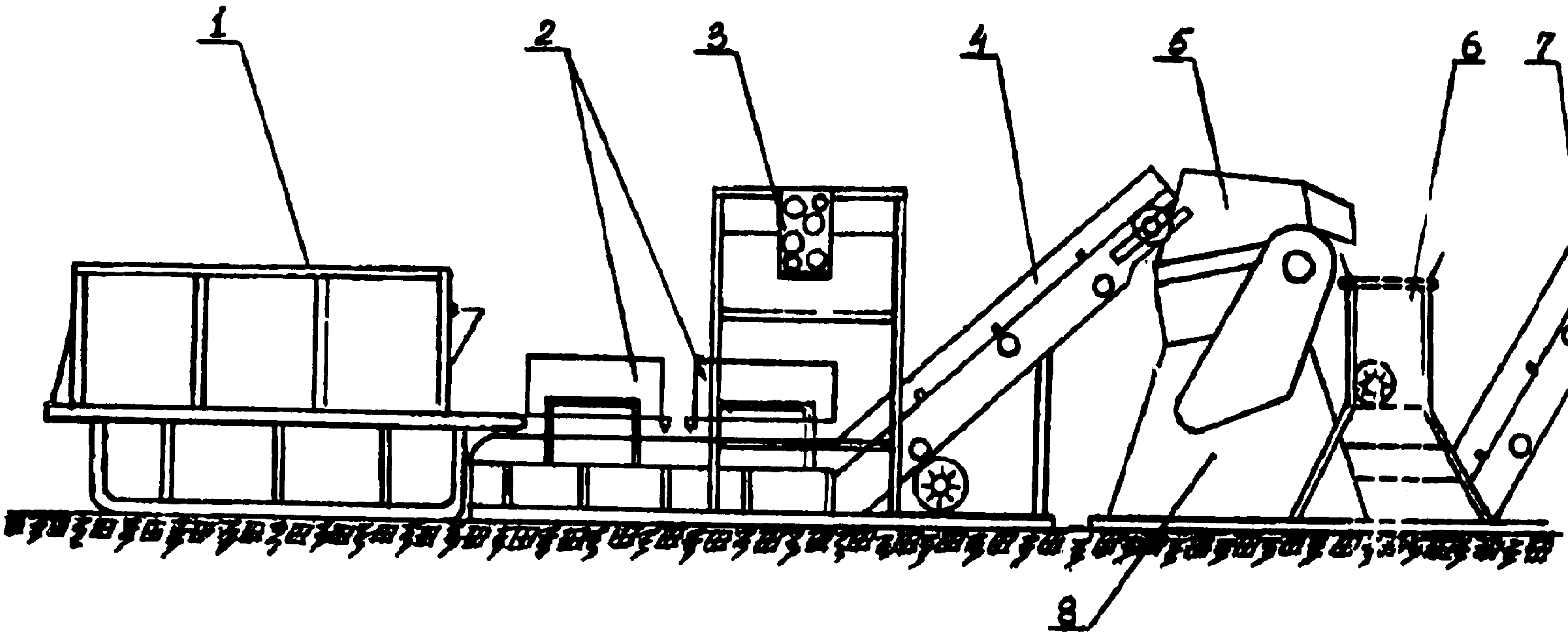

Fig.1
Principal layout of STM-8/20 machine for making of soil, compost and mixtures nith dosing unit:

1 - dosing tank;
2 - capasities for mineral fertiligers;
3 - operator's site nith control board;
4 - feeding conveyer;
5 - roller screen;
6 - disposal conveyer;
7 - unloading conveyer;
8 - mixing cliamber.

The operator's site is a platform elivated over the feed conveyer to ensure observation of all the units of the machine in work. The sight supports the control panel that enables the operator to shut in and off either selected units of the plant at large. There is a screen over the sight to protect the worker from atmospheric precipitation.

The machinery is intended to produce mixtures using the technological process as described below.

To ensure the continuity of technological process, constituent components of the mixture to be prepared are delivered and heaped up beforehand at the working sight in the proximity to dosing tanks. The size of the outlet openings in each of the tanks is selectively adjusted to secure the required discharge of a given component in compliance with its percentage in the mixture.

The production cycle starts with loading of the tanks with mixture constituents and hoppers with mineral fertilizers. The hoppers must previously be adjusted so as to ensure the predetermined application rate. As soon as the plant is put into operation, the doseng tanks are loaded with the components of the mixture using a loading machine. When passing under the fertilizer hoppers they are additionally enriched with nutrients. They are thereafter delivered to the roller screen where undergo partial desintegration followed by bolting to remove large sized particles. After such a handling the material enters the mixing chamber where the bladed rotor communicates rotatory motion to the particles that are made to form a suspended layer spinning under the effect of centrifugal force. Intensifiers over the upper part of the cylinder cleave the layer, and the particles are allowed to repeatedly fall down on the blades which facilitate mixing of the components. The finished product (mixture) is discharged through the outlet opening on the unloading conveyer which delivers it to a vehicle.

Output of the STM-8/20 plant, tons per hour of net working time	23
Consumed power, kWt	14
Personnel	2
Weight, kg	3690

For small structured soil and transplant mixtures preparation the specialized line (fig.2) has been developed.

The line is designed for simultaneous carrying out of following technological operations: crushing, bolting and dosing of components, mineral fertilizer application mixing and loading of the prepared substrate to the transport means.

The line consists of the following units:

1. Crushing machine model RMK-010 (fig.3).
2. Bolting machine model RM5-011 (fig.4)
3. Conveyer MF1-014 to transport substrates.
4. Model STM-8/20 machine for preparation of soil mixtures, peat composts and peaty substances.

The substrate components crushing machine is designed for crushing of peat, mineral fertilizers, soil, as well as mixtures of above mentioned components.

The components crushing machine consists of the following parts: frame with single axle shassis, plank feed conveyer 2, loading tank 3, hammer rotor 7, discharge conveyer 8, electric equipment with control panel 4, latch 5, cage of the hammer rotor 6, support, regulated as for height 9, and working site (fig.6).

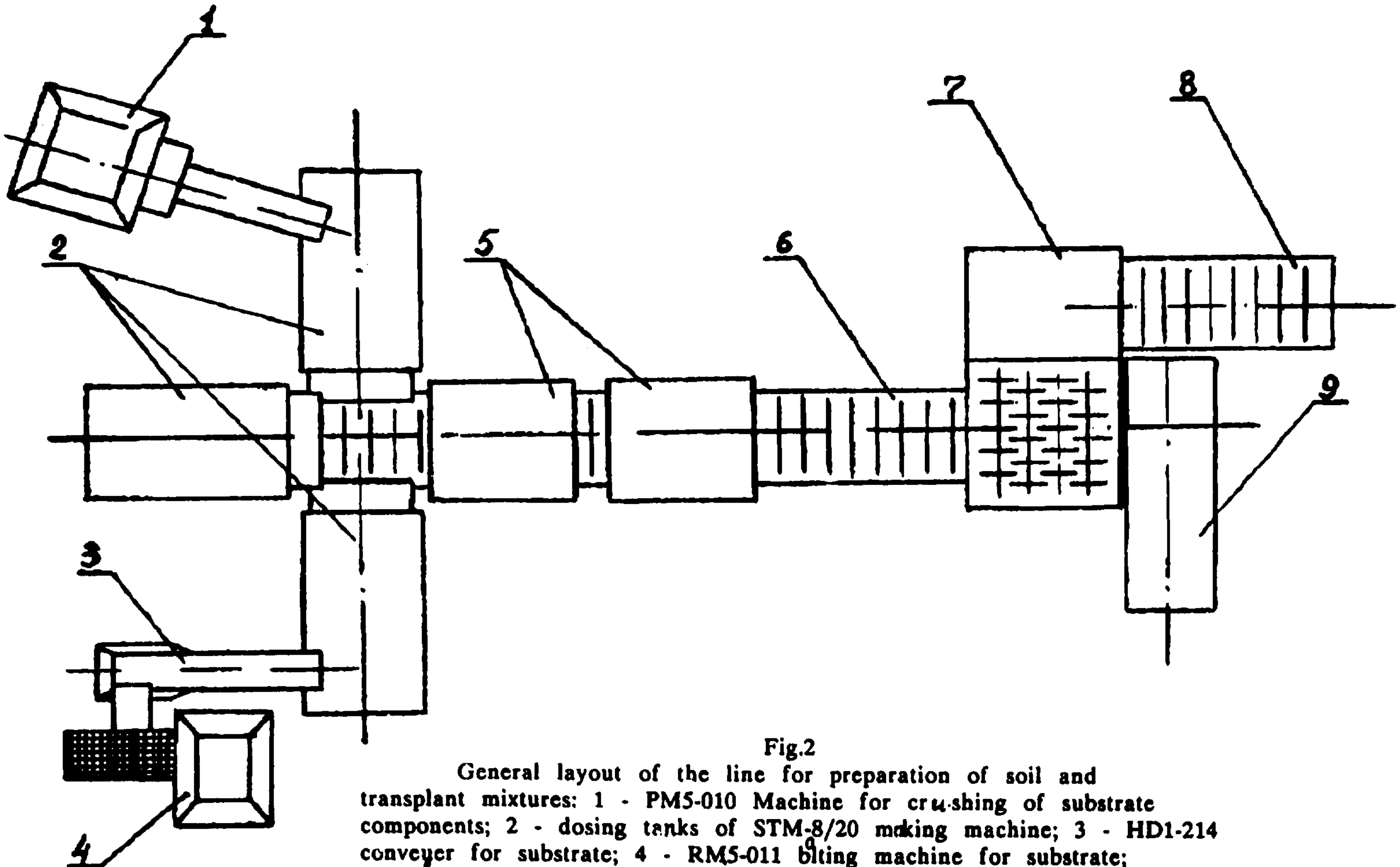

Fig.2

General layout of the line for preparation of soil and transplant mixtures: 1 - PM5-010 Machine for crushing of substrate components; 2 - dosing tanks of STM-8/20 making machine; 3 - HD1-214 conveyer for substrate; 4 - RM5-011 bolting machine for substrate; 5 - capacities for fertilizers; 6 - STM-8/20 machine feed conveyer; 7 - roller screen nith mixing chamber of STM-8/20 machine; 8 - STM-8/20 unloading conveyer; 9 - disposal conveyer.

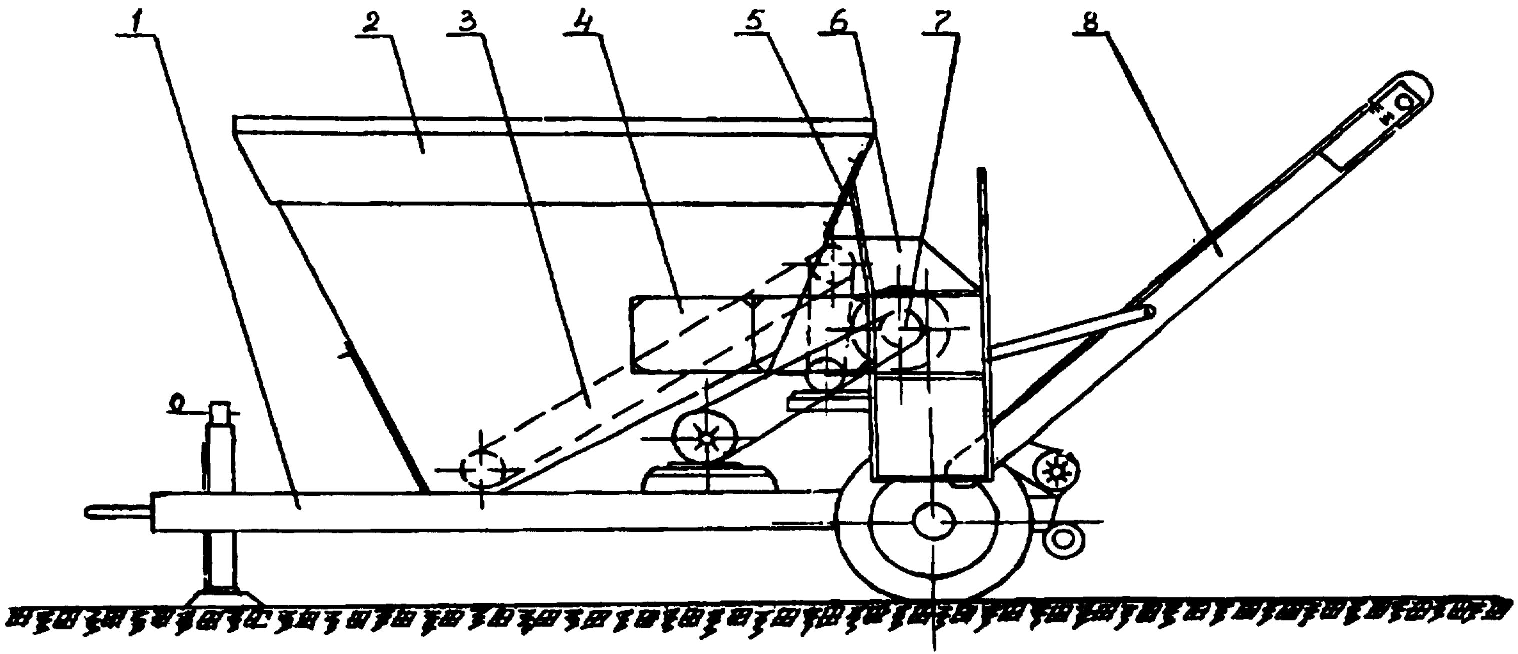

Fig.3

Principal lauout of the RM5-010 machine for crushing components of the substrate: 1 - frame with a single axle chassis; 2 - plank coneyer; 3 - fieding tauk; 4 - control board; 5 - feuder; 6 - cage of the hammer rotor; 7 - Hammer rotor; 8 - unloading conveyer; 9 - support adjusted as for the height.

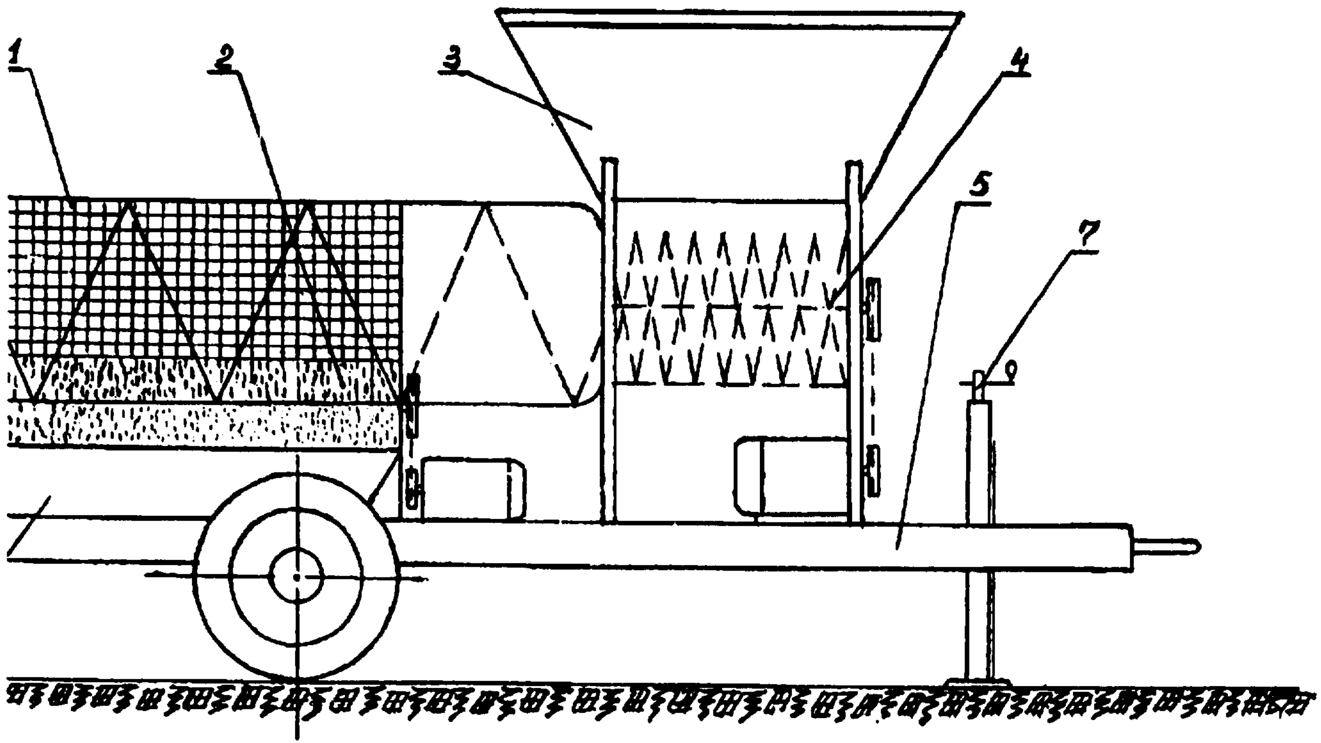

Fig.4

Principal layout of the RM5-011 substrate bolting machine: 1 - bolting cylinder: 2 - brush; 3 - feedingtank; 4 - screw conveyer; 5 - frame with a single axle chassis; 6 - unloading conveyer; 7 - support adjusted asfor the height.

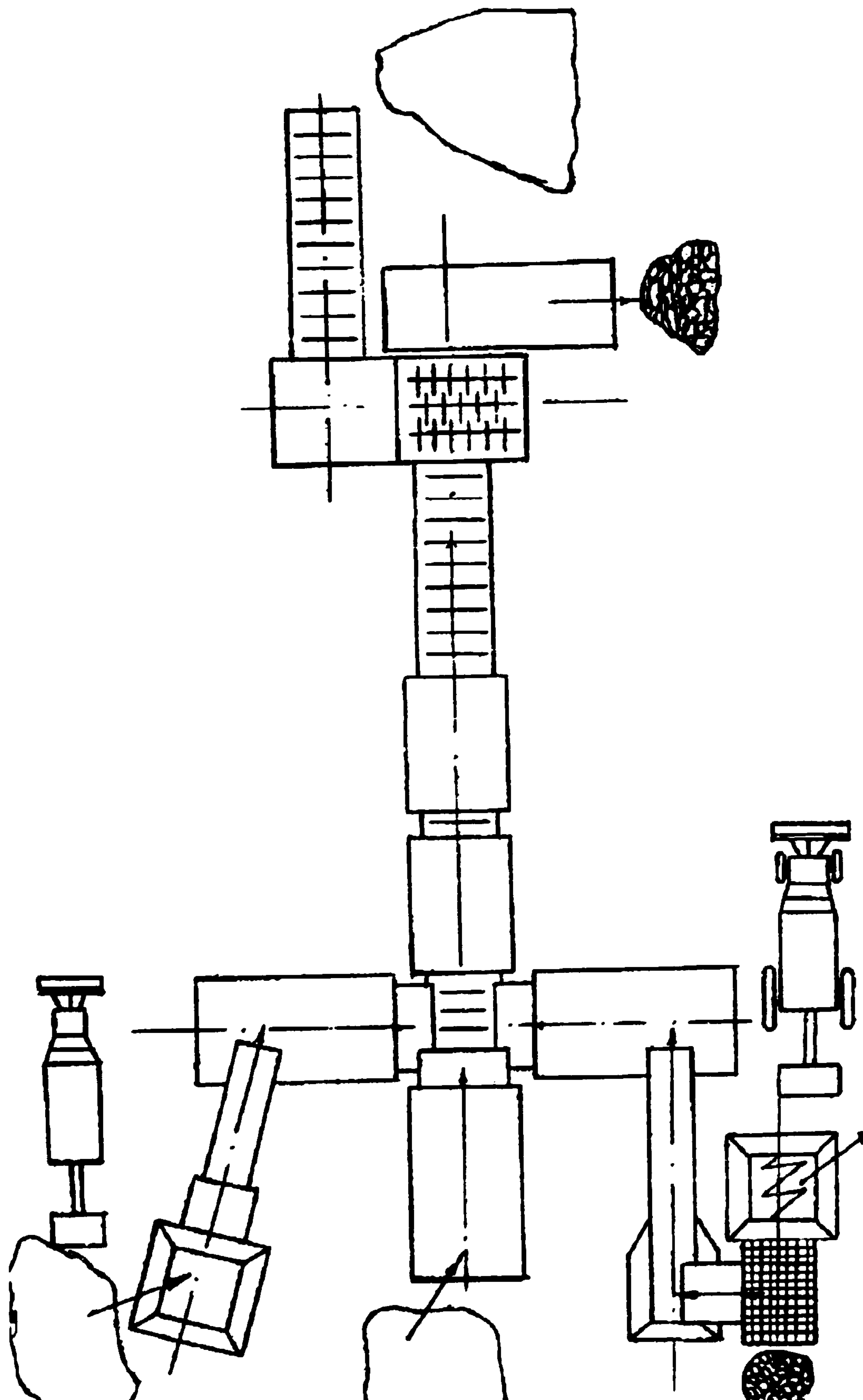

Fig.5
Technological layout of the line for preparation of soil mixtures.

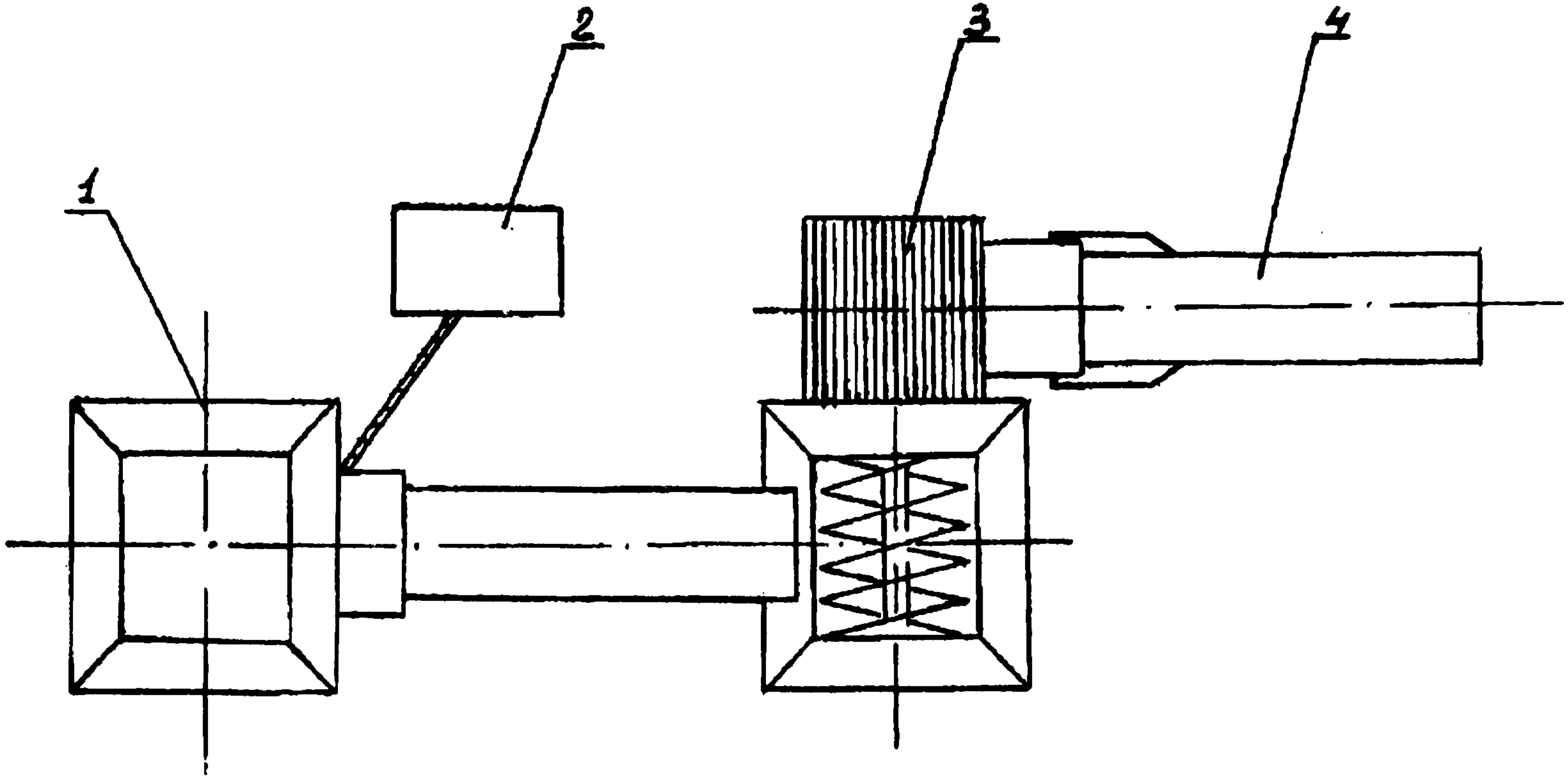

Fig.6

General layout of the line for the preparation of trausplant mixture: 1 - RM5-010 machine for crushing of substrate components; 2 - OZG-120A sprayer for protected ground; 3 -, RM5-011 substrate bolting machine; 4 - HD1-214 substrate conveyer.

Fig 7.
Combined rotary tiller model MPT 1.2

The main working part is a rotor consisting of 4 raws of hinged hammer beaters. The rotor is installed in the metal chamber the lower part of which has a counter-reflecting bar. The rotor is driven with the electric engine through the belt transmission. The rotor can operate in two regimes: 970 rev./min and 1465 rev./min .

The chain plank conveyer is installed in the chamber to discharge desintegrated components.

Afterwards the components are fed to the tank, the bottom of which is locked pl?nk conveyer.

The RM5-011 substances bolting mill is designed for removing of the admixtures with particles exceeding 20 mm from the components.

The substances bolting mill consists of the following parts: frame 5 with a single axle shassis, bolting cylinder 1, brush 2 for cleaning the bolter, loading tank cylinder 3, screw conveyer 6, electric equipment, operator place and support 7 (fig.4).

For bolting of the components the bolting cylinder installed on rollers is used.

Inside the cylinder on a screw line the transporting ribs are arranged which provide the conveying of the bolted material during the cylinder rotation. The cylinder surface is made of grate with 20x20 mm sells.

The brush is used to clean the sells from the adherent particles of components. The brush is driven by the electric motor.

The feed tank looks like a truncated pyramid. On the bottom of the cylinder there is a screw conveyer which moves the material into the cylinder.

The bolted component is delivered to the discharge conveyer which is mounted under the bolting cylinder. Big sized admixtures fall from the end of the cylinder. The cylinder is driven by the geared motor through the chain transmission.

The bolting cylinder is adjustible as for angle of inclination by changing the height of machine support shank.

The NDI-214 substrate conveyer is designed for substrate components transporting from desintegrator to the bolter. It consists of the support frame 3, loading tank 1, electric drive, driving and driven axles and polyvinilchloride belt.

The design description of STM-8/20 machine was mentioned above.

The operator place is installed above the feed conveyer so that to ensure the observation of units functioning.

There is a control board for switching on and off of separate machine units and the line in general. The fender protects the operator from the precipitation.

The approximate technological process of the soil substrates and transplant mixtures preparating line is as follows:

a) Preparation of soil substrate (fig.5)

The STM-8/20 machine for preparation of composts and substrates has to be installed on a concrete site.

The RM5-010 substrate components crushing machine has to be attached to the peat dosing tank and the RM5-011 substrate bolting machine as well as the ND-1-214 substrate conveyer are to be attached to the soil dosing tank.

To ensure continuous functioning of the line according to the technological process during the working shift the components of prepared soil are to be delivered and clamped on the working site near the dosing tanks.

By adjusting the size of the outlet opening of the dosing tanks the required discarge of given component in compliance with its percentage in the mixture is secured.

The line working cycle starts with excavator's loading of feeding tank of the RM5-010 component crushing machine with peat, wherefrom it is conveyed to the STM-8/20 machine dosing tank by the unloading conveyer of the crushing machine.

Simultaneously the second ex.avator loads the RM5-011 bolting machine with field soil and also loads the third dosing tank with manure.

The bolted soil is delivered by the NDI-214 conveyer to the STM-8/20 machine dosing tank.

The tanks of the mineral fertilizer application machine are filled with lime and mineral fertilizers.

The dosing tanks units are adjusted to secure the required output of fertilizers.When starting the line the components from the dosing tanks in the required volume are conveyed to the feed conveyer where the mineral fertilizers are applied into the prepared mass. From the conveyer the components are delivered to the roller screen of the mixing chamber where they are additionally reduced to fragments and cleaned from the large sized particles, which are disposed into waste by the conveyerwhile the bolted components are conveyed into the mixing chamber.

In the mixing chamber the components are mixed and through the mixing chamber outlet opening and discharge conveyer the prepared substrate is either loaded to the transport means or clamped by excavators.

b) Preparation of transplant mixtures (fig.6)

The soil ports, where the vegetable seeds are planted to grow for seedling, are made from the translant mixtures by the machines IGT-10 (USSR) and Bs-1 (Chekhoslavakia).

The transplant mixture is made from the soil prepared beforehand (fig.12) or directly when making soil substrates.

To prepare transplant mixture from the previously prepares soil substrate the RM5-010 substrate components crushing machine, RM5-011 substrate bolting machine, NDI-214 substrate conveyer and OZT-120A sprayer are used.

The technological process of the transplant mixture production is as follows.

The excavator loads ready soil substrate into RM5-010 crushing machine tank, the OZT-120A sprayer feeds into it certain doze of microfertilizer solution.

The ruffled and additionally desintegrated by the crusher mass is fed to the bolting machine tank, wherefrom the particles of more than 20mm size are disposed to waste and the bolted substrate is delivered by the NDI-214 conveyer to the transport means.

When a large volume of the transplant mixture is not required in the period of the period of the soil substance preparation all the machines of which the line consists are arranged in the following sequence: STM-8/20, RM5-011,RM-5-010 and NDI-214. In this case the OZT-120A sprayer feeds the solution of microfertilizer directly to the mixing chamber of STM-8/20 machine. The initial components (peat, horse manure, field soil) are loaded to the STM-8/20 machine dosing tank.

Then the feed conveyer carries the necessary mineral admixtures from the unit for mineral fertilizer application. The ready soil mixture is directed from the discharge conveyer to the desintegrating machine and then to the bolter. From the bolter the transplant substrate is delivered to the transport means by the NDI-214 conveyer.

The principle operating parameters of the line are as follows:

Type of the line	stationary
Driving mechanism	electric
Electric engine power, kWt	35.3
Output, tonnes per hour of net working time	
for soil preparation	23
for transplant mixture preparation	8-10
Crew	5
Dimensions, mm	
length	14800
Width	1550
height	2750
Mass, kg	8600

Calculation of the principle operating parameters of the production line:

a) Calculation of the output of the dosing tank.

The output of the dosing tank is considered to be a continuous process that includes both dosing and transportation of the soil layer.

$$n_\delta = 3600 \cdot \gamma_c \cdot \ell \cdot \int_0^H \int_0^V dH\,dV = 3600 \cdot \gamma_c \cdot S \cdot V_{cp}$$

where: n_δ - output of the dosing tank, kg p.h.

3.600 - conversion factor, seconds per hour

γ_c - volume weight of the mixture, kg/ cub.m

l - width of the outlet opening, m

H - height of the outlet openinng, m

V - average speed, m/sec

S -area of the outlet opening

b) Calculation of the axial speed of mass yield

$$V_{oc} = 2\pi \cdot n \cdot tg\alpha \left(\frac{R_{max} - R_{min}}{2}\right) \cdot 2 = \frac{\pi n \cdot tg\alpha\,(R_{max} - R_{min})}{60}$$

where: V_{oc} - axial speed, m/sec

n - revolutions per minute

α - angle of lead, degree

Rmin- minimal radius of the mixer;m (at the blade base),

Rmax- maximal radius of the mixer (at blade tips)

c) Calculation of the output of the mixer

$$Q = 47{,}1\left[(d + 2\ell)^2 - d^2 V_x \psi \gamma\right]$$

where: l - clearance between the blade tips and the case wall, m

d - diameter of the rotor shaft, m

ψ - load factor for the mixing chamber

γ - volume of mixture, cub.m/h

In this country soil tillage in greenhouses is effected with the aid of rotavators guided by the 0.6 ton power take off driving shaft.

The main working tool is the tiller rotor with knives uniformly fastened all along its length.

The shape of the knife facilitates its entering the soil, turning soil slices and their desintegration.

Of special interest is a combined rotary tiller model MPT- 1.2 (fig.7), which can be used for both deep ploughing (28-30 cm) and shallow rototilling to the depth of 18 cm.

The main units and parts of the MPT-1.2 rotary tiller include bracketed framework, drum axle with working parts (knives), cardan axle, reducing gear box, side drive, lateral face, beam to carry crushing appliances, supporting constructions, case, protected sleeve and screen.

The device being put into operation, the knives of the revolving drum cut off soil layers and communicate rotatory motion to them. Since the rotation speed used to the minimal during ploughing, uplifted soil slices are expected to gravitate upside down onto the furrow bottom. During rotary tillage the speed of the revolving drum is maximal therefore, the cut off soil is violently cast away by the knives to the crushers and on the case walls to be additionally crumbled. The soil surface is leveled by the screen, the depth of ploughing is controlled by vertical rearrangements of the supporting structures.

The degree of furrow slice disintegration in the course of rototilling is dependent on both the rotation number and the position of the screen over the soil surface.

The operating conditions of the MPT-1.2 rotary tiller are mantained as follows:

- output ha/h	
- ploughing	o,27
- rotavation	0.24
- cutting width , m	0.15
- cutting depth, cm	30
- weight, kg	630

Self-propelled shassis , models T-16M, SSh-28T are the principle means of transportation in greenhouse gardening. Their small size and high mobility under conditions in question allow the obeying widely used to transport soil, manure, waste, fertilizers, etc.

The harvest is commonly transported in tractor mounted hydraulic fork loader.

After having been stowed in boxes by the operator the crop is moved in hand carts along the registers to the concrete runway in the central passage of a greenhouse where the boxes are put together on a special pedestal and thereafter transported by the fork lifter to the warehouse.

The carts are rather simple in terms of design, their constructional elements are shown in fig. 8.

The programme of greenhouse building in this country envisages construction of centrally operated spraying systems to control pests. At the same time self-contained sprayers are widely used i.e. apparatuses with individual tanks for pesticidecontaining solotions, autonomous driving mechanisms and spraying appliances.

One of them the OZG-120A sprayer is shown in fig. 9.

The device is under greenhouse conditions to treat plants with a variety of chemicals, e.g. to control pests and pathogenic agents affecting crops with the help of pesticides or carry out extra-root feeding liquid fertilizers.

The sprayer can be made use of whenever shading solutions are to be spread over or washed out from the roof of a greenhouse. ALso, it is operative if disinfection is needed.

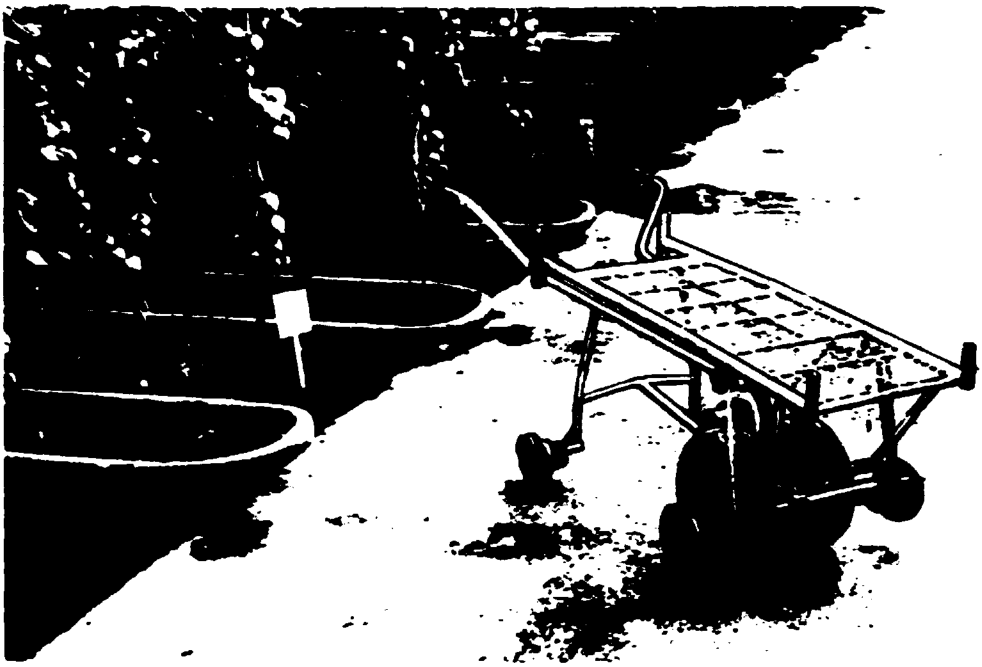

Fig 8.
Carts TUT-100

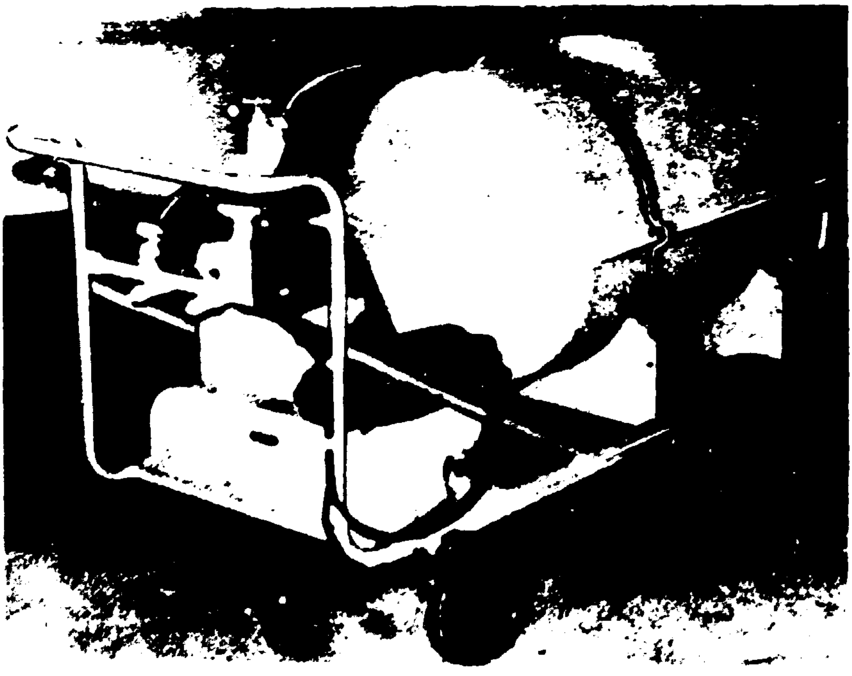

Fig. 9
Sprayer OZG-120A

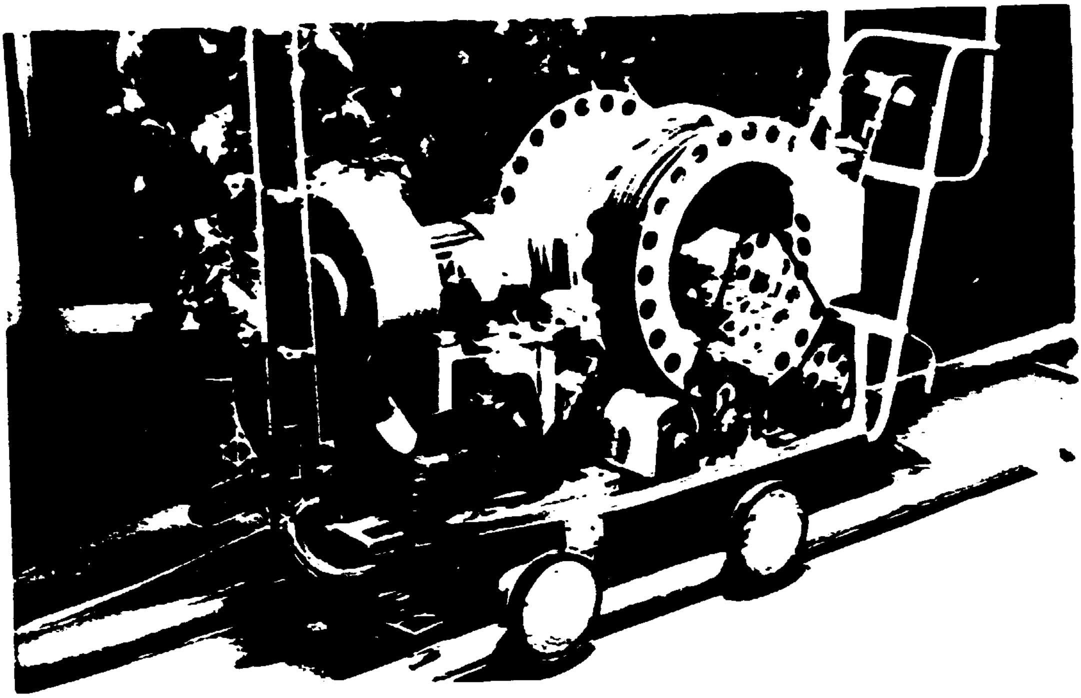

Fig 10.
Sprayer ATOS-0.5

The sprayer has supplementary interchangeable parts for extra-root feeding.

Technical specifications of the OZG-120A:

- output, sq.m.per hour	800-1400
- electric motor power, kWt	2.2
- pump pressure, kgp/sq.cm	up to 18
- capacity, l	400
- dimensions, mm	2000x900x1200
- weight, kg	270

Another model, the ATOS-0.5 automatic sprayer, is used in block greenhouses. It is an electrically driven apparatus fed with working solutions from the greenhouse central feeding system.

The model ATOS-0.5 sprayer (fig.11) is mounted on a selfpropelled chassis and consists of a vertical boom carrying spraying appliances, centrifugal fan with two outlet windows for supplementary nozzles, feeder cable-drum, drum for the supply hose to deliver working solutions from the central system,cable and hose reeling facilities, electric engine to drive wheels of the chassis and fan axle, torque distribution shaft, handle to displace the sprayer from one register to another, operation cabinet to automatically control the motion of the sprayer and its work at large. There is a remote control board at one end of the cable for the same purpose.

All the units and mechanisms of the sprayer are placed within the casing, except for the boom and the ventilator.

Technical specifications of the ATOS-0.5:

- output, sq.m. per hour	1.000
- operating speed, km p.h.	1
- working height, mm	up to 2.500
- consumed power, kWt	1
- dimensions, mm	1.500x650x1.200
- weight, kg	120

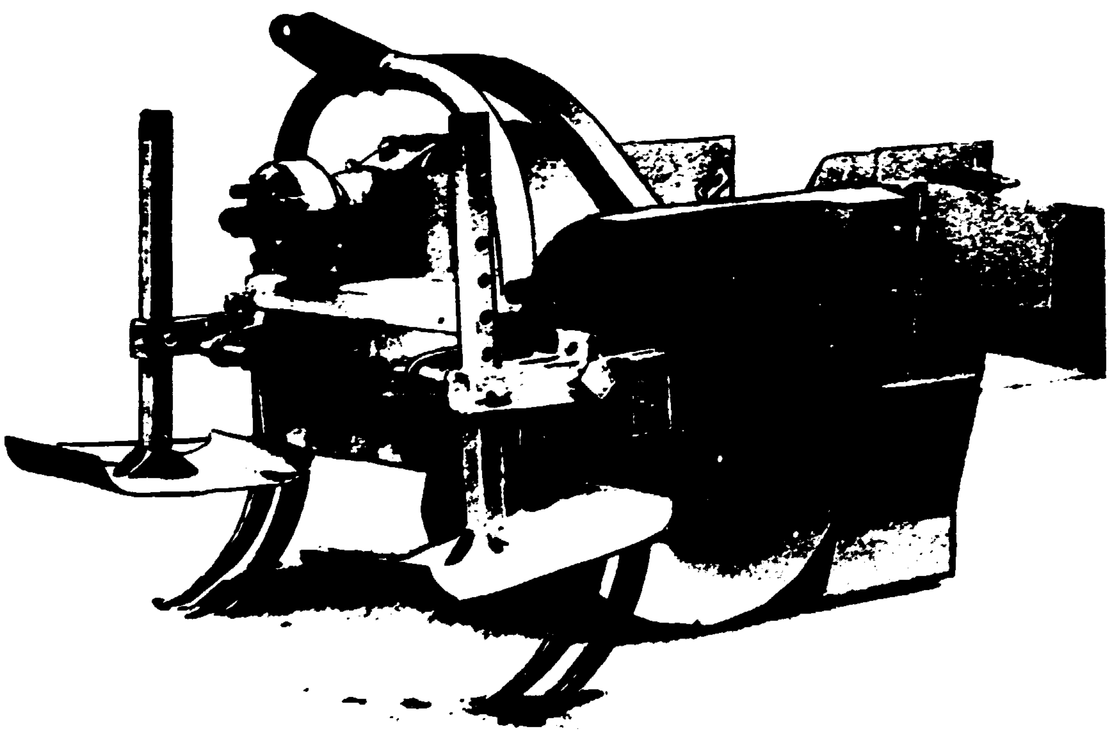

Fig 11.
Automatic sprayer MBZT 1.0

According to the technologies applied and methods of vegetables cultivation in hothouses a number of specialized machines has been developed.

The machine for making furrows and conveying straw bales MBZT-1.0 is intended to make furrows for placing straw bales and covering them with soil when growing vegetables on bales in block and plastic-clad hothouses and to shape seed beds by furrowing.

It is mounted on the "Universal-445Y" tractor.

Specifications:

- output, linear m/h	
furrowing	1200
covering bales	2400
- operating width, m	
furrowing (across furrow bottom)	0.55
covering bales	0.95
- operating speed, km/h	1.5
- overall dimensions, mm	1360x1250x1040
- mass, kg	275

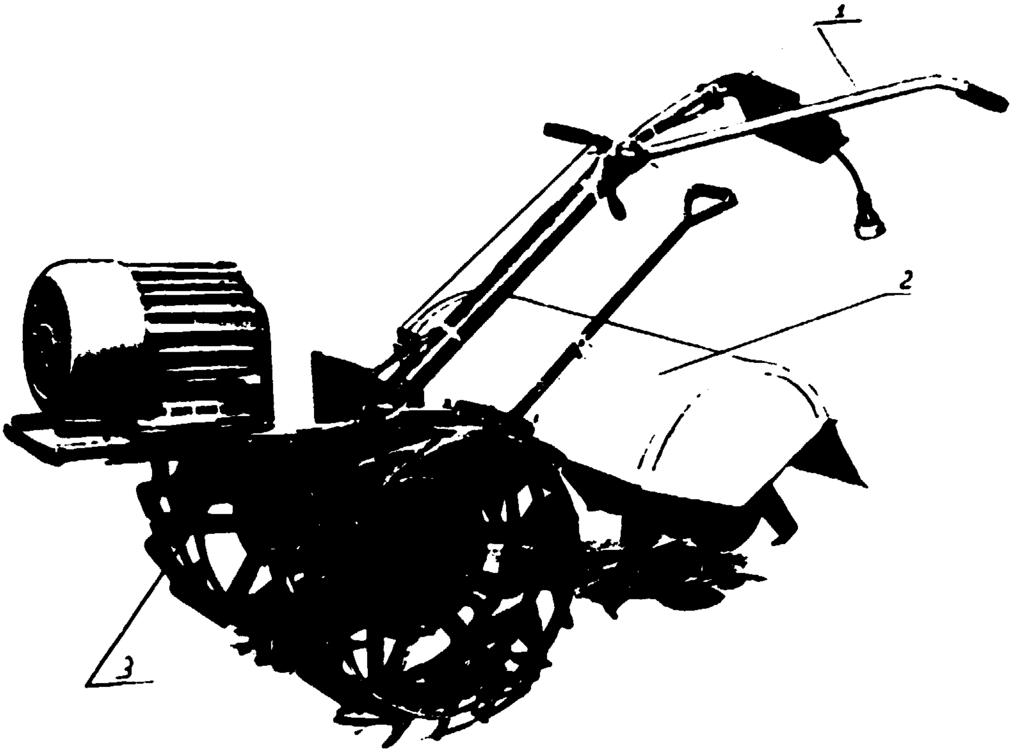

Fig 12.
Electric rotary filler FS-0.7A

Hand-held electric rotary tiller for protected ground FS- 0.7A.

It is intended for cultivation of soil in all finds of hothouses, hotbeds and adjacent plots for preparation of soil mixture and sterilizing the soil by mixing it with toxic agents.

Specifications:

- output, cub.m/h	790
- working width, m	0.7
- tilling depth, cm	6-20
- mains voltage, V	380
- overall dimensions, mm	1835x770x(840-1490)
- mass (less attachments), kg	131

Mounted mineral fertilizer applicator RMU-8,5 is intended for surface application of granulated and powdered mineral fertilizers in block hothouses and on open ground.

Works in conjunction with the "Universal-445Y" tractor.

Specifications:

- output, ha/h	0.9
- operating width, m	4.5
- operating speed, km/h	2.5
- application rate, kg/ha	7C-1000
- hopper capacity, kg	270
- overall dimensions, mm	1360x1390x1055
- mass, kg	143

Tomato flower pollinator OTsP-65 is designed for artificial pollination of tomato flowers in hothouses by shaking the pollen down from inflorescences.

Specifications:

- output, inflorescences/h	2000
- motor supply	storage batteries
- voltage, V	9
- motor power, W	3,6
- vibration amplitude, mm	1.15
- vibration frequency , Hz	65
- overall dimensions, mm	505x40
- mass, kg	1.45

Reducing of labour consumption when growin the vegetables in hothouses is possible only by mechanization and automatization of operations which now are carried out by hand.

