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HEATING OF GREENHOUSES WITH TEPID WATER

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ABSTRACT

Heating greenhouses with low grade calories needs large exchanging surfaces between the warming fluid and the surrounding of the crops. Such exchanging surfaces in the atmosphere are not compatible with the light requirements. Underground heating is not efficient to maintain adequat aerial temperature In this paper, we present an original device of heating by plastic exchanger on the soil as it has been applied with success to several horticultural crops at the Nuclear Center of Grenoble. Tepid water at a range of temperature from 12 to 40°C is distributed at low pressure in flat flexible polyvinyl chloride or polyethylene sleeves lying between the plant rows. For high density crops as chrysanthemum or salads, each plant is growing in an eyelethole fitted up for this purpose. The plastic sleeve is then looking like a flat pillow.

This economical device has a favorable effect on both growing and yield. The air temperature is not needed so high and the root activity is enhanced by the soil warming under the plastic covering. Soil evaporation is limited and weeds are controlled. Neither the soil structure is damaged, nor pests are increasing in a significant way compared with a conventional greenhouse, after three years of operation. Besides, excess heat coming from sun radiations during summer is absorbed by circulating water and stored in a reservoir for night compensation.

The following crops had been tested : lettuce, strawberry, tomato, cucumber, aubergine, Jamaïca pepper, cuttings of ornamental plants, Tokyo chrysanthemum and rose tree. Other crops are feasible. The method is now developping near thermal power plants where low grade calories are largely available. In France, about 9 ha of greenhouses using this technique are under work.

INTRODUCTION

Covered crops protected against low temperature or excessive evapotranspiration are developping rapidly. This trend is correlated to growing use of plastics in Agriculture. During last years, increasing price of energy was accompanied by considerable amounts of low grade calories, the effect of

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which in the environment is indesirable.

The purpose of our research is to develop a heating system able to use tepid water in greenhouses in place of hot water or warm air. Plants need no more than 25°C in their surroundings. The problem is to transfer calories from the heating fluid to the crop environment with large exchanging surfaces without reducing the light level.

To convince producers of the feasibility of heating greenhouses with tepid water, we have carried out an experimentation in Grenoble and will give some results about american *Chrysanthemum*.

1. DISTRIBUTION OF LOW GRADE CALORIES TO COVERED CROPS.

1.1. Available devices and discussion

Several ideas have been exposed or experimented for distribution of low grade calories, for instance pipes in the soil or water film dropping down on the top of the greenhouse. The first device used for open field warming of the soil is not effective enough to maintain the required temperature in the greenhouse atmosphere, the exchange between pipe, soil and air being slow.
The second one presents difficulties of technology and maintenance. It needs many cleaning of the wet surface on the greenhouse.

A basic principle was to have tepid water running through the crop rows in open ditches. This device, good for thermal exchanges is not always feasible, due to the lack of surface and a 100% humidity indoors.

1.2. Description of the plastic exchanges on the soil

The best place to regulate plant temperature is the soil surface : distribution of calories up for leaves and down for roots, eventually, absorption of excess heat from incident radiations, control of soil evaporation and no effect on lighting by lack of aerial facilities. To allow soil preparation, movable plastic sleeves are displayed on the soil just before setting young plants. Tepid water at a range of temperature from 12°C to 40°C is distributed at low pressure in this sort of pillows made from polyvinyl or polyethylene : the flat shape is maintained by eyelets, the hole of which being available to grow high density crops through them.

Fig. 1. Shape of two types of flexible plastic sleeves.

Fig. 2. General aspect of the equipped greenhouse.

This system has been previously described in a paper presented at OSLO, 1974 [1] and is asked for patent in U.S.A. under the n° 539.106.

1.3. Advantage of the system

The first aim of this original device is to valorize tepid water. But other

advantages appears. One of them is the thermal "inertia" of the greenhouse as a consequence of the large amount of water circulating (12 l. per meter of sleeve) or stocked in a reservoir of about 1 m^3 for 16 m^2 under crop. In case of a lack in the tepid water supply, time is available to prevent damages. The plastic covering controls soil evaporation and weed development. It maintains a good equilibrium between root and leave activity. It is clearly demonstrated that a lower temperature above the crop is balanced by warming effect coming from the bottom.