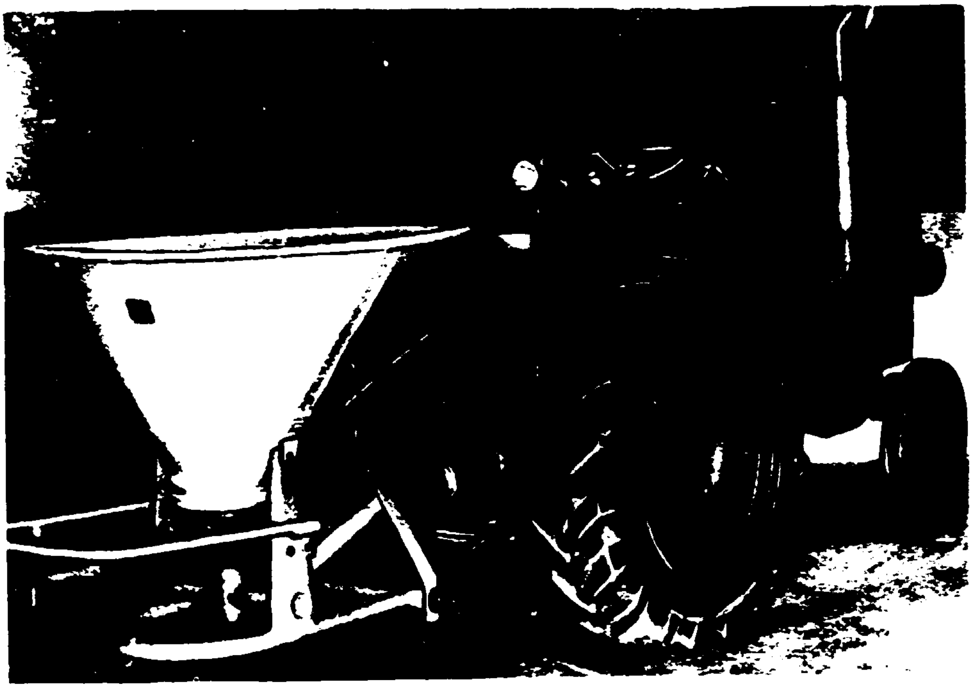

Fig 13.
Applicator RMU 8.5

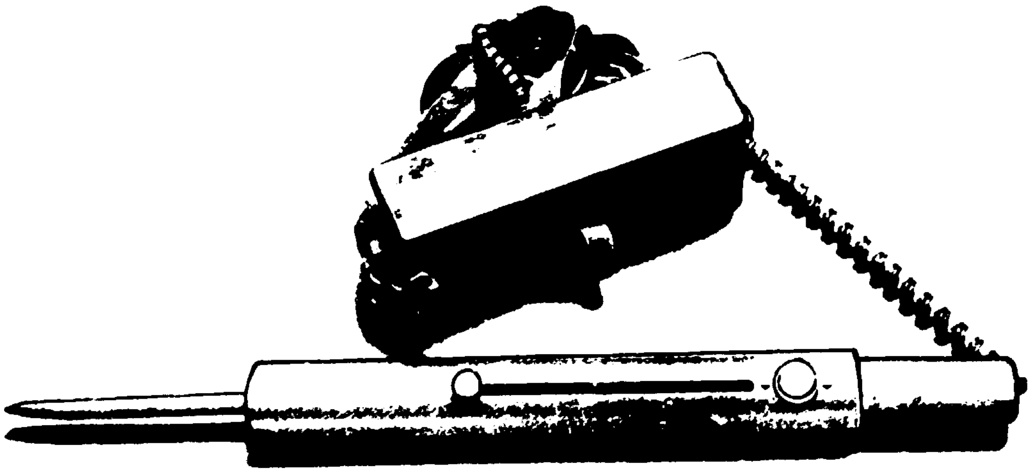

Fig 14.
Pollinator OTsP-65

SINGLE-SHELF HYDROPONIC SYSTEM FOR GROWING VEGETABLES

J.Groiss *

Dear ladies and gentlemen,

I would like to welcome you cordially at the symposium here in Moscow and inform you on my experience in the field of hydroponics within the close system and my attitude to it in brief.

A few words about myself.

I am over 50 now and I deal with hydroponics for 16 years. I am a skilled engineer in machine building and from my early years I am engaged with agriculture. Especially in growing vegetables and ornamental plants.

Then 16 years ago I have learned th at such state of things in agriculture should be changed .Thus the over-using of fertilizers is to make a great damage to the environment. Not immediately, but most likely as time passes.

Unfortunately, my apprehensions were more than justified. But as 16 years ago I was not going to take part in poisoning of environment I decided to use the close system. Since that time we have held agricultural tests only in close system,i.e. growing of plants in nutrient solution by means of hydroponics. I'd like to specify that our firm produces the sets of equipment and has an experimental plant with 16000 sq.m area. All the elaborations made for agriculture and gardening are being tested in our plant for several years before their manufacturing a nd selling.

I am far from considering myself an inventor of h droponics, as it was invented more than 100 years ago Justut fon Liebich who was born in 1803 in Darmstadt and died in 1873 in Munich. A chemist by profession he tried to grow plants in nutrient solution without gumus. Using of mineral fertilizers by Justus fon Liebich considerably improved feeding of plants.

During the last century a numerous attempts have been made in this direction. With this purpose various nutrient solutions have been tried mainly on the plants in the vegetation phase. Information of the success in reproduction of cultures you might meet in literature rather seldom.

Therefore it is not strange that this way of plants growing was limited only by enthusiasts at the experimental stations and bureau and with cultures growing in experimental conditions, climatic first of all.

An installation should be suitable both for a scientist and a practical worker. Inspite of the required expencesit allows to get more reliable and cheaper harvest of plants or part of them (leaves or fruits) of a higher quality as compared to the cu ltures grown in soil.

In this case the production is less expensive as a result of crop increase or rationalization. The guarantee of harvest is provided forby by including such a factor as soil. Recently such aspect as soil became more urgent. Transition to clean mono cultures resulted by the economic necessity in the centers of gardening of such countries as Netherlands, Danmark,Great Britain showed the limited possibilitiesof soil disinfection. Neither steam nor chemical substances used for disinfection to the depth of 90 cm can guarantee irreproachable growing of any cultures even for a year.

It speeds up the process of substitution for synthetic substrates with many new and partly solved problems. Inspite of thet in several years in

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* Proprietor, JG SYSTEM (Engeneering for Mechanical-Electronic Horticulture), Aurtria

Holland a culture grown under hothouse conditions in soil (which is natural for us now) will be a rear thing.

Other factors have something to do with it.The harvest of plants grown in soil is lower. Thus in the initial phase in close system which we call hydroponics by mistake, other substrates are used such as minaral cotton, etc. It results in 10 to 25% i ncrease of crop as compared to good soil cultures.

When growin cultures in soil a numerous regions face such difficult problems as worsening condition of subsoil waters first of all in loams. salts and fertilizers belong to this complex of problems.

The possibility of choice by the plant of a nutrie nt substance in soil is considerably limited because soil loses structureas a result of overusing of fertilizers andbad watering for many years.

The quantity and quality of harvest are constantly decreasing as it is practically impossible to keep the ra tio of nutrient substances because of fertilizers and minerals application.

Watering by means of sprinkling is not natural for hothouses either. Continous rain provides 2mm per hour per hour while watering with the help of a sprinkling head provides for 1,5 to 3 mm per minute.

That were short instructions on the growing of cultures in soil, now we go on studying the question of soil substitution by substrate.

Mineral cotton serves well as a media for plants roots.

The difficulties arise with the removing of waste minaral cotton is used for annual cultures twice and for perennial cultures only once. According to the results of 1985 and 1986 the waste in Holland make about 200000 cub.m.

The minaral wool does not decompose. But the quality of assimilation and enriching of the roots with oxygen represent certain difficulties. Under the continuos watering too little water is absorbing so that the roots can cover their necessity in oxy gen from fresh water. During the watering with intervals the content of salt and pH in the root area is variable.

Due to the above mentioned reasons it is necessary to keep the correlation of nutrient substances within the narrow borders. It is necessary to take into account constant control, purposeful application of nutrient substances and nutrient solution i n relatively short intervals. Subsoil waters pressure also makes considerable problem.

Besides this fertilizers are quite expensive despite the possibility of utilization of cheaper substitutes of conventional agricaltural fertilizers. After it was found out we realized that one can not follow the traditional way because we are just weakening the influence on the environment but we do not exclude it completely.We were seaking for a way to exclude influence on the subsoil waters a nd environment(elimination of minaral cotton) and we came to the conclusionthat it is necesary to utilize more clean cultures with nutrient solutions.

Her ladies and gentlemen we came close to the following factor. Unfortunately in Central Europe we have inflicted great damage to subsoil water balance trying to get an immediate pure profit . Such an approach is widely spread.By the way it was to a great extend the result of insufficient explanatory work. A farmer in Central Europe should realize that since he has purpose oriented mineral fertilizers application and watering he will not have mineral substances washed out into subsoil waters. Besid es he will get more crops with less expences not over-using fertilizers.There is a well-known regularity that a weak link breaks the whole chain.It's a common thing in Central Europe that the Seller of fertilizers is a consultant at the same that is why we receive too much consultation.

I hope you take advantage of our experience and improve the situation in your country.We believe w e manage to bringthe subsoil waters to the normal conditions within 20-30 years to come. I will touch upon this issue at the end of my speech.

Dear ladies and gentlemen. We are also dealing with such technologies as tray cultures or thin film technology (NFT).

We are not working intensively on thin film culture, as the preparation of liquid feeding is quite expensive and damages the environment. At the same time there are problems with enriching of nutrient solution with oxygen.

Thus we consider this system to be erraneous because of expensiveness and environmental protection above all. The thin layer technology (NFT) is rather close to the system which we have elaborated. In practice a numerous problems arise such as lack of oxygen in the roots in case of intensive water flow,exceeding of allowed speed of solution flow in the tube s with small diameter and sharp changes of temperature and ph of pH flactuation in the solution during the day.

There are no wide possibilities of using thin film technologies in regions with warm climate. As difficulties with a strong sun irradiation under the thin film technology are rather hard to overcome. It is as far as other systems are concerned.

Now let's study our system which we have developed and manufacture and which is to be the subject of my report.

When elaborating our hydropomic system we were guided by the following criteria.

1. We should avoid pressure on subsoil waters.
2. The nutrient solution can not be changed during the air, fresh water should be constantly delivered to the main tray - I will give a detailed description of the system below.
3. Optimal feeding of the plant with nutrients, water and oxygen.
4. Provide efficiency
5. All necessary calculations of investments are to be made.
6. The installation should be easily mainteined by a gardener, farmer or engineer.

All these factors were the starting point and were necessary to produce irreproachable, good and cheap food stuff. The cheap price is an important requirement as the growing of crops in close system without inflicting the damage to the environment is senseless if final products will be expensive and inaccessible. Such a system is destined for a failure from very beginning.

After the tasks were set a series of tests were held on extensive areas as only in this case the data received can be used for calculations of efficiency.

Unfortunately large-scale calculations are based on the laboratory tests that is why the practice often disillusions when it is impossible to achieve these fantastic figures one hoped to achieve. We always persue one aim:good and optimal feeding of a plant, not expensive and efficient production of fruits.

During this series of experiments we came across very interesting factors as far as a nutrient solution is concerned. The concentration of nutrient substances contradicts the assumption that the concentration of salts is to be chosen in accordance with various requirements of cultures, while the concentration of ions in the solution has not considerable importance.

But it is evident that ions content per a unit of volume influences the efficiency of the system to a great extent. The density of planting of vegetables such as cucumbers, tomatoes, peppers influences the formation of leaves and crops.

The soil cultures can be planted more densely. The yield of each plant remains the same.

About half of of the plants showed a proportional doubling of the harvest The ratio of nutrient substances has a considerable influence on the yield. Following of the two requirements results in very high crops in the first year of experiments. Experiments showed that 100% and even more increase can be achieved by using our system as compared to the best soil or peat substrate cultures which are widely spread. Naturally the necessary condition is to keep up the concentration of nutrient substances in very narrow borders. The aim is achieved by mixing an extra quantity of nutrient solution in special unit of the separate part of collector. The concentration of nutrient substances lays between 1.5 and 2.5 mS.

The ratio of nutrient substances.

As the experiments showed under certain conditions which are provided for by our hydroponic system, the posibility of choice by a plant is preserved also under the high concentration of nutrient substances.

As compared to the other systems with nutrient solutions it means respectively low ratio of nutrient substances. As dosing of nutrient substances is held in rather strict correlation it is necessary to take into consideration the change of nutrient substances ratio (during the growing of cultures) when composing of the main solution - we indicate as A,B,C and D - to provide for the regulation of pH value.

You may know that when a plant transforms from the vegetation to the generative phase there is a necessity both in quantity and interconnection changes of nutrient substances.One can expect different requirements of species of plants towards another more than from sort to another.

The ratio of nutrient substances for all cultures on all stages of development was provided for cucumbers,peppers, tomatoes, water-melons, eggplants and various ornamental and other plants.

Naturally it is essential to carry out experiments on perennial shrubs.

But the principal correlation of nutrient substances in solution is not a central problem any more, while the three other factors should be exactly used: concentration, oxygen in solution and its pH value. Besides it can be expected that certain additives to the main solutions by more intensive absorbtion of ions by the plants roots influences on the quality.

The only change in the interconnection of nutrient substances which was undertaken for the sake of security was the increase of potassium in the main solution C with consideration of the following factors:

-many sunless days make the absorbtion of ions in favour of potassium and alkaline water requires highly balanced pH value.With more intensive application of solution D, ph value is balanced with nitrogen acid.Also it is necessary to increase the C solution on 10-20% comparatively to solutions A and B.

Now we came close to the most essential factor in hydroponics- content of oxygen in nutrient solution.

Oxygen is a connection link between the concentration of nutrient solution ,pH value and ratio of nutrient substances in solution.

With decreasing of oxygen contentin nutrient solution other mentioned above factors increase in excessive proportion. It became evident after attempts were made to avoid damage inflicted by saltto the water highly enriched with oxygen.

The 15 ppm content of oxygen in water for the plants is equal to the concentration of salt of 6 mS. I underline 6 mS. One can clearly see the importance of oxygen for each plant and its roots often it is the reason of difficulties with synthetic substrates, nutrient solution and soil cultures.

The content of oxygen in water increases with the increase of temperature. Thus under the optomal for growth conditions it excretes less oxygen from the water. While growing of the plants the necessity of oxygen increases thus making another problem.

At various periods of time and under changing climatic conditions the necessity of oxygen for the roots of reproductive cucumbers makes more than 20 mg per hour for a plant.

There is much more to be said about the importance of oxygen absorbtion by the roots. Our experience shows that a plant needs from 20 to 25 mg of oxygen per hour, this quality is obtained under the conditions of thin film technology or in conventional tray modules. When temperature is about 22 C degrees. We have in our disposal from 8 to 8,5 mg of free oxygen for a plant per 1 litre of water. Physics regularities make it impossible to reach higher figures.

It is arranged in our system that the quantity of water is delivered in such a way so that each plant in the tray is provided with sufficient oxygen including the last one in the raw, because we found out that the shortage of oxygen slows the growth of plants.

Our experiments held for a few years proved that in our installation the degree of saturation of oxygen achieved is more than 95 %.

It means that we should provide roots of each plant with a certain quantity of water to obtain sufficient oxygen. Besides oxygen nutrient solution has other very important indices:

1. Decreasing of organic waste as aresult of oxydation (dying of roots, etc.

2. Avoiding of dangeruos concentrations of fungi and fungoid spawns, bacteria or virus.

The first tests showed that it is unlikely that the ill roots can become a hotbed of infection for the entire culture. If there is a sufficient content of oxygen in nutrient solution and additional immunity mechanism works against patogenic microbes in soil. For exact definition of this fenomen further experiments are necessary to be carried out.

It goes without saying that annual plants, e.g. vegetables have their cells or combination of cells torn away around their root system. Normal weather conditions with changing sun intensity duration can cause change in roots stimulation with the coming of generative phase as a result of lack of oxygen, i.e. unaerobe media it can easily appear infections because of putrefactive bacteria.

It is supposed to be dangerous change in nutrient substance and nitrogen ratio. As nitrate transforms to nitrite which is considered to be a poison for plants. It is important to take into consideration feeding, lack of oxygen and phytotoxin.

As nitrates in nutrient solution are necessary for sufficient feeding of plants there can be a concentration of nitrites berause of lack of oxygen. In monocultures with sequences of vegetation and period of rest, at the end of the growth period not ripened roots can fall away. It can be achieved by radical cutting, e.g. roses.

Under the noteable diminution of nutrient substances consumption during a short period of time there is a mass accumulation of dyed combinations of cells. The transfer of nutrient solution to the unaerobe areas is of special danger. For the sake of secure measures it is necessary to decrease the concentration of nutrient solution till the average salt pollution of waste water, i.e. about 0,2 to 0,6.

It is also essential to change pH value. Diluted solution of nitrogen acid or caustic potash solution should be applied.

In previous experiments a numerous cultures although were not checked but influence of dyed parts of the plant on the nutrient solution was studied.

On the basis of the experiments first results can be carefully considered. The correlation between the saturation of nutrient solution with exugen and period of circulation in the system is rather doubtful as in certain parts of installation it appears the lack of oxygen. On the basis of this experience we have designed a block of control which regulates pH value and osmotic conductivity.

In our own department of electronics we have elaborated very sensitive tools as we realized that control is an important factor in providing for a good feeding. The dosing of nutrient substances in hydroponic system of Grois is fully automatic held by means of constant measuring of conductivity.

For this purpose the water is supplied from the conditioning tanks which are part of circulation system and then passes by the sensor.

Under the regular exploitation it is accepted as an admittance a maximum deviation from the established values of nutrient solution which is between 1,5 and 2,5 within the limits 30 micro S=1,2 till 2%. As a result the cultures roots are constantly in osmotic conditions and can have a high absorbing capacity which is a prerequisite of a good harvest.

As I have already mentioned in connection with oxygen the possibilities exist to go further as far as conductivity is concerned. Theoretically the limit will be within 4-5 mS irrespective of water temperature.

As we already know each plant in 12 metres long tray absorbs oxygen but we have no equal quantity of oxygen for the plants in remote parts of the tray as compared to the front raw plants thus the salt content can be increased for more than 2,5 mS.

The same is true in respect of pH value. The figure itself represents itself a negative logarithm of hydrogen and pH 7 concentration which is considered a mathematic neutral point. "H" and "ON" keep the balance. Psycological neutral point of plants is a bit lower near 6,5 pH value. In the culture of nutrient solution this fictitious point is of less interest, more important is to dispose the mineral substances contained in nutrient solution.

The most favourable is considered to be ph value from 5,7 till 5,9. As the plant contains a high percent of all nutrient substances for metal microelements and iron it is expedient to have a formula.

Ph value is regulated with nitrogen acid in alkaline solution or with potassium alkaline in acid technical water.

The problems with saltless water can arise. As a result of acid nutrient solution dosing the amortized technical water is finally submitted to strong flactuations of ph value.

In this case more preferable to use better buffer capacity by additional dosing of inconsiderable (in percent ratio) quantity of unfreshed water for technical water before lead to the collector unit. In hydroponic system of Grois a limited quantity of chloride and sodium are absorbed by usually unsusceptible to both substances cultures. The exact information of quantity and concentration of chloride and sodium suitable for application depend on numerous factors. The most important are: the correlation of water absorbtionto ions in this proportion with inconsiderable evaporation which make ions susceptible to the necessary quantity of water.

It can promote the increase of sodium chloride content in the water. Under the strong evaporation and respectively inconsiderable invisible absorbtion of ions waste water or unproductive additives of salt in the water can be accumulated.

Like conductivity in hydroponic systems, pH value is automatically changed and in case it is necessary it is corrected in the water pumped several times within a minute in an entire tank.

The maximum possible pH deviation for a limited period of time has not to exceed the same value as in case of conc :tivity.

Besides "D" solution with inconsiderable buffer capacity of technical water with lower than 1,5 mS conductivity has to be deluted with pure water otherwise big deviations in ph values and nutrient solutions are inevitable. From the above mentioned discourse it becomes evident that as compared to the other cultures grown in the nutrient solutions in this system it exists less strict requirements to the quality of water. First of all it can be considered to be a border value in the system without consequences for quality and quantity of harvest which also have tolerance of 140 ppm chloride and 90 ppm sodium for especially sensitive plants.

One can come across the same situation with the other mineral substances including fertile elements. In this case of extremely high content of the main element or microelement it is necessary to find a way to decrease the quantity in concentration of nutrient substances or remove it.

Though in the last case it can be defined only as a result of constant test or research so that the initially defined high content of ions in the water preserved constant otherwise the nutrient substances supply should correspond to the changed correlations

Now we returned to the point where we tried to utilize more or less contaminated water.

As the elements which are contained already in polluted water: phosphorus, potassium, nitrogen & other main nutrient substances, e.g. iron & other microelements are taken into consideration and are not used for the main nutrient solution.

Along the above indicated salt forming substances, chlorid & and sodiumthe hole content of salt in the water plays an important role either but under certain conditions it can limit the possibilities for final dosing of nutrient substances.

In acid or potassium water with high content of saltthe buffer capacity should be large & regulation requires high expenditure of acids and alkalines. In this case it is necessary to add nitrogen acid potassium or lime to the nutrient solution.

When the content of salt is within 0.7 to 0.8 ms limits or the content of lime exceds 20o by the German seale of rigidity, carbonate & non_carbonate rigidities indicate on partly fresheningof technical water.

It is not always required under certain circumstances increase of salt /lime content in technical water can be taken into accouat through alternation of pH values of nutrient solutions and concentration of all metal microelements. Here you can come across the decisions, referred to only certain cases.

In principle the temperature in the root system has considerable importance for all the cultures Nowadays it is widely used heating of the lower part of the plant, the roots habitat which leads to the energy saving. In hydroponics the same aims are achieved by heating of nutrient solutions. Utilizing the throughs from styropor we reducethe energy expenses for heating of nutrient solution when the temperature is low indoors.

For frost resistant plants without phase of rest e.g.carnations the temperature about 15 -18° C is recommended.

For cultures which have the phase of rest in non-vegetation period it is ued a nutrient solution having an excessive content of salt in technical water, plus o,1 to o,3 msof subsoil waters when the temperature of nutrient solution is 50°C.

On the other part heat-loving cultures are to have high temperature ofnutrient solution.

The optimal value lays between 17°and 24°C.The use of styropor for throughs & lidsprevents the high heating of nutrient solution when the air temperatureis high.

For the factors of light CO concentration, air humidity and non exceeding of dew point whicn are connected with possibility of fungous infection the same conditions as for conventional soil cultures are valid. Keeping the exceeding air humidity of 85% or at dew point consequently increases the possibility of foliage infection, which makes an essential factor.

The temperature indoors.

The temperature in root habitat layer of soil plays an important role in growth of plants and especially for harvest. It can be considerably saved as well as the temperature indoors as a whole.

When utilizing the vegetation heating technic the heating of building will cost much more than heating of nutrient solution.

If relative extreme content of humidity does not exceed 85% the temperature indoors can be decreased for a short period of time by 8° C degrees during the phase of seedling growing, e.g. for cucumbers. If the minimum temperature for these cultures is repeated, for example at night period, it can be performed with 11-12°C degrees temperature.

Only under the increased danger of infection high air humidity can have a negative influence.

Contrary to it when calculating the profitableness, possibility of maintaining low temperatures indoors plays a great role.

Within constant expenditures sum expences for cultures growing in protected ground play a key role.Every additional increase of harvest per unit of area will have in this connection a decisive meaning for cost of production meaning for cost of production per unit or per 1 kg of material.

In the hydroponic system which we have designed, as a result of technical operations the size of leaves decreases,i.e. it is possible to get 3 plants cucumbers per every sq.m while for normal soil cultures this ratio will be 1,2-1,5 plants per sq.m.

The result can be repeated per 1 linear m of through, on which 3 plants are placed. The distance from the middle of 1 through till the middle of the next one will make 1 m either.

In the researches held untill now all types of vegetbles were testes as for the optimal height of nutrient solution level.

Besides cucumbers and tomatoes specially chosen for the tests melons and water melons with equal heights of level were also taken. The distribution of plants was as follows:cucumbers aimed for canning- 4 plants per 1 through; pepper- 6 plants per 2 throughs (1sq.m).

During 6 years the researches were carried out with salad, cucumbers of various kinds on different stages of growth under variable factors of growth, temperature and conductivity.

High conductivity and type of nutrient substances composition provide for shorter stems and smaller root mass,thus making possible to utilize throughs with relatively small cross-section without negative influence on the required consumption of water and with its low speed. In this case relatively small volume of water is used for filling of throughs. There is no wet surface of soil (because of periodical supply of water) which results in the following.

Only in complete hydroponic system the air humidity in close cultivation facilities can cause the leaf transpiration.

The practice shows that plants sufficiently provided with water can keep the certain air humidity.

If the air humidity drops considerably the plants try to compensate the pressure of the dry air by increased transpiration. The result is: -only by means of an efficient sprinkling device with sprayers the increase of air humidity can be achieved. On the initial stage of culture growing when foliage is not yet developed it is advisable to ensure the air humidity increase to avoid damage of plants.

The decrease of air humidity in close plants growing facility more than by 5 % is not possible.

Air humidity increase is achieved by short term functioning of sprinkling device (max. for 10 sec.) which is to be repeated several times.

Relative air humidity is not to be increased by more than 50%.Otherwise during the night period temperature can drop to the critical limits below which the possibility of infection arises. for example artificial "mealy" dew (for cucumbers).

Description of installation.

The regulating device is made under the module technology. thus making it possible in case of disfunction to replace the deffective module with a new one. The indices of exploitation readiness of the module are:

a)as for conductivity and ph value the same indices are as for positive and negative deviations from fixed given value in percents.

b)as for dosing pumps. Lightening of control lamps during the pumps operations will be special for each of A.B.C solutions and ph concentrate of D value.

The principles of highly productive hydroponics according to our system.

The application of the components required for conventional installations,close facilities and modules is possible for our system.

I would like to specify the establishing of such systems in close cultivation facilities. as the main part of represented researches deal with it.

The worked out criteria have to include the design of unified equipment.

We have tried and succeeded (what is proved by 10 years functioning of our installations) to create a centralized distribution unit which gives an opportunity to operate the installation with 10 000 sq.m production area.

The main part of such device consist of electronic control,circulations pumps (for nutrient solution) control and additional dosing of nutrient substances and adjusting of ph value and C 0 circulations in nutrient solution.

The system of control ensures constant regulation of pressure. temperature and oxygen content.

It is also possible to adjust the device in such a way that it will carry out the regulation of air humidity. heating. and functioning of mixing valves and throttles for ventilation by means of light sensitive elements of heat screen.

For circulation and drainage pumps there are lightening. membranes near the pointer position.

There is also digital indications of drainage pump pressure. nutrient solution temperature. air humidity and oxygen content in the nutrient solution. We have chosen such a type of the facility design as it is quite simple to maintain.

It is not advisable to manufacture the installation completely because there should be an opportunity to a technician or a plant grower to change certain devices by himself. As the expenses are inevitable it is essential to try to minimize them.

Having regulated the salt concentration in nutrient solution by adjusting of conductivity we decide to place three dosing pumps in such a way so they can be mutually calibrated.

Thus it will be possible in case of necessity to calibrate the supply of nutrient substances relatively to each other. Adjusting of conductivity and ph value is performed during the circulation process when the pressure mains is switched off during the dosing of the principal solution and for regulation of ph value in the central mains and for C 0 circulation in the distribution mains.

Any end of the pressure pipe in condition tank was designed so to provide the optimal mixing. The circulation of nutrient solution must be of 3:1 ratio minimum.

The measurement of pressure of the pumps.the temperature. oxygen content in nutrient solution is made on the drainage pump. The circulation and drainage are made by means of 2-3 centrifugal pumps which are to be reliable in exploitation and corrosion resistant.

Checking the various possibilities of gas circulation in nutrient solution we have chosen a double use of a special system by means of which it is possible to get CO from 0 without additional consumption of energy.

I have designed this system of gas interchange in our experimental farm. No additional energy consumption and high efficiency are the distinguishing features of the system.

The coefficient of enriching with oxygen achieves depending on the circumstances (regardless of temperature) the value which exceeds 95% Disposed nutrient solution contains CO from root respiration depending on the phase of plants growth and has minimal oxygen content and reduced content of nutrient substances.

Besides. small part of nutrient solution always returns. Plant absorbtion for transpiration and growth can be under extreme conditions up to 6 litres per a day for cucumbers.

The required quantity of technical water in average according to Central European Standards is approximately 3-3.5 litres per a plant (for cucumbers).

The essential feature of hydroponic system is the technology of reconditioning applied.

In large collecting tanks for return flow the level of water can be adjusted only by means of floats. In this case the maximal level of water is chosen so the system can function for some time after energy switch off.

Before the collecting tank honeycomb filter is fixed which is to be daily checked for sufficient permeability. All the water conductive parts of system as well as collective tanks are to be prevented from the influence of light to avoid unfavourable effects.

The througs for the grown cultures are made of styropore to ensure the heat and respective cold insulation to keep the even temperature of nutrient solution in the throughs during summer when it is hot and during winter and autumn when the cold is penetrating from outside.

We have chosen such material after series of tests.

At the initial stage we carried out experiments with plastic throughs but discoivered that they quickly make the temperature of nutrient solution equal to media.

The same problems arose while utilizing metal throughs, complicated by the problem of oxydation.

After we have achieved the desired aim as a result of long-term experiments we have implemented this technology in production. Today several plants have modernized and automized their production processes on the basis of our system.

They achieve better results in process of growing and profitableness and do not pollute the subsoil waters and environment.

I hope you will try to find an opportunity to inflience the politicians of your countries to adopt lows against poliution of subsoil waters and bring them into practice.

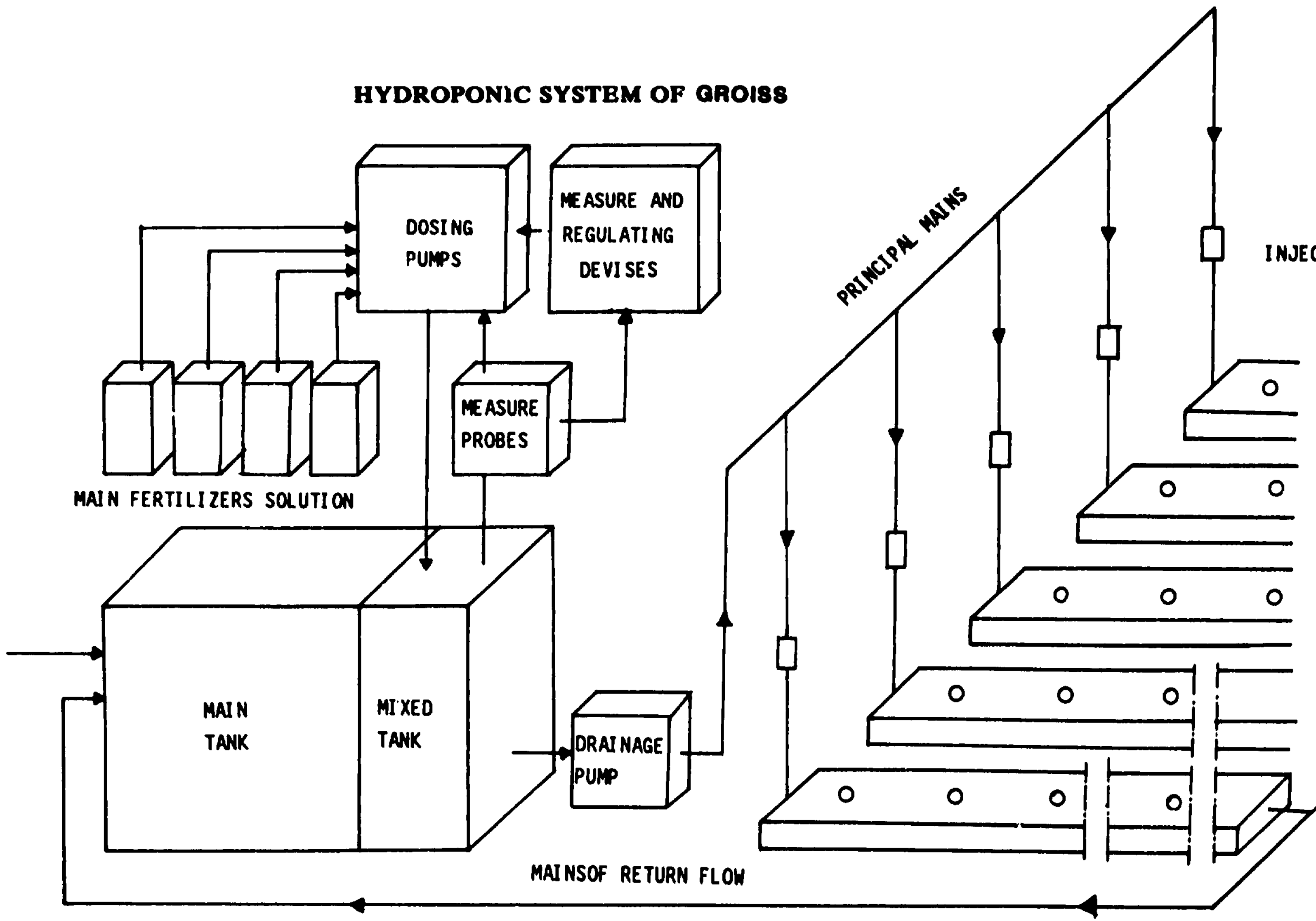
As for us we should do it by all means because it will take no less than 20 years to restore the natural order of environment here in Central Europe.

We must preserve our water as well as you because water is the most important thing we have and utilize. We must take responsibility for decrease of pressure on subsoil waters and environment.

We can parity give up more high crops but it is not necessary. If we create proper regime of growing and optimal condition of nutrition of plants and obtain wholesome fruits that will contribute to provision of food stuff and preserving of health. It is natural I can not cover all the themes in my relatively short report but I will answer all questions with pleasure.

In the written documentation you will find an outlined description of ourclose hydroponic system.

HYDROPONIC SYSTEM OF GROISS



ALL-YEAR-ROUND INDUSTRIAL CULTIVATION OF ECOLOGICALLY CLEAN VEGETABLES IN ARTIFICIAL CLIMATE BY USING HYDROPONIC BLOCK MODULE COMPLEXES, METHODS AND CRITERIA FOR PRODUCTS TESTING AND QUALITY CONTROL.

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One of the latest trends in the development of the vegetables growing in greenhouses is a hydroponics method which utilizes all achievements of chemistry, biology and electronics. The interest to this technology constantly grows because such a method gives plantgrowers every opportunities of sharp increase of crop yield and quality of products under considerably better labour conditions.

Nowadays owing to experience accumulated and achivemements of scientific and technical progress the hydroponics became a method of up-to-date cultivation.

Hydroponic method of agricultural crops growing in protected ground

Depending on the environmental media in which a root system is developping the hydroponic methods that are widely used can be subdivided into three groups.

Water crop method. Under this method the substrate is not used. The root system habitat is a nutrient solution which is in constant circulation. The main shortcoming of this method of growing is quick disturbance of aeration and a possibility of solution infection with pathogenous root habitant microorganisms. Inspite of that we can assume that the method will prevail in the future.

Growing of plants under the water crop method has a number of variants. The technology of thin layer circulation method gains more wide application.

Substrate crop method. Under this method the root system habitat is a solid media of organic, inorganic or synthetic genesis (peat, rind, pearlite, vermiculite, zeolite, sand, gravel, keramsit, minaral cotton, polystyrol, penopolyurethane,etc.). Usually substrate is arranged in form af plant beds or placed into polymer containers of 20-50 lit capacity. Nutrient solution is periodically supplied with the aid of drop system or other sprinkling means.

In this group of hydroponics methods the technologies of plants growing in mineral cotton and peat are most widely used.

The main shortcoming of this method is necessity in large quantities of substrate, its periodical replacement and utilizing of complicated system of drop watering. It can be assumed that the substrate method of

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plants growing is a transitional stage from soil cultivation to pure water crop method.

Aeroponic method. The method envisages the supply of nutrient solutions to the roots in vapour-air (aerosol) form. Inspite of its advantages, the method of aeroponics did not gain wide application mainly

Depending on the way of nutrient solution supply all known methods of soilless plants growing are subdivided into two groups: closed cycle hidroponics where nutrient solution continuously circulates in conformity of the root system, and open hydroponics where the nutrient solution is supplied periodically depending on plants needs and climatic conditions.

Nutrient solutions are the most important factor in soilless growing of plants. They are prepared by dissolving of various salts in water. The composition and influence on plants of nutrient solutions are the same as of natural soil solution.

The content of basic nutrient elements in solutions is shown in table 1, the sources of nutrient elements are shown in table 2. Nutrient solution can be prepared in ready for use (working solution) or concentrated form (50,100 and 200 times more concentrated then the working solution). The first form of solution is used when the areas of growing do not exceed 1000 sq.m and while raising of plantlets. The second form of solution is more convenient , in this case to avoid the sedimentation of salts (when incresing the concentration dissolubility of some salts decreases), the components are to be separated from each

Content of basic nutrient elements in solutions (mg/lit)

Table 1

N	P	K	Co	Mg	Inventors of solutions
1	2	3	4	5	6
		When growing of tomatoes			
180	80	280	360	60	Chesnokov & others
300	120	150	420	50	Chesnokov & others
154	56	167	170	24	Knop
210	31	234	260	24	Hoglend & Arnon
196	31	429	80	24	Gerike
140	38.5	190	165	30	Chesnokon & Basyrina
140	34	244	135	10	Murash & Gorshunova
224	31	234	160	48	University of Cailfornia
151	55	356	200	11	Pardew University
225	55	214	212	11	Pardew University
187	220	213	124	45	Pardew University
122	60	75	151	46	Agronomical station in New Jersey
91	62	223	167	44	Experimental station in Ohio
100	60	280	228	50	South Africa
182	46	273	180	30	Zonneveld taste station the Netherlands
200	40	20	140	40	Manssom, Sweden

When growing of cucumbers

200	70	150	280	50	Chesnokov & others
160	80	330	250	50	Chesnokov & others
150	35	190	200	30	Jorgensen, Denmark
200	45	176	190	43	Mansson, Sweden
168	45	234	140	18	Zonneveld test station the Netherlands

Sources of nutrient elements

Table 2

Name	Chemical formula	Content, %
1	2	3
	Sources of nitrogen	
Ammonium phosphate	$NH_4H_2PO_4$	N-12; P-26
Ammonium sulphate	$(NH_4)_2SO_4$	N-20
Ammonium nitrate	NH_4NO_3	N-35
Calcium nitrate	$Ca(NO_3)_2$	N-15.5;Ca-22
Potassium nitrate	KNO_3	N-13;K-38
Urea	NH_2CONH_2	N-46
Magnesium nitrate	$Mg(NO_3)_2 \cdot 6H_2O$	N-11;Mg-9
Sodium nitrate	$NaNO_3$	N-15
	Sources of phosphorus	
Ammonium phosphate	$NH_4H_2PO_4$	P-26;N-12
Calcium phosphate (1-substituted)	$Ca(H_2PO_4)_2$	P-26;Ca-17
Potassium phosphate (1-substituted)	KH_2PO_4	P-23;K-28
	Sources of potassium	
Potassium chloride	KCl	K-47
Potassium nitrate	NHO_2	K-38;N-13
Potassium sulphate	K_2SO_4	K-45;S-18
Potassium sulphate (1-substituded)	KH_2PO_4	K-28;P-23
	Sources of magnesium	
Magnesium sulphate	$MgSO_4 \cdot 7H_2O$	Mg-10;S-13
Magnesium sulphate (water-free)	$MgSO_4$	Mg-20
Magnesium nitrate	$Mg(NO_3)_2 \cdot 6H_2O$	Mg-9;N-11
	Sources of calcium	
Calcium chloride	CaCl	Ca-36
Calcium nitrate	$Ca(NO_3)_2$	Ca-22;N-15.5
Calcium sulphate	$CaSO_4$	Ca-29
	Sources of microelements	
Manganese sulphate	$MnSO_4 \cdot H_2O$	Mn-32
Zink sulphate	$ZnSO_4$ $7H_2O$	Zn-23
Borax	$Na_2B_4O_7 \cdot 10H_2O$	B-11
Copper sulphate	$CuSO_4 \cdot 5H_2O$	Cu-26
Ammonium molibdate	$(NH_4)_6Mo_7O_{24} \cdot 4H_2O$	Mo-54
Sodium molibdate	$Na_2MoO_4 \cdot 2H_2O$	Mo-39
Ferrum chelat 330 Fe	FeDTPA	Fe-9
Ferrum chelate FeDP	FeDTPA	Fe-6
Ferrum chelate 138Fe	FeEDDA	Fe-5

Ferrum chelat FeEDTA Fe-14

other on two solutions which are named mother solutions as indicated below.

Solution A	Solution B
HNO_3	HNO_3
$Ca(NO_3)_2 \cdot 4H_2O$	H_3PO_4
KNO_3	KNO_3
NH_4NO_3	K_2SO_4
Fe-chelate	$MgSO_4 \cdot 7H_2O$
	$MnSO_4 \cdot H_2O$
	$ZnSO_4 \cdot 7H_2O$
	$Na_2B_4O_7 \cdot 10H_2O$
	$CuSO_4 \cdot 5H_2O$
	$Na_2MoO_4 \cdot 2H_2O$

In case of K O_3big quantity it is to be distributed in the following proportions: solution A-2/3; solution B-1/3.

The fertilizers used differ by their dissolubility in water. some of them are easy to dissolve while others are not. To facilitate the dissolution tanks are filled with water by 75-80% of their capacities, then acids are added and the homogenization of solution occurs. After that the fertilizers are consequently applied, each time the solution is to be strongly agitated till complete dissolving. It is not advised to mix up the fertilizers together before their dissolving in water. It is not allowed to mix together concentrated solutions of fertilizers which containt calcium and sulphur as in this case formation of gypsum occurs ($CuSO_4 2 H_2O$). Gypsum blocks droppers, pipes and adjusting valves.

Hydroponic method of growing allows full control of plants feeding. To control the regime of feeding it is necessary to analyse the solution from time to time. On the basis of analysis of concentration and elements content ratio the correction of solution content is carried out with consideration of plants development and climate conditions. It is advised to carry out constant control of solution acidity (pH) and electric conductivity (EC) with proper correction if pH index deviation is more than + 0,2 point and if EC index is less than 0.5 point.

The main part of hydroponic equipment of all up-to-date systems is atomatic dissolution unit which ensures supply of necessary quantity of solution to vegetation trays, controls the content os solution according to pH and EC indices and corrects it if necessary. The control of O_2 content in solution and regulation of its temperature are also carried out if necessary .

Fig.1 shows the scheme of the automatic unit for root nutrition of plants used in hydroponic growing of vegetables in hangar and block greenhouses. The unit consists of working solution tank (its capacity is to be no more than 1000 lit.), three tanks for A and B mother solutions ans acid, block for solution control according to pH and EC indices, sensors for solution control, circulation pumps which supply nutrient solution to vegetation trays and returns it. Tanks with mother solutions and acid are equipped with dosing pumps which according to command signal supply necessary quantity of proper component to the working solution tank. Tanks with mother solutions are additionally equipped with electric agitators.

While designing parts and components of nutrient solution preparation and supply system it is necessary to take into consideration that it is not allowed to utilize aluminium and its alloys as well as zinc-coated ferrum which educe into the solution some elements inhibiting the development of plants .

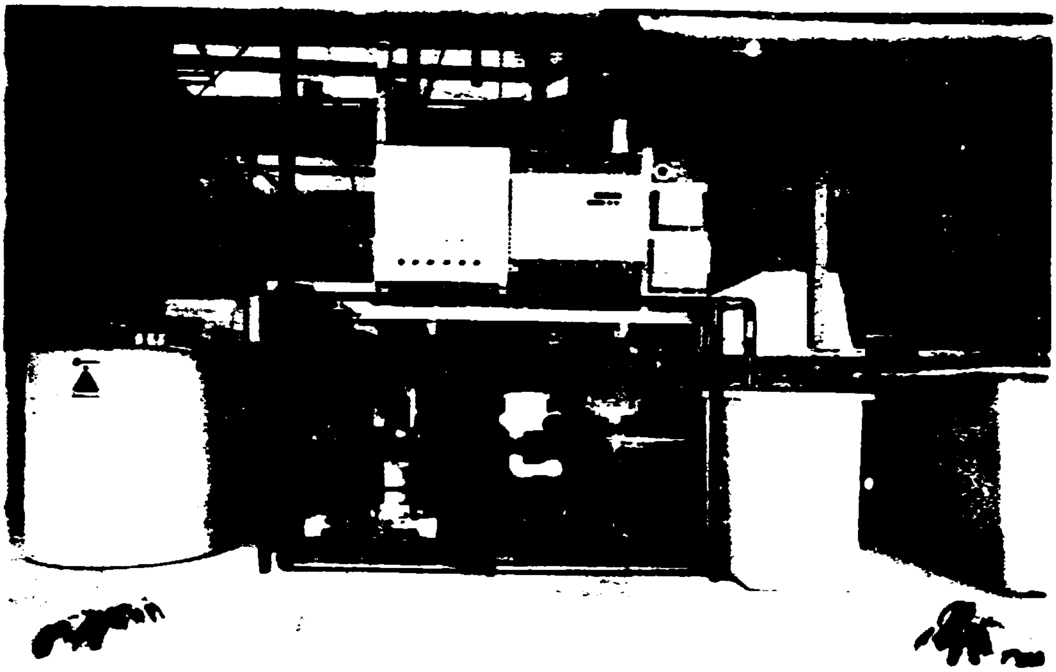

Fig.1
Scheme of the automatic unit for root nutrition of plants used in hydroponic growing of vegetables in hangar and block greenhouses.

One-storey systems for growing of vegetables green food crops

One-storey (or horizontal) hydroponic systems are used mainly in greenhouse installations. In this case water crop or substrate methods can be utilized.

As it was mentioned above the advantageous within water crop method is one of its derivations called thin layer circulation method. While using this method (fig.2) plants are grown in isolated hydrocanals which are placed on special inclined supports. By means of pump nutrient solution from tank is supplied to the upper part of hydrocanal from which under influence of gravitation it flows in form of 1 mm layer along the whole length of the canal and returns to the tank wherefrom it enters the canal once again. Thus a closed cycle of continuously circulating nutrient solution appears.

While designing equipment for thin layer circulation culture it is necessary to envisage a certain rebuilding of the greenhouse where this equipment is intended to be placed, including installation of tanks for nutrient solutions and hydrocanals and providing a necessary inclination less then 20 cub.m per 1000 sq.m of the area of the greenhouse maintained. Under conditions of full automatic control and regulation of the pH and EC indices of the solution the capacity can be reduced to 1.0 cu.m per the same area of the greenhouse. of floor surface of greenhouse.

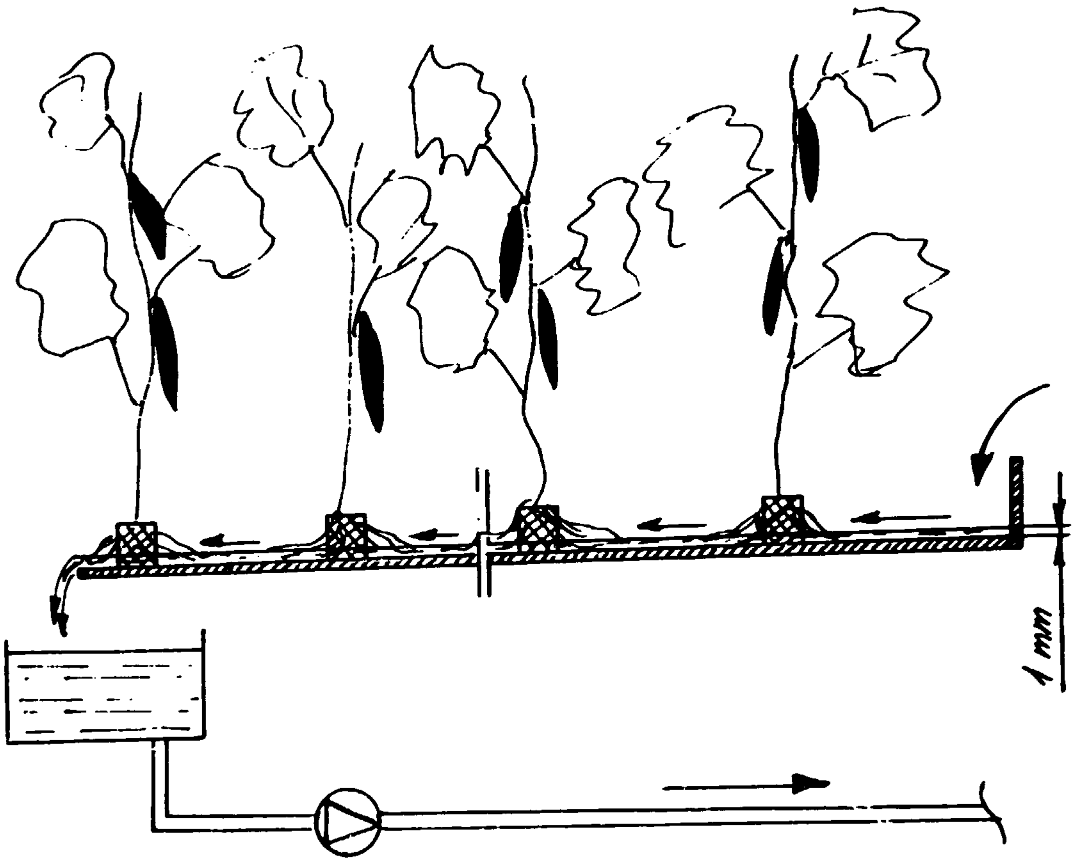

Fig. 2
The scheme of grow with use NFT.

It is necessary to make tanks of water-resistant material which also resistant to acid and alkali influence and do not educe toxic plants elements mainly ions of heavy metals (zinc, tin).

To increase water and chemical resistance capacity it is advisable envisage coating of inside surfaces with inert substances, e.g. ep resin, asphalt varnish, etc. The recommendation is valid also for tanks reinforced concrete installed on the greenhouse floor.

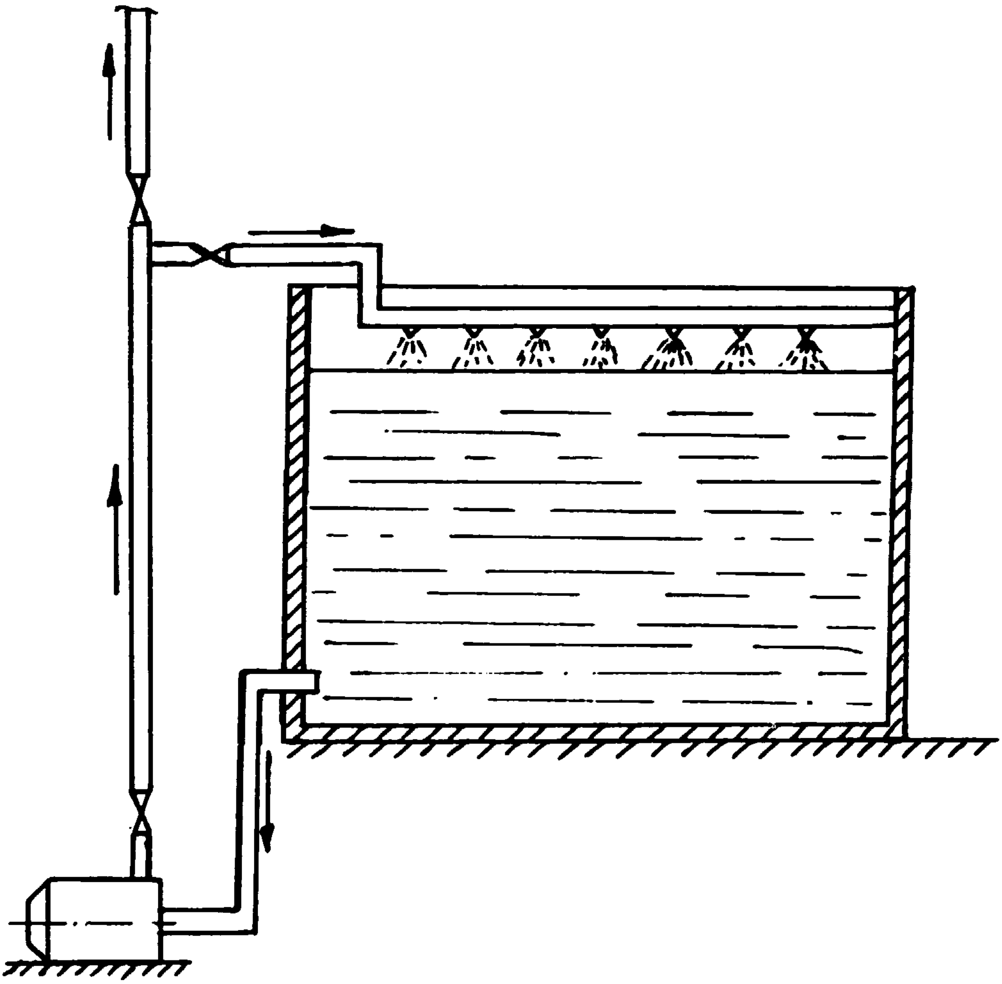

Fig.3
Functioning is performed by pumps without suction manifolds.

The capacity of the tank is defined by possibility of carrying out chemical control and correction of nutrient solution content. If such control and correction of solution content are carried out manually, then the capacity of the tank has to be no less then 20 cub.m. per 1000 sq.m of the area of the greenhouse maintained.

The design of the tank is to provide for a unit for warming of the nutrient solution with automatic regulation of its temperature ranging from 18 to 26 C degrees , float or other device for automatic adjusting of solution level to a given figure and level mete·s to control the quantity of solution in the tank.

The flour of the greenhouse in which hydrocanals are to be installed is to be levelled, thickened and covered with concrete or asphalt providing the angle of inclination (slope; of 1.0- 1.5%. While preparing the slope it is very important to eliminate all the roughness to prevent forming of cavities and to ensure flowing of the solution in form of thin layer.

In the opposite case the content of oxygen in the solution decreases and ethylene in quantities toxic for plants is accumulated.

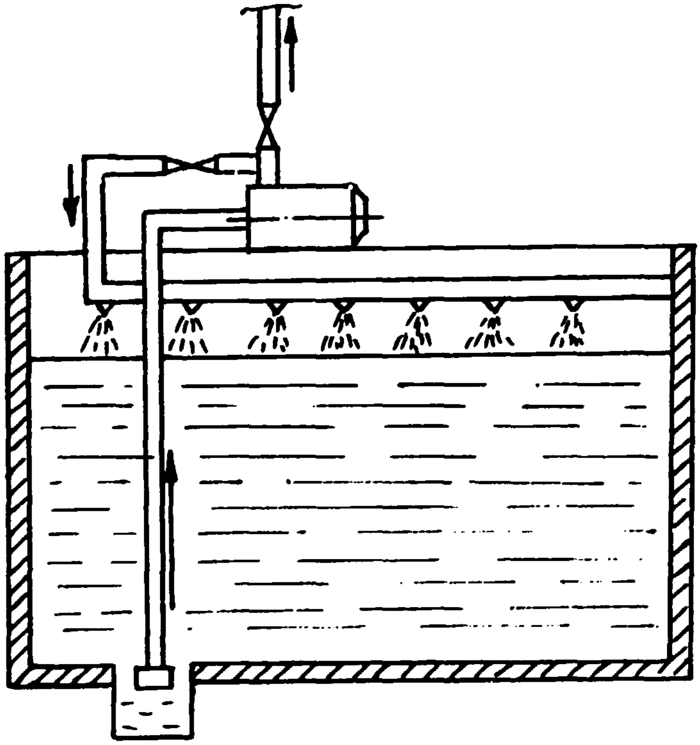

Fig.4

Functioning is performed by pumps with use suction manifolds. while the expenditures for the maintenance of the system increase.

The equipment for supply of nutrient solution from tank is to include pumps, pipes, valves, filters, signal devices and control board. Every system is to be provided with two pumps - working and reserve. If a tank is placed above the level of hydrocanals, then the number of pumps is advised to be doubled.

The most effective functioning is performed by pumps without suction manifolds as it is shown at fig.3. Pumps are to be placed on the foundation installed below the level of tank bottom by 0.3-0.5 m .

Pumping of solution out of the tank may be executed by a way which is more widely used (fig.4). The system is installed above the tank and the suction manifold goes down vertically in to the hollow on the bottom of the tank. The manifold is to be placed at the distance no less then 0.2 m from the bottom and walls of the tank. The shortcoming of the method is that a necessity arises to blow through the pump very often, while blowing the supply of nutrient solution to the plants stops.

The power of the pump is to be more then it is necessary for hydrocanals. When its calculating it is necessary to take into consideration diameter and length of pipes, height of water column and other factors.

Each pump is to have valves allow to channelize the flow of the solution towards the hydrocanals, the tank, purification installations and sewerage when it is necessary.

The capacity of the pumps, pipes and valves is to ensure even supply of 3-5 litres of the solution per minute to each hydrocanal (depending on the dimensions of its bottom) with possibility of selective increase, decrease and stop of the flow and its periodical regulation.

Acccording to the thin layer circulation technology the circulation of the nutrient solution in hydrocanals should be continuous. That is why there is a necessity in a signal device with independent electric supply (accumulator) in case if the electric supply of the greenhouse is cut.

The hydrocanals for the thin layer circulation system may be of various types and manufactured by hand (immediately before planting of plantlets) or by industrial means.

By hand the hydrocanals of black polyethylene (0.15-0.3 mm film) are made. While making such hydrocanals it is necessary to envisage the presence of perforation and holes to ensure the access of air to the root system as in opposite case a considerable quantity of ethylene (up to 2.9 mg/lit) can be accumulated in the solution thus disturbing the growth and development of plants.

By industrial means the hydrocanals of semi-solid polyethylene can be manufactured. In this case the hydrocanals can be rolled up in form of rouleau that makes it possible to facilitate their transportation and mounting in greenhouse. The width of basis of flat rolled hydrocanals is recommended to be of three types- 0.075,0.15 and 0.225 m.

The perspective way is manufacturing of hydrocanals of foamed polystyrene. Heat insulation features of this material allow to keep up stability of temperature inside hydrocanal thus causing the increase of crop yield of plants grown. Foamed polystyrene hidrocanals can be made in form of separate moduls of 1.0 - 2.0 m length which afterwards are assembled in the hydrocanal of necessary length. For hermitization of joints black polyethylene film is to be laid along the entire length of the hydrocanal.

It is expedient to lay down on the bottom of hydrocanals of any type a capillary support stratum made of polymeric material which performs the following functions:

- secures even distribution of nutrient solution along the bottom of canals;

- keeps the flow of solution in form of thin layer and gives an opportunity to prevent stress situation for plants in case of unexpected stop of nutrient solution supply in the event of break down in supply system;

- ensures better striking roots of plants in the initial period after planting;

- promotes uniform distribution of roots in hydrocanals and improves aeration.

Inspite of numerous advantages of the thin layer circulation method the technology of small volume substrate hydroponics with utilization of drop watering equipment is also widely used. This technology is based on the principles of individual supply of necessary quantities of mineral fertilizer and water to each plant in drops.

Fig. 5 and 6 show two the most widely spread methods of implementation of small volume substrate hydroponics substrate hydroponics. By means of this technology cucumbers, tomatoes, peppers, salad, vatious flowers, strawberries, melons, watermelons and other cultures are successfully grown in horizontal plane. Under this method plants are planted in trays filled with substrate, which can be a mineral type substrate, e.g. grodan, rockwool, vilan, gravilen as well as peat substrate in form of peat plates and blocks which are industrially manufactured by dry or wet pressing method. The volume of substrate which is necessary for root system of a plant decreases to 0.002-0.005 cub.m, that is why the new technology was called the method of small volume hydroponics.

While implementing the method shown at fig.5 trays are manufactured of asbestocement pipes of 0.18-0.2 m diameter. The upper part of the pipe in form of segment of 0.1-0.11 m width is cut out and layed on the bottom of the pipe. A clearence which appears works as the drainage opening and a heating plastic tube is fixed in it. From above plates of substrate are layed in on stratum on which afterwards substrate bricks with preliminary grown plantlets are placed.

Between two pipes-trays a moistening tube is laid. It has micro-tubes which perform drop supply of nutrient solution to each plant individually.

While utilizing the method shown at fig.6 a tray is manufactured of black polyethylene film immediately before planting. Unlike the rigid trays the ones made of polyethylene film are much cheaper but serve as a rule during only one season.

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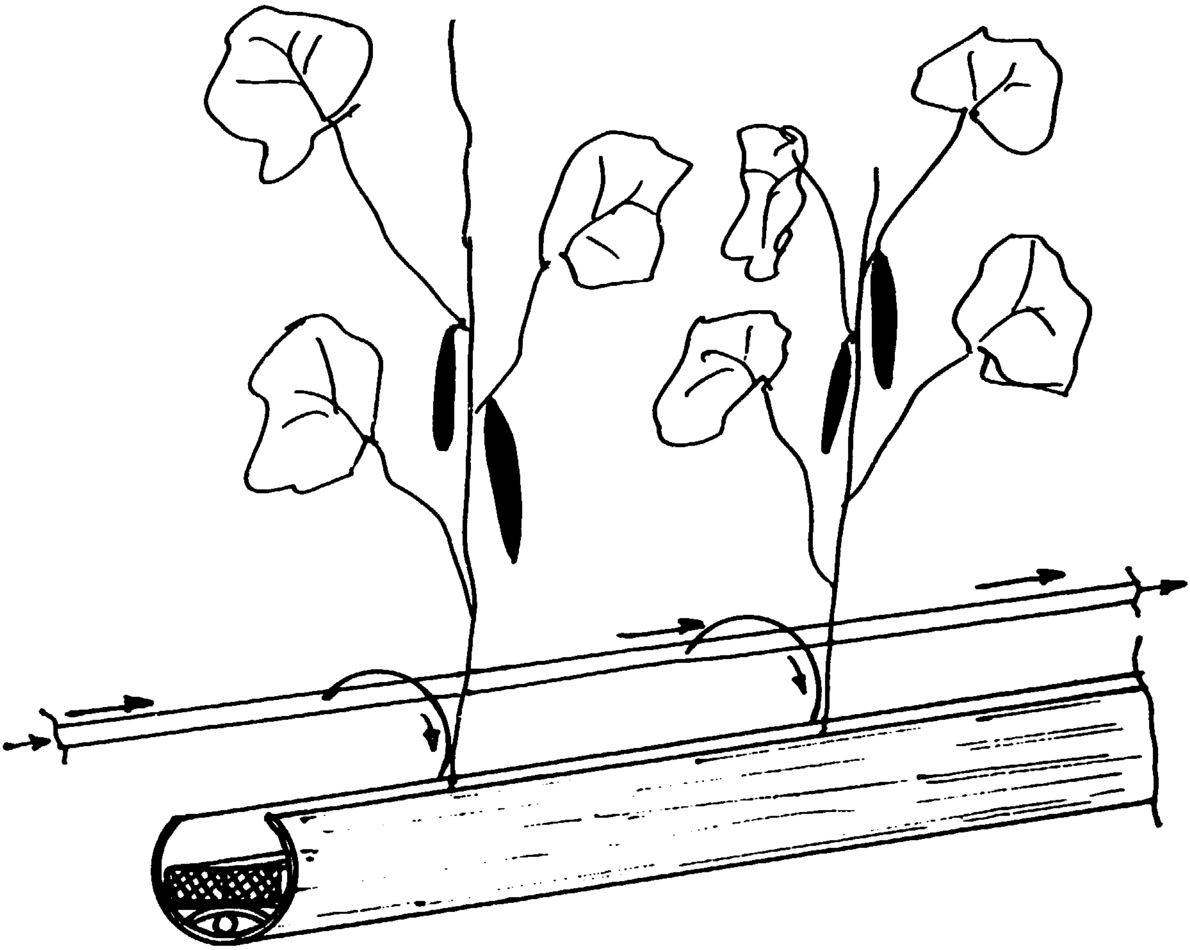

Fig.5

The scheme of grow with use a mineral type substrate in asbestocement pipes.

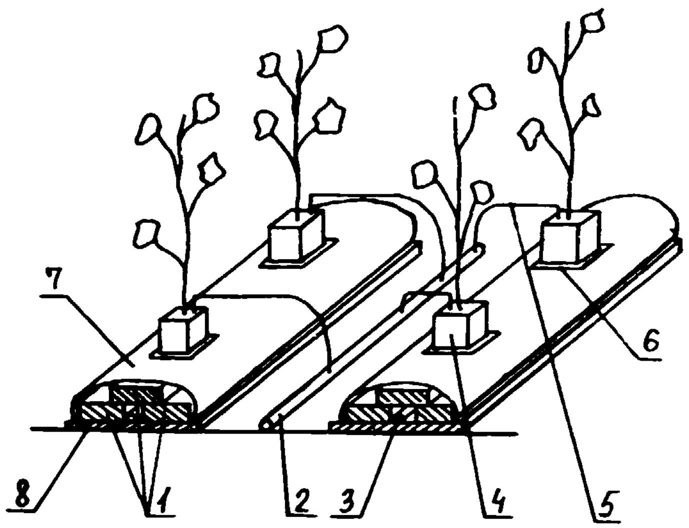

Fig.6

The scheme of grow with use a mineral type substrate in black polyethylene film.

Multi-storeyed hydroponic facilities for productions of plantlets,green vegetables and flowers.

Early multi-storeyed hydroponic facilities were developed for producing green fodder out of cereals to feed the livestock. Undoubtful advantages of this facilities i.e. simple maintenance, reliability in functioning, small area of facilities and possibility to utilize them practically in any heated building allowed to develop the wide range of multi-storeyed units for stable growing green vegetables, flowers and plantlets.

Regardless the fact that first multi-storeyed hydroponic unit for industrial production of spring onion (SGUL-30) was developed already in sixties, its design principles further improved and developed by other multi-storey units (UVR- 1200,TsUG-3,"Chicory") and modul hydroponic installation of "Latuk" and "Vitakon" types are actual till nowadays while designing of new installations of this type.

The technical description of above mentioned units and method of design of their parts are given.

The SGUL-30 "Winter plantbeds" unit (fig.7) intended to force spring onion without substrate. It includes two section framework which consists of support pillars and four storeyed frames housing the germinators. The upper fifth frame serves as a support for starting-adjusting equipment of lightening system. The lightening system includes flat lamp-holders equipped with reflectors. Above each growing storey two lamp-holders with three luminiscent lamps are installed basing on ratio of 120 Wt per sq.m.

The storeyed frame is a welded structure of tubes and angle bars in which rear tube serves at the same time as connecting part of the storey (element of structure) and as a solution distributing main (element of technology). Transversal angle bars have angle of inclination 0.5 degrees to drain sleeve thus making possible to install germinators with the same angle of inclination.

One of support pillars, made of tube,is utilized at the same time for supplying nutrient solution to growing storeys, while the other placed in the center of the unit just opposite distributing main is utilized for drainage of solution from drain sleeves to the tank placed under low growing storey.

Irrigation system includes the tank for working solution, pump,feeding tube, solution distributing mains, drain sleeves and drain tube.

Electric equipment of the unit consists of control box, lightening system and nutrient solution feeding pump.

During growing of spring onion nutrient solution is supplied to the germinators automatically twice per 24 hours according to the given programme. Correlation between quantity of solution supplied to germinator , angle of its inclination and area of its drain outlets meets all the agrotechnical requirements of root nutrition. Solution reaches its level in the germination 2-2.5 min after beginning of its supply. Time of functioning of nutrition feeding system is 15 min per each nutrition cycle.

The UVR-1200 unit (fig.8) consists of two 5-storeyed sections and is intended for growing spring onion, salad, parsley, dill, celery, radish, various seedlings and low-stem flowers.

Fig.7
"Winter plantbeds" SGUL-30

Fig.8
Multi-storeyd Facilities UVR-1200

The framework of the unit is made of support tubes which are rigidly interconnected by means of horizontal frame. From above the framework guides are mounted on which trolley with five- storeyed lightining system of luminiscent lamps slides in horizontal plane. During the process of growing the lightening system moves from one section of unit into other according to given pragramme. Movement of lightening system trolley is ensured by means of two RD type electric motors. Peculiar feature of the lightening system is a possibility to adjust the height of lamps above growing surface of storeys depending on state and height of plants. It achieved by manual adjustment i.e. by turning of special jacks by which every pillar of lightening system is equipped.

Every storey houses two germinators with 1.1 sq.m area each. Nutrient solution is supplied by means of the pump from the floor tank first to germinator of upper storey and then by gravity flow reaches low storeys.

The germinator is made as a tray of rectangular form the bottom of which serves as a bed for substrate and routs layer . Nutrient solution is supplied from one edge of the tray and then flows along its bottom to the opposite edge where a special device is placed which allows to adjust the level of the solution in the tray and the speed of the drainage of the solution to the germinator of lower storey. Principal layout of the germinator equipped with the device adjusting level and drainage of the solution is shown in fig.9. Design of device is as follows. Near side wall of the germinator the hollow cylinder is vertically installed which has outlets on its lower end for solution drainage. The hollow cylinder has a float on its upper part and a ring on its lower part. The cylinder itself is mounted on the guide tube which has solution drainage oultets in its lower part.

To prepare the device for functioning it is necessary to carry out following operations. The float is to be installed at certain level over the bottom of the germinator which corresponds to the level of the solution in it. By means of the ring a necessary area of the outlets of the hollow cylinder is to be adjusted thus providing supply and drainage of the solution in given time.

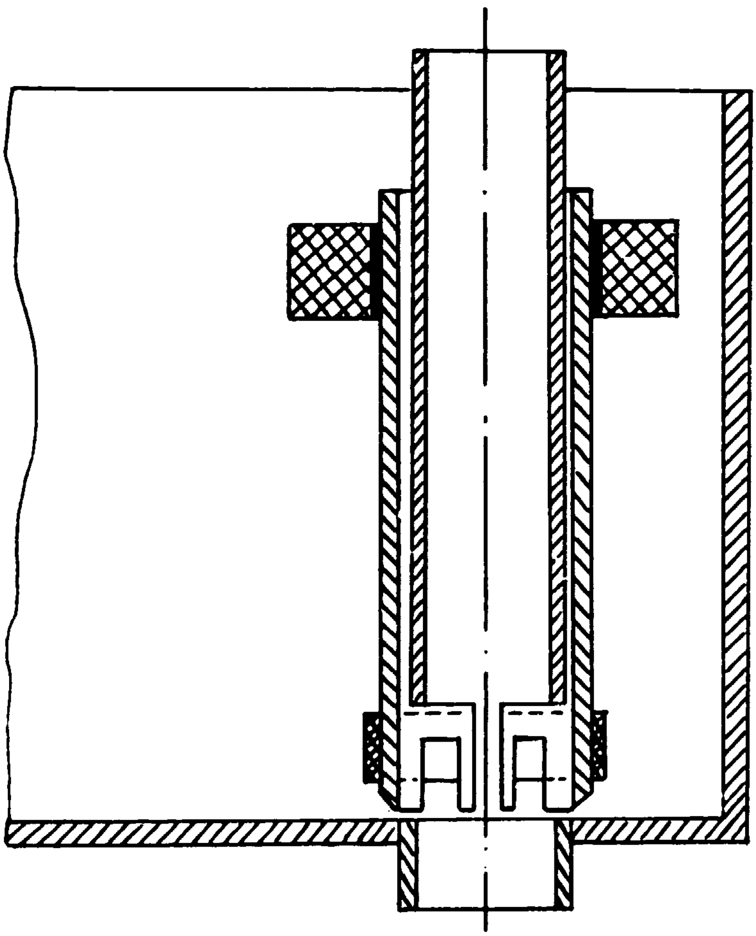

Fig.9
Principal layout of the germinator equipped with the device adjusting level and drainage.

If the level of the solution is maintained above a given value, then the float comes to the surface and removes in upward direction the hollow cylinder which opens the drainage opening in the bottom of the germinator thus making drainage flow more then input one. The level of the solution in the germinator begins to fall down. If the level falls below a given value, then the hollow cylinder closes the drainage opening thus causing sharp reduction of drainage flow and consequently the level of the solution climbs the given value. After stopping of solution supply to the germinator the process of solution drainage through the outlets in the hollow cylinder begins.

Time of solution supply and drainage depends on the area of drainage outlets in the hollow cylinder. By changing the ares of the drainage outlets of the hollow cylinder by means of limiting ring it is possible to adjust the time of solution supply and drainage without influence on final depth of the solution in the germinator.

To ensure the normal nutrition of plants the maximal difference between levels at the beginning and at the end of the germinator is to be as small as possible and the level is to be within allowed limits.

All electric equipment of the UVR-1200 unit with exception of starting-adjusting devices of lightening lamps and pumps is placed in special control box which is hanged by hooks on the side of one of horizontal frames.

Inside the control box magnetic starters of electric engines of pumps and lightening system trolley, time relay of 2RVM type automatic switch, fuses and other switches are situated.

The starting -adjusting devices (throttles) are placed above the lightening system trolley thus allowing to exclude the overheating of the space between growing storeys.

The TsUG-3 unit (fig.10) is designed for forcing bulb flowers (tulips, daffodils, hyacinths, crocuses, etc) and growing astres, carnations and spring onion.

The unit is made as stationary three-storeyed framework with germinators on each storey. The storey consists of frames welded from angle bars. The frames are interconnected by means of support pillars.

As well as at the UVR-1200 unit the germinator of 1.1 sq.m area is equiped with device which adjusts level and drainage of the solution.

System of nutrient solution supply consists of tank mounted under the lower storey, pump and pipeline which supplies solution to the upper storey. The pipeline has a coupler valve by means of which the rate of solution supply to the germinators is adjusted.

The lightening system consists of three frames with six luminiscent lamps of LB-80 type each. The system also has a cable block device allowing by means of manual hoist to place sources of light at necessary height above germinators for each storey at a time.

Switching on and off of light and nutrient solution supply is carried out automaticaly according to a pregiven regime by means of time relay which is situated in the control box hanged on the side of the unit. The control box is the same in terms of design as the one at the UVR-1200 unit.

While designing the units such as mentioned above it is necessary to utilize the materials which can not be affected by the corrosion (plastics, rubber, polymers), especially in places of contact with nutrient solution.

In above mentioned multi-storeyed hydroponic installation plants receive all necessary nutrient substances from the solution while substrate acts only as a mechanical support for them and in a number of cases serves as a means for supplying solution to separate parts of the

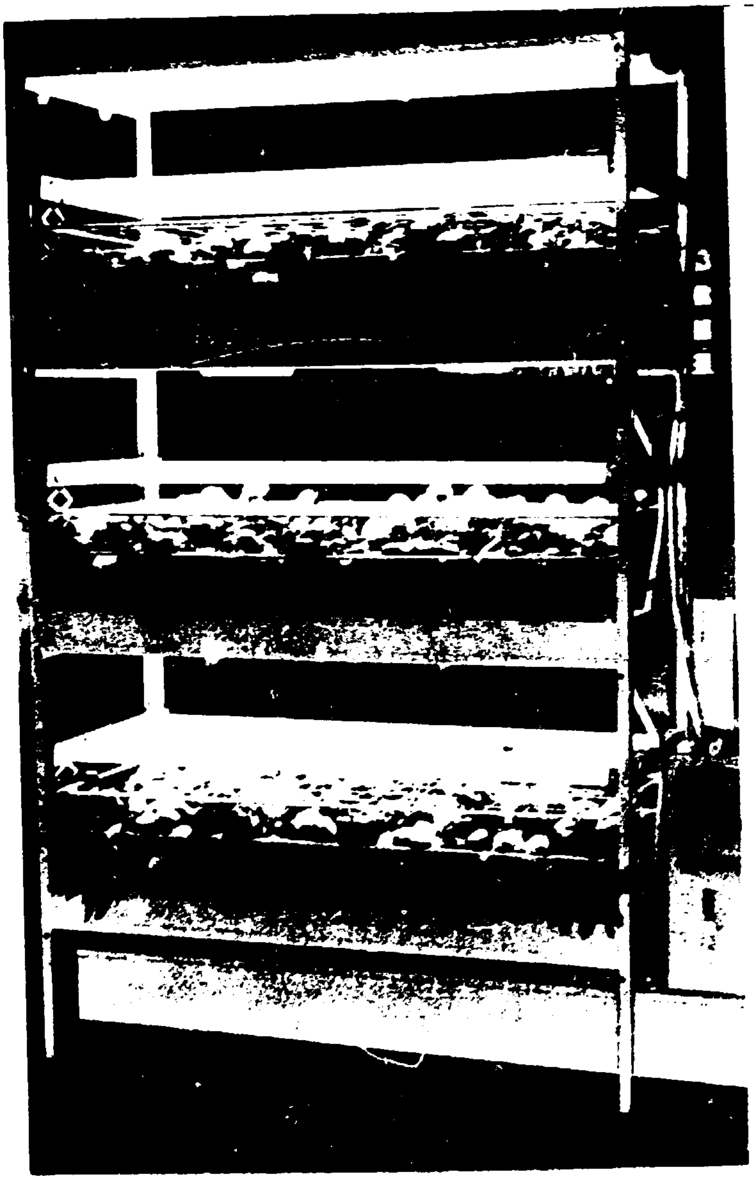

Fig.10
Unit TsUG-3.

root system of the plants.

Reciently the Byelorussian Academy of Sciences developed a method of intensive growing of plants which is as simple as the known [illegible] at the same time leaves far behind all the others by specific [illegible]. The method is based on utilizing as a root habitat and [illegible] or nutrietion of artificial ionexchange resins saturated with necessary for plants macro- and microelements in quantities up to 10% of entire mass of a resin that is in several times more that the natural content of the nutrient substances. Physical and chemical connections between resins and biogenetical elements prevent washing out of latters while watering without worsening of nutrition of plants which consume them in quantities and ratios optimal for plant organism at every stage of its growth. Thus a plant and an artificial substrate make a self-adjusting system which is optimized from point of view of nutrition. While utilizing such a substrate watering of the plants is carried out by water or by 0.1% solution of potassium nitrate, which allows to compensate the diminution of the most usable by plants elements such as potassium and nitrogen. From the point of view of design the units utilizing ion exchange resins can be made according to the layout scheme shown at fig.11. In this case units are assembled from separate identical vegetation moduls which are interconnected by means of electric scheme of nutrition and hydrolic system of substrate watering.

The module consists of vegetation tank filled with ion exchange resin. Within 0.02-0.03 m from the bottom of the tank a perforated insert is placed which is covered with fibre glass in order to prevent washing out of substrate through openings of the insert while watering. Water (or solution) which is supplied to the tank through supply fitting climbs side drain fittings and moistures the substrate, a surplus water flows to the tank. Side fittings are aimed to prevent the overflow of the water. Above the vegetation tank light irradiator with lamp is fixed. Its light window

Fig.11
The modul installation with use ionexchange resins.

is covered with silicate glass placed on the absorber gascet. The irradiator is made as a box which has a flunge for connection with ventilation system removing the heat of the lamp. At the lower part of the box there are ventilation openings. Besides modules unit set includes control board, drain and supply pipelines, pump and electromagnetic valve.

According to given programmes the time relay switches on and off lightening system, pump and electromagnetic valve.

To ensure complite satiation of substrate with moisture the pump is to maintain the necessary level of water (or solution) in the module no less than 30 min.

As the analogue for such units the "Latuk" module hydroponic unit (Fig.12) can be also taken. It was designed by VISKHOM and intended for continuous growing of high quality green vegetables (salad, dill, parsley, celery, radish, etc.). Such units are used for round the year provision of ships crews and personnel of polar stations with fresh vitamin green foods. Block -modular principle of unit design allows to arrange it together with other units in form of multi-storey structure.

The peculiarity of the "Latuk" unit is a shaft with variable pitch screw along which vegetation trays with plants of different ages are moved. The shaft can be rotated by hand or by means of electric drive.

The technological process of this unit includes daily installing of one or a number of vegetation trays with sown seeds on the screw shaft, periodical (once per 24 hours) moving of the trays along the screw shaft with their simultaneous expansion relatively to each other during change of screw pitch and taking down of trays with ready product at the end of screw shaft. Expansion of trays is necessary because the tops of grown plants are spreading.

As sources of light high intensive lamps of DHaT and DRK types are used which provide 1.5-2.0 times more illumination while in case of utilizing the luminiscent tube lamps which positively influences the increase of crop yield and quality of products.

Basing on multi-storeyed construction principle, hydroponic technology and automation of growing regimes the industrial production of practically all food plants can be performed, including not traditional ones such as salad chicory.

The principal layout scheme of multi-storeyed installation for growing salad chicory in non heated buildings under conditions of darkness is shown at fig.13. Heating of grown plants is accomplished with the help of heated nutrient solution which flows along the vegetation trays. By means of regulation of circulation speed of the solution and its level in the vegetation trays and in root system formation zone given temperature regime with precision up to 1°C degree can be maintained at all storeys of the installation. Besides, natural ventillation in zone where formation of salad heads occurs is provided at the expence of positive gradient of temperatures (no less than 6-8°C degrees) between zones where root systems and sprouts of plants are situated.

Forcing of salad chicory on the installation needs 25 days. Depending on a sort the crop yield can be of 25-35 kg/sq.m with the consumption of electric energy of 1.0 - 2.0 kWt.h per 1 kg of production.

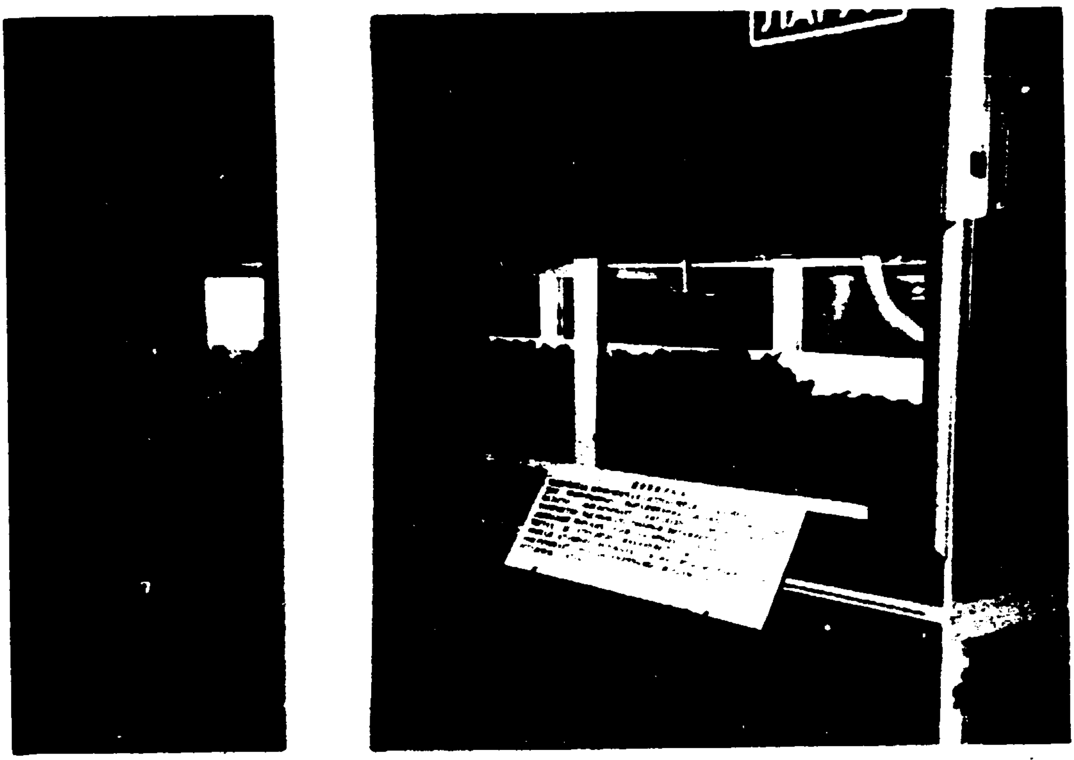

Fig.12
The modul installation "Latuc".

Hydroponic module conveyer systems for continuous growing of agricultural crops

The analisis of perspective development of world industrial production shows that further increase of productivity of common labour and trasformation of productive forces in agriculture from point of view of quality can be achieved only by transition to qualitively new technological principles of ecologically pure (wasteless) production based on complex automation.

In other words already today agriculture faces the principal task of its transition to the industrial basis with ecologically pure biotechnologies which provides:

- obtaining maximal programmed yields of ecologically pure agricultural crops from possibly small vegetation areas;
- isolation, continuity and wastlessness of technological cycles;
- maximal level of automation of all technological operations on plants care, control, regulation, management, etc.

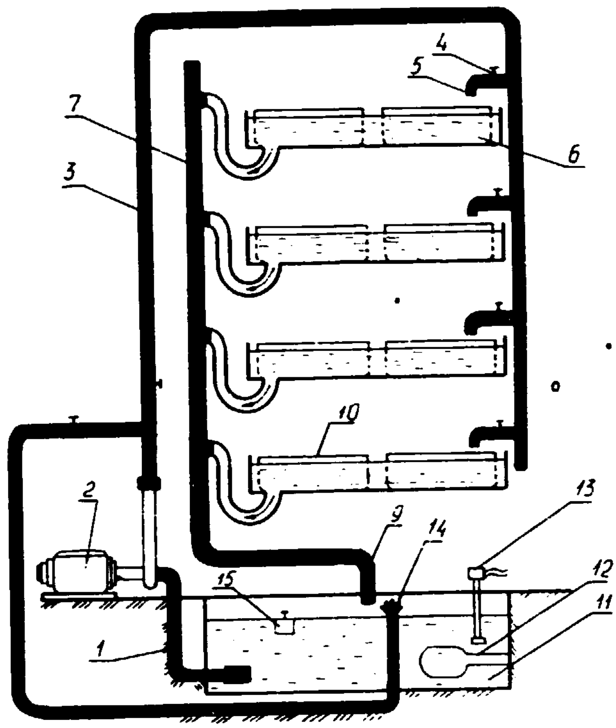

Fig. 13

o

The principal layout scheme of multi-storeyed installa . or growing salad chicory in non heated buildings under conditic . of darkness.

1 - intake piping; 2 - pump; 3 - distribution manifold;
4 - adjustable valve; 5 - sprayer; vagatation rack;
7 - drainage piping; 8 - flexible drainage sleeve;
9 - drainage outlet pipe; 10 - sliding case; 11 - nutrient
temperature adjuster; 14 - ejector.

In accordance with that the basic requirements which define expediency of one or another biological system choice are as follows:

- a technical system is to meet the agrotechnical requirements, not to disturb physiology of plants but on contrary promote increase of their productivity;
- all technical systems are to be highly reliable thus ensuring continuity of vegetation process;

- high level of mechanization and automation of all technological operations is to be maintained with minimal personnel;
- maximum favourable labour conditions and
- the most optimal economic efficiency are to be ensured.

We consider that the solution of this task in accordance with above mentiones requirements can be achieved by wide scale implementation in agriculture of totally new block module complexes utilizing rotary conveyer systems and hydroponic biotechnologies.

An example of principally new technological layout schemes of rotary conveyer vegetation systems is given in fig.14,15.

Production of various crops by means of rotary-conveyer systems is executed in process of continuous, dotted or combinated plants movement mostly along a close endless trajectory. All operations are carried out in certain fixed working places arranged according to order of their fulfilment, that considerably decreases irrational movement of personnel and transport means.

Introducing of rotary-conveyer lines in close cycles with utilizing of hydroponic biotechnologies gives a possibility of the most full automation of processes i.e.:

- maintaining of optimal regimes of all vital systems functioning by means of automatic adjusting of practically all parameters within given limits;
- remote control of functioning of conveyers, lightening system, feeding and conditioning inside the cultivation facilities, including their periodical aotomates start and stop;
- automatic control of each system separately and in functional interrelation and switching off of one or another system (or entire complex) in case of considerable deviations from a normal regime, signals about such deviations are coming automatically to the control board from sensors;
- operating of complex (or separate systems) according to the given programme in the most optimal regimes utilizing computers;
- continuous automatic control of the condition of a drive, tractive parts and other main elements of mechanical systems, providing for high reliability of the whole complex operation.

On the basis of rotary-conveyer lines it becomes possible to exclude the unproductive elements from the technological equipment, to reduce 15-20 times inefficient areas, to low the cost of technological equipment.

The rotary-conveyer lines are restorable and reparable systems, as in case of fault its operating ability can be restored. The world industrial practice showed greater efficiency and expediency of this systems as compared to the others.

VISKHOM in cooperation with a few austrian firms has designed block modular hydroponic rotory-conveyer complex, which can function efficiently in any regions with any climatic and geological conditions.

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 communications and other facilities. Block-Modular Complex (BMC) given here is designed for the specific conditions of the Moscow region.

Fig. 16 shows a principal scheme of the BMC layout which comprises: module (item 1) for 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

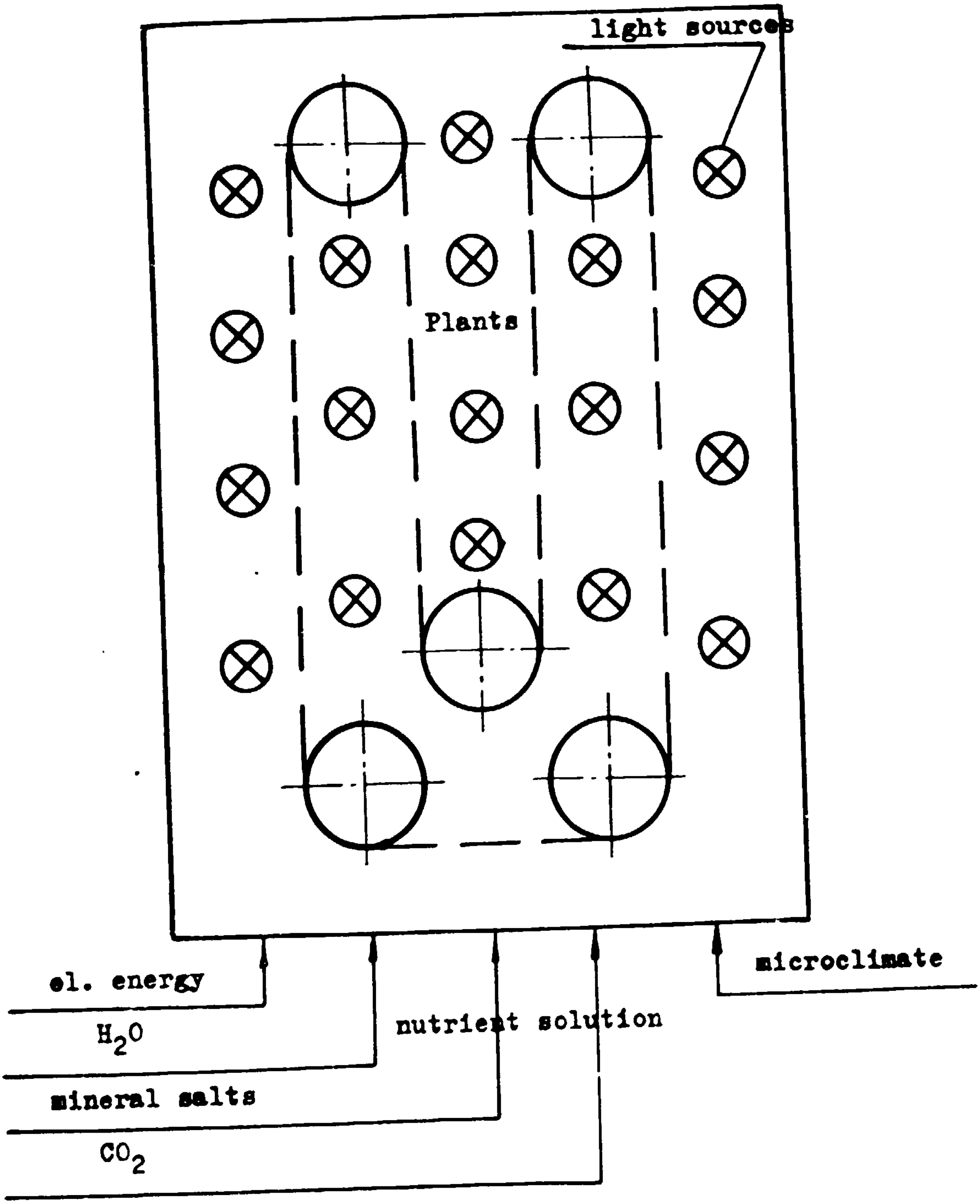

Fig.14
Principally technological layout scheme of rotary conveyer vegetation systems.

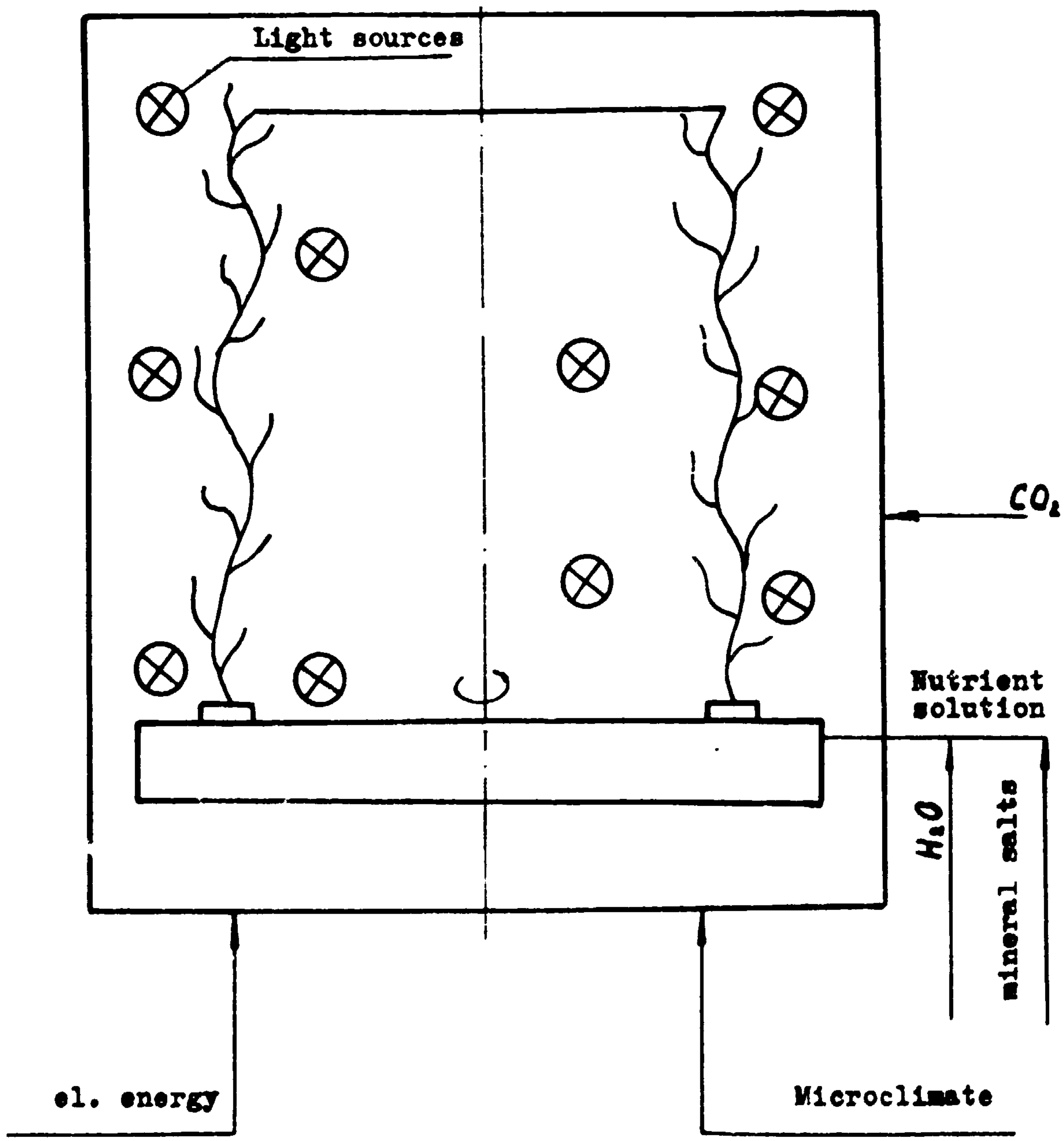

Fig.15
Principally technological layout scheme of rotary conveyer vegetation systems.

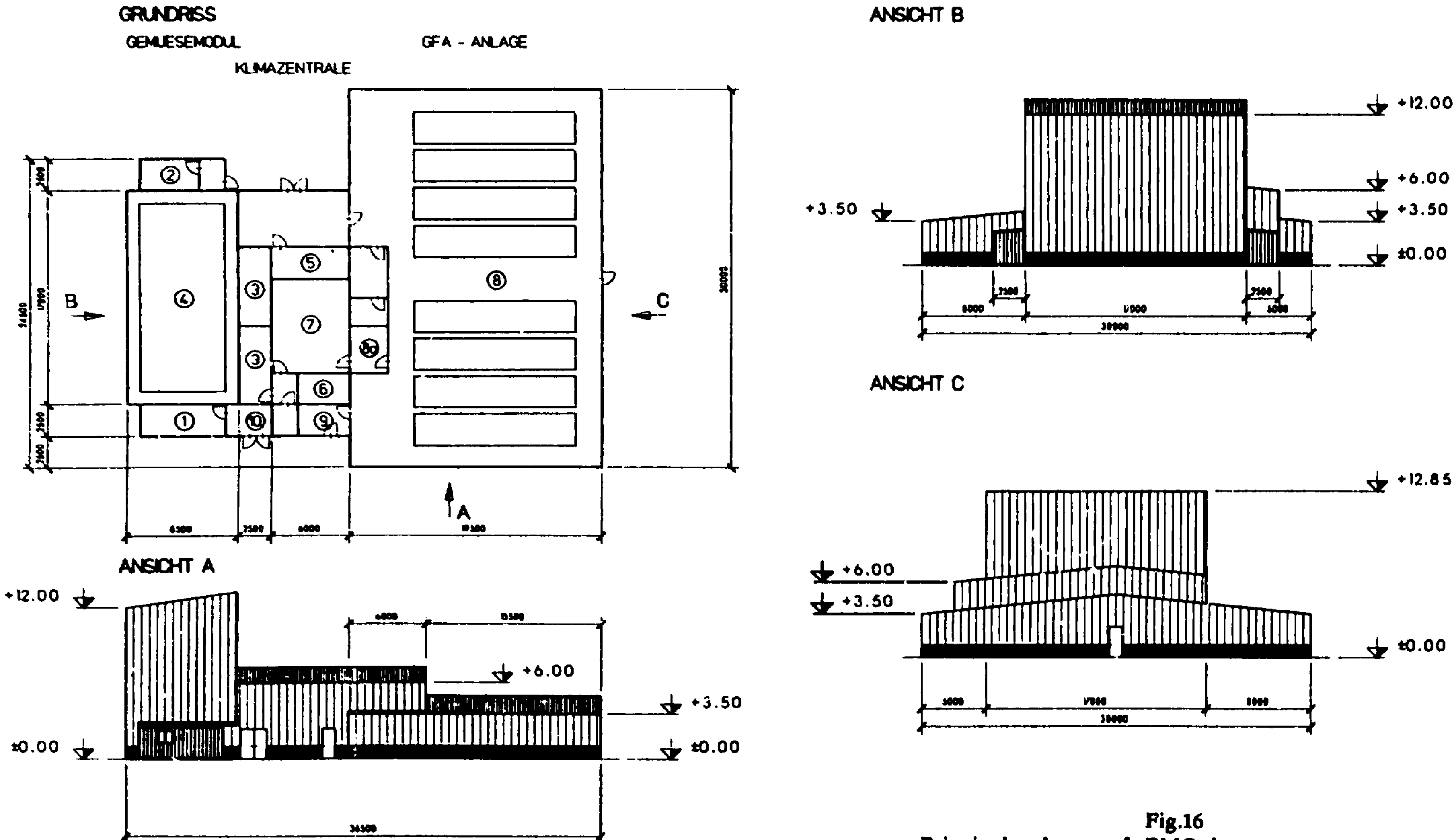

Fig.16
Principal scheme of BMC lauout.

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 3,4,5,6,8 and 10) are standard 20-feet containers.

The module for vegetables growing has the following dimentions: width 8.50 m, length 17.00 m, height 12.85 m. A carrier steel structure is composed of 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 conveyer system as well as the atmospheric loads (wind, snow etc.).

The module for vegetables or forage cereals crops has the following dimentions: width 19.50 m, length 30.00 m, height 3.50 m. The module has a structure of steel frames with a set of 3.00 m. pillars. The pillars arranged inside the module support the conveyer with the driving and tension mechanisms as well as the loads of the roof structure.

The block of the air conditioning system 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.

A conveyer for the transportation of the trays with plants within the vegetation section is secured to the principal steel frame structure.

The conveyer 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 are 1120 mm.

The conveyer 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 secured 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 tention axles.

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

There are 156 trays suspended to the conveyer 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 and covered from above by lids with holes for plants.

The lightening system is designed in such a way that it accomplishes two functions simultaneously: it ensures the lightening 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 "Philips" or DNaT and DRI of Soviet manufacturing) for 400 w each are placed in special light-transparent ventilated tubes.