In the french climate where the heating capacity of the system must be 160 Kcal/h/m^2, good results are obtained by covering 50 to 80% of the soil surface and using water at 30-35°C in winter. We have noted 9°C in the greenhouse atmosphere for an outdoors temperature of -11°C.

Fig. 3. Outdoors and indoors temperatures in Celsius degrees from December 27, 1976 to January 2, 1977 at Grenoble, France.

2. DESCRIPTION OF AN EXPERIMENTAL CROP USING TEPID WATER : GROWING AMERICAN CHRYSANTHEMUM.

2.1. Some aspects of this crop

Though many horticultural plants take advantage of our device, chrysanthemum is particularly demonstrating since this high density crop (64 plants per square meter) covers 3/4 of the total surface in cultivation and grows in strictly definite conditions. The flower is appreciated in all season for its beauty and its long live after picking up. The knowledge of the standard cultivation in conventional greenhouse has permitted to clearly point out the value of heating with tepid water.

We have chosen the most popular american varieties cultivated in France. See TABLE 1.

TABLE 1. Chrysanthemum varieties and number of cuttings for the 170 m^2 experience in greenhouse with heating by low grade calories.

2.2. Main facts concerning the crop

Fertilization :

- Potassium sulphate	4 Kg/a)	Oct. 10, 1976
- Superphosphate	2 Kg/a)	" " "
Plantation of rooted cuttings		Nov. 05, 1976
Fertilization		
- Potassium nitrate	2 Kg/a)	Nov. 22, 1976
- Ammonitrate	0,6 Kg/a)	

Pesticides treatments

- Benlate	60 g/100 l.	Nov. 05, 1976
- TMTD	325 g/100 l.	" " "
- Pentac WP Quino	125 g/100 l.	Feb. 02, 1977

Dwarfing treatment with Alar 85 at 25 cm^3 of concentrated solution per liter

only for :

- CRACKERJACK	Dec. 06, 1976
	Dec. 30, 1976
	Janv. 31, 1977
- NICOLETTE	Dec. 06, 1976
- STARSTREAM	Dec. 06, 1976

Lighting : 2 hours in the middle of the night from Nov. 11, 1976 to Dec. 12, 1976

First flower Feb. 15, 1977
2 weeks before scheduled with conventional greenhouse.

2.3. Favorable effect of heating at the soil surface level.

The measured temperatures as they appear on the Fig. 3 and 4 were below the recommanded ones in night time. Fig. 4 shows a higher temperature between plants than above them.

Fig. 4. Compared temperatures above plants (h = 1.5 m) and between plants.

The usual test of air temperature above the growing crop is no longer significant. In conventional greenhouse heated by the ambient air, variety such as "Tampa","Deep Tuneful" and "B.Y. Tuneful" would have no growing under 16°C. In our case,despite of a lower temperature in the air, we had a better precocity which is a good economical factor for the producer.

CONCLUSION

Heating greenhouse with tepid water near thermal power plant is no longer a problem. In France, 9 hectares of greenhouses are already under work for several types of market gardenning or flower production : lettuce, strawberry, tomato, cucumber, aubergine, Jamaïca pepper, cuttings of ornamental plants, chrysanthemum and rose tree. Other crops are feasible depending on the producer willing.