The temperature of the external bulbs of the lamps rises up to 250°C degrees and for their cooling an air stream of constant temperature is delivered to the light-transparent tubes from the air conduits 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 conduits and to the common collectors. Both ends of each tube are provided with a flap gate which may by closed if it is necessary to repair a tube or replace a lamp.

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 degrees. 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 degrees: 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.

The equipment for the nutrient solution preparation used in both modules is arranged in one container.

In fig.17 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 vegetables module and in the center a water supply unit common for both systems is shown.

The system for the praparation of the nutrient solution for the vegetables module comprises: a plastic tank of 1000 lit capacity for the working solution; six 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 level in the tank; electromagnetic valve in the fresh water supply line; pulse meter 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 (GF) 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, monotor of the magnetic pump-meters "A" and "B" with a series interface for transmitting data to the central control board.

The system for preparation of nutrient solution for the leaf vegetables module, like the described above, has similar units and equipment, except for the tanks "C" , "D", "E", which are not necessary in this system.

The water supply unit comprises: a plastic tank of 1000 lit. capacity, level regulator of water in the tank; electromagntic 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.

The equipment of the leaf vegetables module comprises 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 conveyers 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 vegetational mass of plants.

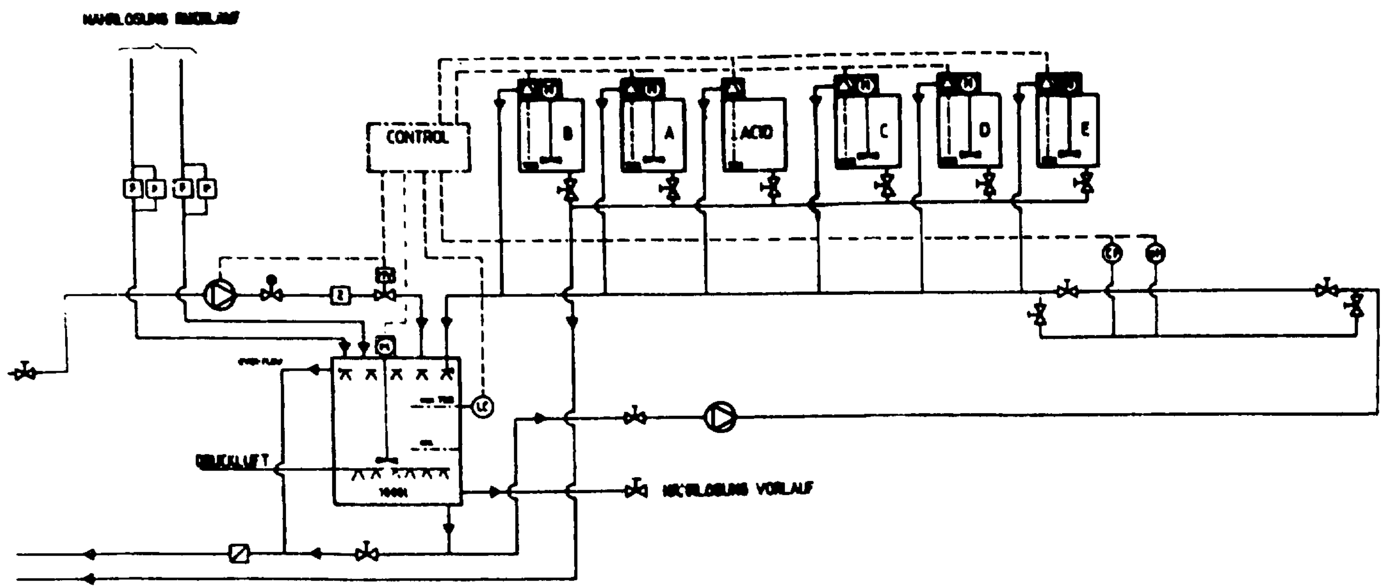

Fig.17
Scheme of preparation of the nutrient solution.

Each technological belt conveyer 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 conveyer 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 system 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 conveyers comprises 4 sets of travelling tanks for germinated seeds, loading mechanisms and other accessories.

A scheme of the combine system for the microclimate parameters regulation of the BMC vegetation sections is given in fig.18. 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 was mentioned, the principal source of heating of the vegetation section is the lightening 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 lightening 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 called seasons.

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.19). All the parameters are controlled by means of functional regulators consisting of a transducer of the controlled parameters, trasducer-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 equiped 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.

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 measure data through the bus system to the central computer.

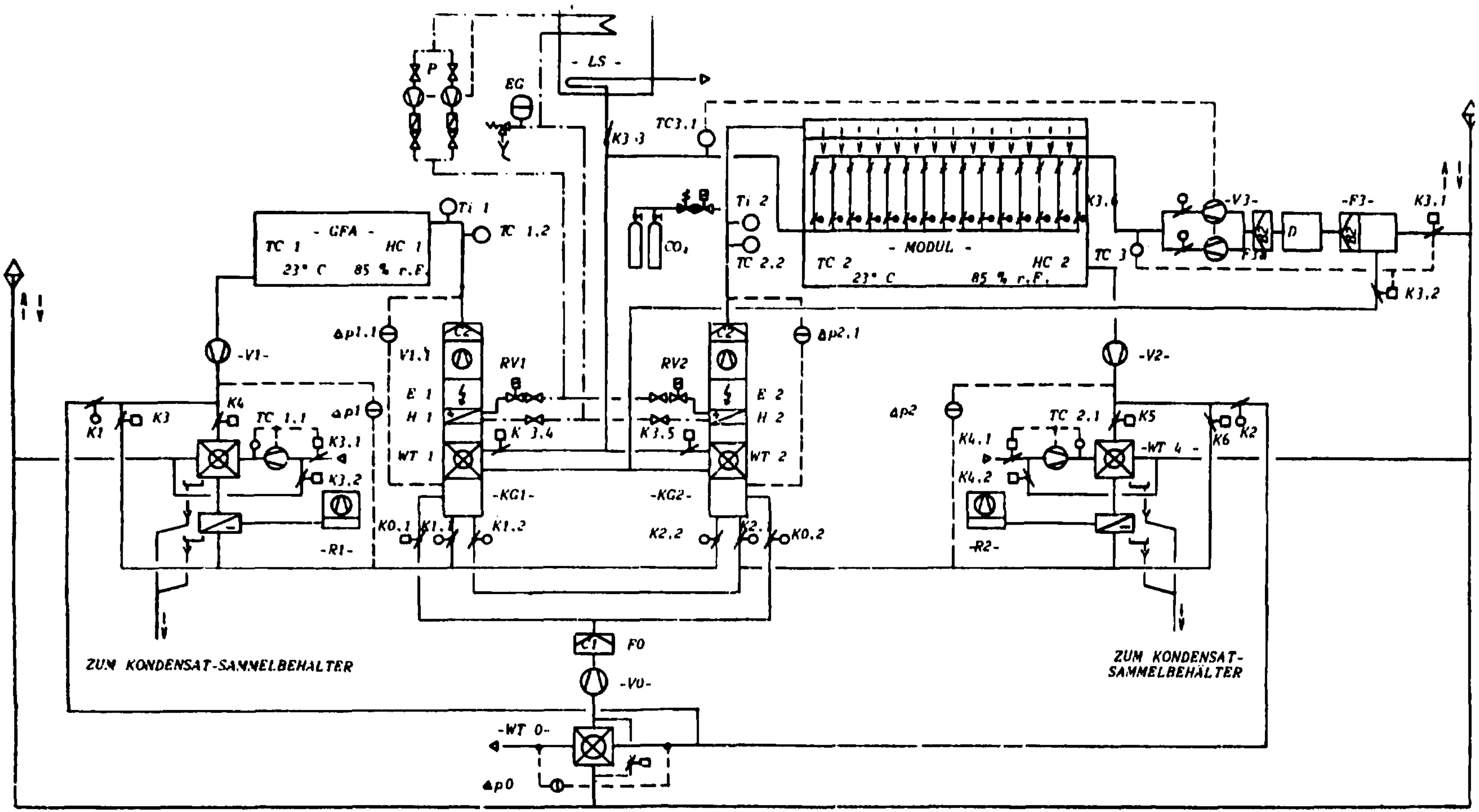

Fig.18
Scheme of the combine system for the microclimate parameters regulation of the BMC vegetation sections.

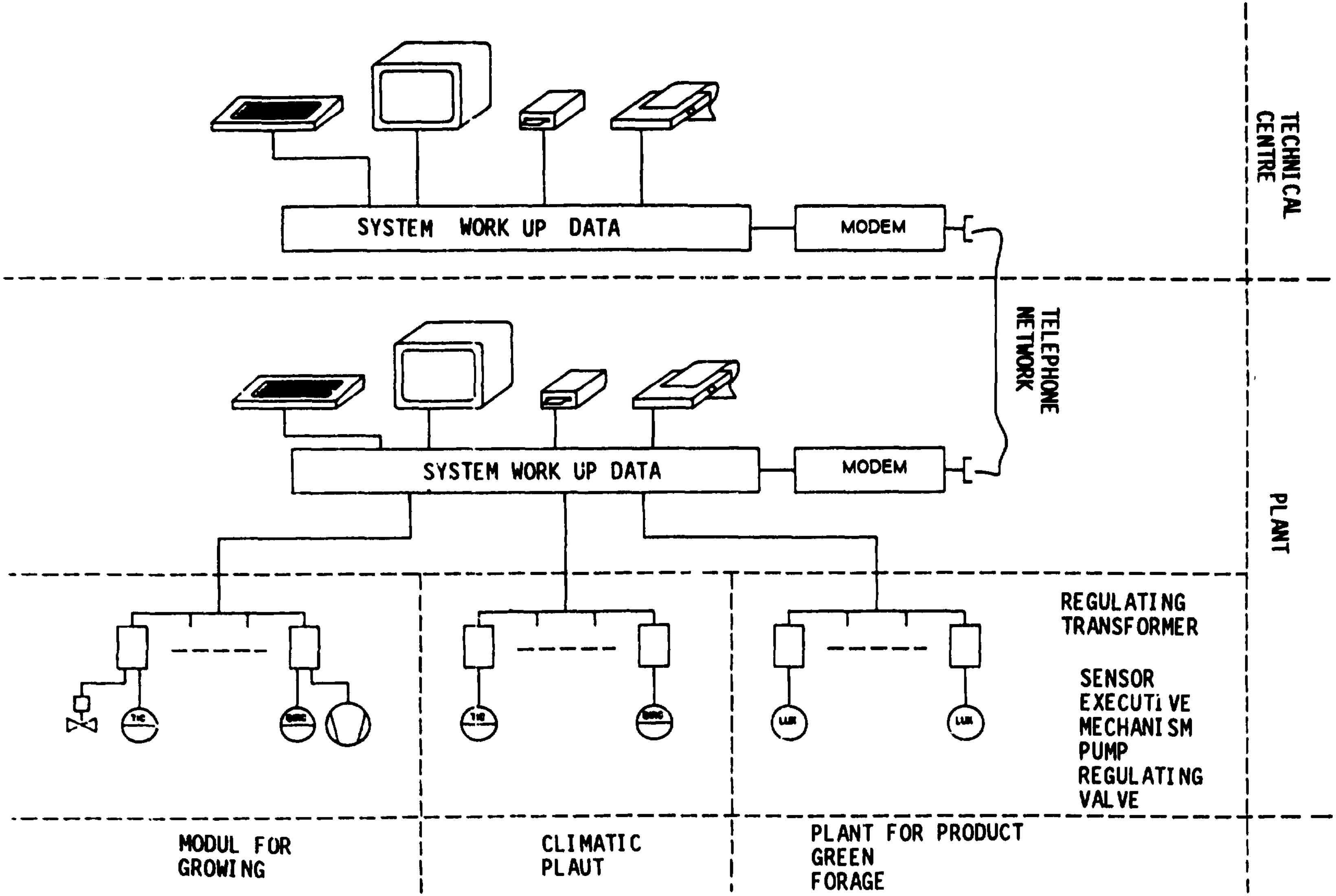

Fig.19

Structural scheme of the decentralized control system of the BMC.

By means of computer programmes certain regulators and data receivers are called, the data are collectes intc 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 the trends may be plotted for the temperature, humidity, pH, phosphorus, potassium, nitrogen, CO content, light intensity, etc. With the aid of other programmes deviation reports are made up as well as eventual instructions are given for the maintenance personell.

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 programme.

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 center may attend a net of BMC of a whole region. This cuts considerably the customer's agrobiological stuff maintenance costs.

The described Block Modular Complex is a multi-purpose technological plant which allows to ensure an efficient and stable production of different vegetables all the year round.

With insignificant modifications of the cultivating facilities (trays) the BMC may be successfully used for flowers, berries, melons and other crops growing.

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

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PRINCIPLES OF CLEAN TECHNOLOGIES AND SUSTAINABLE SYSTEMS IN INDUSTRIAL CROP PRODUCTION

W.I. Bauerle *

PREFACE

The future of controlled environment agriculture is dependent on the development of sustainable cultural, and technically sound management principles and environmentally safe programs that can provide a diversity of high guality products to the consumer using good management and marketing practices.

Such a program includes the development of a totally closed-loop water nutrient and management scheme where the only significant water loss is through plant transpiration.

Such an ambitious venture will reguire the capability to predict the behavior of the plant and the effluent. Reliable and guantitative predictions of nutrient concentration can be made only ifwe understand the environmental and biochemical processes controlling ion uptake within the growing and developing plant.

ABSTRACT

Groundwater contamination is a major world socioeconomic problem that has its roots in technological development. Considering the sources and causes of groundwater contamination, such as septic tanks, municipal and industrial sewer systems surface and subsurface mining, acid mine drainage, gas and oil field activities, bighway deicing, saltwater intrusion, herbicides, insecticides, fertilizers, irrigation returnwater and runoff in general, it becomes imperative that no simple solution can address the problem adeguately or comprehensively.

Agriculture is not only the largest ground water user, but also is the largest non-point source ofcontamination at least in the United States (Johnsrud and Rauschkolb, 1988).

Once the water is contaminated, the options available for its use are both limited and costly. Also, immense costs to the public are associated with its attempted clean-up.

Oaturally inherent with the control of the plant"s external environment is its potential for complete sustainability. Greenhouses provide the controlled environment making several factors possible: 1) season extension; 2) a yield increase per crop area of a magnitude up to 10-15 times that of the field; and 3) biological control of insect pests. The greenhouse is, therefore, established as a place in future world food production schemes.

The ability to collect the water effluent as well as the capacity to control the concentration ofeach individual nutrient and the interaction between various environmental and crop parameters such as crop type, size, physiological age, and genetics contributes to a totally recirculated effluent sustainable system. Implementation of such a sustainable system will go a long way in reversing the water contamination problem and making groundwater ecologically safe over the short- and long-term.

Scientific principles, including biological" plantmetabolism, irrigation, culture" environment, technological, and chemical, can be brought together that results in an industrial clean technology and sustainable plant production system in controlled environment agriculture.

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INTRODUCTION

Industrial Ecology

Contamination introduced into the sub-surface from non-point sources will be rapidly spread over a relatively large area because of the nature of the loading pattern. Agriculture is the largest non-point source user of water and, therefore, has a significant impact on the overall water management and water quality practices throughout the world. Of the 88 billion gallons of ground water used in the USA per day in 1980, 68% is estimated for irrigation of crops (Patrick, 1987). The agricultural industry is not only the largest water user, but also it has been identified as a major source of water contamination (Johnsrud and Rauschkolb, 1988). Countries around the world are facing similar pollution, saline water, or water shortage problems that lead to poor or no crop production and ultimately human hunger and/or starvation.

Contamination of these enormous amounts of water result in pollution of ground water sources and lead to ecology concerns as the contaminated water is redistributed back into soils" groundwater reservoirs or waterways. Groundwater that is present in the crust of the earth serves not only as a widely distributed source of water but also as a host and transporting agent for contaminants.

Intensive production of many crops in controlled environment agriculture or "industrial crop production" requires high inputs of water, nutrients and disease and pest controls in order to achieve the yield and quality demanded by such capital intensive systems. Unfortunately, these high inputs currently result in the need to leach effluent that is high in reserve nutrients and/or pesticides or other chemical products. A similar situation is evident in the production of field crops. However, the problem of effluent in field crops is currently far more difficult to control since the problem can encompass large land areas. In non-irrigated field crops the application of fertilizer before or during planting early in the plant"s growing cycle can be leached away by rain before it is required for crop development. In irrigated crops the effluent problem can be decreased by proper placement of fertilizer in the plant root zone. In controlled environment agriculture the problem is more temporary since the grower has the opportunity to control the applications of water, nutrients and control chemicals. The cultural methods are far more precise, overcoming vast land area problems inherent in the field agriculture operation. Typically, yields of crops from controlled environment agriculture are approximately 10-15 times greater than those from field crops, which can justify the level of control used. While these procedures solve the nutrition/toxicity/disease problem and provide for a clean, high yielding crop, they contribute significantly to the ground water pollution in the area (Huttar 1989). The problem of ground water pollution is usually left to the community infrastructure to deal with via sewage treatment plants river clean up and treatment of groundwater by individual households after it is pumped from wells.

In many parts of the world where commercial fertilizer is used, agriculture is beginning to feel the wrath of local communities and the law over the pollution of groundwater supplies. Contamination of groundwater by nitrates is one of the largest sources of non-point pollution in the United States (Freeze & Cherry, 1979. Nitrates dissolve in groundwater. As an anion (NO_3^-), it is not retained by the soil. A major source of nitrate contamination is from manure fertilizers on farmland. Nitrogen fertilizers are an important source of nitrate levels found in groundwater from agriculture ar... It has been estimated by Ragone et al.

(1981) that the maximum non-point nitrogen load to groundwater in Oassau County, Oew York for one year to be 10,000 to 10,500 metric tons. One-half or 5,200 tons was estimated to come mainly from lawn fertilizers--other sources are individual waste-disposal systems.

Oitrate concentration in natural uncontaminated pristine guality imit g allowed for drinking water is 10 ppm nitrate-nitrogen. Too much nitrate in drinking water can cause methemoglobinem'a or blue baby disease in infants and may also increase the danger of cancer in the population as a whole (Miruish, 1977). There is a strong geographical correlation between nitrate intake and gastric cancer (Hartmann, 1963).

Hallberg (1985) determined that since the 1960's an increase in the use of nitrogen fertilizer has been paralled by a similar increase in nitrates in groundwater. Fifty-four million tons of commercial fertilizer were used between 1980 and 1981, 48.7 million tons and 42.3 million tons between 1981-1982 and 1982-1983, respectively. Nitrogen accounts for 6.0 to 20% of these amounts. Much of the applied nitrate is not utilized by crops and is subseguently lost through leaching (Madison & Brunett, 1985).

I. Idustrial Productivity

An acceptable reward is a critical economical element for any successful commercial agriculture enterprise. Any operation's revenue is influenced by the guantity and the guality of the crop--two critical components of the marketable crop yield. Yield of a plant is directly related to the level of pbotosynthesis and the carbohydrates produced. High yields are acbieved by keeping the production of carbobydrates manufactured by the pbotosyntbetic process at the highest level possible during vegetative growth and fruit or plant product development.

Greenhouse Environment--The four major inputs into the greenhouse environment, light, temperature, relative bumidity and carbon dioxide are developed to work in harmony with plant growth and development.

Light -- Incoming solar radiation is optimized by using a light color floor in order to reflect incoming solar radiation. Light is a form of higb-guality energy and should be utilized for plant growth to its greatest degree possible. Using light reflecting material from the floor causes the plant to produce more carbohydrate" resulting in greater sustainable yields (Bauerle, 1981, 1981-1) (Fig. 1,2).

Figure 1. The effect of mulching practices on tomato yields of cultivar M-R 13. (Bauerle, 1981)

	Wt. per plant kilograms
Glass Greenhouse - White Mulcb	7.85
*Double Poly Over Glass - White Mulcb	7.76
Glass Greenhouse - Straw Mulcb 6.57 Glass Greenbouse - Aluminum Cloth Mulch 6.99	

Figure 2. The effect of snow-white plastic mulch on tomato yield (Bauerle, 1981).

	On. Fruit per plant	Wt. of Fruit (grams)	Wt. per Plant (kilograms)
Snow-White Mulch	48a*	154.2a	7.4a
No mulch	46a	140.6b	6.5b
Percent difference		8.8%	12.3%

*Numbers followed by different letters are significantly different at the 0.5 level of probability.

The light reflecting off the floor causes the plant to develop in the following manner:

1. Increases photosynthesis and thus carbohydrate accumulation.
2. Increases plant transpiration and nutrient uptake by reducing RH.
3. Reduces total energy regulrement in greenhouses.
4. Reduse internodal plant length.
5. Reduces incidence of disease by removing free water from plant environment.
6. Allows for uniform distribution of water in soil.
7. Reduces relative humidity (RH). B. Provides better ventilation and higher CO_2at leaf.

Temperature - A controlled temperature benefits the plant's metabolic functions plus:

1. Root metabolism constantly optimized.
2. Plant metabolism more uniformly controlled.
3. Uniform temperature regulates nutrient uptake by plant.
4. Uniform plant development.
5. Potential for temperature adjustment according to plant needs.
6. Crop timing more easily obtainable.

Relative Humidity (RH) - Control of relative humidity works in close harmony with other environmental parameters in some of the following ways:

1. Increased ligbting results in controlled plant transpiration by controlling the relative humidity.
2. Controlled humidity reduces leaf diseases.

The change from liguid to gas results in absorption of heat energy from the greenhouse and conseguently in its cooling. Less free water in the greenhouse environment causes a faster solar temperature rise during morning hours thus causing earlier ventilation.

Photosynthesis is the process whereby the plant uses converted carbon from carbon dioxide to produce a sugar or starch. This allows for a way to store energy for later use by the plant, mammals, etc.

Although directly related work on chemical-nutrition in plants has focused mainly in toxicity or deficiency. The complex metabolic enhancement possible through chemical nutrition has not received much research effort until recently due mainly to: 1) lack of technical development; and 2) lack of clear understanding of the active role that the essential plant nutrients has on the overall carbon accumulating plant parameters. Chemical nutrient control is a complex variable. Sixteen elements are currently recognized as essential for plant growth, while the role of selenium, silicon (2), and titanium are under investigation by various researchers (19). The essential elements recognized are: hydrogen (H), oxygen (O), carbon (C), nitrogen (O), phosphorus (P), potassium (K), sulfur (S), calcium (Ca), iron (Fe), boron (B), magnesium (Mg), manganese (Mn), zinc (Zn), molybdenum (Mo), chlorine (Cl), and copper (Cu). Carbon is obtained from CO from the atmosphere and the source for hydrogen in water. Water and oxygen from the atmosphere contribute to plant growth. All of the other elements are typically found in the soil or are supplied artificially through fertilizer.

Metabolic processes witbin the plant, as effected by plant species, physiological age and environmental conditions, regulate the uptake of nutrient elements. This has allowed plants to be fertilized with a wide variety of approaches, as producers seek to provide an adeguate nutrient level for plant growth. Although such fertilization fits the plant most of the time" there are periods of growth or environmental conditions when certain nutrient levels are limiting plant production. Diurnal NO_3-levels within spinach plants under two different light levels were substantially different from each other in work done by Tychsen (1976). Electrical conductivity (EC) is currently being used throughout the world to supply mixed nutrient solutions (Smith, 1987 and Welleman et al., 1984), yet on roses and carnations Alt (1980) showed a relationship between EC and P, but not EC and O. A plant is a dynamic unit that is gathering light energy, transforming that energy through photosynthesis into carbobydrates. Nutrient uptake is affected by carbohydrate production, a metabolic process regulated by genetics, physiological age and environmental factors.

Using tomatoes Gent (1986) had a 41% greater total nonstructural carbohydrate concentration at high irradiance than at low irradiance.

In pumpkin, nutrient influx of O, P, K, Ca, and Mg changed significantly as plant age increased (Swaider, 1985). Higbest influx rates varied in time for P, K and Ca, while highest influx rates for P and Mg occurred during the same 6- day period.

Research clearly shows the changing dynamics of chemical nutrition not only to environment changes, but also to physiological changes that occur in what generally could be defined as the vegetative and fruiting (product) phases when biocbemical cycling change the metabolic demand for nutrients.

General Sustainability in Greenhouses

Naturally inherent with the control of the plant's external environment is its potential for complete sustainability.

In addition to allowing for the control of inputs and outputs, greenhouses make it possible to extend the crop production season to an entire year. These two factors, control and season extension, combined in growing practices in greenhouse contributed for a yield increase per crop area of the magnitude of 10- 15 times that of field production. This figures will establish a future role for greenhouses in the world food production scheme.

In tropical climates where food production can occur annually, greenhouses provide a better control from the external weather as well as insect and disease attack. Greenhouses also provide a method to produce food without contamination of the environment or groundwater with chemical fertilizers and pesticides. Greenhouses of the future will help the mechanism to recycle effluent and biologically control pests.

Sustainable greenhouse plant production principles are available to both industrial and third-world nations where successful farming must follow sustainable principles.

Principles of Plant Nutrient Uptake

Nutrient uptake is an active plant metabolic biochemical process which has a defined range for every nutrient. When high concentrations of both essential and non-essential elements come in contact with plant roots or leaves, some will enter the plant, although the plant metabolically attempts to regulate their entry based on internal concentration. In fact, the plant regulrements for maintenance and growth are significantly less than the amounts now being recommended and used by the agricultural industry.

Recycling water systems need to precisely "match" and "tailor" the inorganic nutrient input with the metabolic process of the specific plant species being grown (Bauerle, 1987).

Sustability of Open-Drain vs. Clise-Loop Irrigation Systems

A. Open Drain Watering and Nutrition

The current economics favor open-drain systems wherewater is plentiful and fertilizer costs are minimal. However, there is an overall disadvantage of open- drain systems. Irrigation water, containing various nutrient salts including nitrate, which when lost from the system results in overall pollution and contamination of groundwater in the immediate area and long-term pollution of aguafers. Plant fertilization with open-drain systems reguire a significant addition of nutrient salts because the water entering the system contains few nutrient salts before being enriched. The advantage of open-drain systems is the possible control of nutrients in the water as it is enriched before use. This advantage is far outweighed by the disadvantage of losing a significant portion of nutrient salts as indicated in Figure (3).

Figure 3.

TRANSPIRATION AND DRAINAGE WATER CONSUMPTION WITH ESTIMATES ON FERTILIZER USAGE

	Plant Transpiration m /m	Leach to drain m /m	Water to drain as%	Fertilizer used Ha/kg 1.0 E.C.
Open-Drain watering	1.2-1.6	0.9-3.2	20.100	7,920
Closed-Loop	1.2-1.6	0	0	4,922* 909**

*Fertilizer used calculated at a rate creating a constant E.C. of 1.0 micromhos on water volume used for transpiration and drainage.

**Actual fertilizer used calculated on the return of enriched effluent.

Closed-Loop Watering and Nutrition

In closed-loop systems, the irrigation effluent is collected for reuse. The ability to collect the effluent opens a whole new era in the understanding of plant nutrition and the use of inorganic and organic fertilizers is beginning to unfold for commercial growers (Bauerle, 1990, 1990-1).

Proper nutrient control of the recycled water must be maintained or excesses soon begin to influence plant growth and guality. In addition to the maintenance of a proper nutrient balance, attention needs to be given to the processing of the outgoing/return nutrient enriched recycled water to ensure:

1) absence of foreign particles;
2) maintenance of balanced nutrient content;
3) maintenance of the proper oxygen level;
4) freedom from various pathogenic organisms; and
5) a stable nutrient chemistry.

C. pH Stability and Water Chemistry in a Close-Doo Hidroponic System

Maintaining the pH at 5.6-5.8 in the incoming and return water is critical to recirculating systems:

1) absorption ability of roots;
2) solubility of all nutrients;
3) biochemistry changes in root;
4) nutrient uptake; and
5) nutrient availability.

Water pH can be controlled by a several means. Liguid CO_2can be added into the recirculating and/or incoming water, but availability of $CO_2$and a control mechanism are reguired.

Supply of nutrients to the crop could provide some pH control, but the most universal and simplest way for constant control of pH is to use either phosphoric acid (H_3PO_4), sulfuric acid (H_2SO_4) or nitric acid (HNO_3) through a positive displacement proportioning injector. The acid not only controls the pH, but can also be used to supply essential phosphorus, sulfate or nitrate based on plant nutrient reguirements. Figures 4,5 show a manual water pressure operated proportional injectior capable of injecting the above mentioned acids or solutions of fertilizers.

In the future, the procassing of the recycled water will be critical to the success of closed-loop systems.

D. Use of Water

One can estimate that between 20-80% of all water used with automatic drip irrigation goes to drain. This represents a significant amount ofwater use, and fertilizer loss. Further, the drainage has caused excessive humidity and other problems. Humidity control from dripping greenhouse roofs has led to excess venting, resulting in increased fuel consumption on cold days.

E. Hidroponic Aeration

Aerating hydroponic solutions is critical to the success of the system, simply because oxygen supply to the root absorbing surface is critical for respiration processes. The principles and complexity of variables such as environment, plant metabolism and respiration, disease potential, hydraulic conductivity ofwater, biological reaction, that are directly dependent on oxygen are vast. The lack of incorporation of air (oxigen) into a recirculate hydroponic solution is synymous with failure.

However, there are three factors that are inherent to hydroponic solutions that should be briefly discussed:

1. The increasing importance of oxygen with decreasing moisture tension. Oxygen supply to the root is reduced as moisture tension decreases. In hydroponic solutions oxygen or air dissolved in the water is the primary carrier of oxygen to the plant root. There is a continued increase in ion uptake by the

roots to an oxygen percentage of 8 to 10.

2. Oxygen content in water is directly related to the water temperature . What normally occurs in an industrial hydroponic operation is that the hydroponic solution is pumped to channels and applied to growing plant roots. At this point not only the roots extract the oxygen from the solution" but generally the solution begins to increase in temperature resulting in a release of dissolved oxygen. The recirculated nutrient solution returns to the sump tank with less dissolved oxygen then it is potentially capable of holding.
3. Plant growth is sensitive to the reduction in oxygen level (Gislerod and Kempton, 1983; Bradford and Yang, 1981; Curtis and Zeotmyer" 1949. Drew and Lynch, 1980; Greenwood, 1979).

Growth rate, root mass, root appearance, leaf area, water consumption, and yield are, reduced by low oxygen. Further interactions between depleted oxygen in the root zone and plant disease have been reported by Drew and Lynch (1980), Schoenewiss (1975).

Principles of Nutrient Injection

The Computerized Nutrient Injector has the ability to adjust the ratio of each individual nutrient in its recipe (Bauerle, 1988). This is accomplished by a multiheaded injector with a variable capacity to adjust the concentration of each specific nutrient coming from stock tanks containing standard concentrations of the nutrients.

It is able to react to crop inputs, such as crop types, size, physiological age and genetics. Crop size, such as leaf area, and the number of plants, or environmental parameters such as light, diff- ion pressure deficit, or the injector can accept other external inputs in concert with the environmental computer. The nutrient application is not practical only to ensure adeguate supply of nutrients to a crop but also as an effective tool for controlling the growth and development processes of a crop.

The capability built into the computerized injector can easily react to and supply accurate concentration of nutrients to a dynamically active biological biochemical system (Bauerle, 1990-3).

B. Comparingthe Principles of ConductivityEC and Tailoring Specific Individual Nutrient Ratios

Nutrients supplied at various concentrations based on conductivity (EC) of the fertilizer solution were compared to four ratios of potassium to nitrogen (K to N) at 1:1, 2:1, 4:1, and 6:1.

The growing medium consisted of 45% coarse vermiculite, 45% peat and 10% perlite. The growing medium was selected because it has a coarse texture and was less likely to leave material collecting around the base of the plant stem at the soil line. Hight conductivity leveks and 1:1 ratio resulted in severe injure and subsequet death of plants.

Measurements were taken on plant height, leaf length and width, stem thickness girth, fresh and dry weight.

C. Effect of Conductivity as Growth Control

Conductivity (EC) is a very useful measurement of fertilizer concentration, but it must be realized that conductivity as it is currently commercially used finds its control based on the osmotic potential of water vs. the osmotic Potential of the root cell. If the conductivity of the nutrient solution is higher than the conductivity of the root, water moves out of the root cell until the osmotic potential is at egullibrium. Conductivity control assumes a passive nutrient uptake by the root there is no means for individual nutrient addition or deletion from this type system.

Figures 4, 6, 8, 10 and 12 show the influence of conductivity on various plant parameters. The linear reduction in growth parameters above 3000 micromhos as the fertilizer concentration continues to increase clearly indicates that fertilizer needs of the Plant are not satisfied by conductivity control. The linear reduction in all growth parameters provided by increasing conductivity can give a commercial producer a false sense of control. The plant response to higher conductivity is to increase its root respiration which depletes valuable sugars in an effort to increase its osmotic potential. A short-term gain can result in a longer-term loss in plant yield and guality as seen in Figures 18 and 19, which compare general conductivity control to ratio of K to N at a specific conductivity. Higher ratios of potassium to nitrogen can easily result in as much as a 40% increase in fresh weight. More important however, is the plant"s ability and efficiency to convert the proper fertilizers to dry matter. Figure 19 shows that a 43% gain in dry matter at ratios of K to N of 4:1 and 6:1 a lower dry matter produced at the 1000 conductivity is an inability to replace the nitrogen reguired to accelerate the growth rate at that conductivity.

D. Effects of Tailoring Specific Individual Nutrient Ratios

Applying nutrients as a retio is an initial step in the dynamics of individual nutrient application tailored to plant

growth and development. Plants grow with conductivity control vs. ratio of potassium and nitrogen show significant differences in their growth patterns. It is apparent that increase in conductivity produces a linear reduction in plant growth, while potassium to nitrogen at specific ratios significantly increase crop fresh and dry weight.

The ratio of potassium to nitrogen reguired to produce higher yields changes as the concentration of the two essential elements change in solution (Figs. 5, 7, 9, 11, 13). This indicates that at low-solution concentrations there may be deficient guantities of nitrogen available in solution to produce optimum growth at the higher potassium levels. The development of a system able to supply each essential element independent of each other could realize potential yield increase over an application of a given blend controlled by conductivity.

Higher ratios of K to N result in a significant increase in plant hei. ght, leaf length, width and main stem girth (Figs. 14, 15, 15, 17).

By changing the ratio of K to N from 1:1 to 4:1 at a conductivity of 3000 micromohs produces a 42% increase in plant dry weight (Fig.19). Further at 6000 micromohs and 9000 micromohs approximately 30% addition in dry weight occurs, however, comparing 6000 to 9000 conductivity at a ratio of 4:1, 30% less dry weight is harvested.

By applying nutrients as a ratio it becomes evident that the plant produces a greater fresh weight and dry weight and that plant size and morphological development is positively influenced (Fig. 18, 19).

EFFECT OF CONDUCTIVITY ON PLANT HEIGHT

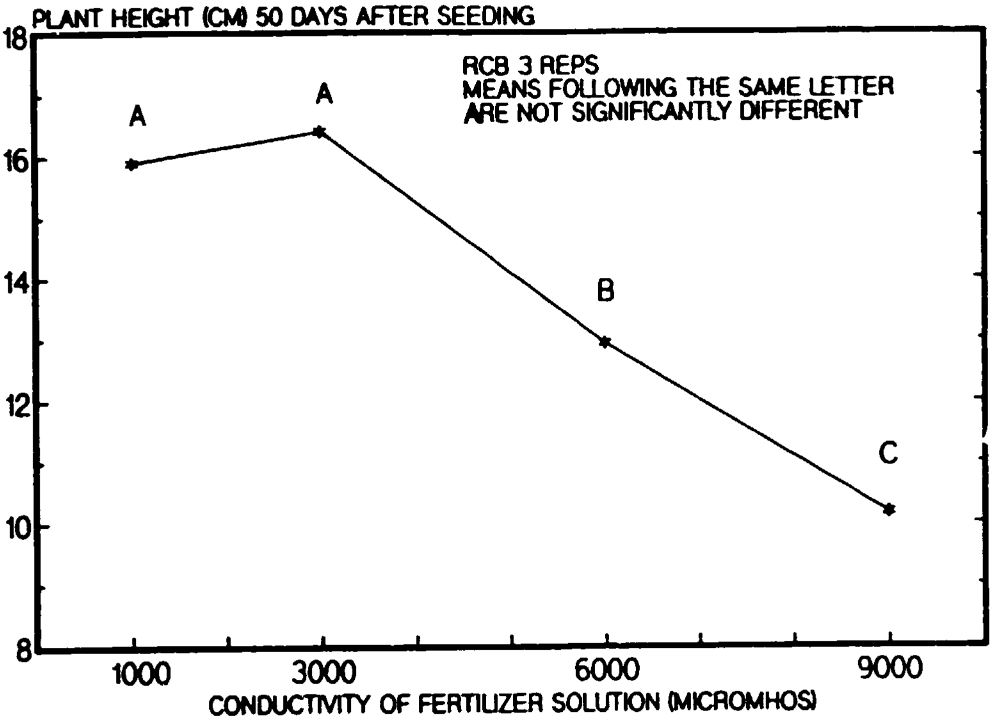

Figure 4. Effect of Conductivity on Plant Height.

EFFECT OF K TO N RATIO ON PLANT HEIGHT

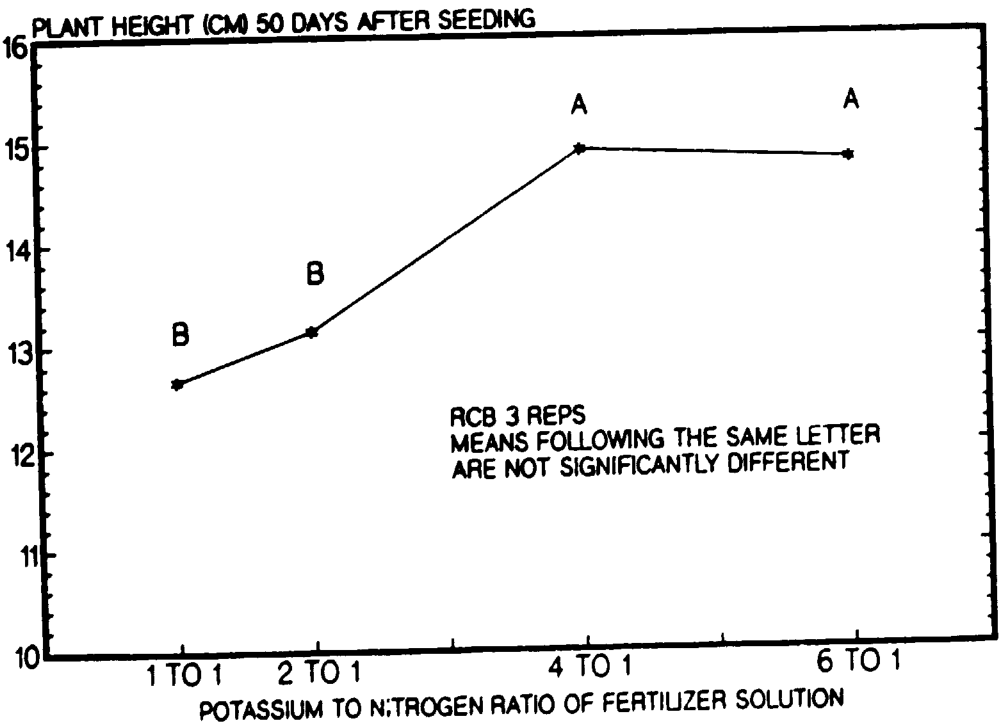

Figure 5. Effect of K to N Ratio on Plant Height.

EFFECT OF CONDUCTIVITY ON LEAF LENGTH

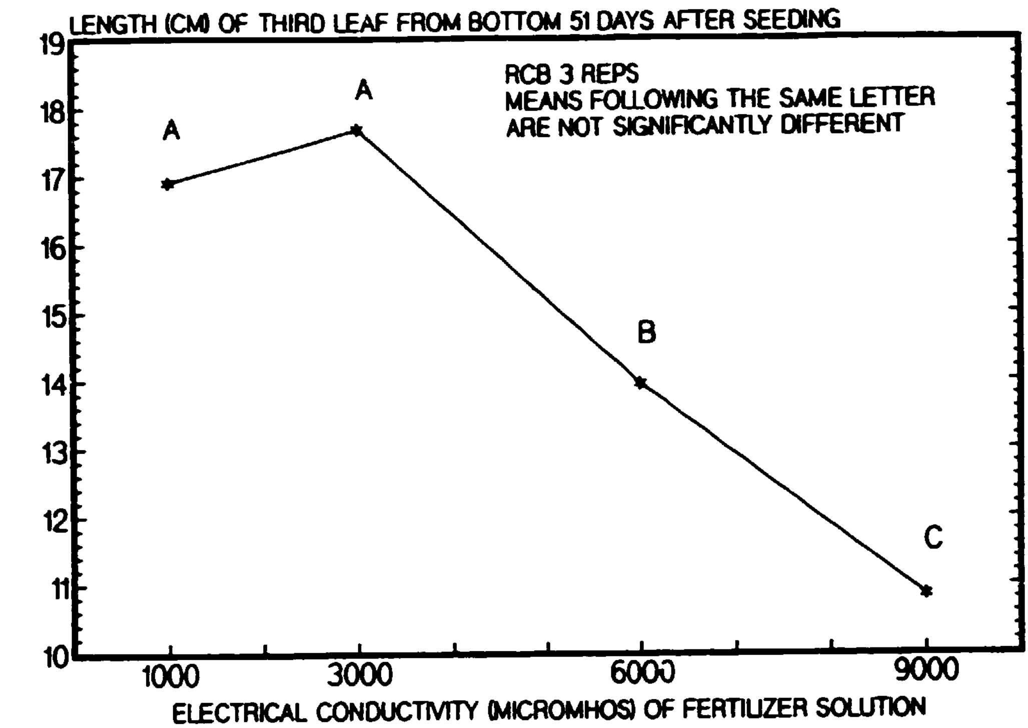

Figure 6. Effect of Conductivity on Leaf Length.

EFFECT OF K TO N RATIO ON LEAF LENGTH

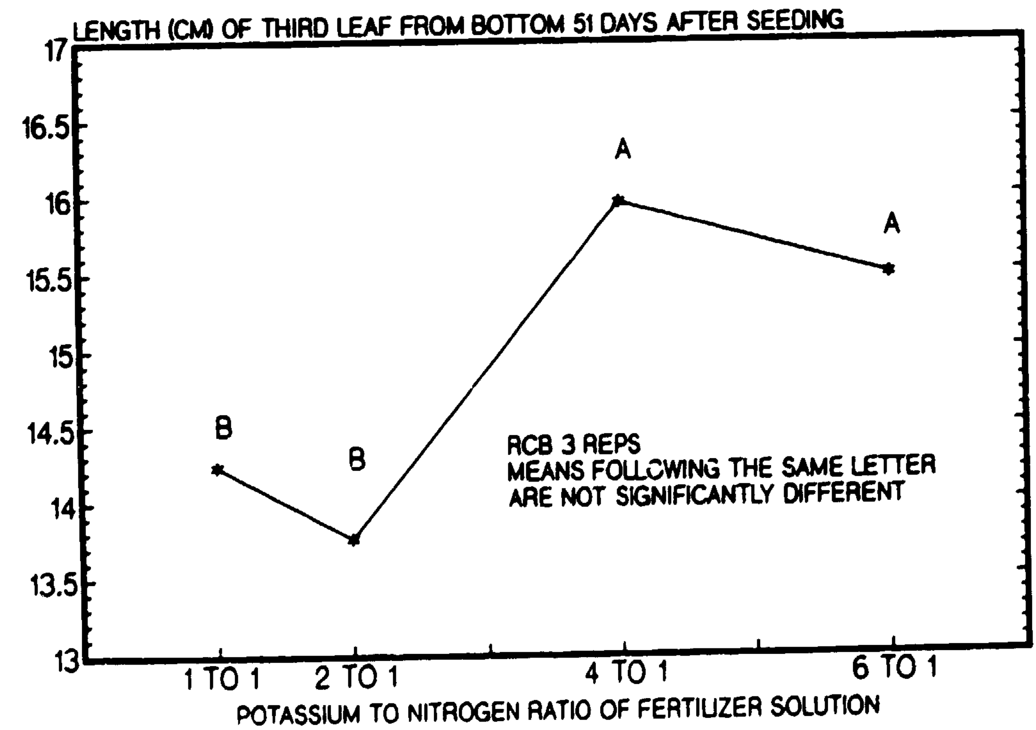

Figure 7. Effect of K to N Ratio on Leaf Length.

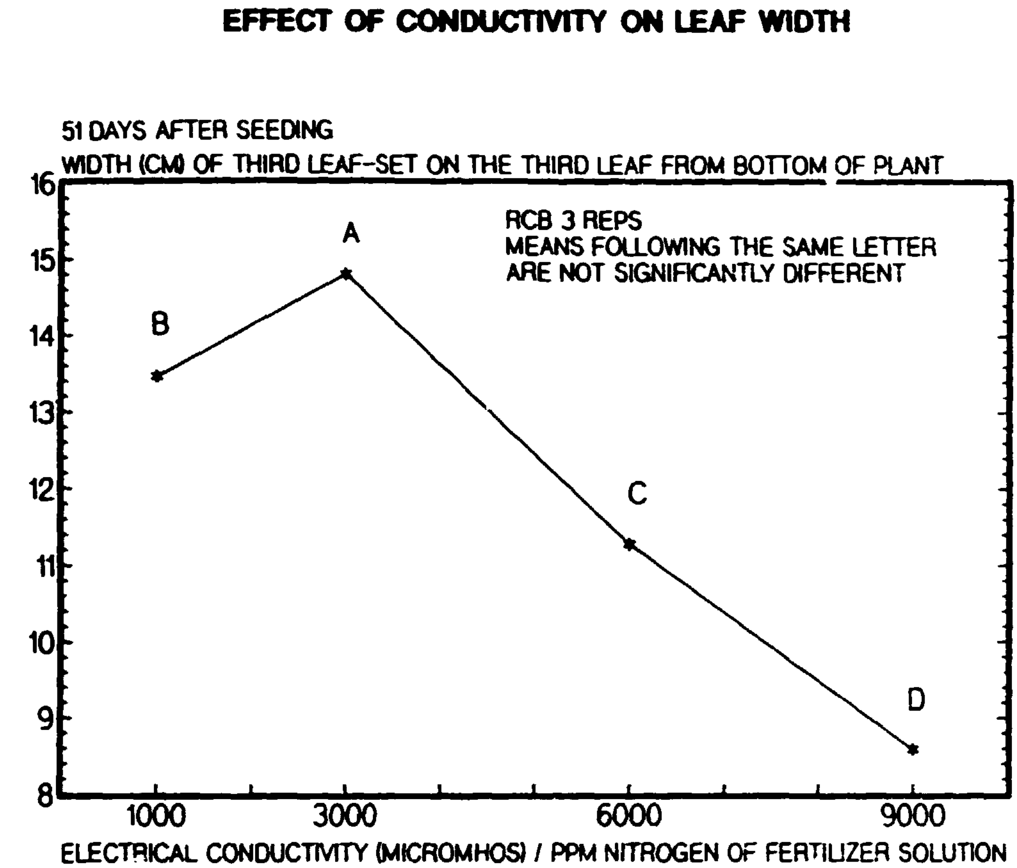

Figure 8. Effect of Conductivity on Leaf Width.

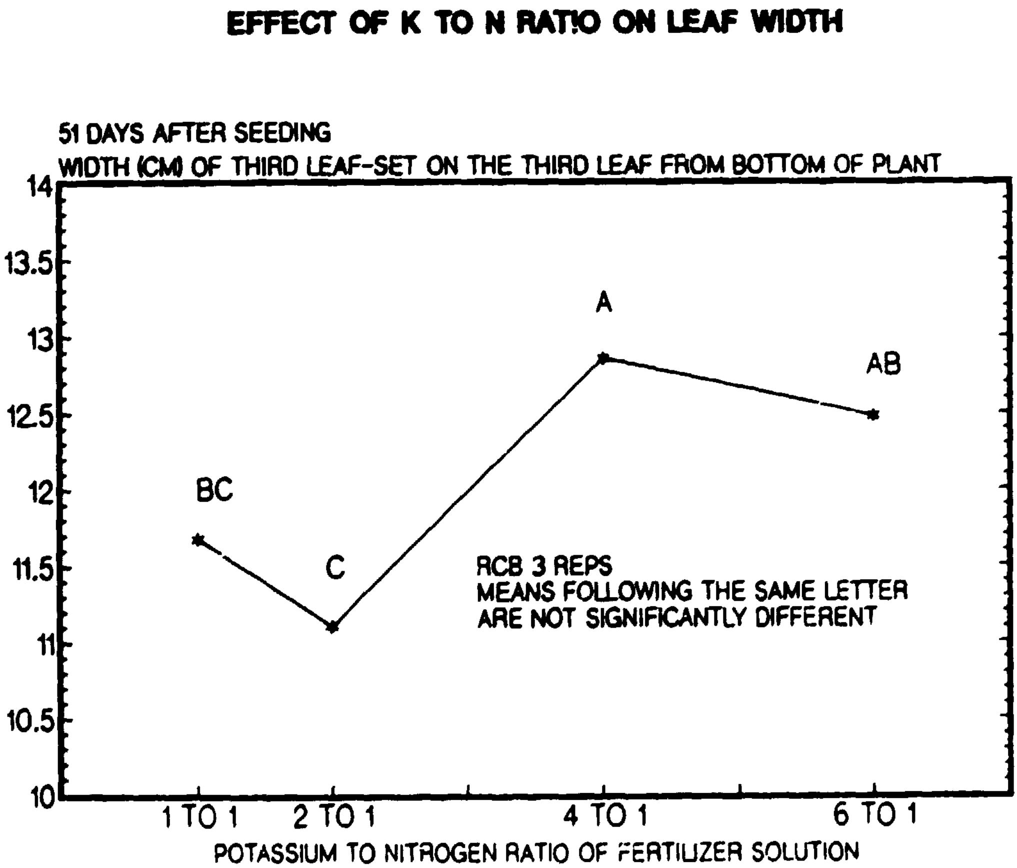

Figure 9. Effect of K to N Ratio on Leaf Width.