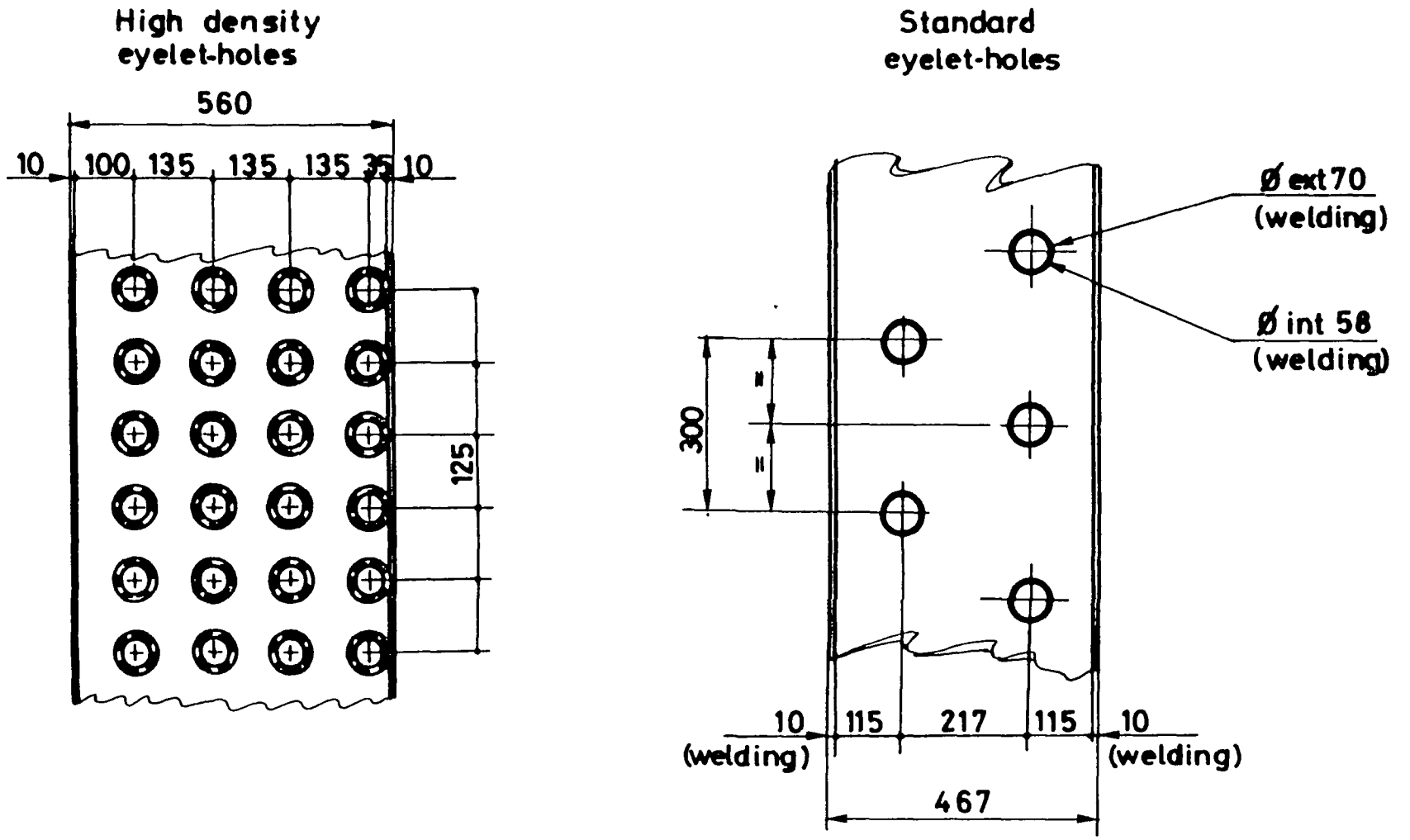
Bibliography

[1] - BALLIGAND P., GRAUBY A., FOURCY A., BOUVIER de CACHARD M., DUMONT M. Use of thermal wastes for Agriculture, Pisciculture and domeshome heating. OSLO, 26-30 Août 1974. IAEA SM 187/33.

TABLE 1

Chrysanthemum varieties and number of cuttings for the 170 m^2 experience in greenhouse with heating by low grade calories.