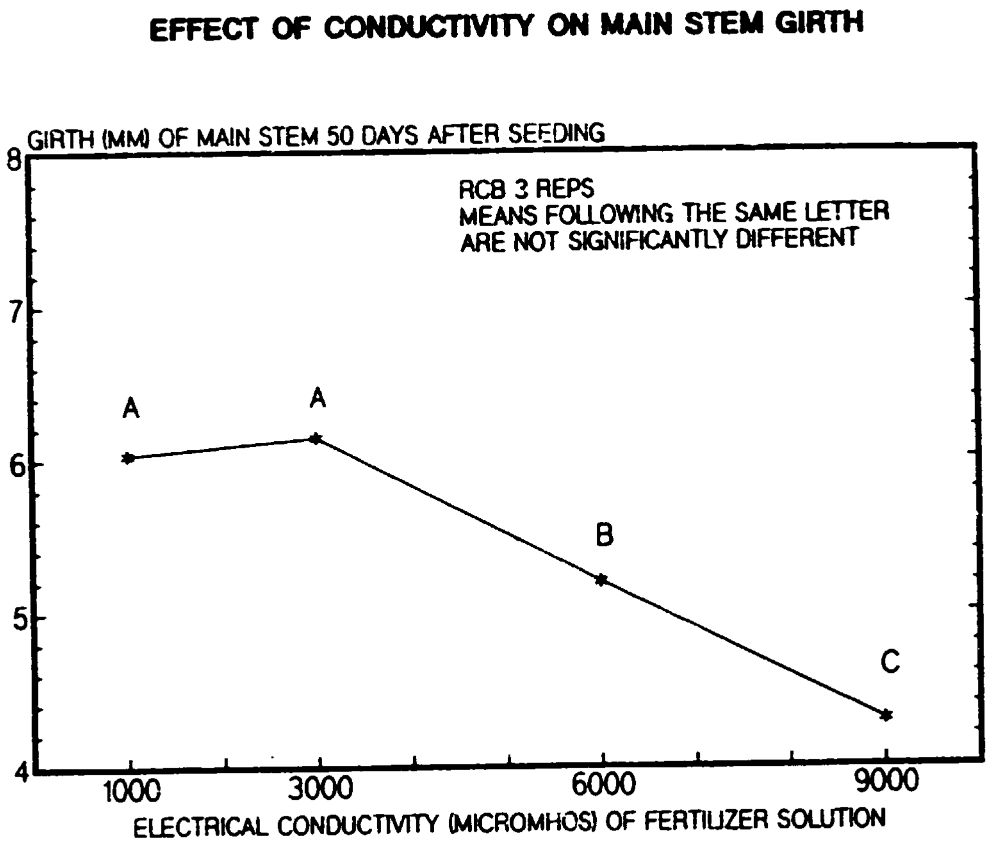

Figure 10. Effect of Conductivity on Main Stem Girth.

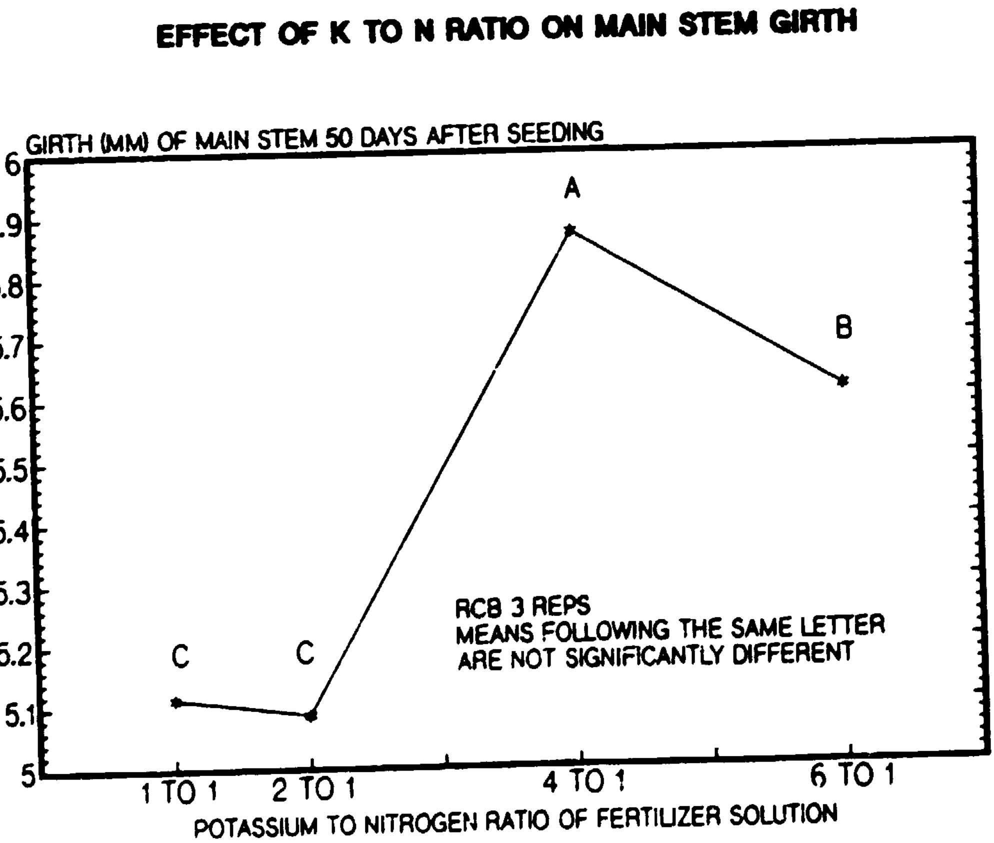

Figure 11. Effect of K to N Ratio on Main Stem Girth.

EFFECT OF CONDUCTIVITY ON DRY WEIGHT

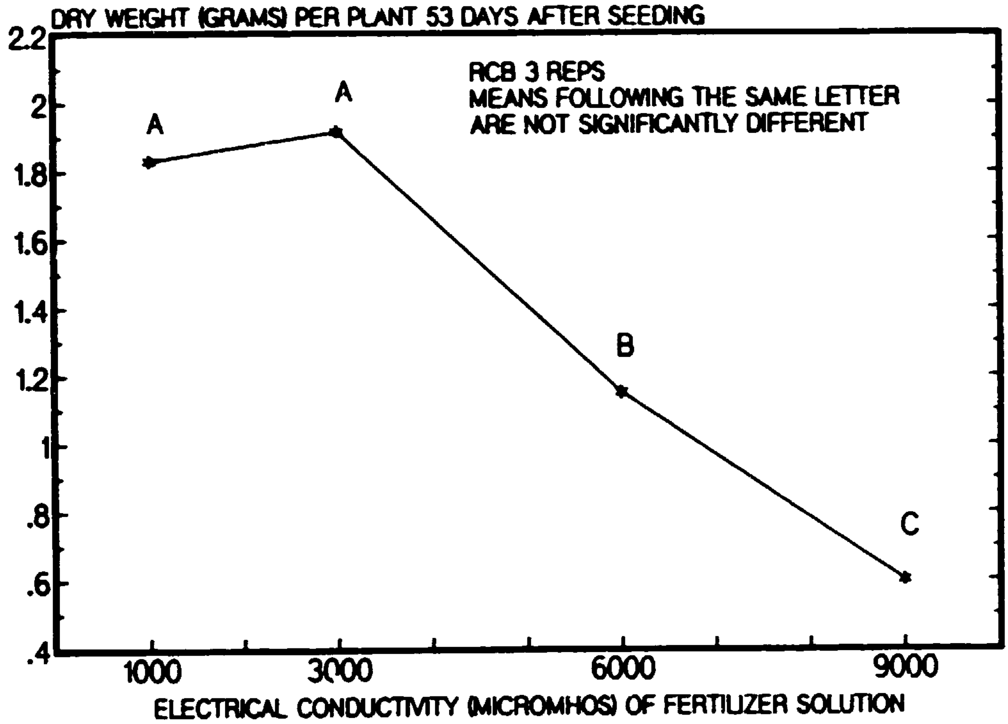

Figure 12. Effect of Conductivity on Dry Weight.

EFFECT OF K TO N RATIO ON DRY WEIGHT

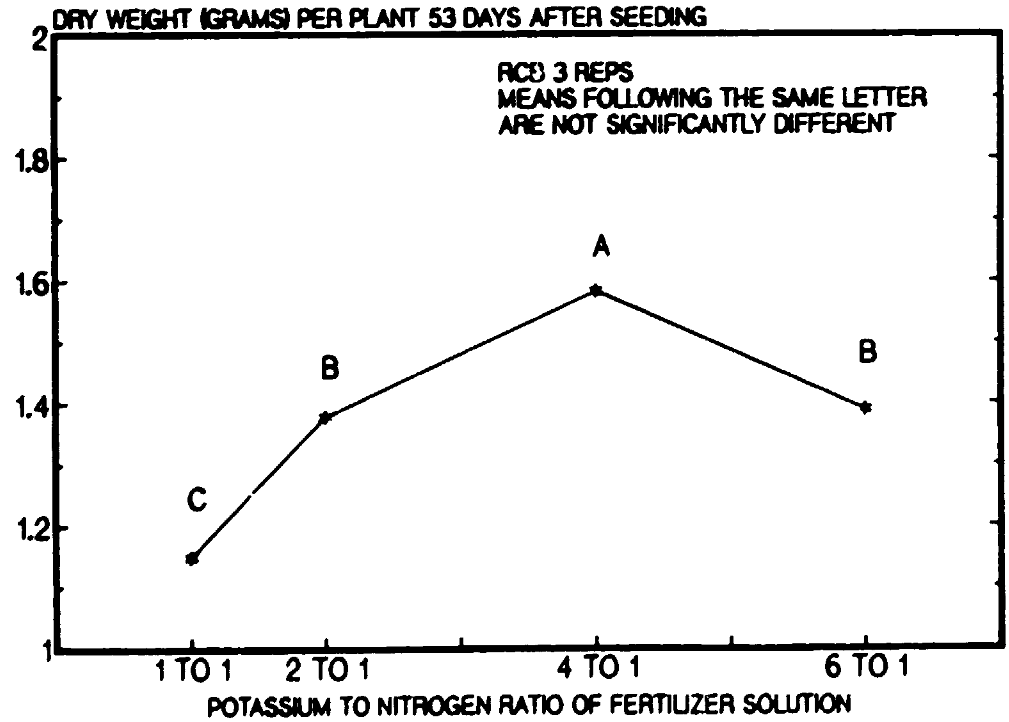

Figure 13. Effect of K to N Ratio on Dry Weight.

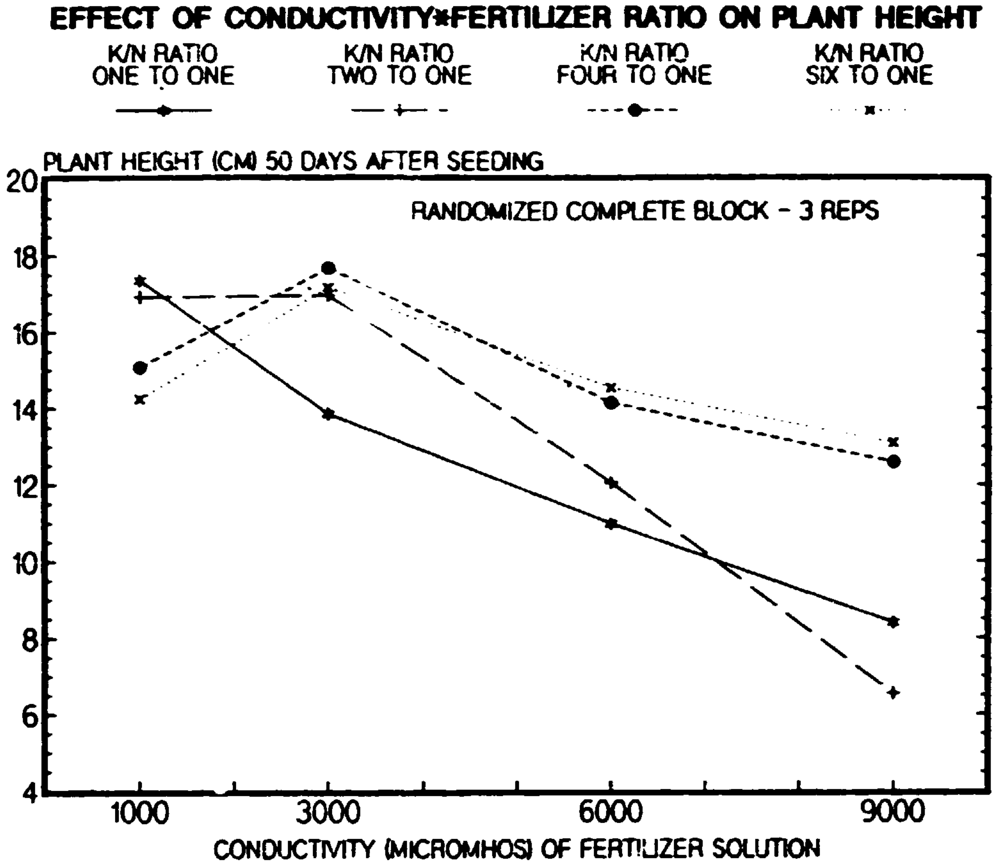

Figure 14. Effect of Conductivity and Fertilizer Ratio on Plant Height.

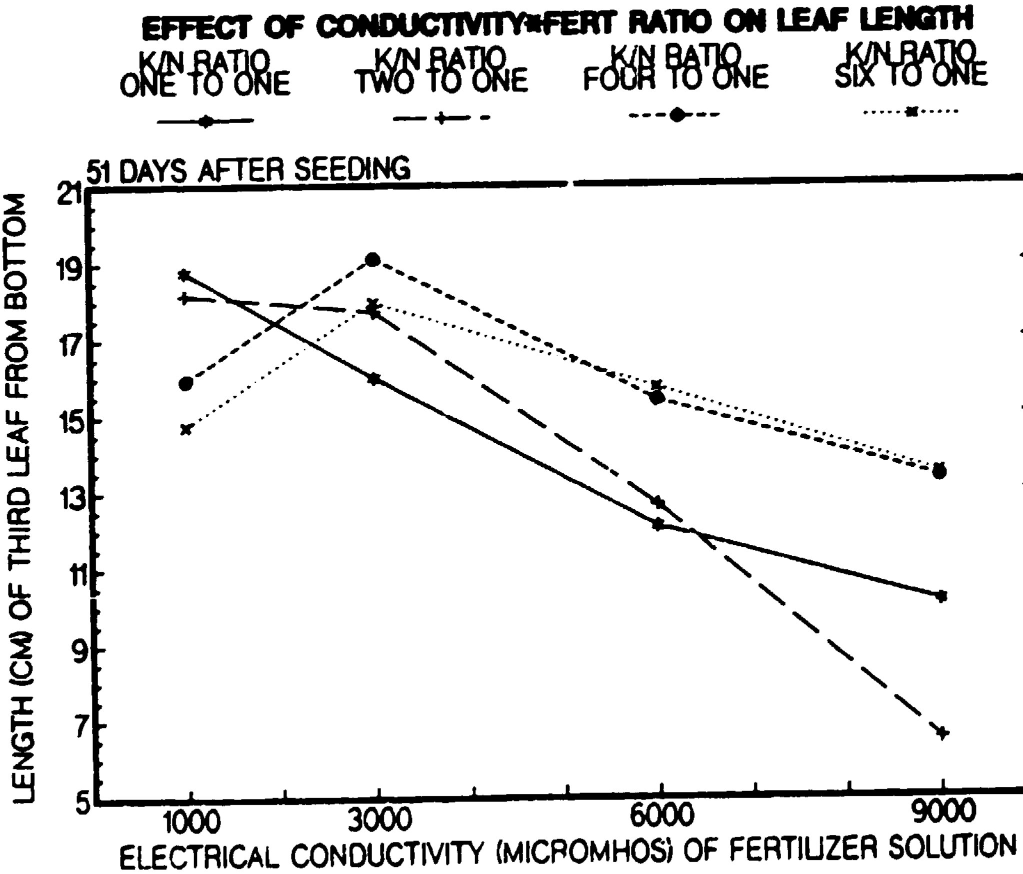

Figure 15. Effect of Conductivity and Fertilizer Ratio on Leaf Length.

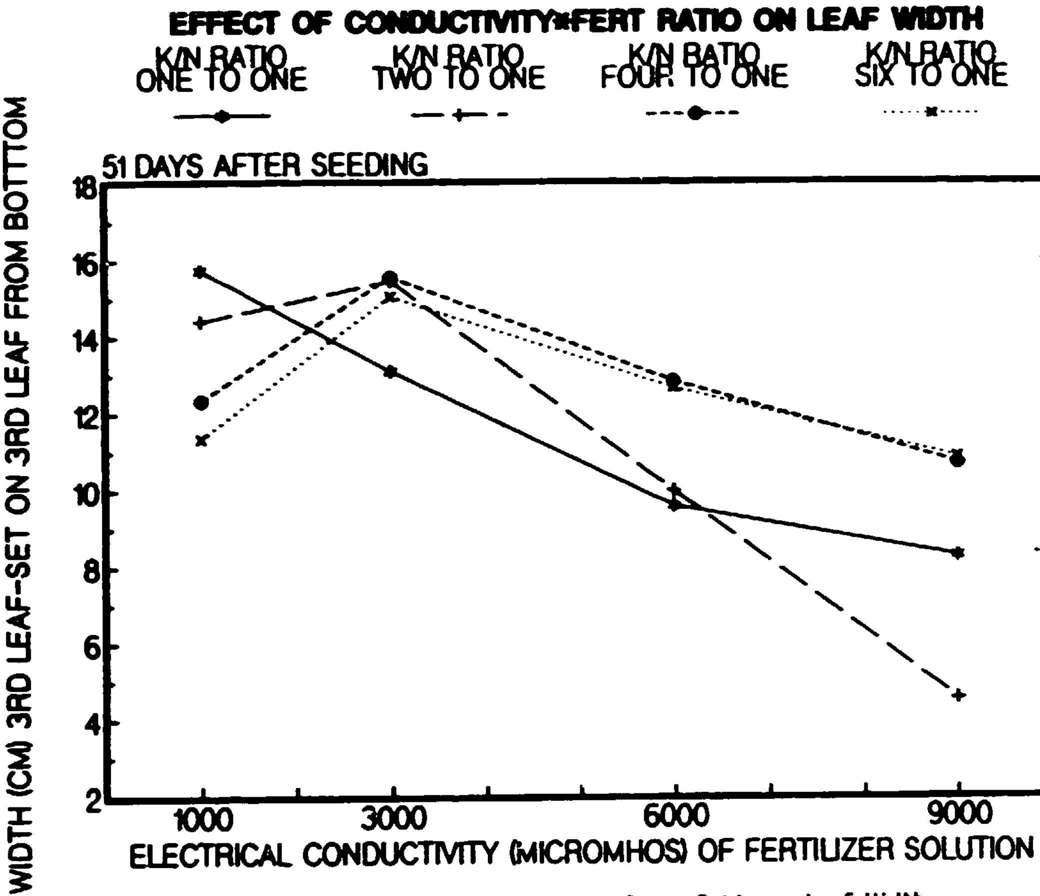

Figure 16. Effect of Conductivity and Fertilizer Ratio on Leaf Width.

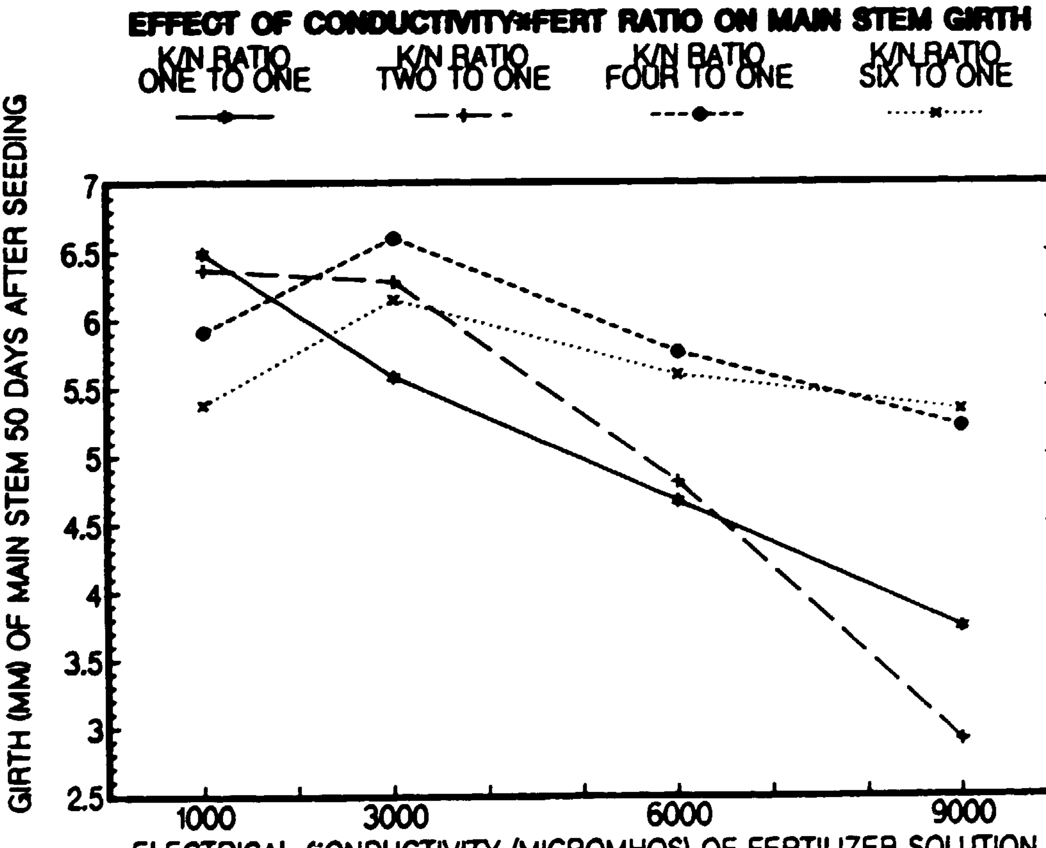

Figure 17. Effect of Conductivity and Fertilizer Ratio on Main Stem Girth.

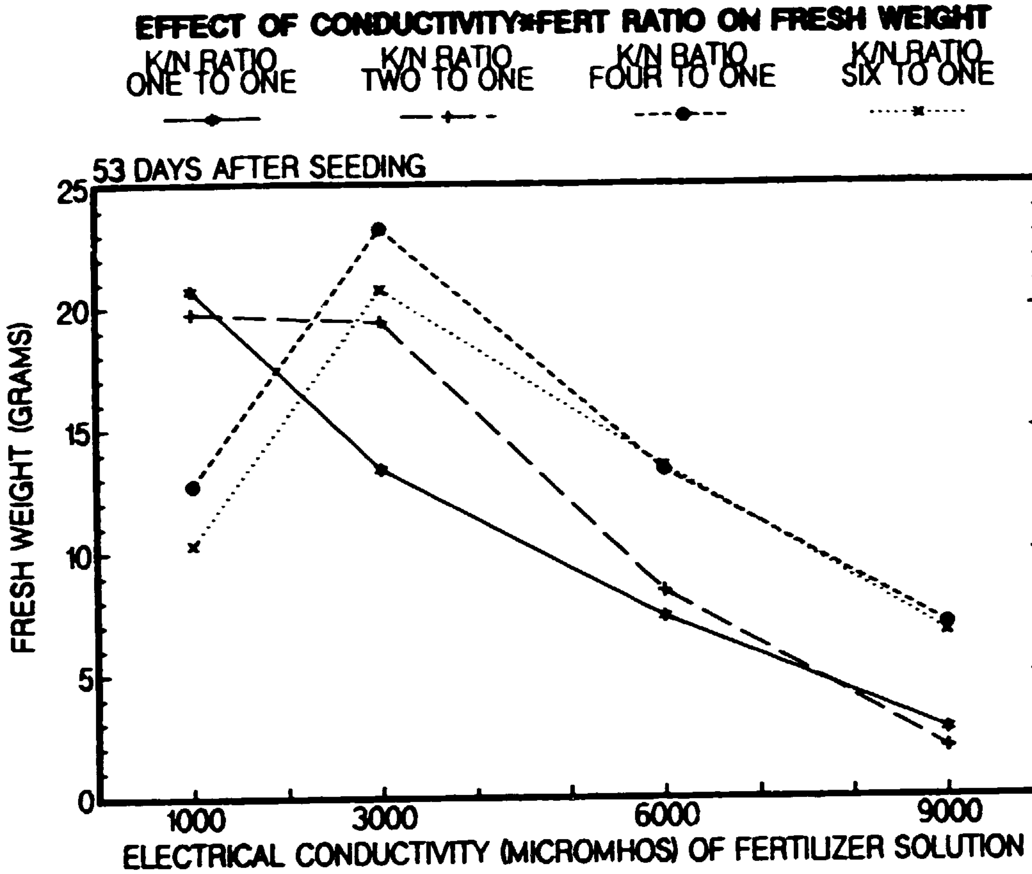

Figure 18. Effect of Conductivity and Fertilizer Ratio on Fresh Weight.

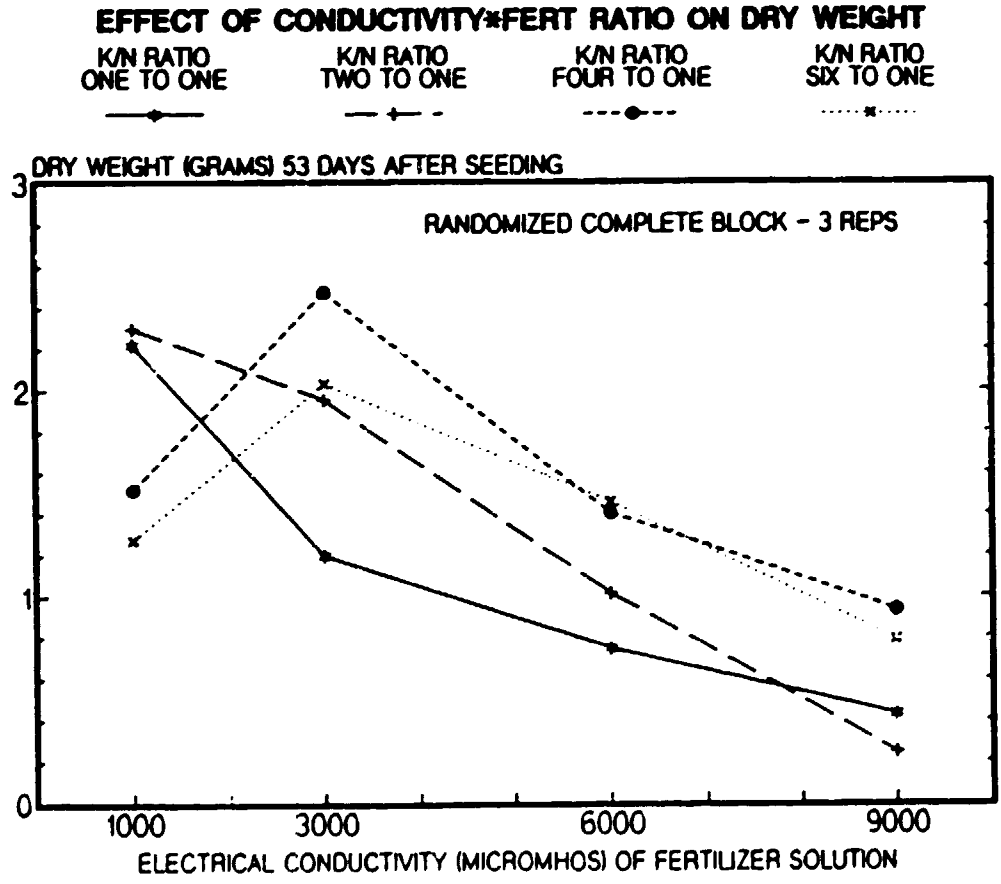

Figure 19. Effect of Conductivity and Fertilizer Ratio on Dry Weight.

Commercial Sustainable Subirrigation Systems

In addition to pure hydroponic systems where the plant roots are constantly exposed to the nutrient solution" there are a number of systems where some form of organic or synthetic media is used. Plant roots obtaine their water and nutrient supply from all hydroponic subirrigation systems in two ways: 1) either the nutrient enriched water is constantly flowed or sprayed on the root whereby the root interacts directly with the passing fluid" or 2) media is placed on special floors where subirrigation occurs on demand. The difference in nutrient uptake principles is that in flowing solutions the recirculated effluent rapidly changes in nutrient concentration. Therefore, each specific nutrient content in the return water has to be determined in order to know the amount of fertilizer and fresh water needed for the new supply. In the second method, plants are placed in containers on special subirrigated floors. Water-containing nutrients enter the containers by both capillary action and mass flow as the subirrigated water surrounds the container to a depth of approximately 5 cm (depending on container size). Nutrient enriched water moves throughout the pot as a result of hydroponic and osmotic conductivity as well as electric potential. The difference is the nutrient concentration in the return recirculated water remains constant. While the composition of the specific nutrient in the container has the potential to increase its concentration as the plant actively selects specific nutrients regulred for a balance metabolic activity.

Improper formulation of the specific nutrients in the subirrigated water could result in longer-te toxicity problems in the growing media.

A. Automatic Nutrient Injection - The System

The BAHM, Inc. Computerized Automatic Individual Nutrient Injection System has been built for commercial growers to give the specialized tools regulred to produce the highest yields and guality products. This research has been conducted by Dr. William L. Bauerle in response to growers reguests for control of plant growth by individual nutrient injection into irrigation lines. It is currently being used in intensive North American agriculture today. The Computerized Automatic Individual Nutrient Injector has been brought to the greenhouse industry by BAHM, Inc., to meet the future needs of the grower and the environmental concerns of society.

Developments include both the hardware and software technology, giving the grower the capability of using the prescriptions for individual injection and also the capacity of interfacing with a weather station or process environmental computer.

The fact that the injector is also used in commercial, industrial and potable water treatment areas emphasizes the accuracy, dependability, reproducibility and durability of this equipment.

I. The System Hardware features a water-driven, multihead injector capable of delivering from 1.2 $m^3$to 70 m^3per hour or irrigation water and incorporating individual fertilizer elements with an accuracy and reproducibility of 0.5 mg/Kg (0.5 ppm) for each injected fertilizer nutrient. The water motor drive feature adds to the fail-safe feature and permits nutrient injection only when pressurized water flow is supplied to the system, as the flowing water is used to operate the injector heads for nutrient injection.

II. The System Software is the brains for the control of the injection system that mixes and distributes nutrients to exact specifications to the crop.

The computerized injector is connected to a personal computer (PC) that can function on set schedules by a connection to an environmental control computer or a separate weather station can use meteorological data to prescribe nutrient and water schedules. The decision-making model integrates information such as physiological age and condition of the plants, expected growth rates, plant health, solar radiation and micro-climate parameters. This information is analyzed by the decision model to compute which nutrient recipe should be used for the prevailing conditions. Once acceptable ranges of nutrients have been finalized, the model computes the setting of the injector ensuring that all nutrients are within suitable limits.

This information is combined with data from the climate control computer to determine both irrigation and nutritional reguirements. The computer then instructs the injector to irrigate with the nutrient settings reguired.

III. The System Merits: This system permits control of all individual nutrients in a recycled nutrient-enriched water system. Limitation to the continued recycling lies in the chemical guality of fresh water, makeup or effluent water. Inorganic elements found in the water must be able to be metabolized by the plant.

Subirrigation recycled-water systems using the nutrition principles developed in this software system have been in op- eration formore than fiveyears with total nutrient control and without loss of any water to drainage. Plant health, yield and guality have been maximized in the recycle systems.

Further potential can be foreseen when computer models will be able to calculate specific plant transpiration (water loss) rates in order to apply water according to exact plant demands. The environmental computer and the computerized automatic nutrient injection system are two special tools for the commercial grower to control plant growth.

Water pollution of leached inorganic nutrient salts can be eliminated when the incorporation of a specific nutrient is aligned with the plant's needs of that specific nutrient is aligned with the plant's needs of that specific nutrient.

Conclusion

The grower who uses the conductivity system for control regulates the solution conductivity and not the specific nutrient. Therefore, he can only hope that the nutrients reguired by the plant are in adeguate amounts to meet plant growth needs.

To insure this, the grower increases the nutrient amount to a point where he begins to control the osmotic potential of the plant root. Meanwhile, in an effort to maintain the proper EC in the root system, he continues to leach away nutrients not used by the plants. Potentially this makes the conductivity controlling system a tremendous groundwater polluter.

Applying individual nutrients in harmonywith plant growth reguirements has the potential to reduce the leaching and ultimately, the groundwater pollution of fertilizers. Further, the control of nutrition becomes an effective tool for controlling the growth and development process of the plant.

Commercial fertilizer systems and practices that have evolved over the past 60 years are seriously outmoded. Agricultural producers cannot continue to waste valuable resources such as fertilizer or continue to pollute the groundwaterwith chemicals. The inherent predictability control provided with greenhouse environment systems can in the recent future lead to an environmentally safe sustainable agriculture system that ensures the delivery of a viable and plentiful food supply.

The pioneering plant nutritional concepts of individual nutrient injection developed and implemented with decision analysis and expert systems at the Ohio Agricultural Research and Development Center have resulted in a totally controllable, sustainable and environmentally sound system for future food production.

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NEW ROBOTIC SYSTEMS FOR GROWING VEGETABLES IN GREENHOUSES.

*E.S. Sysoev *, Y.N. Lipov ***

Despite the fact a set of machines has been developd in the USSR for major process in warmhouses, both labour and power per unit of product still remain high at farm warmhouse works.

The problem of reducing labour content is most pressing in warmhouse plant growing since warmhouse centres - both agricultural enterprises and auxilary agroshops of industrial enterprises - are in or near large cities where manpower is particularly scarce so thar additional manpower resourses thus made available for service at plants and analgamated industrial enterprises make for a substantial improvement in their labour productivity and in efficinccy of the national economy as a whole.

Work has been arranged at most warmhouse centres so that each team has its allotted area to peform the entire cycle of process steps thereon. Incidentally, successful mechazation of any job cannot reduce the team numbers sinse such operations as shaping plants, harvesting and some others involve maximum labour content.

The methods now used to grow crops in warmhouses dublicate traditional farming agriculture in the open. A warmhouses closes a field area which is planted with up to 4 plants per square meter, and in this case the roots take about 60% of the area. At the same time, the entire surface of the field is warmed up, sterilized, tilled, ets.

A research into the ways of integraded automation of jobs in warmhouses has shown that a substantial reduction in the service personnel with a simultaneous decrease in power requiments due to lower consumption of light fuel is attainable by development of a robotic system.

Such system including means of small-scale mechanization and machines for some individual operation alongside the perlacement of manual labour by manipulators and other automatic tools allows to change the arrandiment of the root zone within the vegetation area of a warmhouse, thus reducing its size.

The trend in development of robots is such that class of tecnology having found its application in industry is gradually gaining wider use and can be employed in agriculture. However, robotization of agriculture will require a crucial modification of traditional processes and is hampered by social, pschological and economic factors.

Best suited in agricultural production for introduction of robots are stationary production andproduct-treating facilites.

In plant growing, among other fields of agriculture, it is warmhouse production that is closets to the solution of the problems of intergrated automation of oil production processes. Here an industrial factory method of manufacturing products has alreadi emerged into being - i.e., the servise zone is consentrated, climatic conditions are stable, the structure is of rigid geometri, utilities and transport flows and process steps are invariable.

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Application of warmhouse robots will require a number of changes to be made in the warmhouse. More specifically, the pipes of aboveground heating in inter-row spasings that are used as transportation tracks for warmhouse trolleys and automatic sprauing cannot ensure a sufficiently uniform notion of a robot and serve as the basis for carrying out the entire cycle of process steps. Therefore, it is necenssary to modify in part the design of a modular warmhouse so as to arrange fixed transportation tracks as to create a set of mobile automatic devised having programmed control. this is possible if a coordinate prinsiple is used for cultivating plants.

During a research into and development of a robotic system, the necessity is taken into consideration to introduce step-by- step individual systems and elements. Their introduction in the warmhouse now in operation must improve substatially labour conditions and raise the efficiency of production.

A diagrammatic representation in sestional view of a warmhouse for operation with a robotic system is shown in Fig.I. The narrow root zone of plants is disposed between rigid construction structures having a low heat capacity and constituting a foundation for transport and process equipment. In this case, the warmhouse itself remains without changes - a factor which makes it possible to utilize existing typical designs and convert the structures now in use.

A robotic system for modular warmhouse must include the following major components:

- a transportation-coordinate systems with an all-purpose mobile powered vehicle;
- a system of technical vision;
- a universal manipulator;
- a set of specialized tools;
- an automatic control unit.

Three principal stages of the practical use of these mechanisms may be marked out as follows:

- partial robotization including mechanization and automation of transportation and technolog cal processes that are subject to mechanisation and automation for objective reasons. At this stage an automatic module is maneged by an operator who is also expected to replace executive mechanisms. Only robots of the second generation are made use of at this stage;
- the stage of complex robotization is characterised by the use of robots in all technological processes including those which are currently based on manual labour. For all that, the operator remains to be the key figure in the system of technological control, and all operations are supposed to be fulfilled at his commands;
- at the stage of overall robotozation of technological processes, from sowing to harvesting, any man's interference is virtually excluded. They are governed by control systems responsive to information about the physiological state of plants coming from sensors. These systems are expected to be designed so as to simulate appropriate intellectual functions.

A peculiar feature about robotizarion of vegetable raising under greenhouse conditions is the necessity to move executive mechanism quite a long way about cultivated plants in the majority of the most labour-consuming operations, e.g. plant training, pollination, etc. These procedures may be referred to as technological transportation to underline involvement of transport functions in the hothouse production. Moreover, greenhouse farming requires a variety of purely transport operations such as removal of finished agricultural produce, package delivery,

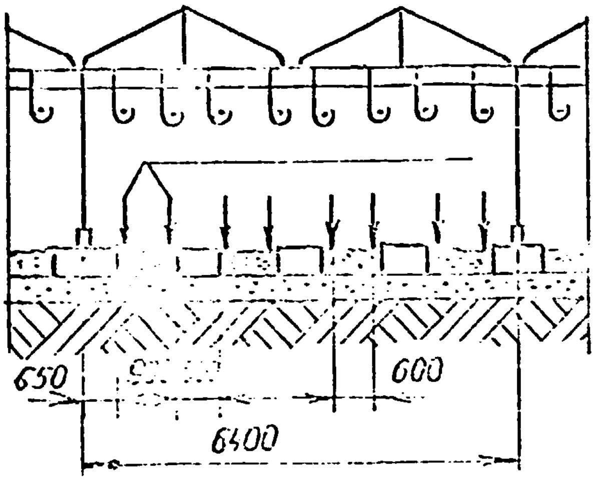

Fig.1
Warmhouse for operation with a robotic system.

transportation of equipment, etc.

On the basis of researches held the samples of the coordinate transport system elements for block greenhouses were elaborated.

It can be inferred from the above reasoning that RC of block greenhouses must be fitted up with a net work of communications.

There are two alternative approaches to the construction of such transport systems. The traditional one which is wide spread in industrial enterprises suggests that agricultural machinery and implements shoul be stationary, with objects of production, i.e. crops, being displaced so as to pass by a few fixed points of the technological line where they may undergo necessary processing.

Transport systems of this type are already available for block greenhouses in a number of countries. They are organized either as production lines or as base on transport facilities fitted with mobile growth chambers. Unfortunately, such systems are metal consuming and can only provide for a strict succession of plant treatment operations which is not altogether convenient. Therefore we consider it more rational to rely on such a mode of organization of transportation in block greenhouse farming which would imply that crops form the stationary component of the system.

There are good prerequisites for the use of a relatively simple scheme of construction of RC transport systems in greenhouses. The most essential among them conclude:

- limited zone of transportation;
- regularity in distribution of greenhouse facilities;
- intersection of communications only at right angles.

All this does not appear to make high demands of the mobility of RC elements. Robots may have no more than two degrees of freedom to move unimpeded. The so-called coordinate systems seem to display the greatest efficiency under such conditions, straightforward movements of their transport modules being limited to those in the alternative perpendicular directions. As far as block greenhouses are concerned the rectilinear movement along one coordinate ("X") would correspond to the movement along the main passage while the other (coordinate "Y") would stand for interraw movements (Fig.2, 3).

A transport system based on the above principles can be realized by using relatively simple technical means. At the same time the system of orientation of RC elements appears to be greatly simplified due to their movement along a single coordinate.

Analyses of demands with respect to the RC transport system for block greenhouses tends to indicate that the most rational approach to their construction must proceed from the employment of two types of technical devices. In terms of automation such systems are referred to as multi-module.

RC for block greenhouses based on the type of transport system described above is an aggregate of a carrier robot and an automated module. The former (2) moves freely along the main passage (1) of the greenhouse while movements of the module (4) are confined to a given section where it is delivered by the carrier (fig. 2). Electric supply of the RC elements can be effected either from storage batteries or through a cable using the specially designed by VISKHOM cabledrum. The rectilinear movements of the carrier and its interraw positioning are controlled by means of reading appropriate optical marks.

It is essential to point out, that the mechanization and automation of transportation level has its own importance. The presently existing set of technical means for transportation operations in greenhouses has been formed without certain conception, mainly at the expense of the machines intended to be used on the open ground, and hand carts. There is no yet specialized system suitable for transportation inside the greenhouses with the trellis technology of cultivation and it has a negative influence to the conditions and efficiency of labour in greenhouses.

VISKHOM has carried out a number of researches to develop the greenhouse transport system meeting the present demands.

Fig. 2 shows the scheme of the coordinate transport system (CTS) functioning. As it is clearly seen, the scheme consists from 2 main devices: transport platform and interraw modules. The last ones are intended for aggregating of robots between the raws. The platform carrier consists of the greenhouse transport module, whith travels in the main passage of the greenhouse and serves for interraw modules transportation from one interraw to the another.

For the CTS creation the transport movement lines have been studied. It became evident that the maximum number of calls for module carts along the main passage is 9 tours per hour, the maximum number of calls for discharging the ready products from a section is 1.4 weight units per hour (1 weight unit-500 kg.). The intensity of tours takes place beginning from the 12-th week of crop harvesting and continues for 7 weeks. As a mathematic model of the transportation flows in block greenhouses the Poisson model of events flow can be used.

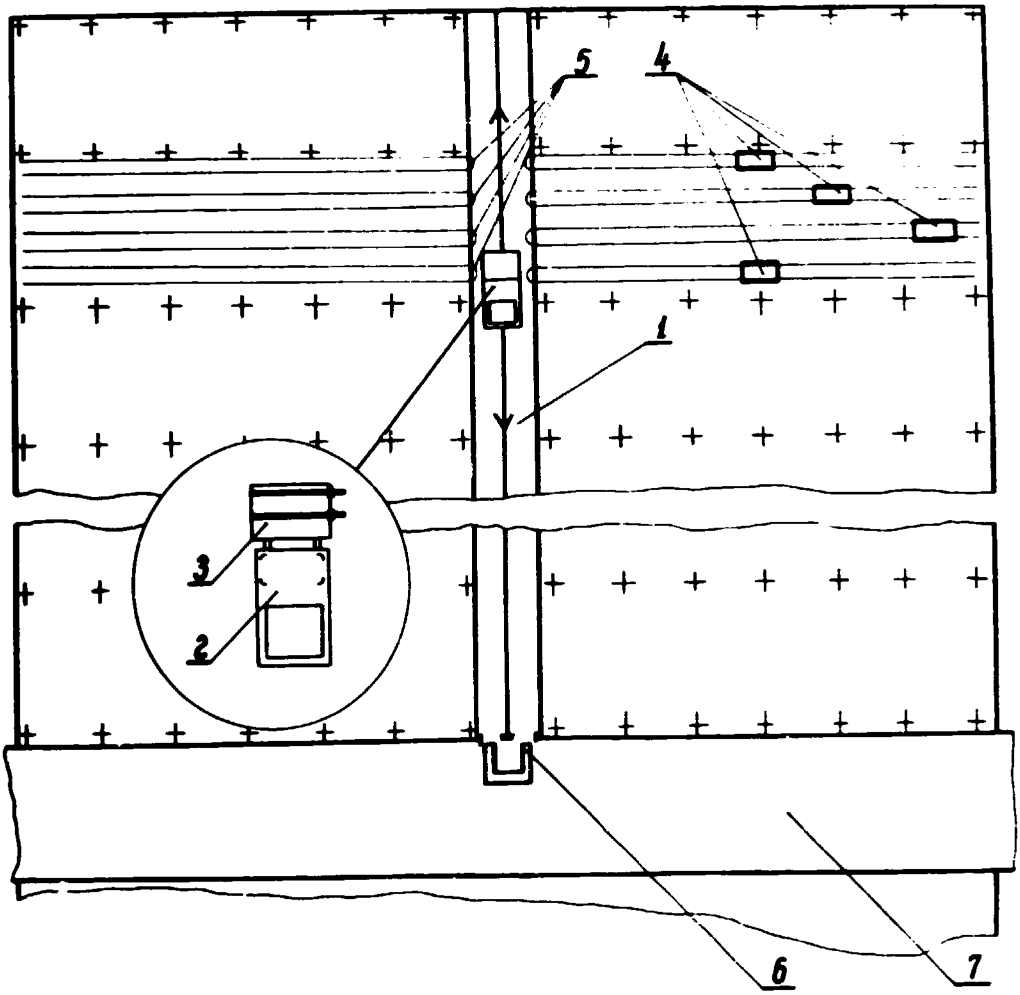

Fig.2
Coordinate-transport system for greenhouse with automatic enegy supply of mobile robot:

1 - concrete passage;
2 - transport modul;
3 - ladder device;
4 - mobile robots;
5 - supporting constructions of passages;
6 - overlouding table;
7 - coridor between grinhouses;

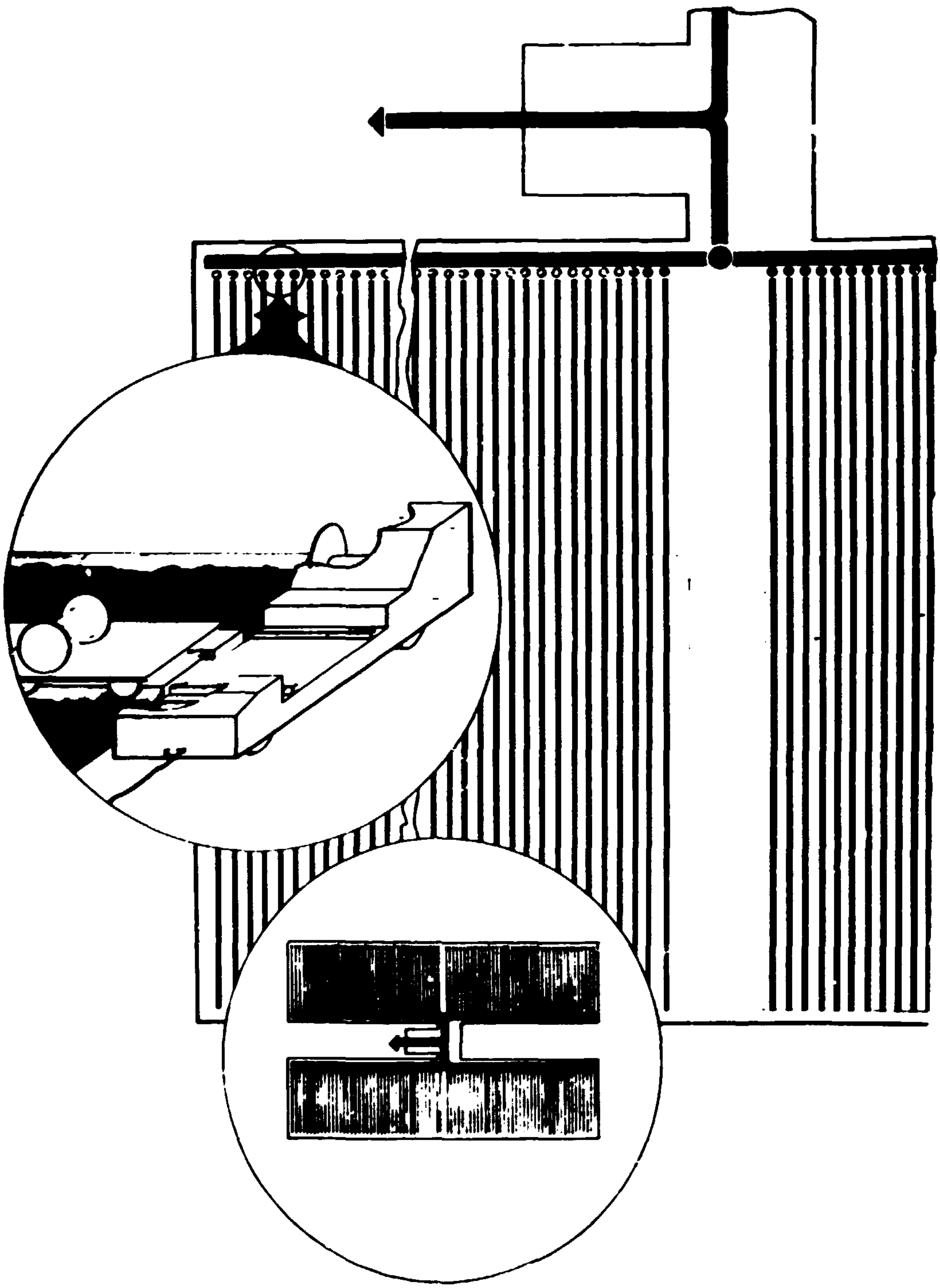

Fig.3
Transport passages scheme in greenhouse.

According to the information obtained a mathematic model of CTS functioning for block greenhouses has been elaborated. When its creating the proportions and methods of intensive work were used. The model analysis by means of computer allows to come to the following conclusions.

The most influence on the idle stand coefficient of the transport means have:

-the efficiency of man or machine work in combination with the transport system;

-yield volume of the single plant crop per unit of the vegetation time;

-number of transport means operating in the interraws and their speed.

In standard greenhouses of 1 and 1.5 hectar area the coordinate transport system is to have one platform carrier for the main passage and 4 interraw devices for 1 hectar or 6 interraw devices for 1.5 hectar greenhouses.

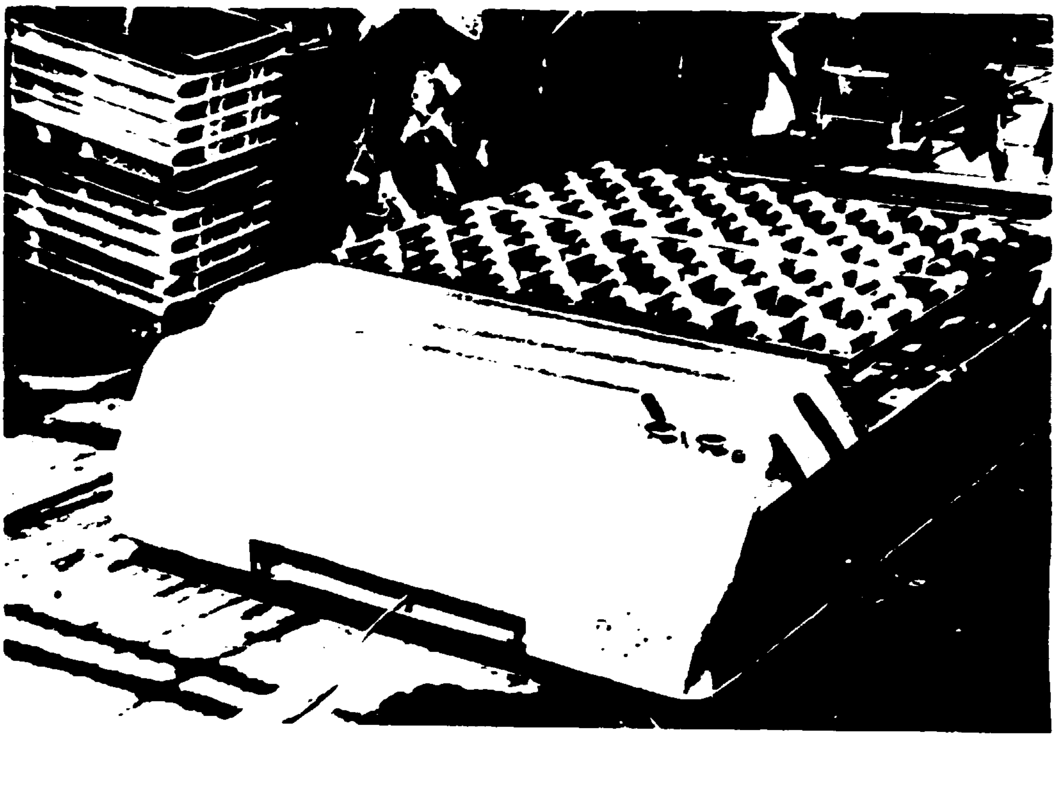

Fig.4
Universal mobile transport-energetic mean.

In the standard greenhouses when cultivating the nonpollinating sorts of cucumbers the coordinate transport system should have parameters no less than:

-platform carrier speed	0.33 m/sec
-interraw device speed	0.38 m/sec
-load capacity of the platform carrier	330 kg

While the rate of harvesting is 0.25 vegetable units per second the tranport coordinate system is not to be used in greenhouses with more than 220 interraws. The coordinate transport system elements idle stand coefficient does not depend on the greenhouse interraw length. But when loading capacity of the interraw devices is less than 240 kg the length has not to exceed 55 meters.

For automation of production processes it is necessary to have an adaptive control over automatic tools, including manipulators, based on search detesting systems and sensors for short-distanse detection and randing of manipulation objects.

Sinse the plants are positioned unsertainly in spase, and the floscules, fruit and other objects of treatment are distributed at random, a robotic system for warmhouse requires to be outfitted with a well-developed system of tehnical vision which must ensure:

- recognition of floscules;
- recognition of "waste"leaves;
- recognition of pest and desease nidi;
- recognition of warmhouse structural members;
- recognition of fruits;
- recognition of plant outlines.

The result of ivestigations undertaken have shown that such system can be developed on the principle of recognizing objects optically. Fig. 5 shows a scanner developed by VISKHOM and used for investigation of optical properties of a vegetation field in a warmhouse.

Scanner, used for investigation of optical properties of a vegetation field in warmhouse.

The signal thus obtained is then processed electronically according to a predetermined algorithm so that the tool is enabled to be aimed at such a point in spase where a plant is characterized by a combination of predetermined physical properties which are required for this process step to be carried out.

The method of analyzing the level of reflected optical radiation and spectral compositin in accordance with the results gained in processing statistically the signal from the photodetector of the skanner sensor allows to evaluate both the geometrical parameters of the vegetable medium (position of stalcs, leaves, fruits and their dimensions) and the intensity and quality of biological processes.

The scanograms obtained by means of the above-mentioned scanner were used to determine the spectral composition and parameters of the photosensor signal differentially for a fruit and the background and to estimate how the random variable signal is disributed.

The specificity of measurements consists in that, along with investigations of smoll arears of leaves, stalk and fruit, it is necessary to investigate also their combinations over alarge area, i.e. note the optical properties of the vegetation stretch formed on an espalier in an elongated row 36m long. For this purpose the scanning optical-mechanical system was fabricated so as to allow the surfase being investigated to be

Fig.5
Optic scanning system for measuring optic characteristics of plants.

scanned relative to the photodetector and the reflections of oll the surfase to be measured coninuosly or discretely.

The scanning optical-mechanical system is actually a mechanical device for scanning the surfase being investigatedrelative to a point-ture photosensor.

In order to reveal the most characteristic features which mace a certain object to stand out against the bulk of vegetation (a fruit, a dry leaf, a damaged plase, etc.), measurements have been taken both for a plant as a whole and for each object to be detected separately. The properties that were investigated in this way were as follows:

- a relative reflection factor;
- a reflection spectrum;
- a waveform and amplitude of the signal generated by the photosensor;
- a geometrical position of the object being investigated in spase;
- a time history for the intensity of reflection from the object, for instance, from a fruit in the process of its ripening.

The scanning optical-mechanical system was along the rows of plants over the registers of aboveground heating with a predetermined pitch whilescanning successively the spase with the carriage moving from its extreme lower position to a predetermined height. The electrical signal from the photosensor was first amplified and then fed into a digitalto-analog converter and through a transcriber into a numerical printer.

The operation of numerical printer is synchronized so that each line on the numerical carriage corresponds to a line of scanning the object being investigated. A scanogram obtained as a result of scanning a predetermined spase represents a form filled up with lines of digits from 0 to 9 and characterizes in relative units the intensity of reflection at a particular point in space.

The portions of the vegetation background where the objects of interest were situated, were photographed, and the photos made to the same scale with registration were brought into concidence with appropriate scanograms. Such measurements were repeated during the entire period ofvegetation.This made it possible to define the ranges of relative reflection factor for various parts of a plant and to process them by statistikal methods, as well as to determine how the reflection factor varies throughout the period of vegetation.

Processing the results of reflection measurements was mainly aimed at distributing the values belonging to various regions of the backgroud and of the object by comparing scanograms and

relative reflection factor were input into the memory of a computer. Then the average value of reflection coefficient, the dispertion and the distribution law were determined for each class of values. After this the value was set into a logic unit, and an integral value was defined to evalute the probability of missing the object or its false detection.

The tachnical vision as developed based on the results of this research ensures a high reliability in detecting the objects. Misses were only at 25%, the undetected objects being not "lost" since these would come into the visibility zone during consecutive passes and scannings.

Manipulators and specialized tools depend on those process steps which they have to fulfil. At the same time, the process cycle itself must be revised in oder to adapt it to new technical requirements. In general, these these requirements are such that the work practice in a warmhouse should be suitable for application of robots.

Preliminaries outside the farm warmhouse works will undegro few changes. Even today a 100% mechanization is achieved here.

The process will continue to be stationary. The novelty resides in the fact that the substrates prepared will be loaded into transport containers in which the step of sterialization will be made coicident whith transportation.

Seedlings will be cultivated for the open ground, and this has been already achieved, in special warmhouses with a robotic system of the first generation based on an automatic brige-type chassis outfitted with an accessory set of special tools for the entire work cycle, incluiding tillage, sowing, picking and cassettings.

When free from seedlings, these warmhouses will be used for growing salad and other green crops with the aid of the same and other machines.

It seems that seedlings can be cultivated for warmhouses on multideck automated installations in cassettes with artificial lighting, these installations operating on the principle of automatic storage and arranged in special premises or corridors of warmhouses.

Planting of the seedlings must be effected with the use of the same process containers in which they have been grown. For this purpose it is reasonable to utilize the technical means of brige type (Fig.6). Incidentally, the same technical means having accessory tools is inItended for uniform laying of soil and for tillage.

The soil substrate will be sterilized by stationary equipment mounted over a transport way or by means of the same brige-type chassis.

For some time the plants will be tied up, formed and pollinated manually using an all-purpose transport module, which in future will be equipped with automatic manipulators for performing these operations.

A first-generation robot - ATOS-0.5 opposite warmhouse selfpropelled atomizer - has been developed for continuous spraying of plants and launched in production. A local pest control will be carried out by an automatic machine of the same type, but with the use of technical vision.

Harvesting is one of the most difficult operations for mechanization. As for tomatoes it is required to raise special kinds having clusters ripening together simultanously tier by tier.

To automate harvesting of cucumbers, efforts are now made in VISKHOM to great a harvesting machine Type YM-I equpped with technical vision and manipulator (Fig.7) to gather a fruit and lay it down into a container. This has required to develop a principally new method of harvesting espallier. This method comprises a step of detecting separate fruits without contact by

illuminating the entrie stock of a plant with a radiant enegy flux, receiving that enegy back from the stock thus illuminated, converting it into an electrical signal by means of the photosensor, and recognizing a fruit though amplitude selection. For harvesting the fruits of only a predeterm ed size, illumination should be effected within an optical range of wavelenghs, and the reflected radiant enegy flux is converted into an alactrcal signal by means of matrix photosensor simultaneously with detecting the shape of the plant portions being illuminated as a result of summing up the elements of the elements of the matrix photosensor, then the fruit size is determined after the amplitude selection of the sum signal as to duration by means of electronic analyser, and after this a fruit-removing mexhanism is guided to the fruit by means of forming a coordinate signal that identifies the position of this particular fruit which is then picked as soon as the phase of the phase of the coordinate signal coincides with that of the signal from the alactronic analyser.

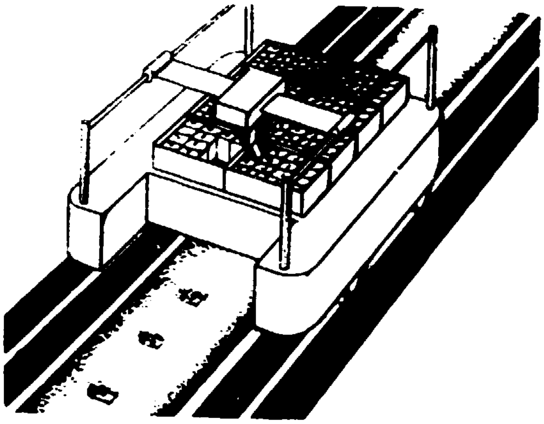

Fig.6
Bridge type robot unit for glasshouse.

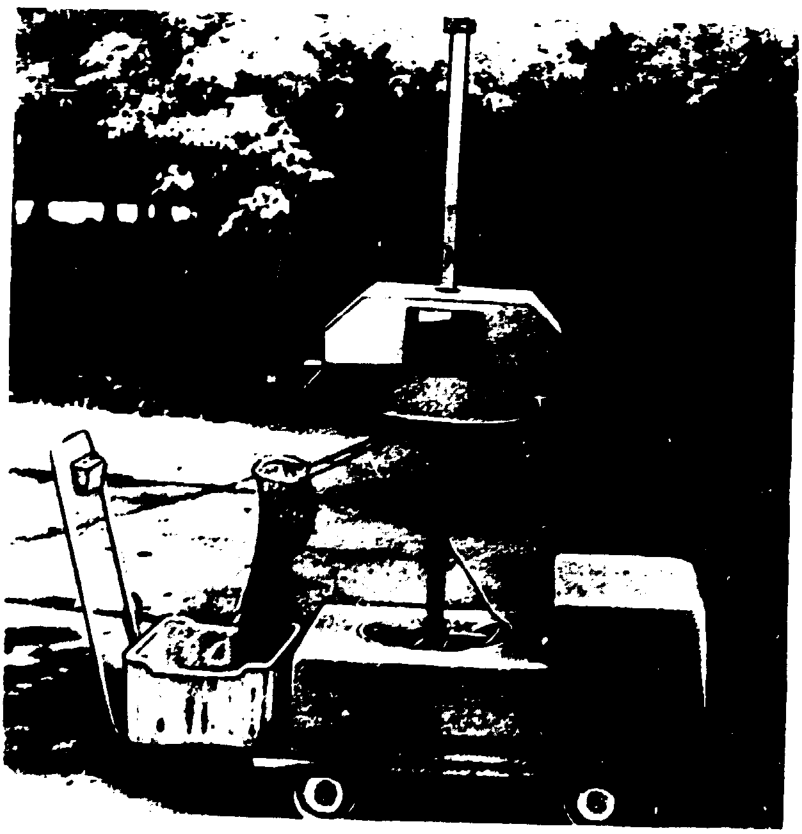

Fig.7
Robot YM-1 robot for automatc harvesting of cucumbers.

A divise for removing fruits (Fig.8) comprises a carrying rod and a fruit-remover in the form of an andless belt which serves as a movable mouth. In order to ensure reliable gripping and twisting off fruits of varios sizes, the rollers at the mouth inlet are connected to the driving pulley by means of levers and spring-loaded crank machanism.

Positive results have been obtained during in-the-field tests of the YM-1 robot for harvesting cucumbers.

The all-roud package of agricultural processes in growing plants comprises a large number of operations are imposed on accuracy of carrying them out while the obgects of manipulation have approximataly equal masses.

That is why the snatcher excludes damaging of vegetables and works satisfactory while harvesting cucumbers of 38-60 mm diameter and the mass of no more than 0.435 kg.

The theoretic and experimental work makes it possible to consider as positive robots implemantation in industrial ptotected ground plant growing.

In a number of cases the use of such system does not give the sufficient economic effect, but the improving of labour conditions and keeping up of personnel in good health compensate the expences made. Besides, in the regions with the lack of skilled labour power and the necessity of qualitative food products the robot complexes can be considered as the solution of problem.

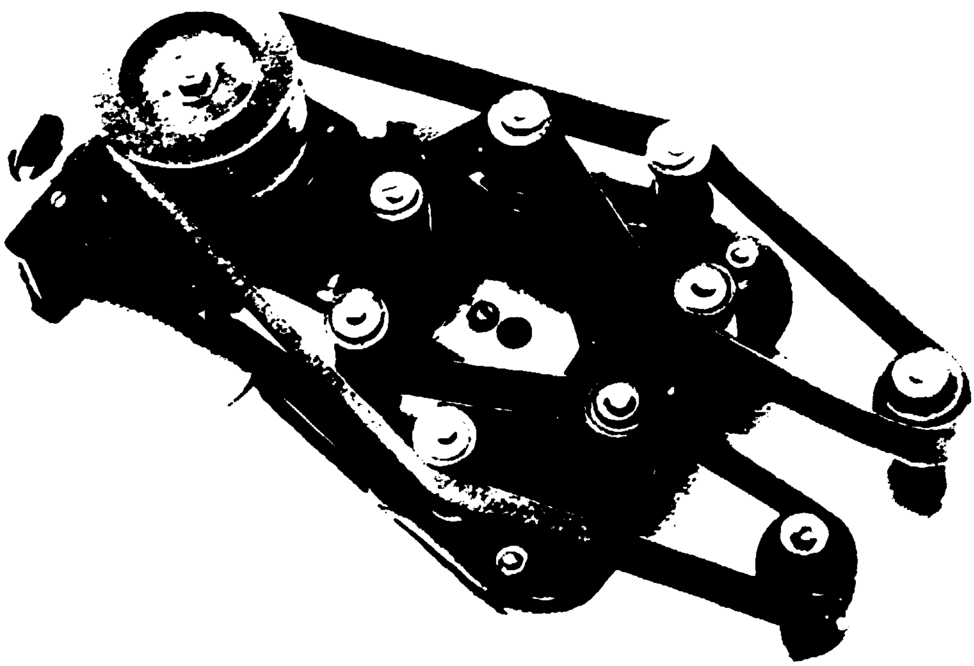

Fig. 8
Devise for seeding and keeping the fruit.

An example of inculcation of elements of robot systems into plant-growing is elaboration of firms "VISSER" and "AGRISYSTEMS" (Holland) (Fig.9 - Fig.11).

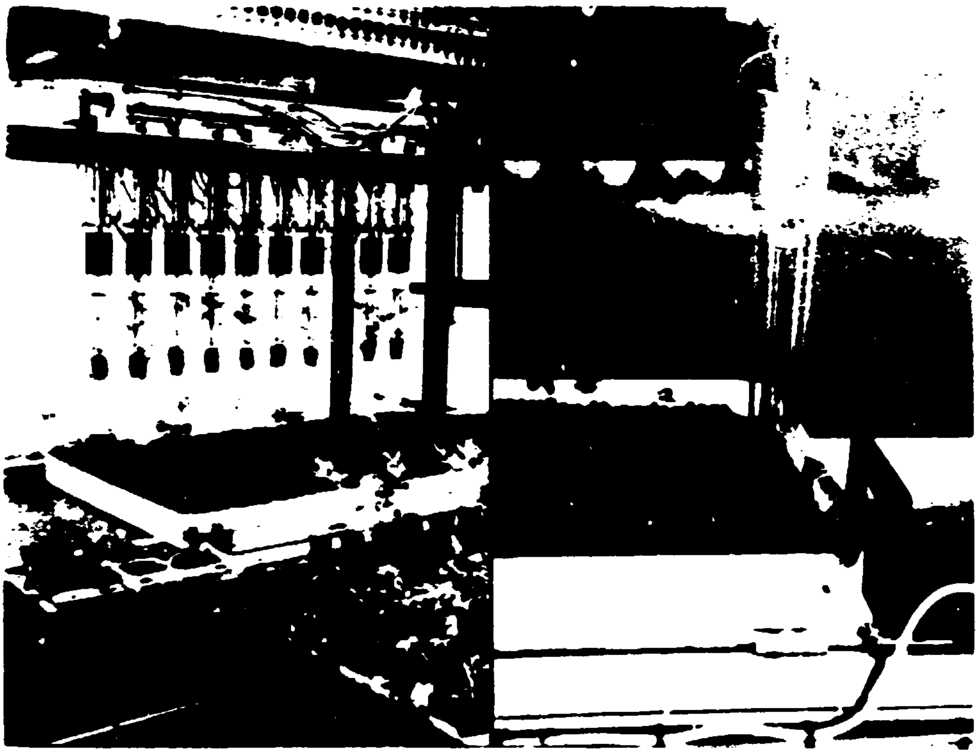

Fig.9
Automatic planting fingers ("VISSER", Holland).

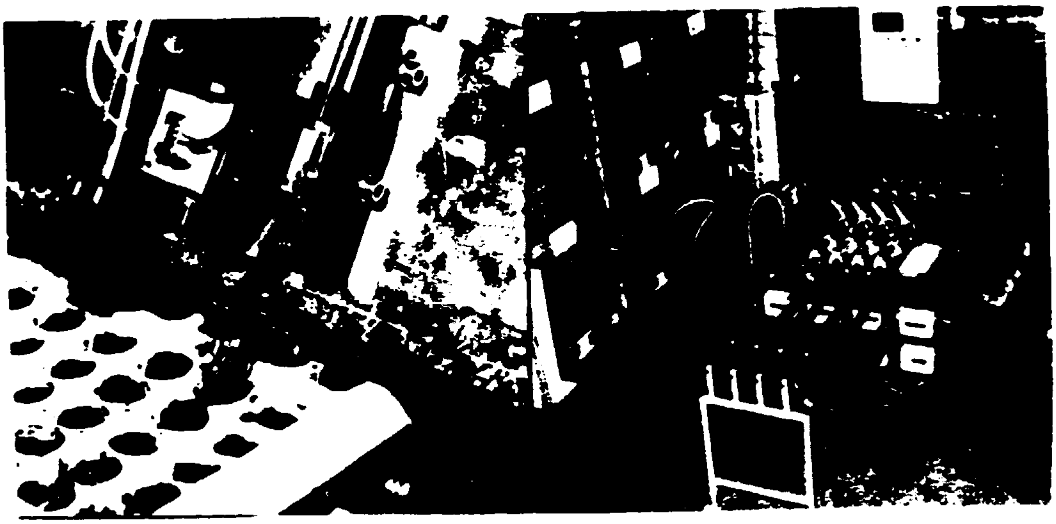

Fig.10
Plant mechanism (a) and plant-o-mat with four planting units (b).

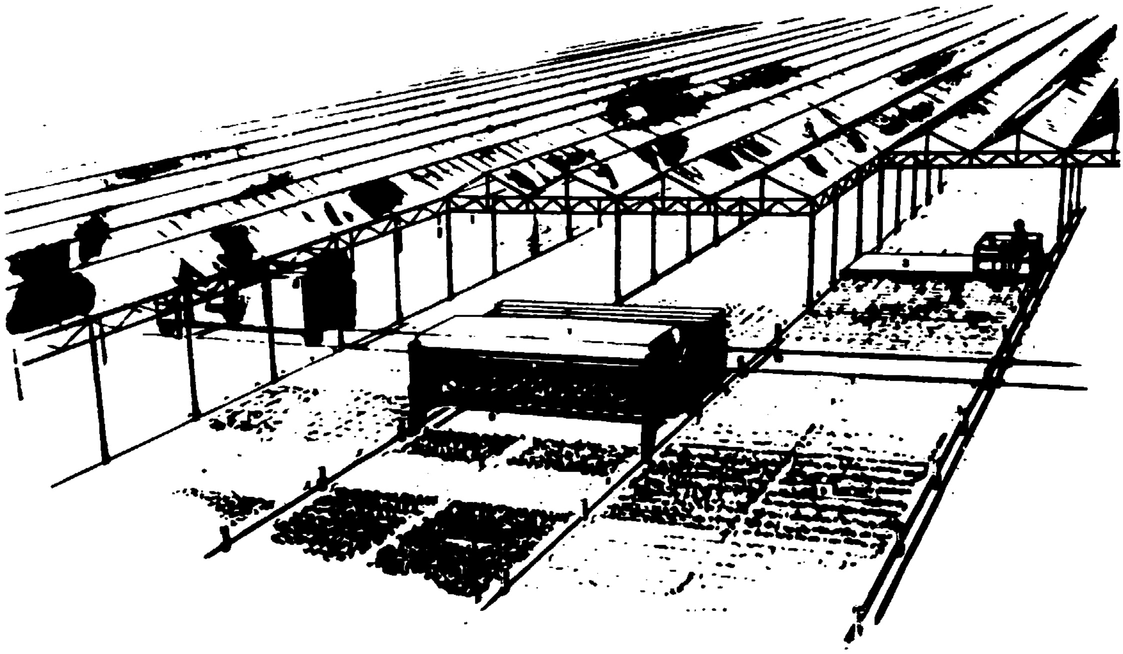

Fig.11

Fully computerised greenhouse transport system, suitable for internal and external use.

NEW METHODS OF PROJECTION OF TECHNICAL SYSTEMS FOR PRODUCTION OF ECOLOGICALLY CLEAN CROPS

Dr.A.Dlugy *

There is no necesity in discussing the problem of actuality of preserving the natural characteristics of food products and at the same time raising of the productivity.

The main role here has to be played by production of vegetable food products int the conditions of protected environment. Such environment can be created with traditional greenhouses and special climate constructions with completely imitated condituons necessery for life providing.

Traditional food-products manufacture (in natural way) is known and is being used for a long time. But such manufacture in artificial conditions is a result of the few last decades technical progress, and nowdays this field of activities is in its revolutionary development.

As it is wildly assumed Holland is a leader here and consequentely it can be considered as a sourse of information for analysis and extrapolation of tendencies of development in this field of production. On the example of this country we can see how, according to the new researches in the fields of biology, selective breeding and chemistry on one hand, principally new production technologies which considerably differ from traditional (in the open soil) are created and are being created.

The pecularity of products manufacture in the protected soil is availability of greate quantity of small producers with practically the same quntity of methods and to provide ability to compete mostly everyone of them makes active reseach in new ways of growing, in improvment of impements of production and improvment of equipment.

As a result of such situation now they have some limited quantity of small and middle firms producting a big range of machines and equipment by single specimens. This creates difficulties in systematization of equipment in its mass production and in exchange of experience of its effective use. And a relatively small stuff of constructors is not able to work at all the range of machines and equipment complex, nessesary for providing of all technological process even connected with only one type of plant. For the U.S.S.R. conditions this problem becomes even more actual because big greenhouse farms which conclude each one dozens of hectares and big producers of equipment are not able to solve the problems of big range of technical means flexibility and mobility of development.

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* President, A.I.D. Consulting Co. USA

So nontraditional big range of equipment and at the same time the small value of production of each type ,high complexity of production is the bright pecularity of machine-building for protected soil.

This pecularity considerably reduces rates of transition from traditional methods of manufacturing of food products ,subjected to harmfull influence of inviroment to more pure intensive methods in artificial conditions.

One of the factors which considerably reduce acutness of the pointed contradictions is the field which is from the first glance far from agriculture the field of computer modeling and projecing. Now there is known a lot of computer systems of automatic projecting.

Especially high level of automation was reach in the field of elaboration of electronic devices using such programmes as "PCAD" ,"ORCAD" and similar oriented on the IBM compatible computer means. Speaking about systems of automated projecting for maching-building, most popular up to this time were software packages "AUTOCAD", possibilities of which are constantly being widened from are version to the next.

Especially big expirience was accumulated in automobile-building. Practically there are no modern factories which can do without full automatic projecting cycle. Some of them have Numerical Control machines (NC).

Many other branches of mass production also for many years have be using successfully means of automated projecting.

Besides, traditional CAD systems don't give an opportunity to unite in one programme modeling, drafting, solitity analysis, and NC machines controll.

The latest branch in RAD/RAM so called "Solid Models" solves this problem. Some of "Solid Models" programmes are not convenient in use, because they make a constructor thinking min geometry figures categories to which he doesn't get used.

Design engineers today resiston using solid models because available tools force them to change design methods.

Whereas most engineers start with a rough idea ,which is refined through series of interations, present modeling software forces engineers to think in terms of final design.

Another problem is that solid modeling is not integrated well with other CAD functions such as drafting ,analysis and NC toolpath generation. Prescritly ,each leg of the CAD process has its own model-generation phase. For example geometry from a drafting system often is not acceptable as a model in finite element analysis. Therfore a special modeler called a processor is used to generate the FEA model.

Trimming cycles.

In many industries today the product design to manufacturing cycle is less than six months. The most efficient way to complete products in such a short time is for designer and manufacturing engineer to work concurrently. However with most existing technology the design engineer must finish before the manufacturing engineer can begin work.

Lately development software packages seek to shorten the design-to manufacture cycle by providing a single model ,which serves as a base for all design and manufacturing applications. If a single model is used ,and it is updated continiously ,both design and manufacturing engineers can work concurrently.

Wire-frame models are the core of many drafting programmes ,however they do not contain all the geometric data reavired for applications such as analysis and NC machining. In addition ,wire frame s cannot provide data such as mass properties. As a result most newer tools use the "Solid Model" as a base. According to experts solids theoretically meet requirements for a complete unambigeous baseline that can provide all data reavired for application.

Unfortunately ,most solid modelers do not live up to theoretical expectations ,and they typically are difficult to learn and also use. These systems are stati-they allow the user to create a model ,but do not let the use change the model significantly. Changes in design can be made only creating a new solid.

Solid-modeling systems must be changed before designers will be able to use them in real engineers. For example, solid modelers must move from being batch processor to being interactive.

To use systems for design, engineers must be able make small changes in the model and see the results immediatly. Solid modelers will never be easy to use as long as they are geometry driven, rather then parameter driven. In other words, engineers should be able to develop a "Solid model" by defing basic parameters and features, rather than by giving the system exact geometry. For instance, a designer should be allowed to start a design by describing basic characteristics such as shape, heightandc width. Dimentions assigned to the basic geometry, than could be used to change the basic design. The engineers should also be able to define relationships between parameters, such as height and length.

Today solid geometry is generated by performing Boolean operations. This means that engineers must add substract on intersect geometric primitives to form a design. This design does not have dimentions associated with it, so it cannot be changed by changing dimention values. Some modelers do carry along a programme description of the solid in tree form, and this constructive solid-geometry (CSG) tree can be manually edited to change the model. However, as CSG tree reavire a lot of memory, it is generally deleted when the model is saved to memory. This changes cannot be made easily.

New modelers.

New modelers try to provide engineers with tools that allcv them to design the way they think. The modelers permit engineers to built descriptions of geometry. They let engineers communicate with the computer sustem in same languge engineers. Inother words, engineers use terms like fillet, pocket, and chamter. rather than terms such as add chamter, rather than terms such as add Boolean primitive A to Boolean primitive B.

More important, new modelers use an object-oriented database approach. This means that rather, than dealing with geometric entities such as lines, arcs, and cycles, the systems deals with parts as objects that have parametric relationships from one to another. For example in new systems engineer may set a parametric relationship so the modeler would know that if the diameter of acylinder is changed, the dimention around the top of the cylinder should expand or contract with the change. Most modelers do not let users set such parametric relationship.

New solid modelers also allow users to apply manufacturing constraint models. For example if a company routinely uses 3/4 in bolt a global manufacturing constraint can be placed in the solid-modeling system that would prevent designers from using any other size bolt without engineering justification.

The first system optimised to support changes in part and assembly design is PRO/ENGINEER (Paraιetric Tecnnology Corp. USA). This system has created a new standart for computer aided design software. Using innovative dimension-driven, solid modeling technology PRO/ENGINEER supprots interactive design modifications to models of mechanical assemblies and parts.

The user can easily and interactively modify the design by changing any dimensions or relationships system automatically propagates the change throughout the model. The system provides complete associativity between solid models and their drawings and can automate the entire design engineering process from conccept through fully detailed assembly design. (see Fig.1 to Fig.5)

Begining with conceptual sketching and assemble layout, the engineer uses feature-based construction techniques to impart ingineering knoiwledge to the system database. The engineer constructs each part as a basic form which is subsequently modified using common engineering features: protrusions, slots, through holes, rounds etc. Each feature is dimensially defined by symbolic names as well as numeric values. The dimensions in the part or assembly-creating a fully parametric model. (see Fig.6)

This feature based, parametric construction technique allow PRO/ENGINEER to capture the infent of the design engineer, making later design modifications rapid and easy. The design engineer can also impart knowledge to a design by developing realationships between components of an assembly (e.g. height = 2 * width) (see Fig.2).

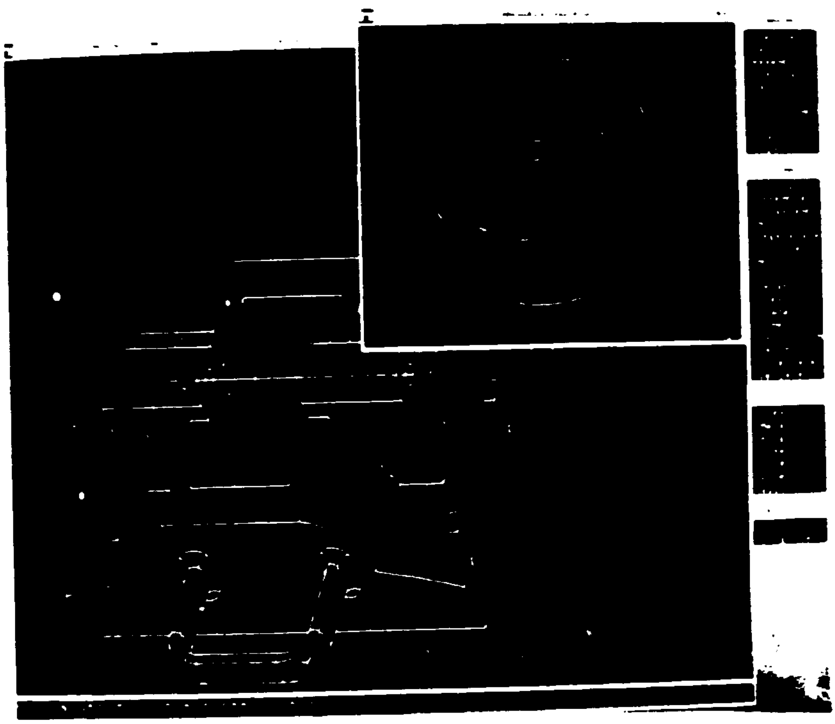

Fig.1
Two parts of the future assembly.

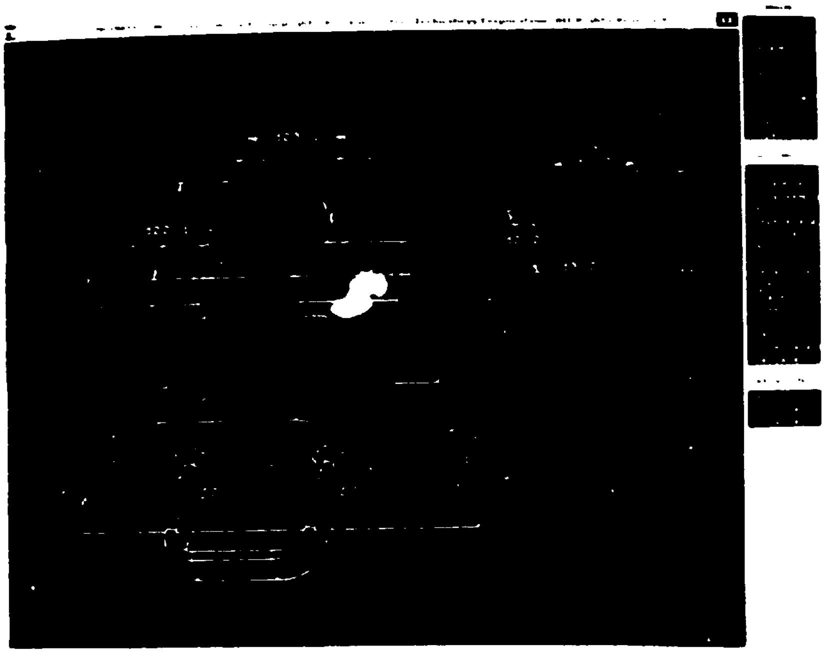

Fig.2
Show relations between parametrs.

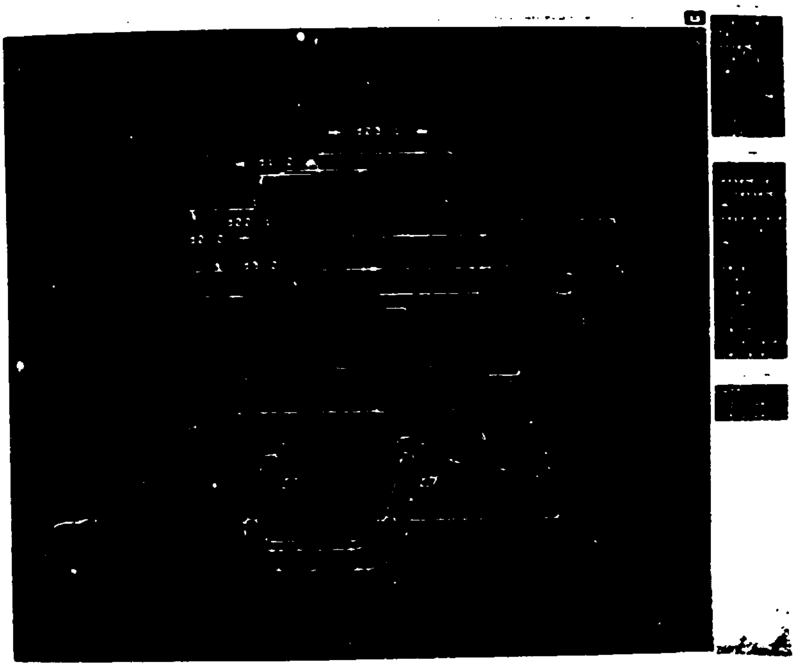

Fig.5
Complete assembly.

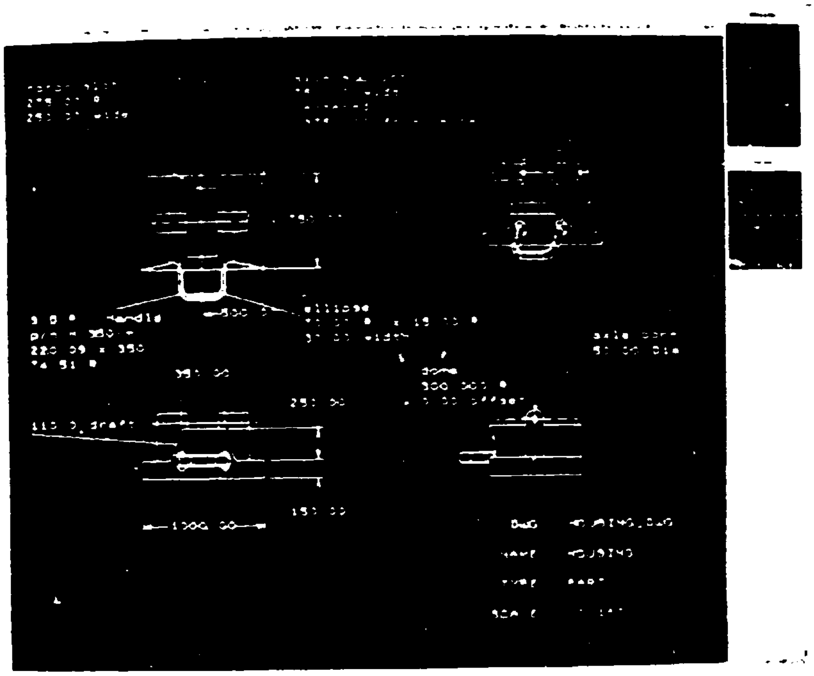

Fig.4
Automatically generated drawnis.

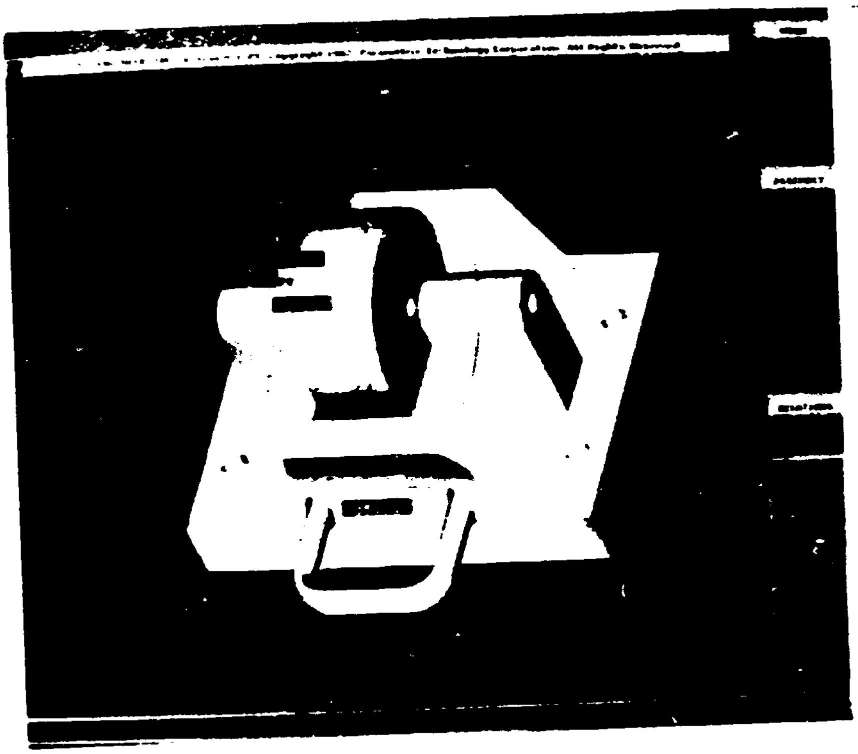

Fig.5
Saded model of assembly.

Because PRO/ENGINEER understands the relationships between dimensions, fetures, parts and assemblies, a design can be alerted quicly by modyfying dimensions, redefining relationships or defining new features. For the first time design engineers can easily perform series of "What if ... " analysis to test the impact of changes to design parameters PRO/ENGINEER can create fully dimensioned drawings and cross- sections from a solid model at any time during the design process. There is complete associativity between the model and its representation in an ingineering drawing. Changes made to drawing are automatically update any related drawings. This associativity ensures that the integrity of the design is mantained in both the 2D drawings and the 3D solid models (see examples of PRO/ENGINEER created models (Fig.7,8,9)).

So the possibilities which the system PRO/ENGINEER opens for us give an opportunity in few hours and minutes make the optimization of all the construction, not introducing different changes into its separate elements. Besides, the buyer of the product may order any changes at his own discretion and this doesn't influence on speed of elaboration and manufacturing because full software package equips with controll means and autematic centres with NC machines.

And we all may expect rapid development of constructions, because the intellect of constructors will be many times forced.

The process will begin analogous to the one which took placc when electronics was developing. Then in the period of few years' the generation of equipment was changed.

Fig.6
Parameticly dimensioned shaded model of part.

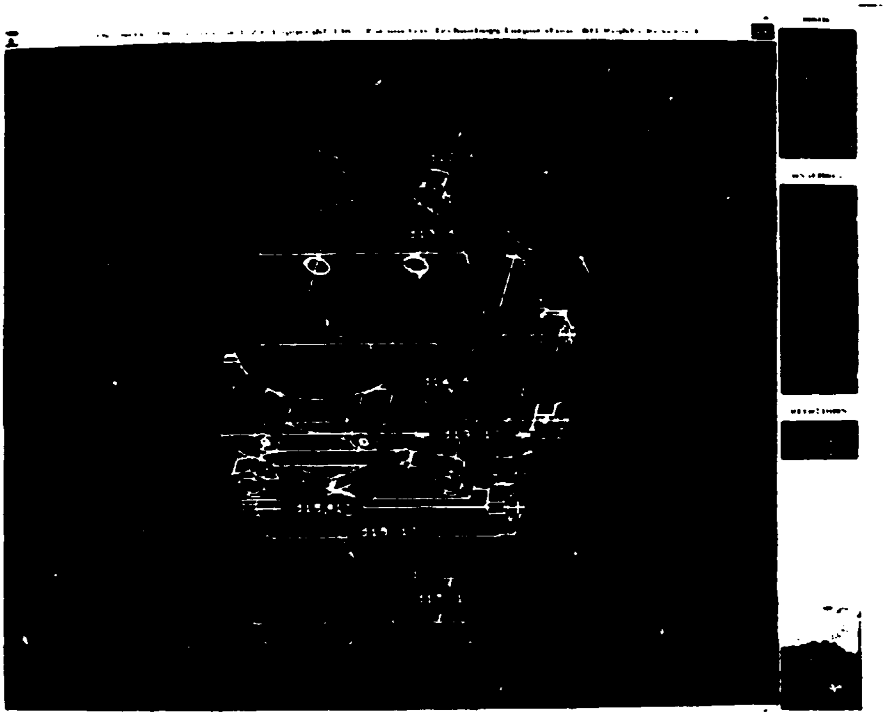

Fig.7
Example of assembly.

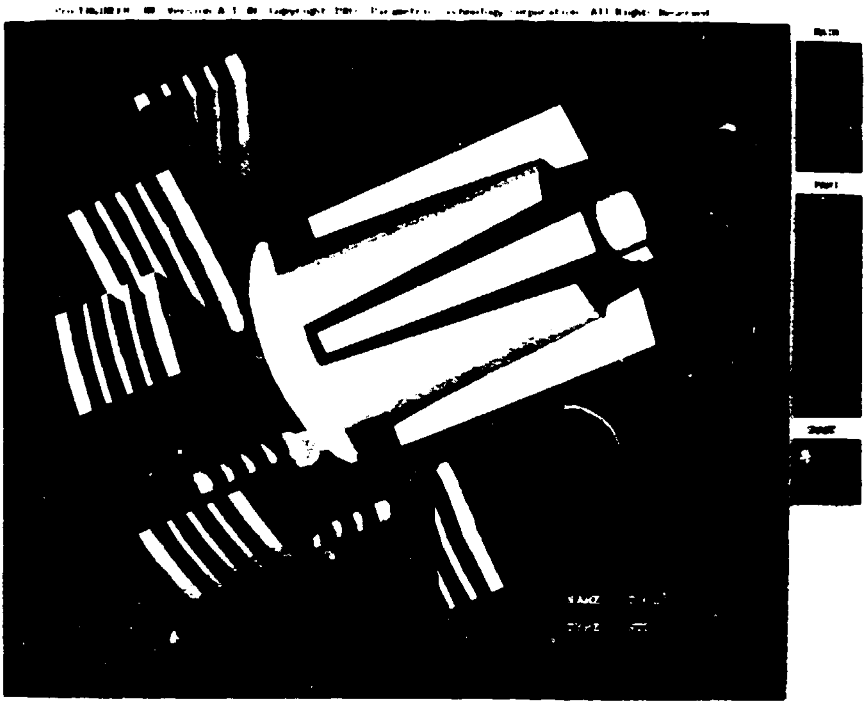

Fig.8
Example of cotting tool part.

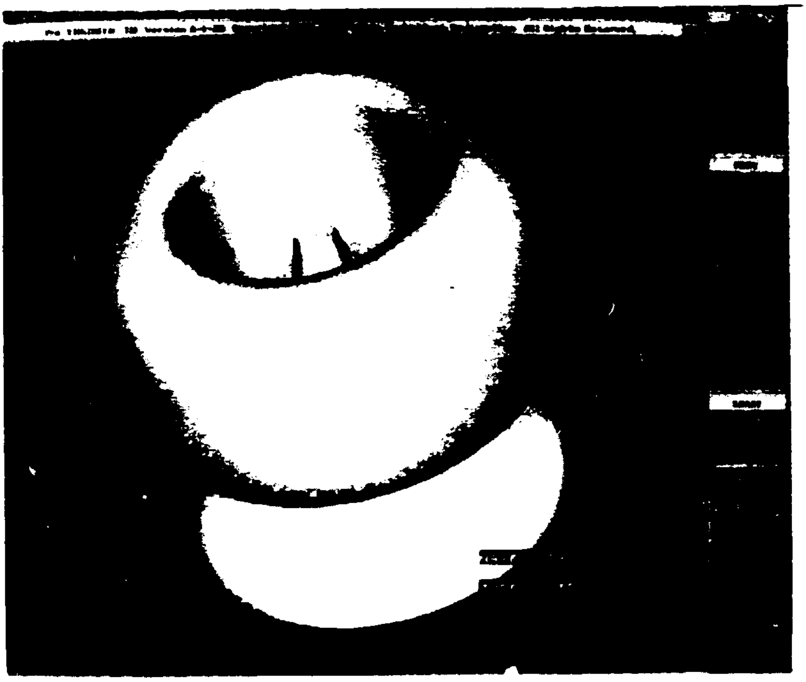

Fig.9
Example of shaded part with complex surfaces.

AUTOMATIC SEEDLING PLANTING EQUIPMENT AND ITS OPERATION.

*Y.N. Lipov *, B.A. Shulzhenko ***

1 Introduction

The seedling growing technique of agricultural plants cultivation is the most effective way to obtain the maximal harvest in predetermined time. The most important phase of plants development, including seeds germination and formation of plants reproductive organs occurs in protected ground facilities in which by means of technological implements and machines system the optimal soil and climate conditions are provided. It is a common knowledge that at this initial phase of development a plant needs the minimal area for feeding. That is why one hectar of protected ground can provide the seedlings for 135 ha of opened ground as for cabbage and for 60 ha as for tomatoes. Nevertheless in practice such proportions can not be achieved because of negative factors influence, such as seeds germinating ability, weak force of growing, unpropriate care and damaging in process of seedlings transplantation which make the above mentioned proportions 1:100 and 1:50 respectively.

In the USSR the anual need in various plants seedlings is about 30 billions. The existing level of seedling losses results in waste of crop from 15-20 % of protected ground during a rush early spring period. Consequently two urgent problems arise:

-to achieve 100% output of high quality seedlings per unit of greenhouse effective area;

-to keep up the seedlings in terms of quality and quality during their harvesting, transportation and transplanting.

In a number of countries a certain progress was made to solve these problems. The most success was achieved where the growing and transplanting of seedlings are considered as stages of integral technological process.

Unlike the other transplant material the seedlings have no the elements of automation: no element of their characteristic can serve as a technological basis for interaction with working parts of machines. That is why up to now all manipulations with seedlings were manual thus requiring in average 11 hours of manual labour per 1000 seedlings. Therefore since the 30-s of this century in the USSR a great number of inventive proposals were made on creation of artificial seedlings processes technological base which meets the requirements of automation, i.e. the forming of regular geometric forms of root parts of the seedlings (peat-soil bricks, paper cylinders , hexahedral prisms, pyramidal or conical forms). This trend of seedlings processing mechanization development is common for the USSR and other countries. Machines and equipment for transplant nutrient substrates preparation, various types of peat pot makers, paper cylinders manufacturing lines and transplanting machines in which all seedlings processing operations are based on the

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regular form of seedling root part were created. Though the machines are not widely spread in the USSR. Potted seedlings cultivation covers no more than 8-10% of transplant growing ares. The main reason is that potted seedlings harvesting, tranportation and transplanting are highly labour consuming operations. Each hectar of open ground needs in average about 5000 kg of transplant material while the state of pots at the moment of transplantation fails to meet the requirement of transplantation process automation because their initial forms are distorted.

That is why all operations with seedlings during the transplantation are carried out by hand, which makes 0.3 t/h per a person.

More progressive trend of mechanization of transplant seedling operations lays in utilizing of seedlings charged magazines which are placed on the transplanting machine and ensure delivering of seeedling by the piece into a planting device. To secure the operations with magazine it was charged with seedlings with stripped roots i.e. so-called potless seedlings. Few countries,e.g. France ("Picador"), Bulgaria (NIIMESS), USSR (VISKHOM), carried out farm tests of samples of machines for charging magazines with seedlings and automatic planting machines. The advantages of new method of potless seedlings preparation and planting were defined. It resulted first of all in the improvement of labour conditions of workers employed in seeglings planting. The magazines were charged with seedlings under the shelter on stationary machine. Each magazine was loaded with 500-1000 seedlings. The only function left for the operator of transplanting machine was replacing of empty magazines with charged ones. The consumption of labour was 1.1 man-hour per 1000 seedlings.

The only shortcoming of magazines charged with ready .seedlings was the impossibility of keeping the seedlings inside the magazines for a long time. Practically the time between the picking of seedlings in greenhouse till their planting in the field was not to exceed 60 minutes. All this required highly organizes line technology of picking the seedlings in greenhouse, their charging into the magazines and automized planting of seedlings in the field. Any getting out in the technological process caused by breakages or weather conditions resulted in great losses of transplant material. That is why the use of magazines initially charged with seedlings was not widely adopted.

The described method was replaced with cartrige technology of seedlings raising and planting, which is its logical continuation. The essence of new technology is that the cartrige serves as multiple vegetation vessel for seedling raising, container for seedlings transportation and magazine in transplanting machine for delivering the seedling by the piece to the planting device. The cartrige has rigid structure and keeps its initial dimensions during all stages of seedlings processing and planting thus being a relyable technological basis for development of mechanization means for filling of cartriges cells with substrate , sowing of seeds in centers of the cells, the seedlings treatment and cleaning the cells from non germinated seeds, removing of seedlings cartriges and field transportation as well as planting the seedlings from the cartriges. Thus the cartrige method of transplant raising and planting introducing an opportunity of complex automation of all seedlings processing operations not only in vegetable growing, but in plant growing at large.

The main advantage of cartrige method lies in possibility of continuous preservation of seedlings inside the cartrige, as various operations with the cartrige filled with seedlings do not affect them. Even the process of planting the seedlings out of cartriges practically excludes damaging of their trunks and roots.

The cartrige method of seedlings raising gives wide prospects for application of system of selected and nonvirous vegetable seedlings growing. It appears an opportunity to organize the skilled production of qualitative seedlings in cartriges and their delivery to facilities, farms and persons under contracts.

Looking backwardly, it appears that a cartrige method of vegetable seedling raising and automated planting came into existence in this country at a vegetable processing plant in the city of Kharkov (1960-1970). The first cartriges looked like honeycomb of greater size. It should be noted for the sake of justice that it was the most rational and economically efficient cartrige in terms of design. This form of the cartriges was futher utilized by "Lannen Tehtaat Oy" (the"paperpot"system), "Iammar" of Japan. Therefore the further rationalization of the cartrige design was far from bio-engineering systems and resulted in technologically simple structures with coordinate or hexagonal arrangements of square, pyramid and conic cells on a rectangular formed cartrige. Presently about a hundred types of various purpose cartriges are known and it became necessary to work out the international standard for them. Such standards for the seedling raising and planting cartriges will speed up the process of cartrige method implementation in many countries contribute to the increase of quality of the vegetables and development of the economic basis of vegetable growing the world over.

2. VISKHOM achievements in development of automated machinery for seedlings production and planting

Within VISKHOM there is a specialized scientific-research and design department on complexes of machines and implements for protected ground. In the framework of the agricultural machinery building branch the department is the main coordinator of scientific research , test and design works. The department initiates in holding of traditional international exhibitions on greenhouses and their equipment.

2.1 Machines and implements for potted seedling production and planting

In 1972 VISKHOM started the elaboration of concept for cartrige method of vegetable seedling raising and planting. One of the methods which reached the stage of tests under farm conditions was the method of seedlings raising inside cells of spiral cartriges and their planting by means of cartrige transplanting machine.The method was so simple in terms technical realization that already in 1973 the field testing of 4 raws automated transplanting machine have been held. The spiral cartrige (fig.1) is a plastic preperforated band with 30 meters length along which with 50 mm spacing the pertitions of 30 mm height echc are fixed in the cross-section direction. Every partition is wider than the band by 10 mm and is fixed symmetrically as for the band. On a free upper rib of the partition there is a groove which is equal in width to the perforated band. The extreme particles are of variable height. Behind the extreme particles the idle parts of perforated band are left. They have tips which can be locked in the perforation of the band.

To mount the spiral cartrige the following operations are to be carried out. The idle part of the band is to be rolled up in form of rouleau of given diameter which is defined by initial engagement of the tip with perforation opening. Afterwards the entire band is to be coiled up over the rouleau with partitions directed inside and the other tip of

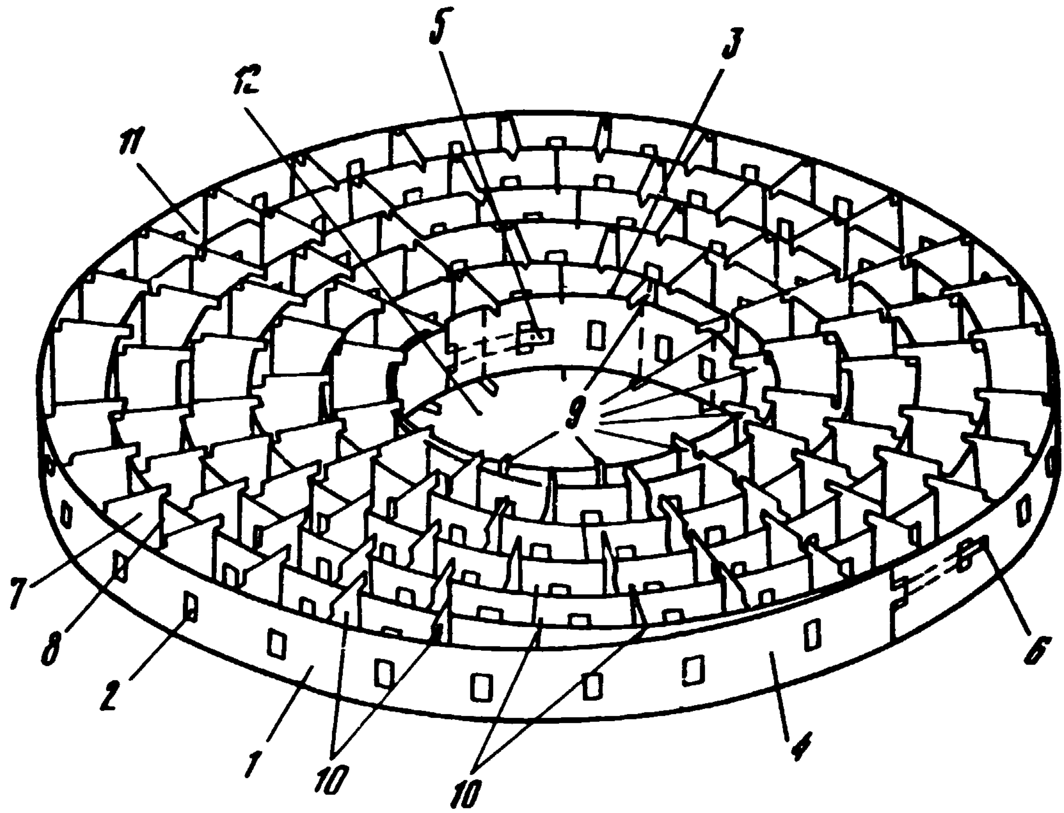

Fig. 1

Spiral cassete constructed by "VISKHOM" a.s. N895312:
1 - flexible tape; 2 - perforation; 3,4 - free of partition ends of the tape; 5,6 - fixators of the inside and outside circles; 7 - partition; 8 - fiqured cut in the partition; 9,10 partition of variable height; 11 - cell; 12 - inside plantitng hole.

the band is to be fixed in the same way as the first one i.e. by locking on the nearest perforation opening. When coiled up in form of spiral the band with partitions presents the cells which can be filled by nutrient substrate and sowed with seeds (or planted with seedlings).

As the cartige coils on their entire length are engaged to each other by means of the grooves in the partitions, the spiral cartrige keeps its form during all operations with it, i.e. transportation, placing onto the machine , etc. The cartriges are installed upon the shielded surface of the greenhouse bed in chess-board order thus ensureing the coefficient of productive area utilization equal to 0.85.

The cartridges charged with seedlings are delivered to the place of planting by racks the shelves of which are the trays which serve at the same time as inclined support for the seedlings cartridge of transplanting machine.

On the transplanting machine (fig.2) the idle part of the cartridge band is to be run through the screw band guide and fixed on the receiving reel. During the machine movement in the field the band with speed proportional to that of the machine movement and to the given spacing of planting is re-coiled on the reel while the seedling are grabbed by elastic rings of planting disk and are planted into the raw made by the ploughshare.

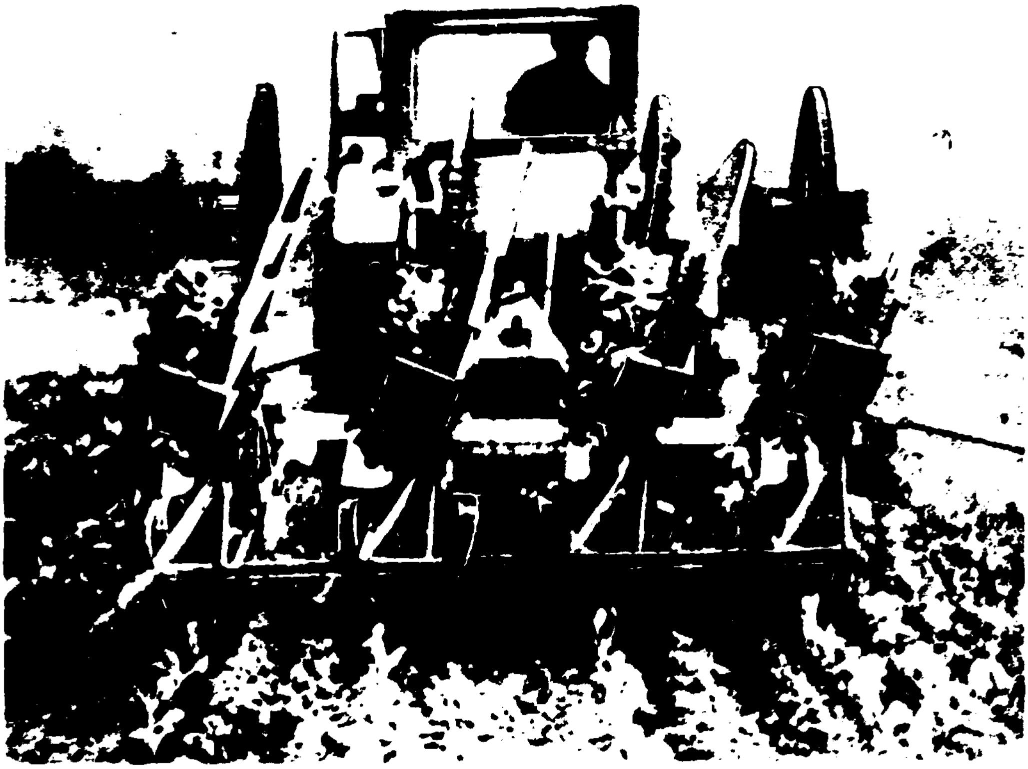

Fig. 2

Automatic seedlings planting machine "APM-4" constructed by "VISKHOM" a.s. N843815. and transplanting of seedlings by 6 times.

The design solutions of the cartridge and the transplanting machine were patented in the Netherlands, USA, Finland and Japan.

The method of filling of spiral cartridges with substrate and sowing of seeds in them was developed and patented in the USSR. The feature of this method is that the cartridge with through cells is filled with substrate from below and the seeds are sown into the cells from above. Afterwards the substrate is thickened to increase the contact with the seed.

Field tests of spiral cartridges for seedling raising and for automatic transplanting machine showed that such cartridges ensure the seedling output of 530 seedlings per square meter and automized seedling planting with a rate of 300 seedlings/minute for one raw and reduction of labour consumption when picking up and transplanting of seedling by 6 times.

The specifications of spiral band cartridge:

- perforated band length, m	30
- band width, cm	5
- band thickness, mm	0.7
- working length of band with partitions, m	25
- diameter of coiled cartrige, m	1.0
- average dimensions of a cell, mm length 50 width 31 height 60	
- number of cells in a cartridge	500
- mass of empty cartridge, kg	4
- mass of charged cartrige, kg	30

Specification of ARM-4
automatic transplanting machine

Type of machine	mounted on tractor of 1.4 t class
Number of raws	4
Interraw spacing, cm	50,60,70
Planting spacing, cm	5,10,15,20,25,30,40,50
Planting depth, cm	6-15
Type of planing device	rotary with two meeting disks of 750 mm diameter
Feeding of seedling to the device	mechanical by means of re-reeling of cartridge band
Mass, kg	800
Crew	
during working shaft	1 (tractor operator)
during cartridge replacement	2 (workers)
Output , ha/h	1.5

In 1984 for the first time the ARM-4 machine for spiral cartridges seedling planting was demonstrated on the international exhibition "Selkhoztechnica-84" and highly appreciated by specialists.

During the international exhibition "Selkhoztechnica-90" an advertisment stand is presented informing specialists on the latest achievements of VISKHOM in this field.

As a principal patents holder Viskhom is ready to carry out negotiations with interested firms on selling of licences and establishment of joint production of the entire machinery complex.

The USSR has a tremendous peat resources. That is why utilization of peat as basic component for single use cell cartridges is effecient for this country in terms of ecology. Besides that the USSR can export such cartridges to interested firms. The "Lentorf" manufacturing assosiation in the city of Leningrad produces peat loaded cartridges with a cell volume of 45,80, 140,350,650,1000 cub.cm packed in carton boxes.

Single use peat cartridges make it possible to automate the process of seedlings transplantation. Presently VISKHOM develops and tests the automatec transplanting machine for such cartridges and welcomes cooperation with interested firms.

In the framework of cooperation between VISKHOM and "Growing system", USA automated mounted device for machine Holland Transplakter of 1265 modification, widely used in the USA, has been developed. By means of such mounted set the machine is capable of planting the seedlings from "Growing System" made flexible rectangle cartriges in automated regime. The device is patented and exhibited in "Selkhoztechnica-90".The distinguishing feature of its design is compact interconnection of self-unloading rack for seedling cartridges and device for picking up the seedling from cartridge cells with seedlings delivery by the piece into rotary holemaking planting device. The automized set can also be mounted on TR-2 transplanting machine of "Lannen Tehtaat Oy", Finland.

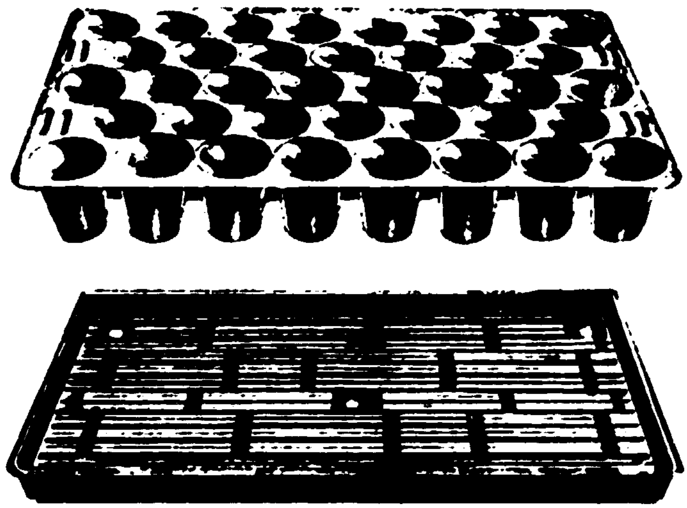

Fig. 3
Flexible cassette of the firm Growing systems. USA.

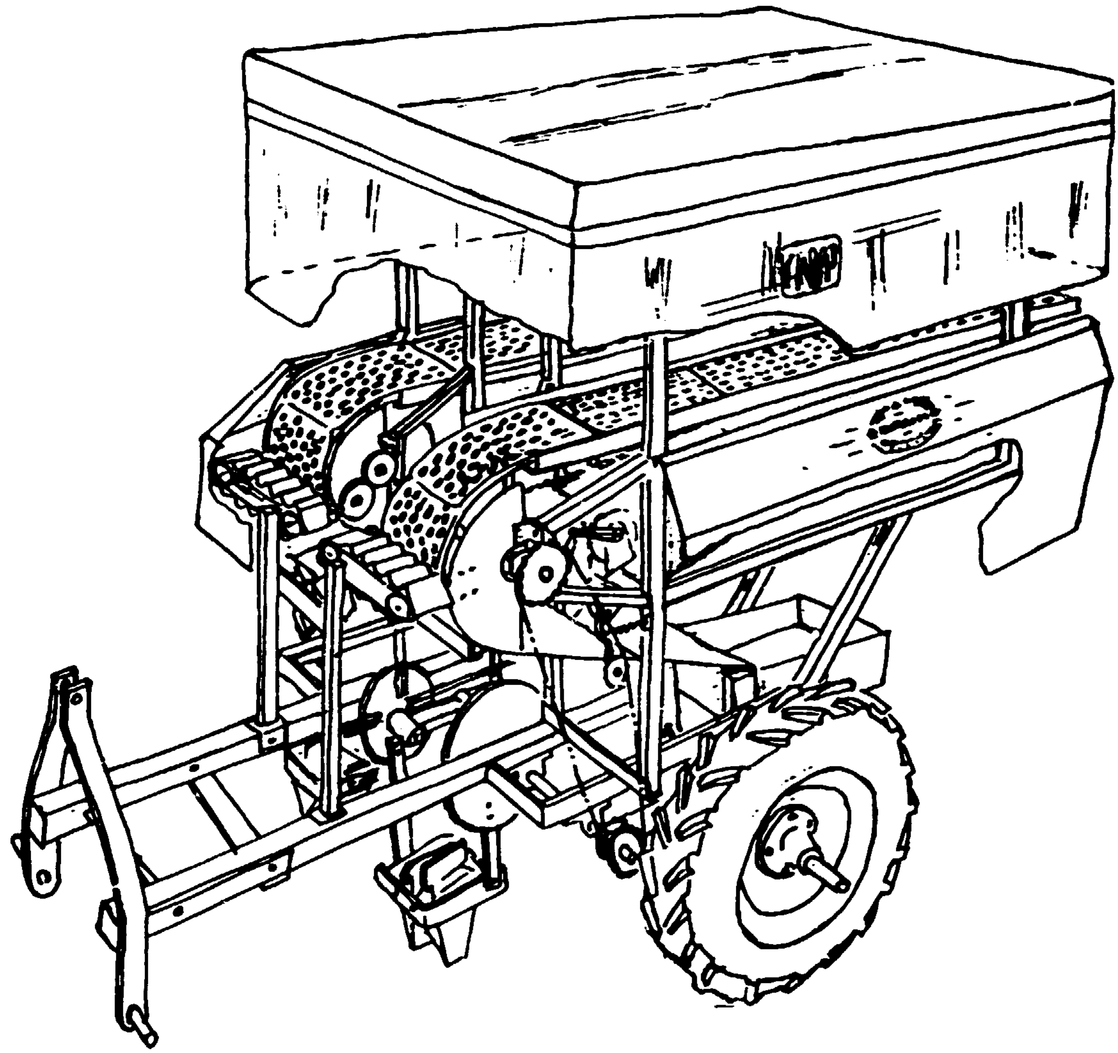

Fig. 4
Automated additional eguipment to the machine Holland Transporter, mod.1285, created in the scientific-manufacturing enterprise "VISKHOM."

Specifications of the automated mounted set (fig.3,4)

Loaded cartridges with seedlings (96 seedling per cartridge)	54
Average rate of seedlings feeding into the planting device (per 1 raw), seedlings per minute	120
Drive	by shaft of rotary planting device or by machine wheel
Mass (without cartridges), kg	300

The automated set allows to increase the machine output by 3 times and to reduce the consumption of labour during transplantation processes by 6 times. It appears an opportunity to increase the machine bout length up to 1000 m. With the aid of the set the transplanting may be carried out by one man (tractor operator).

As a result of cooperation between agroindustrial enterprises of the USSR and "Lannen Tehtaat Oy" of Finland in the field of vegetable growing the use of cartridge method of seedlings raising on the basis of Plantek 144 and 64 plastic cell cartridges of rigid type continuously extends. For cartridge seedlings planting the Plantek has developed the Plantek Automat 144 machine in which the cartridges are delivered from the rack to the planting device by hand and installed in its guides. The further process of planting goes on in automatic regime. The only work left for the operator is to collect empty cartridges and to replace them with charged ones. A trained operator is able to manage alone 3-raws transplanting machine. For 8-hours working day an operator has to carry and exactly load about 10-12 ton of seedling cartriges to the guides of the planting device. It considerably exseeds the allowed norms of weight per a person. To facilitate the operator's work it is possible to engage two operators in 3-raws machine managing. Even in this case we can expect the positive effect from the automatic transplanting machine functioning. The main shortcoming of the "Plantek Automat 144" machine in terms of design is the absence of mechanisms which compensate blanks in the cartridge cells which are the result of non-germination of seeds or caused by other reasons. One cartridge of 144 cells while raising cabbage seedling from seeds with 98% factor of germination gives to the moment of planting about 10% of blanks.

There are two ways to solve the problem: to find out empty cells in the cartridge in the process of seedling raising by visual expection and to compensate them by manual picking up of reserve seedlings, or as it was mentioned above, to provide the transplantiing machine with a blank compensation. We consider the second way to be more preferable.

Therefore the department for protected ground machine complexes of VISKHOM has developed a totally new concept of automatic transplanting machine for seedlings planting from cartridges of Plantex 144 and Plantek 64 types. The essence of the concept is that from the cartridge which is smoothly moved simultaneously with the translational movement of the machine and with given planting spacing the seedlings are continuously fed by the piece to the seedlings channel by means of punch mechanism which is controlled with a system which follows up the cartridge movement and the presence of seedlings in cartridge cells. The chosen concept of machine design allowed to simplify to minimum the mechanical part of the machine, fully exclude the influence of driving mechanisms on the precision of punches entering the holes in the lower part of the cartridge and eliminate blanks resulted from the absence of plants in cartridge cells. After that the electric follow-up system with punch executive mechanism has been developed. The automatic transplanting machine marked as MR-3

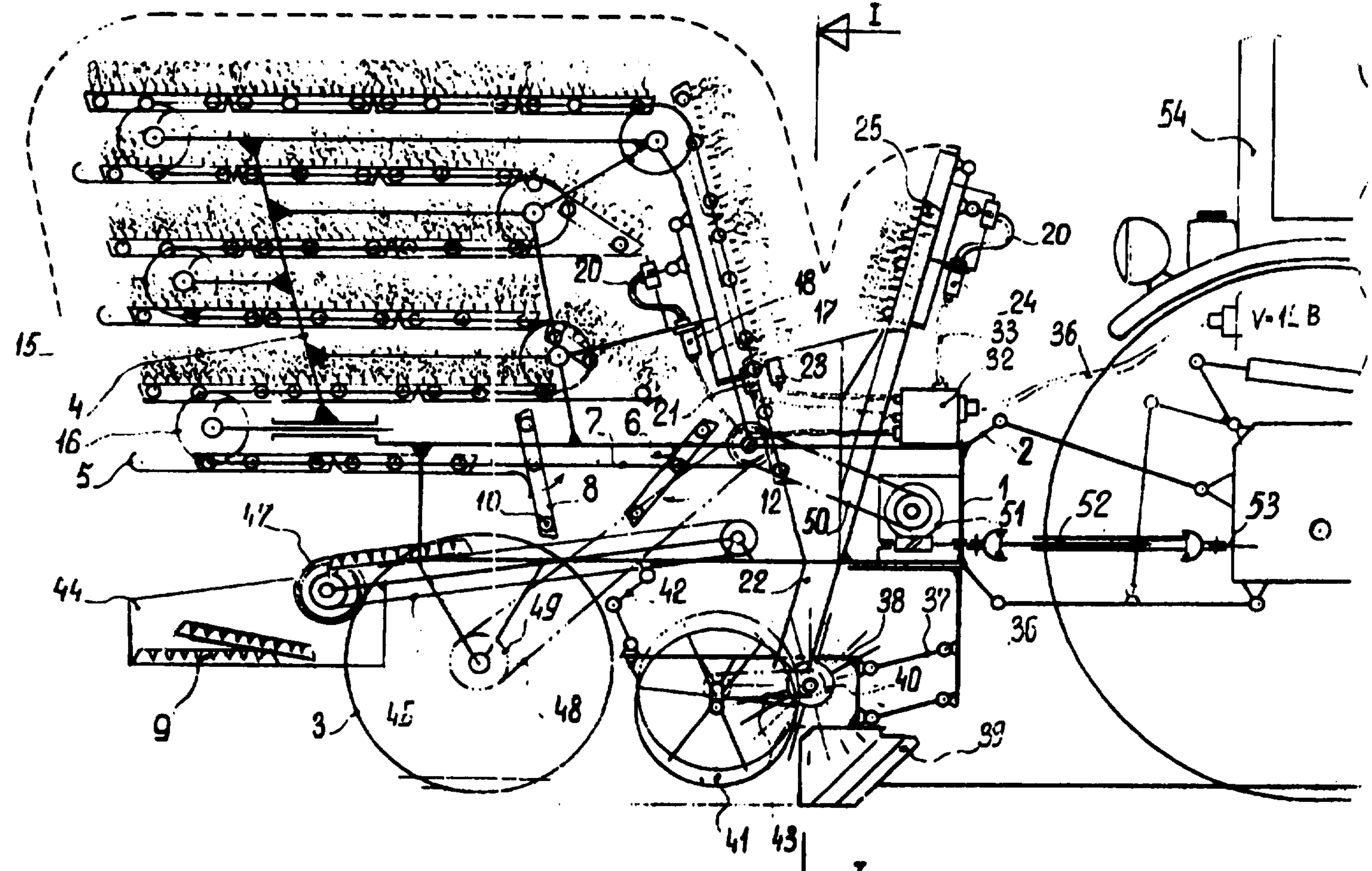

Fig. 5
Automatic seedlings plantingmachine "MR-3."

(fig.5) is equiped with conveyer rack with the capacity of 22 seedlings cartridges per one planting section, which ensures the machine working bout of 950.0 m without additional reloading with cartridges (with the planting spacing of 0.30 cm and the cartridge of Plantex 144 type).

The machine can be managed by one tractor operator. Specifications of the MR-3 machine.

The type of machine	mounted on tractor of 1.4 t class
Number of planting sections	3
Interraw spacing,min.,cm	60
Planting spacing, cm	10,15,20,25,30,40,50
Planting depth, cm	6-15
Number of simultaneously loaded cartridges per one planting section	22
Mass (without chardged cartridges),kg	900
Dimensions, mm	
length	2250
width	2100
height	2150
Crew	1(tractor-operator)
Output,	ha/h 0.4

The potless seedlings are grown in film covered hothouses by the method of straight sowing of seeds into the prepared beds. The seedlings are harvested by manual picking up and placing into boxes. The seedlings planting into the open ground is carried out by transplanting machines with manual seedlings feeding from boxes to snatchers of planting device. The labour consumption is 2-3 man hours per 1000 seedlings.

The department of machine complexes for protected ground of VISKHOM in cooperation with a number of scientific and design organizations in the USSR has developed a bridge cultivation system for film covered greenhouses which provides 10-15 times reduction of labour consumption.

The essence of bridge cultivation system for film covered greenhouses is that the technological base for all operations in greenhouse is presented by levelled and rigidly installed metal rail along which an electric power means is moving, the latter fits for all the machines and implements for cultivation of seedlings and other greens.

The advantages of the bridge cultivation system in film covered greenhouses as compared to traditional system on tractor or two-wheel mini-tractor are evident:

- it excludes the thickening of soil in greenhouses;
- it allows to perform technological operations in automatic regime, the operator is out of zone with harmful conditions;
- it ensures the technological interrelation between all consequent operations of crops or seedling raising and harvesting;
- it ensures the even and rectilinear movement of all working organs along the greenhouse and relatively to the soil, with given height or depth, which positively effect the quality indices of their functioning;
- it creates the opportunity for mechanization of seedligs, radish and other greens harvesting;
- it opens a possibility to carry out the work day and night according to prepared programme in automatic regime.

It is evident either that according to the up-to-date criterions of economic evaluation the bridge cultivation system for film covered greenhouses will be unprofitable regardless the sharp decrease of manual labour consumption. But from the point of view of present priorities in the field of ecology and man's health the bridge system of cultivation undoubtly can achieve the technological breakthrough in the agricultural production. That is why it is necessary to accumulate the experience for future already today in order to make it closer. Basing on this concept the specialists from VISKHOM department of machine complexes for protected ground have carried out detailed studies of the problem of bridge cultivation method for film covered greenhouses taking as an example the production of the tomatoes seedlings. During the researches a few variants of bridge electric chassis with a set of implements for production and planting of potless seedlings were developed.

For the greenhouses with 9 meters span width the ShMT-9 three points electric chassis (fig.6) has been developed. It consists of central force carriage of bicycle type which moves on the single rail track, laid along longitudal central line of the greenhouse, and two side booms with guide lathes and carriages with mounting devices for hanging implements and machines, fixed on them. The side booms are fastened to the central force carriage with one end and rest upon self-guided wheels with pneumatic tyres with another end. The wheels with pneumatic tyres run along the levelled ground track passing along the side walles of greenhouse.

To deliver the electric chassis to the parallel sections of the greenhouse the electric transportation cart is used which moves on the guide tracts along the connecting passage of the greenhouses complex. The system of top contactors ensures the precise conjunction of the cart relatively to the single rail track of the greenhouse. The programmed control device ensures the fulfilment of soil cultivation, seeds sowing, plants processing and seedlings harvesting operationss in automatic regime. Having finished the given operation in one section of the greenhouse the electric chassis moves upon the transportation cart and waits the operator command to transfer to another section of the greenhouse.

Specifications of the ShMt-9 chassis

Power of force carriage engine, kWt	4,5
Minimal tractive effort, H	2000
Gauge of side booms support wheels, mm	8400
Working speed, km/h	0.18,0.25,0.75
Power of side carriages engines,kWt	0.5
Power of engines for lifting and lowering of working parts and machines, kWt	0.75
Dimensions, mm	
Length	2800
Width	8600
Height	1950
Mass, kg	1500
Input power	cable,V=350 V, 50Hz

The electric transportation cart for moving the chassis to the adjacent and opposite sections of the greenhouse consists of 2-axle carriage , in the center of which the turn table with guide track for central force carriage of the ShMT-9 shassis is mounted. The cart equiped with electric drives for moving the electric chassis along the passage of the greenhouse and for its turning for 180 degrees in case of chassis transferrence to the opposite section of the greenhouse.

Fig. 6

Bridge electric chassis with three supports "ShMT-9", constructed by "VISKHOM".

Specifications of the transportation cart

Power of engine for moving, kWt	1.5
Power of engine for turning the chassie, kWt	1.5
Cart's gauge , mm	2500
Speed, km/h	1.0
Dimensions, mm	
length	2000
width	3000
height	500
Mass, kg	600
Input power	cable, V=380V, 50Hz

The set of machines for seedlings growing, picking up and planting in the field was developed for the ShMT-9 electric chassis.

The FOP-1.5 rototiller for presowing cultivation (fig.7) has central drive for tiller cylinder which ensures smooth conjunction of adjacent passages without influence on thickness and structure of soil. The tiller is driven by the electric engine placed on the cage. The control of the electric motor switching on and off is fulfilled automatically at the beginning and at the end of working run.

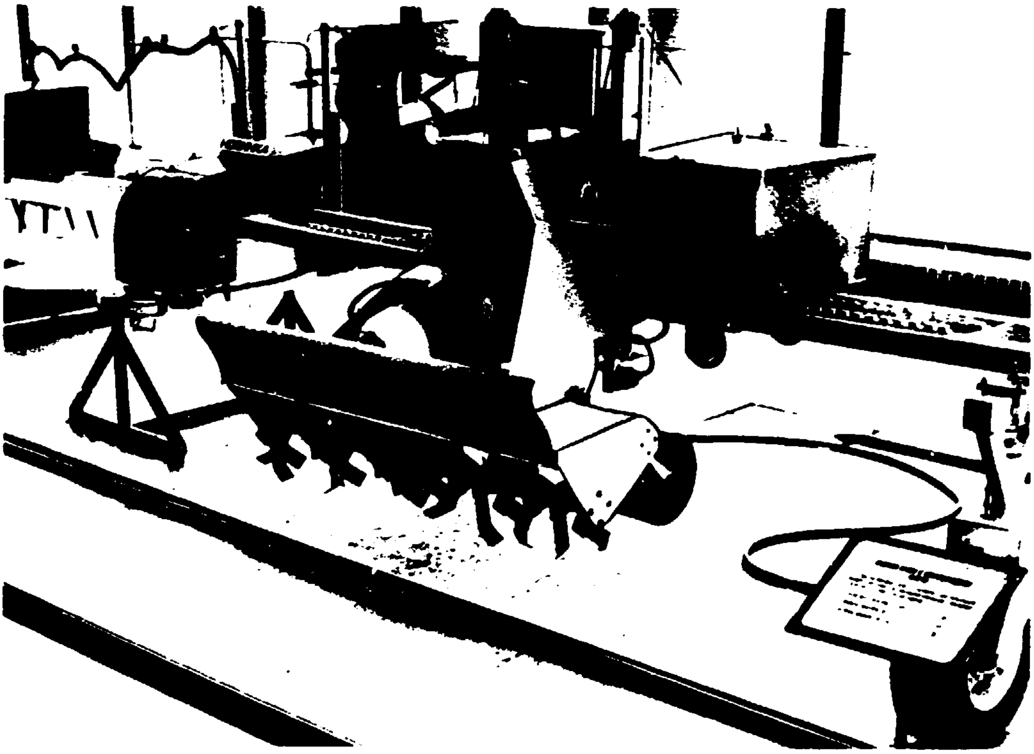

Fig. 7
Milling cutter for beforeplanting prepearing of soil "FOP-1.5" for brige electric chassis.

Specifications of the FOP-1.5 rototiller

Type of machine	mounted with "Accord" type mounting device
Input power, kWt	3.0 380 V
Rotor revolutions per minute	30
Working width, mm	up to 160

Working speed, km/h	0.75
Output, ha/h	0.1
Mass, kg	170
Dimensions, mm	
length	960
width	1600
height	950

The electric chassis can carry two FOP-1.5 rototillers simultaneously and their summed output is 0.2 ha/h.

For precision sowing of seeds of seedlings and greens in film-covered greenhouses the 36-raw drill has been developed (fig.8). The drill has an original design which has been patented in the USSR. It utilizes the sowing device of pneumatic type with suckers which perform the oscillatory movement. The drill is also equipped with socket device and instead of conventional ploughshares it has chequered support cylinder which maintains absolutely even depth of seeds implantation. The drill has four-position sucker which ensures sowing of cabbage, radish, pepper, eggplant, tomato and greens (salad, fennel, etc.) seeds.

Specifications of the drill

Type of the drill	mounted with "Accord" type mounting device
Input power, kWt	
for vacuum pump drive	3
for sowing device drive	0.5
Working width, m	1.8
Number of sown raws	36
Interraw spacing , cm	5
Spacing between seeds in the raw	3.0,5.0,8.0,10
Depth of seeds implanting, mm	15
Working speed with sowing spacing of 5.0 cm, km/h	0.36
Output as for 5x5 cm sowing scheme, ha/h	0.065
Mass, kg	228
Dimensions,mm	
length	1210
width	1070
height	1015

The ShMT-9 electric chassis can carry two drilled simulteneously and their summed output while sowing the seeds is 0.13 ha/h.

One of perspective models of the department is the machine for picking up the potless seddlings with their simultaneous loading into the single band cartridge, which serves as a magazine of automatic transplanting machine. Thus the both machines - for picking up the seedlings in the greenhouse and for seedlings in the field - are technologically interconnected.

The single band cartridge is a flexible perforated band of 63 m length, along which with 60 mm spacing 1000 seedling snatchers are uniformally fixed. One end of the band is fixed on the reel on which the whole band is to be rolled on afterwards. The spacing between coils is 20 mm. When coiled in form of rouleau the cartridge has a diameter of 1000 mm. The mass of an empty cartridge is 25 kg, the mass of cartridge charged

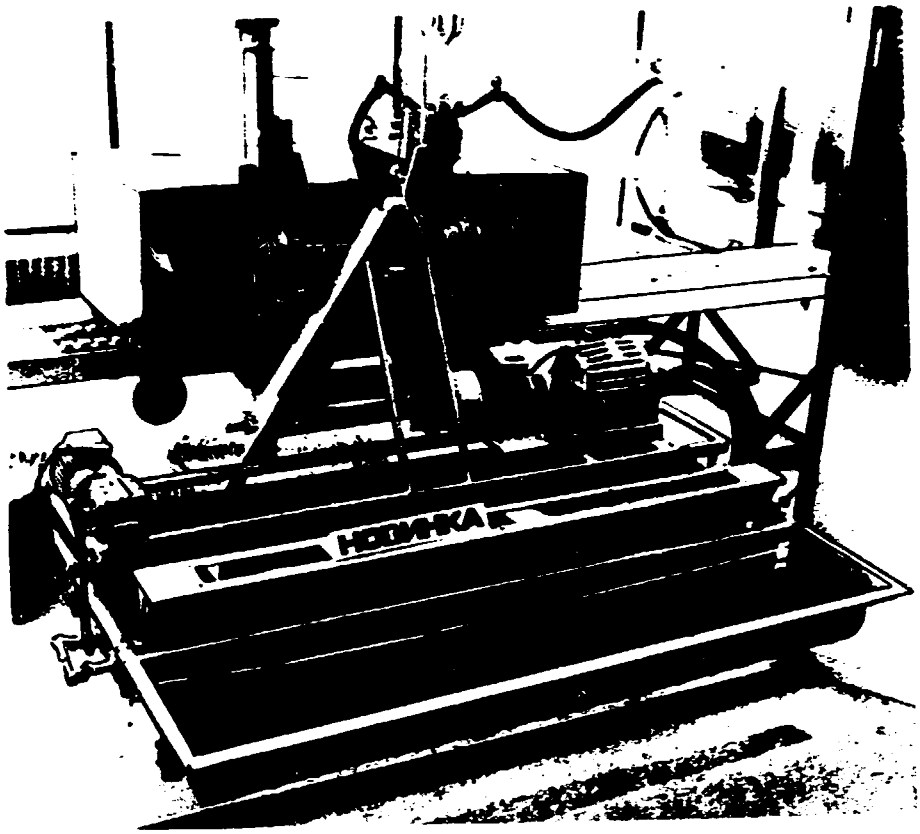

Fig.8
Exact sowing sec-drill for brige electric chassis.

with seedlings is about 40 kg. Each cartridge accomodates 1000 seedlings.

Because the automatic transplanting machine for delivering the seedlings from single band cartridges has 6 raws, the machine for picking up the seedlings into the cartridges will be of 3 raws (because one electric chassis is mounted with two seedlings picking machines at a time).

The MVR-3 machine for picking the seedlings into the cartridges (fig.9) has an original solution in terms of design of picking up the potless seedlings into the snatchers of single band cartridge without blanks independently of the conditions of seedlings in a harvested raw. Another original working unit of the MVR-3 macnine is the pneumatic divider which divides not only the raws between the seedlings but also the tops of the plantlets in the raw. The machine is equipped with a digging knife and three-raw picking device.

Specifications of MVR-3 machine

Type of machine mounted with "Accord"	type mounting device
Picking sections	3
Interraw spacing, mm	600
Working speed, km/h	0.36

Output, seedling/h	21000
Mass (without cartridges), kg	300
Mass with cartridges and seedlings, kg	500
Dimensions, mm	
length	2500
width	2100
height (with cartidges)	1950
Input power, kWt	
for ventilator drive	3
for picking up devices drive	1.5

The ShMT-9 electric chassis can be mounted with two MVR-3 machines and their summed output while picking up the seedlings is 42000 plantlets per hour thus ensuring the functioning of one ARM-6 automatic transplanting machine.

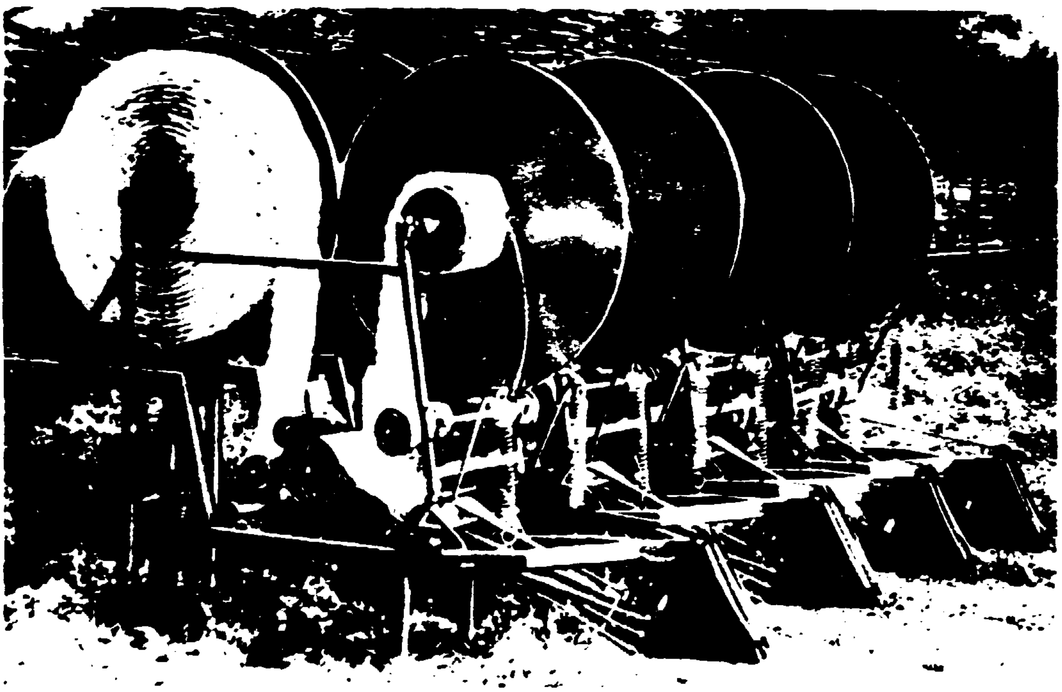

Fig.9

Seedings choosing machine with simultanious laying into cassettes "MVR-3" for brige electric chassis.

On the MVR-3 machine the all three cartridges are placed on one telescopic shaft. When the ShMT-9 electric chassis moves into the passage of the greenhouse and climbes the transportation cart the two blocks of seedlings cartridges are removed from the MVR-3 machines by hydraulic manipulators and instead of them the MVR-3 machines are loaded with two blocks with three empty cartridges each. After that the electric chassis moves down the transportation cart and the process of picking the seedlings goes on while the transportation cart with two blocks of cartridges charged with seedlings moves along the greenhouse passage to the place where the transport means waits to deliver the cartridges to the field.

The transport means which transports the cartridges to the field where the automatic transplanting machine is the GAS-51 truck (fig.10) on the platform of which water tank, oil tank with hose and 3-arm turning holder for cartridges blocks are mounted. The holder is driven with hydromotor. Four blocks of seedlings cartridges are installed on two arms of the turning holder. The third arm remains empty and will be engaged for removing and fixing of empty blocks of cartridges from the transplanting machine.

The ARM-6 automatic transplanting machine consists of analogous three arm turning holder for blocks of cartridges, band moving mechanism, ploughshares and pressing rollers.

The seedling cartridges blocks are fastened to the snatchers of two arms. On the snatchers of the third arm the blocks with reels for rolling on of empty single band cartridges are mounted. Thus every planting section has two cartridges with seedlings (2000 seedlings per planting section) that ensures the non-stop run of the machine in case of 0.25 m planting spacing (e.g. for tomato seedlings) equal to 500 meters. The process of seedlings planting by the machine goes on in the automatic regime. By the signal coming from the sensor which controls the start and stop of rerolling of the working length of the seedlings cartridge band the tractor operator starts or stops the moving of the machine. Then 2 operators who maintain the machine replace the cartridges. A replacement of the cartridges takes about 6 minutes.

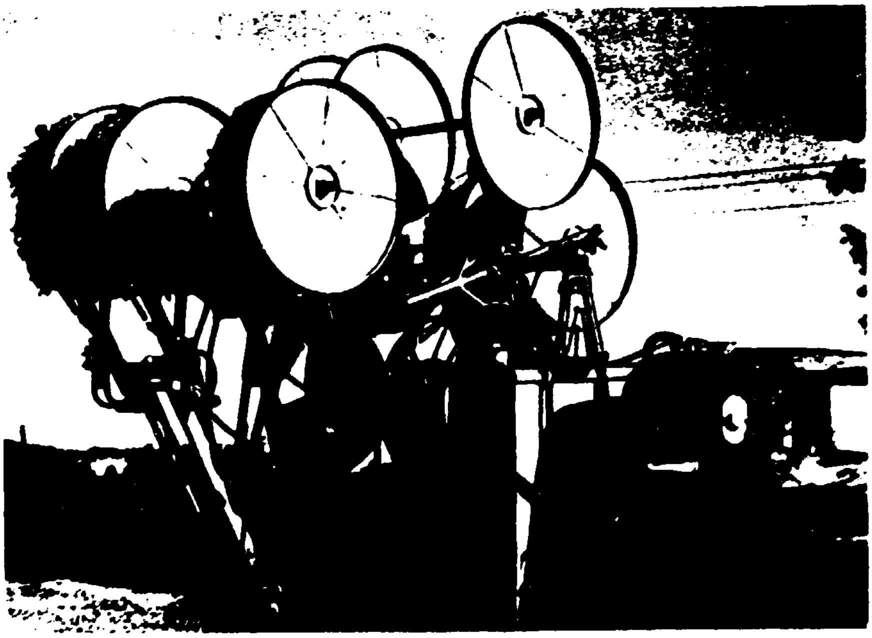

Fig.10
Cassette transporter on the basis of autotank "GAZ-51"

Specifications of ARM-6

Type of machine semi-mounted on 3 t class tractor

Working width, m	3.6
Planting sections	6
Interraw spacing, mm	600

Planting spacing, mm 10,15,20,25,30,40,50 Seedlings loaded on the machine at a time 12000 Watering tanks capacity, l 2x1100 Working speed (with 30 cm planting spacing), km/h 2.1 Output (with 60x30 cm planting scheme) ha/h 0.756 Crew 1 (tractor-operator)

	2 (operators)
Mass (without cartridges), kg	1500
Dimensions, mm	
length	3200
width	4200
height (without cartridges)	2800

The above mentioned set of the machines which can be mounted on the bridge electric chassis is the principle for the potless seedlings cultivation and planting. Other complementary machines have been developed for the seedlings and greens cultivation e.g. sprayer, cultivator, root cutter, combined machine for radish planting, radish harvesting machine, etc.

The bridge system of cultivation in film covered greenhouses has been preliminary tested under farm conditions. The results of tests are the trustworthy source of initial information for further improvament of the separate working units of the machines and the system as a whole.

Main conclusions and proposals

The method of agricultural plants growing from the seedlings gains a wide application in the USSR. In vegetable growing it is spread on the area about 750 000 ha. The annual need in seedling is about 30 billions.

In the south regions of the USSR the main accent is put on the potless technique of tomato,cabbage,pepper and eggplant seedlings growing, while in the nothern regions the only potted seedlings method is used. The potless seedlings make about 90% in the present ratio.

The implementation of the cartridge method of seedlings growing and planting in this country will result in the reduction of volumes of potless seedlings application. The development of automatic transplanting machines for seedlings planting from cartridges contributes to this trend.

The machines developed by VISKHOM make it possible to broaden considerably the sphere of use of the cartridge seedlings cultivation method. The time has come for the International Standards Organization to work out the unified requirements for such cartriges in order to make them useble for all over the world. As a basis for such a standartization the cartridges of

, Finland, , USA, spiral

cartridges of VISKHOM, USSR and others can be used. The advantageous trend in plant growing is the use of the

bridge cultivation system which prevents the desrtuction and thickening of the soil and reduces content of chemicals in it.

The bridge cultivation system for film-covered greenhouses which was developed by VISKHOM, USSR pertains to the ecologically clean technologies. However in the course of primery tests of this systems under the farm conditions the complex of problems arose which demands to combine efforts of scientists in the framework of the international concord of nations.

It is expedient to set up an international research institute on problems of bridge cultivation system not only for film-covered greenhouses but for open ground, e.g. in the field of selection and seed-growing, rice and vegetables cultivation,etc. Such an institute can be found in the USSR.

COMPLEX OF MACHINES FOR PREPARATION OF COMPOST.

*Y.N. Lipov *, A.V. Khromov ***

Champignons - are the delicious food product. Their taste qualities are by no means inferior to the best forest mushrooms. Champignons contain a plenty of protein, carbohy:rate, the phosphorus available yields to a majority of fish products.

The demand for this valuable product increases from year to year. To meet the demand there is a necessity of the mushroom production planned increase by the farms, situated close to cities and industrial centers.

In up-to-date industrial champignon growing complexes the mushrooms are grown all the year round irrespective of regions, weather conditions with even annual production of mushrooms. It allows to satisfy the consumer's need in fresh mushrooms round the year without necessity in canning and long preservation.

The annual crop of champignons from 1 sq.m of cultivation area in mushroom growing complex reaches about 120 kg and even more. It becomes possible owing to use of high crop sorts of mushrooms, utilization of special cultivation buildings, equipped with facilities for automatic keep up of microclimate, developing for complex mechanization of all the principal production processes.

The most high level of development in industrial mushroom growing is presently achieved in the Netherlands. The Dutch firms specialized in the subject export the advanced industrial mushroom growing systems"under lock"to many developed countries. "AgriSystems" is the leading firm in the Netherlands specializing in design of machines for champignon production.

In this country the industrial champignon growing has been practically launched since 1976, when two Holland manufactured mushroom growing complexes with single zone technology, 1 hectar cultivating area and annual capacity of 850 tonnes of mushrooms each have been put into operation in Moscow surburb farm "Moskovsky" and Leningrad firm "Leto".

Afterwards a plant for the production of grain based mycelium with 300 tonnes annual capacity manufactured by "AgriSystems" of Holland either was put into operation in the sovkhoz "Zarechie" near Moscow. There is a mushroom growing complex with multizonal technology and cultivation area of 0,25 hectar.

Foreign experience as well as the information obtained while exploiting Holland manufactured industrial mushroom growing complexes with a single zone technology and the mycelium production plant with the unit for champignon growing under the multizonal technology made it possible for soviet scientific research and design organizations to develop their own industrial mushroom growing complexes with multyzonal technology and cultivation area of 1,0; 0,75; 0,35 hectars. To provide the complex mechanization of all the principal production processes in industrial mushroom growing complexes all the necessary machines and implements were designed and manufactured.

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The industrial technology of champignon growing includes 3 main production processes:

-compost preparation;

-casing soil preparation ;

-champignon growing.

The peculiar feature of industrial champignon growing in the USSR is that the champignon farms are spread over the country far from each other and their areas are up to 1 hectar each. Under these circumstances it is not advisable to build high capacity centralized facilities for production of compost and casing soil since the resulting high transportation costs would affect the economy of production. The only proper solution is to have individual compost production for each mushroom house (or a small group of mushroom houses located close to each other).

The experience of All Union Scientific Research Institute of Agricultural Machine Building (VISKHOM) showed that it is preferable to utilize general purpose machines for compost and casing soil production. So it proved to be efficient to use a combine which is capable to fulfil the technological processes of forming compost clamps, sredding the clamp afterwards with or without moistening of clamp matter and application of g·psum. The combine operating in the compost farm has a high leading capacity and efficiency.

It is justified to utilize the general purpose machine which provides for dosing of peat and dolomit powder, eliminates foreign admixtures, mixes all the components with simultan·ous moistening and delivery of casing soil to a transport means.

Below there is a design and process description of the KPK- 30 combine for compost and casing soil production.

The principal components of compost making machines are: cylinders, conveyers, beaters and forming chamber.

Spike-shaped working parts have the best performance in forming culmiferous compost masses; the function of the spike- shaped parts is to comb out the compost mass from the clamp and feed it to auxiliary working parts. In all possible arrangements of machines and various types of working parts there is always a forming chamber placed immediately after the beaters and used to form a compost clamp.

Another common feature of the system is the fact that all the processes involved in compost preparation are to be performed by individual specialized facilities. It has to be noted that it is unprofitable for small scale mushroom growing farms to use machines for gypsum application on top of a compost clamp like "Tilot" applicat since in case of 1 hectar mushroom house such a machine would have to be operated only 10 to 15 minutes a week.

Study of the machine design makes it possible to reveal that quality of prepared compost can be increased by further improvement of the working parts arrangement and their active interaction with composted material; a most promising way to make the machine less metal - and power- intensive is to develop a multi-purpose machine (i.e. a combine) capable of doing all the operations associated with preparation of compost; a machine of that kind can be employed both at small and large farms. A most judicious and promising arrangement is the cylinder-beater system of working elements in a machine featuring a forming chamber, a device for receiving and feeding the incoming matter to the working element (cylinder) when the first clamp is to be formed, and a gypsum application device; all these components enable joint execution of the three operations: formation of the first compost clamp, shredding of this clamp in future with or without moistening of clamp matter and application of gypsum.

Having this objective in mind, researchers of the All Union Research

Institute of Agricultural Engineering (VISKHOM) have undertaken process research and experimental design work with a view to justify the tecnological concepts and working out a design of a combine for compost preparation, i.e. KPK-30 combine. A prototype model of this combine has been tried out for a prolonged period of service time in the compost preperation shop affiliated to the mushroom house at the "Moskovsky" state farm; the tests have been undertaken to compare this combine with Dutch machines manufactured by "Tilot". Basing on the test results, the combine operations has got an approval and the combine has been recommended for full-scale production. At the moment the KPK-30 combine is in service with a large number of farms in the USSR.

Fig.1 shows a general view of the KPK-30 combine for compost preparation.

Technical description of the KPK-30 combine.

The combine for compost making is desig ned for the first compost clamp formation, its further shredding and application of gypsum.

The combine consists of the following working parts: collector unit ,chassis with a drive, gypsum application unit, working chamber, pick up cylinder, watering unit and control system.

The collector unit is a metal tank which has three fenders. The tank is mounted on a separate frame with 4 castor wheels.

The chassis of the combine consists of the frame which is the basis for all gears, front and rear wheels. The rear wheels are the driving ones. Each rear wheel has an individual drive. It includes geared motor, reducing gears and chain transmission.

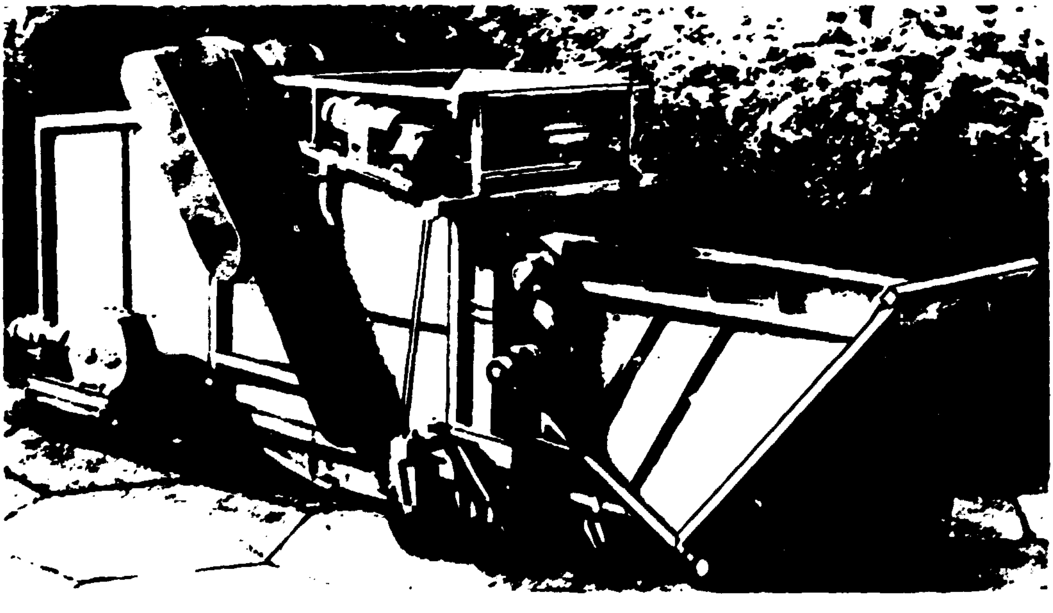

Fig 1.
General view of the KPK-30 combine.

The gypsum application unit has the following main parts: hopper, conveyer with drives. The unit is fastened to the upper of the machine. The conveyer is driven by means of clutch from the geared motor, worm gear and chain transmission.

The working chamber looks like the steel box, welded of stainless steel sheets. The sheets are welded to the machine frame. The working chamber contains working members, pick up cylinder and shredding beater.

The pick up cylinder looks like a closed metal drum which consists of hollow shaft with three rims fastened to it. The teeth wich are dispersed along two stroke line from the center to the periphery are on the transversal bars fastened to the rims. The drum diameter between the ends of the opposite teeth is 1,9 m. The drive of the pick up cylinder consists of the electric engine, Vee -belt transmission and gear.

The shredding beaters look like a hollow shaft with diameter of 180 mm with welded teeth located on two stroke screw line dispersed from the center to the ends with beater rotations. The shreddind beater's drive consists of motor-variator and Vee- belt transmission.

The forming chamber consists of 2 vertical and parallel formation fenders. The forming fenders look like the metal walls with variable geometry. In the end of the forming chamber there are doors. Inside the formation fenders in their upper part there is a reflecting lip intended to prevent the little compost particles from reaching the rear part of the forming chamber. The reflecting fender is mounted on the combine frame by the spinning axle. The angle of inclination to the horizontal line of the other end of the fender can be changed with the help of chains.

The watering unit is a tube with holes which is above the pick up cylinder. The tube by means of conduit is connected through the water receiver with the drum with a long rubber hose on it, connected to water pipe line. The tap allows to regulate the water flow intensity through the holes in the tube.

The control system is designed for control of compost making machines. The equipment of the control system is aimed for working outside under conditions of the increased dust and aggressive steams with the ambient air temperature rate +25°C and relative humidity of air - 98%.

The control system ensures:

-on-going work of electric appliance

-impossibility of electric appliances switch out when the voltage is applied to control units.

-protection of electric engines from overloading and shirt circuit.

-necessary mechanical blockings providing the safety during the exploitation of technological equipment

-hand and automatic control

-pre-launch, technological and emergency light and sound sygnalling

-emergency switch-off of the control system.

The system includes the control unit, remote control, a set of sensors, providing operation in the given technological regimes.

The KPK-30 combine control unit with dimensions of 930x700x400 mm, a mount applicat, is fastened directly to the body of the machine. On the front panel of the control unit there are switch on and off buttons for magnetic starter of the circuit unit, the button for emergency stop of mechanisms, light indicator "Circuit"; two fuses for control circuits, regime switch and technological regime switch.

The control system of the combine works as follows:

-By pressing the button "On" the magnetic starter is switched on through the contacts of which power is applied to the automatic switches and through them in the circuit, which is shown by the indicator "Circuit".

If the switch "Regime" is in the position "Adjustment", it allows to start and stop the operation of engines from the remote control. In this case tere are not any technological blockings in control circuits of electric engines except for the pick up cylinder electric engine, which has the current sensor in its control circuit.

-If the switch "Regime" is in the position "Automatic" it makes it possible to start and control the electric engines of the KPK-30 combine automatically in 3 technological regimes (the regime of the first compost clamp formation, the regime of the second compost clamp formation, the regime of clamp shredding).

- To stop the electric engines in any of the regimes it is necessary to turn the switch "Regime" into "Off" position.

-Emergency stop of electric engines in any of the regimes ("Adjustment" or "Automatic") is achived by pressing the button "Emergency stop" in the control unit or the remote control.

The control system of the KPK-30 compost making combine is designed for the distance control when forming the compost clamp. It includes:

-the KPK-30 control unit
-remote control
-RF 8000 camera sensor
-rectilinear movement sensot (VISKHOM design)
-copier sensor (VISKHOM design)

The specification of the KPK-30 compost making combine.

Type of combine	self-propelled
Drive	electric
Input power, kW	
for clamp formation	23
for shredding and gypsum application	26
for shredding without gypsum application	23
Working width, m	1,8
Working speed, m/h	
on clamp formation and shredding	28-32
on further shreddingd	55-60
Transport speed m/h	600
Output, t/h	
on clamp formation and and first shredding	50-60
on further shreddind	up to 100
Crew	1
Overall dimensions, mm	
during clamp formation	
-length with doors opened	8750
during clamp shredding	
-length with doors opened	6750
-width	3280
-height	3100
Mass, kg	
during clamp formation	8000
during clamp shredding	6000
Number of cylinder's revolutions / min	20-22
Number of beater' revolutions / min	300-600

Function of control unit in the regime ""Adjustment":
-press the button "On", the indicator "Circuit" lights.
-turn on the switch "Regime"in "Adjustment" position;
-press the button "Stop" of operating electric engine to stop the engine;
-press the button "Reverse" and start the electric engine in reverse direction;
-in case of emergent stop of the all operating electric engines, press the button "Emergency stop" on the remote control;

The technological process description of the KPK-30 combine. The KPK-30 combine performs the process of compost fermentation. The formation of the first compost clamp is achieved by the following. There is an end fender installed in the forming chamber which prevents the spreading of compost and shapes a vertical wall at the end of the clamp. After that the drive engines for beater and cylinder are started.

The compost mass, moistened and softened during the previous phase is fed to the collector unit with the aid of the front fork lifter. The pick up cylinder, turning towards the combine movement in upward direction, grabs the compost mass from the collector unit, partly mixes it, shakes, enriches (at the
expense of air flow, made as a result of working parts functioning) with oxygen and delivers it to the shredding beater.

The shredding beater being rapidly turning mixes it once more, reduces to fragments the mass, enriches with oxygen and throws it towards the reflecting lip. The mass being reflected by it falls into the forming chamber, where the clamp is being formed to the necessary size. After feeding of the forming chamber with compost the combine starts functioning. The combine can operate with intervals or continuously with low speed.

The front fork lifter feeds the mass into the collector unit until the formation of the clamp of the needed length will be over.

The formed clamp is kept for 2-3 days, during which the biological process of compost fermentation takes place.

Afterwards the first shredding of the compost clamp with simultaneous gypsum application and moistening is implemented. The shreddings of compost clamps are necessary to reduce fermentation term as well as to mix the top (dried) layer with the innner part of the compost. Gypsum is applied for compost neutralization. For this purpose the collector unit is removed from the combine. The needed quantity of gypsum is loaded by the front fork lifter to the gypsum hopper.

The first shredding of the compost clamp is done in the following way.

The combine is moved to the existing clamp until the pick up cylinder teeth reach the compost mass. The supporting fender, which forms the beginning of the clamp is installed in the forming chamber till it reaches the reflecting shield. Then the drived engines of the shredding beater, pick up cylinder and drive wheels become operational. During the first shredding the combine operates with the first speed. Moving over the clamp, it provides the constant feeding of compost onto the pick up cylinder. During the pick up cylinder rotation its teeth comb out the parts of compost from the clamp, which (the parts) being separated from the teeth fall to the shredding beater. After the pick up cylinder will be above the clamp by half of its diameter the unit drive for gypsum application is launched. The conveyer deliveres the gypsum through the window at the top of the combine into zone where compost particles are found in a suspended state, thus contributing to the continuous distribution of gypsum through the entire compost mass. The operating system of moistening moistens compost.Further on the process of shredding goes on as during the formation of the first compost clamp.

When the combine leaves the clamp the support forming fender is close to the end of the clamp in order to provide more compost grabbing by the pick up cylinder and prevent spreading of the remaining compost clamp part over the ground.

The technological process of further shredding occurs in the same way. The only difference is that the gypsum application unit is out of work.

The compost shredding in the same clamp with the aid of the designed combine is carried out three times in predetermined periods.

The quality of shredding depends upon the trajectory of particles movement. To define the trajectory it has to find out the interaction of the cylinder's and beater's teeth with compost particles.

Compost is a heterogeneous mass containing the particles adherent to the cylinder's, beater's teeth and particles with less or without adhesion to the teeth.

The scheme of the cylinder, which axle moves with speed is shown on fig. 2a. In certain moment the cylinder's teeth reach the position AoBo and grab compost particles which spread all along the tooth AB .

During rotation of the cylinder the particles are casted under the influence of centrifugal forces of inertia. The particles which contact the cylinder, i.e. positioned close to points A of the teeth can not reach the zone of beaters because of friction forces.

For instance the tooth AB in the position AoBo during rotation influences the compost particle, moving in the same direction with the tooth. As the compost particle can travel not only with a tooth, but also relatively to it, then in common case the center of particle masses will perform complicate movement. It consists of movement with the tooth and movement relatevely to the tooth.

When analizing the flat parallel movement of compost particle, taken as a mechanical system its position can be defined, if the coordinates and of center of particle masses as well as the angle of its rotation round the axis, running through the center of masses (fig.2b) are known. The positive direction of the angles and is accepted to be clockwise.

As a result we have three summerizes coordinates α , ρ and β .

Utilizing the differential equation of Lagrange of the second kind in the summerized coordinates α, ρ and β, we obtain the following system of equations:

$$\left.\begin{aligned} \frac{d}{dt}\left(\frac{\partial T}{\partial \dot\alpha}\right)-\frac{\partial T}{\partial \alpha} &= Q_\alpha ;\\ \frac{d}{dt}\left(\frac{\partial T}{\partial \dot\rho}\right)-\frac{\partial T}{\partial \rho} &= Q_\rho ;\\ \frac{d}{dt}\left(\frac{\partial T}{\partial \dot\beta}\right)-\frac{\partial T}{\partial \beta} &= Q_\beta , \end{aligned}\right\}$$

where T -the kinetic energy of a particle;

$Q_\alpha, Q_\rho, Q_\beta$ -summerized forces;

$\dot\alpha, \dot\rho, \dot\beta$ -summerizes velocities.

Having defined these values and after a number of mathematic transformations of the system of equations (1) we obtain following dependences:

-the angle of turning for a compost particle while contacting with a cylinder tooth is

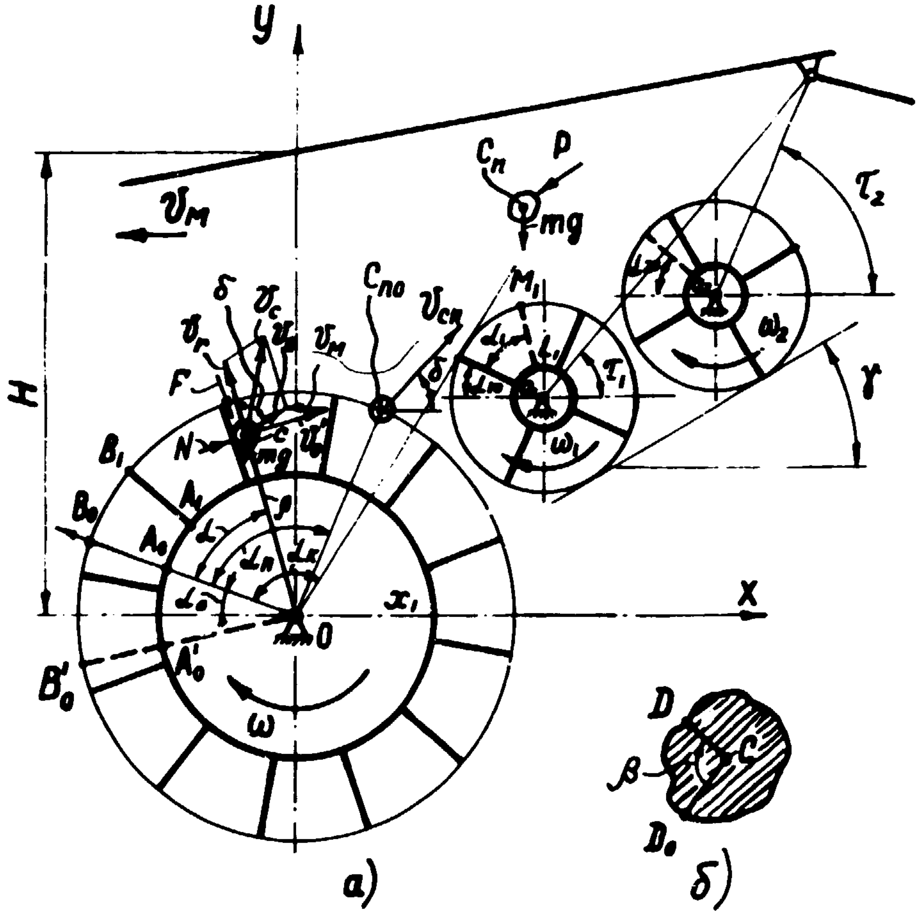

Fig.2
Scheme of interaction of pick-up cylinder and beater and beater which are the working parts of compost making machine: a) - general view; b) - scheme of a substrate partikle movement.

$$\beta = -\frac{f \cdot z_K}{z_{um}^2 \cdot \omega^2}\left\{\frac{2 \cdot C_1 \cdot \omega^2}{K_1} \cdot (e^{K_1 \cdot \alpha} - 1) - 2\alpha \cdot \omega^2 \cdot (C_1 + C_2) - 2 \cdot g \cdot \sin\varphi\left[\sin(\alpha_o + \alpha + \varphi) - \sin(\alpha_o + \varphi) - \alpha \cdot \cos(\alpha_o + \varphi)\right]\right\}$$

where z_K arm of force relative to the center of masses C for a compost particle;

$K_1 = -f + \sqrt{1+f^2}$
$K_2 = -f - \sqrt{1+f^2}$ constant coefficients, depending on coefficient of friction;

ω - angle speed of the cylinder rotation;

C1, C2 - constants of integration.

- trajectory of the center of the particle masses in chosen system of coordinates.

$$\rho = C_1 \cdot e^{K_1 \alpha} + C_2 \cdot e^{K_2 \alpha} + \frac{g}{2 \cdot \omega^2} \cdot \sin(\alpha_o + \alpha + 2\varphi)$$

In case of adhesion the regularity of the alternation of the center of particle masses position is expressed in the following way

$$\rho = C_1 \cdot \xi \cdot e^{K_1 \cdot \alpha} + C_2 \cdot \xi \cdot e^{K_2 \cdot \alpha} + \frac{g}{2 \cdot \omega^2} \cdot \xi \cdot \sin(\alpha_o + \alpha + 2\varphi)$$

where ξ - coeffifient of adhesion, the value of which defined experimentally;

g - acceleration of incidence;

$\varphi = \operatorname{arctg} f$ - the angle of friction (here f is a coefficient of friction).

Dependences (2) - (4) are justified only in those limits in which is changing from $z + z_K$ till $z + \ell$ (here z is the cylinder radius, and ℓ is the length of cylinder tooth).

For the compost particles reaching the beaters it is necessary for them to lose contact with the cylinder teeth before the angles α and α become equal (α_K is the angle between the line OAo and the tangent to the external circle of the teeth of the beater next to the cylinder, which runs through the point O).

For example a compost particle leaves a cylinder tooth in a position where the angle $\alpha = \alpha_n$ ($\alpha_n < \alpha_K$).

In this case the absolute velocity V_{cn} of the center of particles masses C_{no} will make

$$V_{cn} = \sqrt{V_M^2 + \omega^2(z+\ell)^2 - 2 \cdot V_M \cdot \omega(z+\ell) \cdot \sin(\alpha_o + \alpha_n) + \dot{\rho}_M^2 + 2 V_M \dot{\rho}_M \cdot \cos(\alpha_o + \alpha_n)},$$

where

$$\dot{\rho}_n = C_1 \cdot K_1 \cdot \omega \cdot \xi \cdot e^{K_1 \cdot \alpha_n} + C_2 \cdot K_2 \cdot \omega \cdot \xi \cdot e^{K_2 \cdot \alpha_n} + \frac{g}{2\omega} \cdot \xi \cdot \cos(\alpha_o + \alpha_n + 2\varphi)$$

V_M - translational speed of combine.

The angle δ of the velocity vector V_{cn} inclination to the horizontal axis is calculated from the equation

$$\cos\delta = \frac{\omega \cdot \sin(\alpha_o + \alpha_n)(z+\ell) - \dot{\rho}_n \cdot \cos(\alpha_o + \alpha_n) - V_M}{V_{cn}}$$

Consequently the start of compost particles travel will take place under condition when the center of masses is in the point with coordinates $\alpha = \alpha_n$. and $\rho = z + \ell$. and velocity of the center of particle masses V_{cn} makes the angle δ to the horizontal axis.

The value of the angle α_n has to be those that the compost particles, having left the teeth and made certain trajectory, fall in the zones of the first or second beater or in the forming chamber zone. If the plane system of coordinates XOY is drawn through the point 0 as it is indicated in the fig.2a, the the coordinates X_o and Y_o of the point C_{oo} can be expressed as follows:

$$\left.\begin{aligned} X_o &= (z+\ell)\cdot Sin(\alpha_o+\alpha_n-90^\circ) = -(z+\ell)\cdot Cos(\alpha_o+\alpha_n); \\ Y_o &= (z+\ell)\cdot Cos(\alpha_o+\alpha_n-90^\circ) = (z+\ell)\cdot Sin(\alpha_o+\alpha_n). \end{aligned}\right\}$$

Experimentally and by further processing of the experimental data it has been determined that the air resistance to compost particles movement is directly proportional to the masses of particle and to the velocity in the first degree i.e.

$$P = -K\cdot m\cdot V$$

where K is a coefficient of proportionality.

The differential equations of the center of pa^rticle masses movement in the chosen system of coordinates will be as follows:

$$\left.\begin{aligned} \ddot{x} &= -K\cdot\dot{x} \\ \ddot{y} &= -g-K\dot{y} \end{aligned}\right\}$$

Having solved the system of equations (8) we obtain the equation of a particle masses center trajectory

$$y = y_o + \frac{x-x_o}{V_{cn}\cdot Cos\delta}\left(V_{cn}\cdot Sin\delta+\frac{g}{K}\right) + \frac{g}{K^2}\cdot \ln\left[1-\frac{K(x-x_o)}{V_{cn}\cdot Cos\delta}\right]$$

where

$$x = x_o + \frac{V_{cn}\cdot Cos\delta}{K}\left(1-e^{-Kt}\right)$$

Consequently to avoid the drawing of compost by the cylinder teeth under the beater it has to be $\alpha_n < \alpha_\kappa$

As for design it should be taken into consideration that the angle α_n has to be less then α_κ approximately by 10 degrees, i.e.

$$\alpha_n \leqslant \alpha_\kappa - \Delta\alpha \quad (\Delta\alpha \approx 10^\circ)$$

It is the first condition to the design of the machine and the cylinde·.

The second condition is that the height of compost particulars flight trajectory is not to exceed a certain height, making approximately 0.9 of distance H from the cylinder's diameter.

Thus the second condition to the design of machine can be expressed

$$y \leqslant 0{,}9H$$

The third condition is that the thrown particles are not to reach the cylinder after their free flight. This condition may be expressed

$$y_{x=x_1} > y_1$$

where $y_{x=x_1}$ is the value y when X=X1.

Taking into consideration the trajectory curvature it can be admitted that the velocity of the particles when loosing contact with a beater teeth will be directed towards the reflecting shield. If the angle δ of inclination to the horizontal line of the velocity V_{cn} of the particle at the moment of its leaving is less then the angle τ of inclination to the horisontal line and more than the angle γ. That is why the main condition of the satisfactory fanctioning of the beater lays in observing of the inequation

$$\gamma < \delta < \tau$$

For the first beater, considering the expression (7) we have

$$\gamma < \arccos \frac{\omega_1 \cdot \sin(\alpha_{10}+\alpha_n)(r_1+\ell_1) - \rho_n \cdot \cos(\alpha_{10}+\alpha_n) - V_M}{V_{cn}} < \tau_1$$

for the second beater

$$\gamma < \arccos \frac{\omega_2 \cdot \sin(\alpha_{20}+\alpha_n)(r_2+\ell_2) - \rho_n \cdot \cos(\alpha_{20}+\alpha_n) - V_M}{V_{cn}} < \tau_2$$

In places of compost contact with forming fenders (fig.3) the friction arises. As there are two fenders and the processes executed by each of them are identical, the summed force of resistance $P_{o\delta u_4}$ is

$$P_{o\delta u_4} = 2P,$$

where P is the force of resistance to fender movement as a result of friction with compost.

Divide the area OABCDEO into 4 parts:

OAEI, EIAAIE, EAIBID and DBIBC.

As for the area OAEI the clamp is in its formation stage, while for the area EIAAIE (of rectangle form), EAIBID (trapezium) and DBIBC (trapezium) the clamp is already formed. Then

$$P = P_I + P_{II} + P_{III} + P_{IV}$$

where $P_I, P_{II}, P_{III}, P_{IV}$ is the force of resistance to the fender movement on the sections OEI, EIE, EDI, DICI respectively.

On the sections OEI with extending of distance from the point O the height of the clamp increases. Approximately it can be considered that the increase takes place along the straight line under the angle of α_ρ to the clamp base.

Let's draw the system of coordinates with the center in the point O and the axis X directed along the fender basis reversally to the machine movement and the axis y directed upwardly, and let's take the elementary parallelepiped on the section OEI.

The parallelepiped is pressed from the upside by the entire mass of the compost layer. That is why in any point of the parallelepiped the pressure q can be expressed

$$q = g\rho'(x \cdot tg\,\alpha_\rho - y),$$

where g -acceleration of free incidence;
ρ'-density of compost.

The pressure on the part of the parallelepiped will make $q\xi_0$ (ξ -coefficient of the side thrust). Under the pressure influence on the moving fenders, which is normal, the tangental pressure arises, which is equal to $fq\xi_0$ (f - coefficient of friction between fender and the compost).

The elementary force of friction between parallelepiped and fender is equal to

$$fg\rho'\xi_0\,(x\,tg\alpha_8 - y)\,dx\cdot dy$$

Having transformed the expression (16) with consideration (18) we will finally obtain

$$P_{\delta u_4} = \frac{1}{3} fgH_\delta^2\rho'\xi_0 \Big\{L_1+3L_2+L_3\Big[3+\frac{L_3}{H_\delta}tg\sigma_1\Big(\frac{L_3}{H_\delta}tg\sigma_1-3\Big)\Big]+$$
$$+L_4\Big[3\Big(1+\frac{L_3}{H_\delta}tg\sigma_1\Big)^2+\frac{L_4}{H_\delta}tg\,\sigma_2\Big(\frac{L_4}{H_\delta}tg\sigma_2+3\frac{L_3}{H_\delta}tg\sigma_1-3\Big)\Big]\Big\}$$

The described method makes it possible to express the dependence of the force of resistance to forming fenders movement to their parameters, sizes of the clamp and characteristics of compost. With increasing of of parameters H_δ, L_1, L_2, L_3, the compost density and the coefficient of the side thrust the value of the force increases.

In fact, the compost quality is dependent on the way the gypsum is dispersed in the compost mass; the more evenly gypsum is spread through the compost mass, the more uniform the acidity of the compost mass happens to be distributed. To improve the distribution, a special device for gypsum application is developed; this device is to be mounted on the combine top, i.e. above the pick up cylinder and beaters. More uniform distribution of gypsum through the entire compost mass is attained by gypsum application into the fluidized layer of compost matter. In this process of combine operation, the pick up cy[illegible]nder grabs compost particles conveying them to the next working element[illegible]re is a zone where compost particles are found in a suspended [illegible] after they have just lost contact with the cylinder teeth, and it is [illegible]is zone that gypsum is applied. While gypsum is dry, it is very l[illegible]se. In this way mixing of the two flows takes place. It has to be emphasized here that the Tilot machine applies gypsum on top of a compost clamp, where the gypsum absorbs water and turns into cloddy conglomerate within a very short time; this is inhibitory to its further mixing with the compost matter, thus preventing its uniform distribution in the compost clamp.

Experimental research has been undertaken to establish a degree of uniformity of gypsum in the compost matter. The said research has essentially consisted in the following:

Whenever gypsum is applied in compost mass, the former happens to be dispersed in the compost unevenly, i.e. with different density, hence, the acidity of the compost mass might be different at various points of the particular clamp. To determine the values of deviations in compost mass acidity suitable tests have been performed, icluding measurement of values, data processing and their statistical analysis. A control plot has been allocated in the compost clamp. For acidity measurement, samples have been taken from 12 representative points of each of the five cross-sections spaced by one meter along the clamp length. Acidity of the samples picked from the compost clamp has been measured in pH units by an

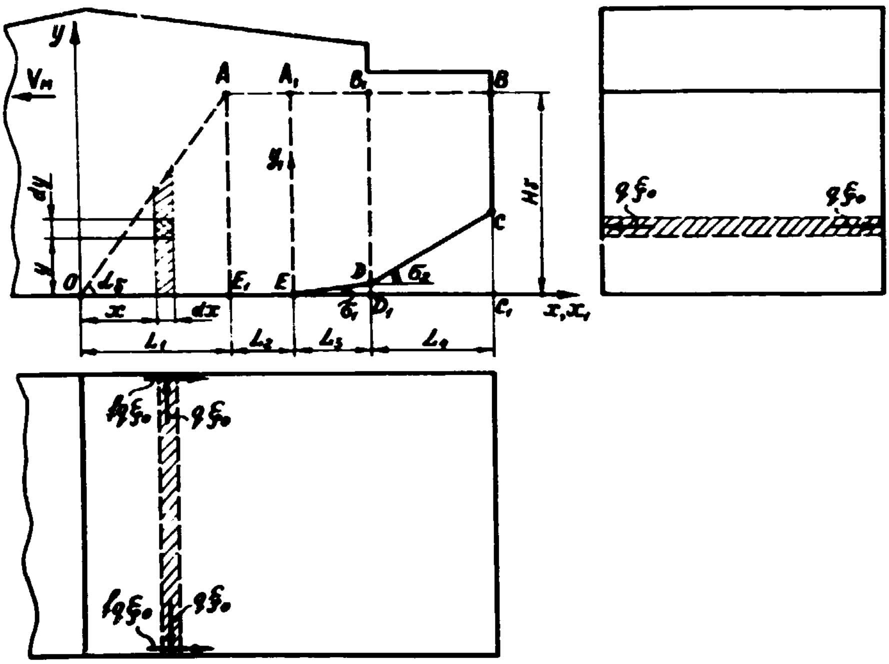

Fig 3.

Sheme of calculation out of the force of resistance to the movement of forming fenders.

EV-74 general- purpose ionometer.

All the measurements and calculations have been based on the assumption that the distribution of stochastic acidity value "x" in the given compost mass behaves normally after each shredding cycle.

A statistical analysis of stochastic value "x" has allowed a conclusion to be drawn that a probability density function of stochastic value "x" is subject to the normal law of distribution and can be described as follos:

$$f(x) = (\sigma_x \cdot 2\pi)^{-1} \exp - \frac{(x-m)^2}{2 \cdot \sigma_x^2}$$

where σ_x - the rms deviation of stochastic value "x" m - the expectation of stochastic value.

Pearson's criterion of agreement (χ_i^2 method) has been used to make an assesment of conformity with the normal law of distribution. The χ^2 distribution enables an assesment of the degree of consistency in the distribution figures obtained both theoratically and statistically.

Appropriate calculations have been made to prove that the value

$$\chi^2 = \sum_{i=1}^{n} \frac{(m_i - n \cdot p_i)^2}{n \cdot p_i}$$

where n - number of all measurements involved in one experimental cycle;

m - number of test results falling within one interval;

p_i - probability of falling within digit places;

as it has been calculated on the basis of the actual test data, there is no doubt in the normal nature of distribution. The probability of fitting in the same digit places at the design values of χ^2 amounted to 0.4 -0.7. This is not a law probability, therefore, the above assumption as to the normal nature of distribution of acidity value "x" is rather possible. Fig. 4 offers a graphic representation of the distribution laws followed by the stochastic value of compost mass acidity measured after each shredding cycle, both for the KPK-30 combine, and for machines manufactured by Tilot Co.

The dynamics of compost quality variation after each sequential shredding cycle permitted to be elucidated as a result of calculations of the expected value m and rms deviation , as well as the acidity value "x" together with a general analysis of three figures.

Basing on the calculated values of m and σ, curves of the average acidity of compost mass versus the number of shredding cycles, and the uniformity of gypsum distribution in compost versus the number of shredding cycles have been constructed (fig. 5).

A study of the above curves speaks strongly in favour of the KPK-30 combine which appears to be producing compost of higher quality. It is obvious from the charts that three shredding cycles performed on a newly formed compost clamp are sufficient for the KPK-30 combines to bring the compost to the standard agrotechnical requirements. In addition to that the uniformity of gypsum distribution in compost mass is much higher in case of the KPK-30 combine than that produced by similar existing machines.

A KPK-30 combine employed to replace three machines used to perform the three operations involved in compost preparation makes it possible to produce a 2.5 - times reduction in the metal-to-weight ratio and cut the energy- to-weight ratio by 1. 5 times.

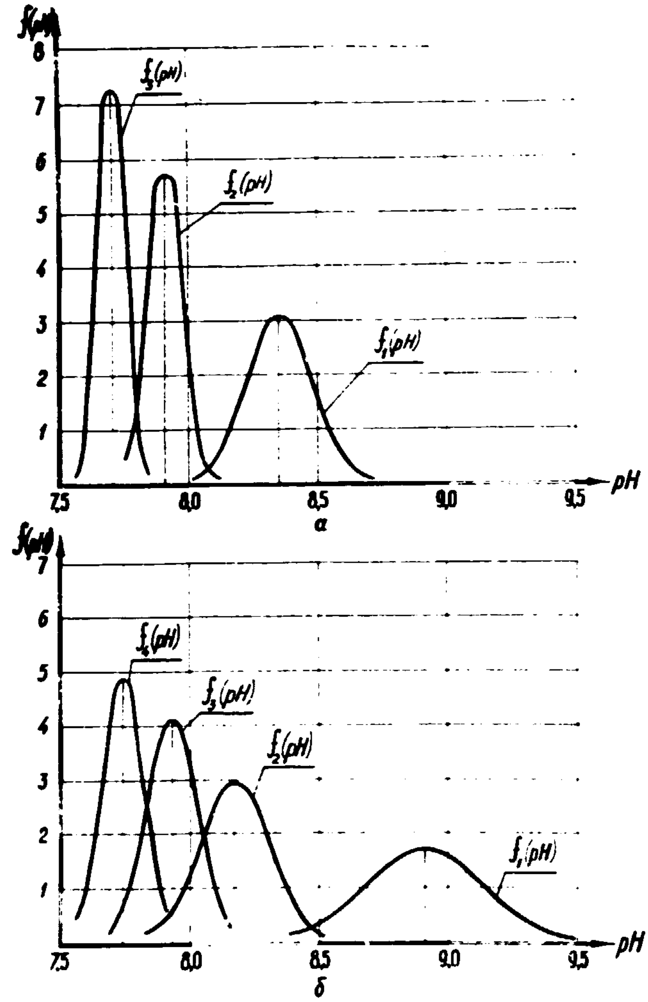

Fig. 4

Graphic representation of the distribution laws followed by the stochastic value of compost mass acidity measured after each shredding cycle, both for the KPK-30 combine, and for machines manufactured by Tilot Co.

Mechanized preparation of the casing soil.

The casing soil creates the necessary conditions for formation of mushroom body. It is assumed that the soil is to meet the following requirements for growing of high quality champignons:

- to have the water resistant small cloddy structure, preventing crust formation and excessive density in the process of watering;
- to have close to neutral reaction of soil (of water extract 7,2-7,6);

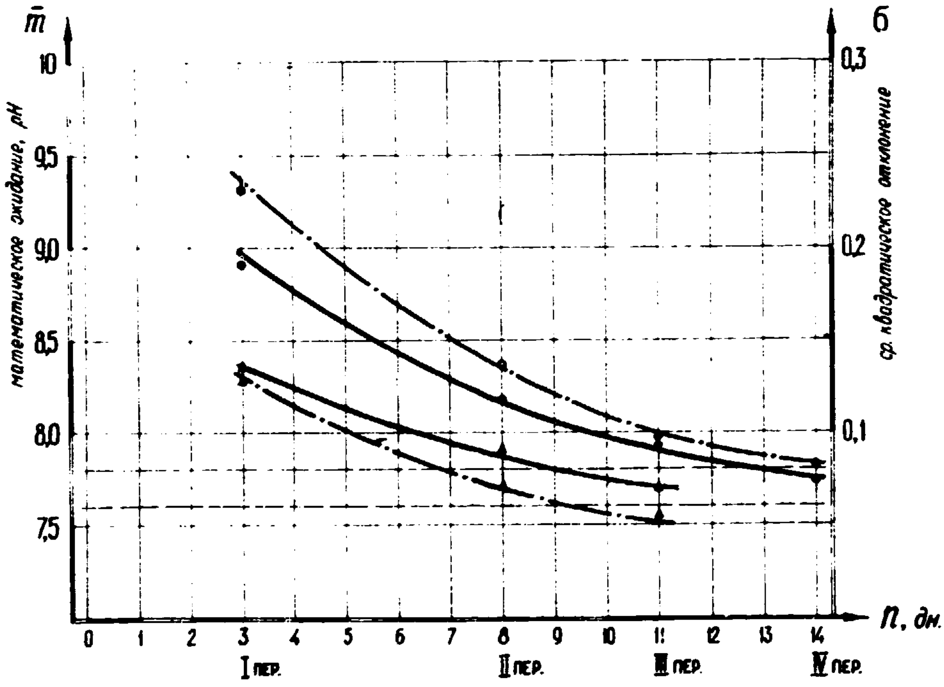

Fig 5.

Average acidity of compost mass and uniformity of gypsum distribution in compost versus the number of shredding cycle.

- to have high water absorbtion capacity and sufficient water and air penetration ability, not to contain much nitrogen, especially organic one;
- to have a sufficient quantity of calciun, which is necessary for the regulation of soil acidity;
- to be devoid of oxid compounds of macro- and microelements.

The cover soil provides necessary conditions for forming fruit bodies of mashrooms. It is found that for grwing high-quality common mushrooms the soil must meet the following requirments:

- to have a water-resistant fine lump strukture preventing formation of a crust, and little densing in the process of irrigation;
- to have a reaction of the medium clos· to neutral (pH of water extract

of 7.2 to 7.6);

- to have hing moisture capacity and suffisient waterandair petmeability, and to contain a small amount of nitrogen, particularty organic;

- to have enough caltium needed for controlling the acid content of the medium;

- to have no lower oxide macro- and microelements.

Soil covering prepared from low transitional peat in a mixture with dolomitic meal (limestone, marl) meets these requirement to best advantadge. From 4 to 10 parts of peat are tacen per part of dolomitic teal. In tnis case the size of the individual particles of the dolomitic teal must not exceed 5 mm. Larger tractions depress the planting stock.

The cover soil moisture conent must also de strictjy definite.

The specialists of the VISKHOM Research Institute have developed a cover soil moxer which meet the abave requirements to best advantage. Ageneral view of the mixer is shown in Figure 6 while its flowsheet diagram is shown in Figure 7. The systemconsists of the following basic units: a wighing hopper (1), a screen (2), and unloanding conveyer (4).

The weighing hopper is structurally made as a hopper having verticel walls separated along its lenght into two sections. A belt conveyer is provided on the hopper bottom; while the front walls of both secions are provided with ports having controled gates.

The screen comprises four beater shafts with triangular plates mounted thereon. The screen is located above the mixer neck.

The mixer consists of a cylindrical housing assommodating a rotor having blades mounted along a helical line on the rotor surfase.

The mixer is driven by an electric motor having input power of 11 kW.

The unloading conveyer feeds the finished cover soil to transport vehicles.

To provide contiuous operation of the mixer in a work-shop, an appropriate amount of peat and dolomitic meal are prepared in the workshop. Before starting the machine, the ports in the front walls of the hopper sections are opened as required. Then the dolomitic meal is charden into the rear chamber of the conveyer is started. In so doing, the dolomitic meal is being transported as a layer from the rear chamber to the front chamber of the hopper for its entire lenght, then the c;nvrver drive is switched off. Then the front chamber of the hopper is charged with peat laid onto the dolomitic meal layer.

During the operaticn the mixer drive is switched on and the components of the cover soil are fed from the hopper by the conveyer to mixer screen makes the peat and dolomitic meal loose, separated large impurities and feeds the mass to into the mixer. Water supplied into the mixer. Water is supplied into the mixer simultanously. In the mixer housing the components are uniformly mixed, wetted and then the ready mixturi is supplied onto an inclined conveyer, by means of which it is charged into transport vehicles.

The peat and dolomitic meal are neing added continuosly into the hopper chambers in the process of operation.

TECHNICAL DATA

Consumed power, kW	11
Weighing hopper volume, m	2.6
Output capacity, t/hour	up to 26
Operating personnel, person	2
Overall dimensions, mm:	
leght	500

width	2800
height	2500
Mass, kg	2000

The commercial tests have confirmed the high operational efficiency of the MPZ-30 machine when it is used for prparing cover soil. The cover soil prepared with the aid of this machine features a fine-grain structure with high uniformity of distribution of separate components so that this machine fully satisfied the requirements imposed.

The tests of the KPK-30 combine have shown that, when perfoming the operations of forming clamps, their subseguent shredding and adding gupsum, its afficiency is practically the same as that of respective analogous machines manufactured by the "Tilot" Company (the Netherlands). It should be noted that the weight of the KPK-30 combine is twice as low as that the weight of the above company.

The KPK-30 combine also provides better quality of finished compost. This is obtained due to fine and uniform shreadding of straw in the compost mass and more uniform shredding of straw in the compost mass, which is made in a fluidized bed.

It is also found that when the KPK-30 combine is used, a compost of required quality is prepared through three shredding operations instead of four as it takes place in the case of the "Tilot" machines. This makes it possible to reduce the production cycle for one shredding operation and reduce enegy consumption by 20-25% when preparing the compost.

The KPK-30 combine has high maneuverability and this provides more effective utilization of the production area in compost workshops.

The requirements are fully met when the casing soil is being prepared from lowland and transitional peat in combination with dolomit powder (marl, limestone). Per one part of the dolomit powder from four to ten parts of peat should be taken. Separate particles of dolomit powder are not to exceed 5 mm in size. The fractions of larger size will surpress the planting material. The humidity of casing soil is strictly stipulated either.

VISKHOM has developed the machine for casing soil preparation, which optimally meets all demands.

The technical description of casing soil preparation machine.

The machine is a stationary installation supplied from electric main of 380 V voltage (fig.6).

The main units of MPZ machine are: crusher 1, dosing tank 2, conveyer 3, roller screen 4, feed conveyer 5 , two components tank 6, mixing chamber 7, unloading conveyer 8.

The dosing tank is a collecting box, divided for 2 sections with outlet port. In the rear section a crusher is installed which reduces to fragments the peat in packages. It can be replaced for a standard tank if necessary. The belt conveyer serves as a movable bottom of the tank. The collecting box is installed above the conveyer and is fixed in this position by a frame made of tubes and angle bars. The collecting box has plumb walls. The conveyer (movable bottom of the box) is an endless smooth belt. The belt is locked into the endless chain conveyer set round the driving and the driven cylinders. The cylinders shafts are fixed in bearings at the ends of a tube frame. Between the cylinders there are supporting star-wheels attached to the tube frame. From the rear of the collecting box under the conveyer there is a drive of the geared motor placed on the plate welded to the tube frame.

The roller screen contains a disjointable frame which is bolted in the rigid construction. In hollows of the frame side walls in bearing sleeves the beater shafts are fixed. The shafts are installed in such a way that each side of the triangle beater makes 90 degrees with the side of adjacent beater of the next shaft. The roller screen is installed on the filler of mixer with the help of shanks. made of angle bars and fixed with bolts.

The feed conveyer is a frame construction of tubes and channels to which the cylinders shafts are fastened with the aid of bearings. The cylinders are rounded by an endless belt with planks attached to it. Between the cylinders on the tube frame there are the supporting star-wheels. Under the conveyer on a plate welded to the frame there is a geared motor which is connected with conveyer by a chain drive through an intermidiate shaft. There is a tank receiver on the lower end of the conveyer above the conveyer belt.

Two components tank consists of the collecting box divided on two sections with an outlet port and horizontal belt conveyer which serves as a movable bottom for the tank. The tank is attached to the frame made of tubes and channels. The walls of the tank are inclined. The conveyer (movable bottom of the tank) is a plane belt locked into the endless chain conveyer set round the driving and the driven cylinders. The cylinders shafts are fixed in bearings on the ends of the tube frame. There are supporting star wheels attached to the frame between the cylinders. Under the conveyer on a plate welded to the frame there is the geared motor connected with the conveyer by a chain drive.

The mixing chamber contains rotor cylinder made of cylinder tube. On the surface of the rotor cylinder there are working blabes arranged along a screw line . The working blades are fastened in the eyes on the surface of rotor by two bolts. The rotor group is fixed by ends of its shaft in self adjusting bearings located on trapezium form sizes which serve as a frame. The mixing chamber is driven by the 10 kWt electric motor.

The unloading conveyer is a welded construction which frame consists of horizontal and inclined parts.

At the ends of the frames in bearings the conveyer cylinders are installed which have star wheels on their ends. There is a conveyer belt with scrapers on the cylinders and the supporting star wheels. The chain scraper conveyer is used for unloading of the prepared mixture. The conveyer is driven from the geared motor by the chain transmission. The working units of MPZ machine are driven by electric and geared motors.

The technological process description.

The technological process of MPZ machine is as follows. To ensure continuous work of the machine during the working shift it is necessary to deliver to the working site soil, dolomit powder, lowland peat which are the components of the mixture(casing soil). The size of the dosing openings in each of the tanks is selectively adjusted to secure the required discharge of a given compone[illegible] in compliance with the percentage in the mixture.

The production cycle starts with loading of the tanks with mixture constituents. First the rear section of two components tank is loaded with dolomit powder. After loading of the section the movable bottom (conveyer) of the dosing tank starts its movement and the dolomit powder is conveyed [illegible]rough the outlet opening as a layer of a certain height to the outlet [illegible]ort, passing through the front section. The dolomit powder passed thro[illegible] the first section creates a layer along the conveyer belt of the dos[illegible] tank. The functioning of the dosing tank is based on the dosing of constituents through the openings of collectors. The packaged peat is loaded to the tank where the crusher is placed. When operating the crusher loosens pressed packaged peat, which falls through the crusher on to the belt of the inclined conveyer. Through the dosing opening peat is conveyed as a layer of a certain height to the outlet port passing the front section.

If the lowland peat supplied is not in packages but is taken from the clamp the crusher may be switched off or replaced by a standart tank. In this case the both sections of the tank under the inclined conveyer are fed by the lowland peat. As the peat makes 60-70% of soil mixture the tank collector for it should be of more size than for the other components. By the machine start the continuous work begins during which the sections of dosing tanks are reloaded by the mentioned constituents. The components dosed by the dosing tanks are conveyed in the form of "puff- pastry" to the roller screen where the foreign admixtures are extracted. After that the constituents are conveyed into the mixing chamber and fall onto the unloading conveyer through the outlet port. The conveyer discharges the prepared mixture to the heap or transport means.

The components are loaded to the machine by a loader manned by machine operator while another operator starts and stops the machine.

Specifications of the MPZ-30A machine.

1. Type of the machine	stationary
2. Drive	electric
3. Voltage, V	380/220
4. Main input power kWt	21.7
5. Total dosing tank capacity for peat, cub.m	2.15
6. Dosing tank capacity for dolomit, cub.m	1.38
7. Dosing tank capacity for soil, cub. m	1.38
8. Transport speed	stationary
9. Output per hour t/h:	
average	26.4
operating time	22.4
10. Operating time efficiency coefficient	0.85
11. Crew	2
machine operator	1
operator	1
12. Overall dimensions, mm	
legth	11940
width (with unloading conveyer)	2800
height (with the dosing tank)	2300
13. Clearence	not defined
14. Total mass, kg	3000
15. Limits for the working units adjustment (as to the height of dosing opening), mm	
-dolomit powder section	20-100
-peat section	0-250
-soil section	0-150
16. Lubrication places	
monthly	no
seasonly	37
17. Ports	
feeling	5
discharge	5
18. Types of oil	
unified	1
original	no
Lubricants	

unified	1
original	no
Hydromixtures	
unified	no
original	no
19. Adjustment points	17
20. Width of dosing tanks belt and loading conveyer, mm	800
21. Dosing tank belt speed, m/sec	0.09
22. Dosing tank cylinder angle of inclination, degrees	10
Type of mixing chamber	rotary, single shaft
Rotor revolutions per min	375
Pitches of screw thread	4
Type of unloading conveyer	scraper
Conveyer belt width, mm	400
Belt speed, m/sec	0.28
Angle of conveyer inclination, degrees	38
23. Feed conveyer belt speed, m/sec	0.09
24. Two components tank belt speed, m/sec	0.12

Field tests proved the high efficiency of MPZ-30 machine in casing soil preparation. The prepared soil has a small cloddy structure with even spreading of constituents in it and fully meets all the requirements.

Заказ № 73-91

Т - 300 экз.

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