Variety	Number of cuttings
Galaxy	250
Yellow Galaxy	250
Crakerjack	500
Starstream	1 000
Deep tuneful	250
B.Y. tuneful	250
Dark illini Springtime	500
Golden Tokyo	500
Super White H 9	250
Super White low T°	250
Pink Winner	500
Tokyo	500
Nicolette	250
Tanja	250
	5 500



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-Patent CEA. FRANCE-

Measurements in millimeters-

Fig.1 SHAPE OF FLAT FLEXIBLE PLASTIC SLEEVES -

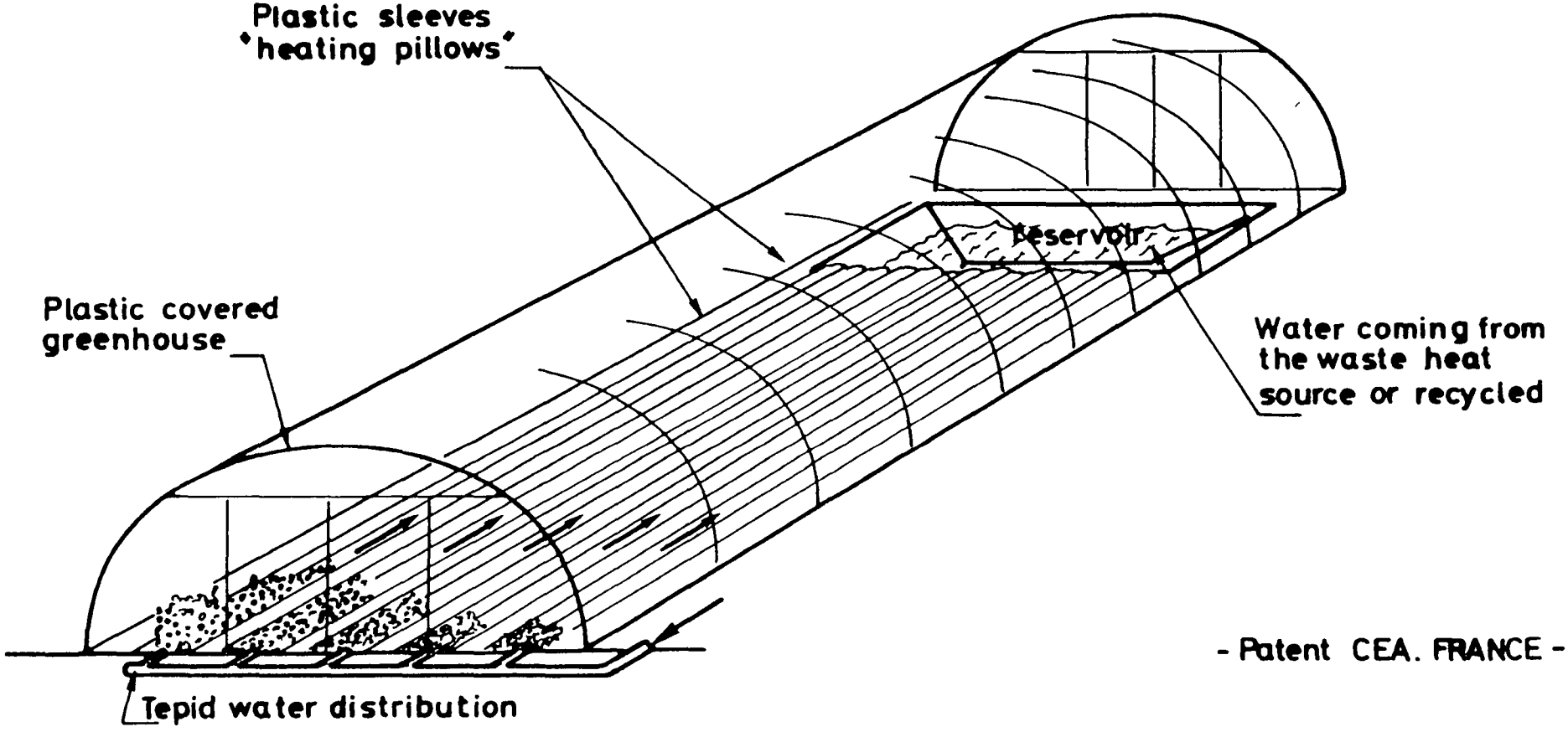

Fig. 2 GENERAL ASPECT OF THE EQUIPPED GREENHOUSE_

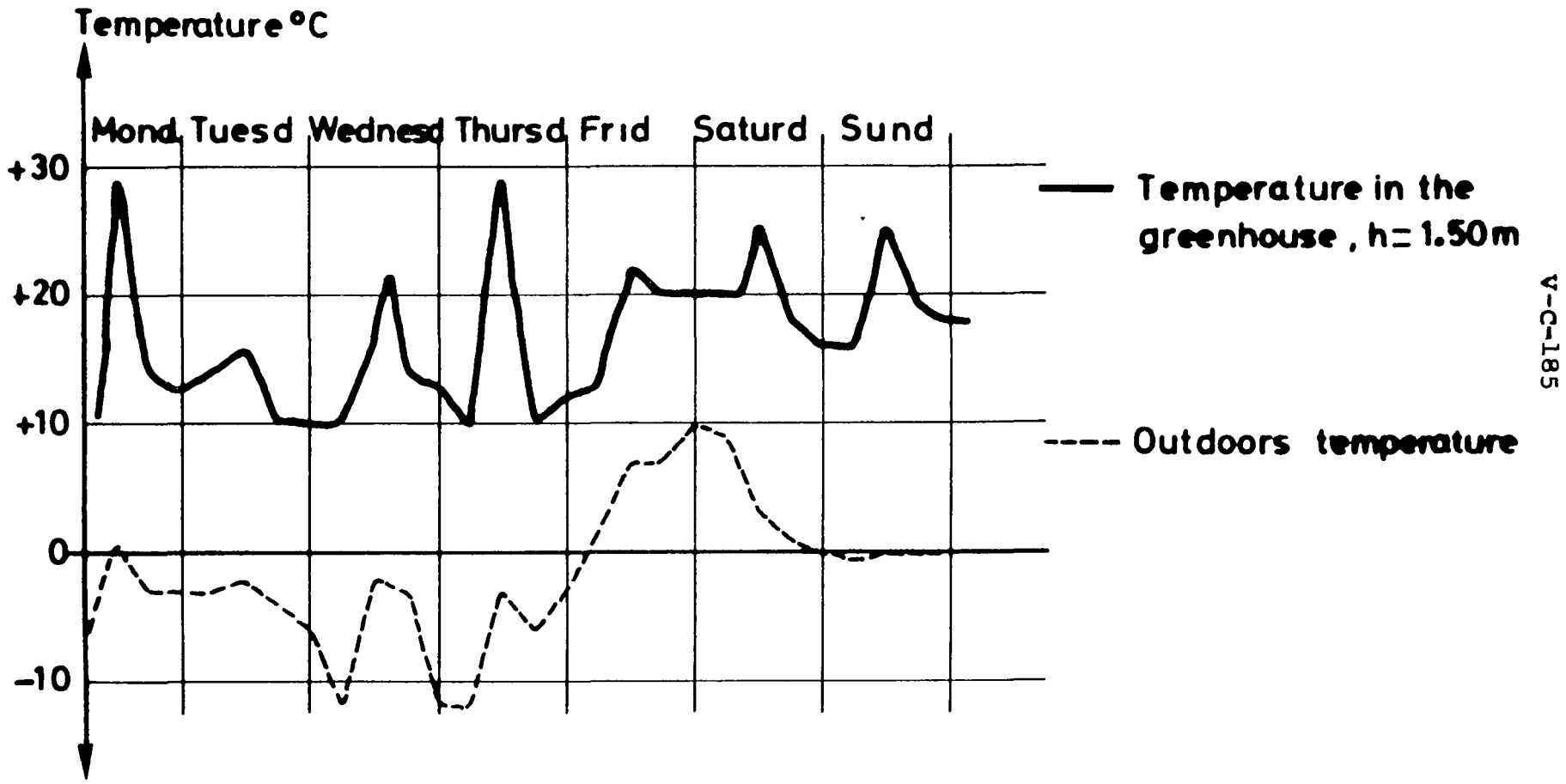

Fig. 3 INDOORS AND OUTDOORS TEMPERATURES FROM DECEMBER 27, 1976 TO JANUARY 2, 1977 AT GRENOBLE, FRANCE.

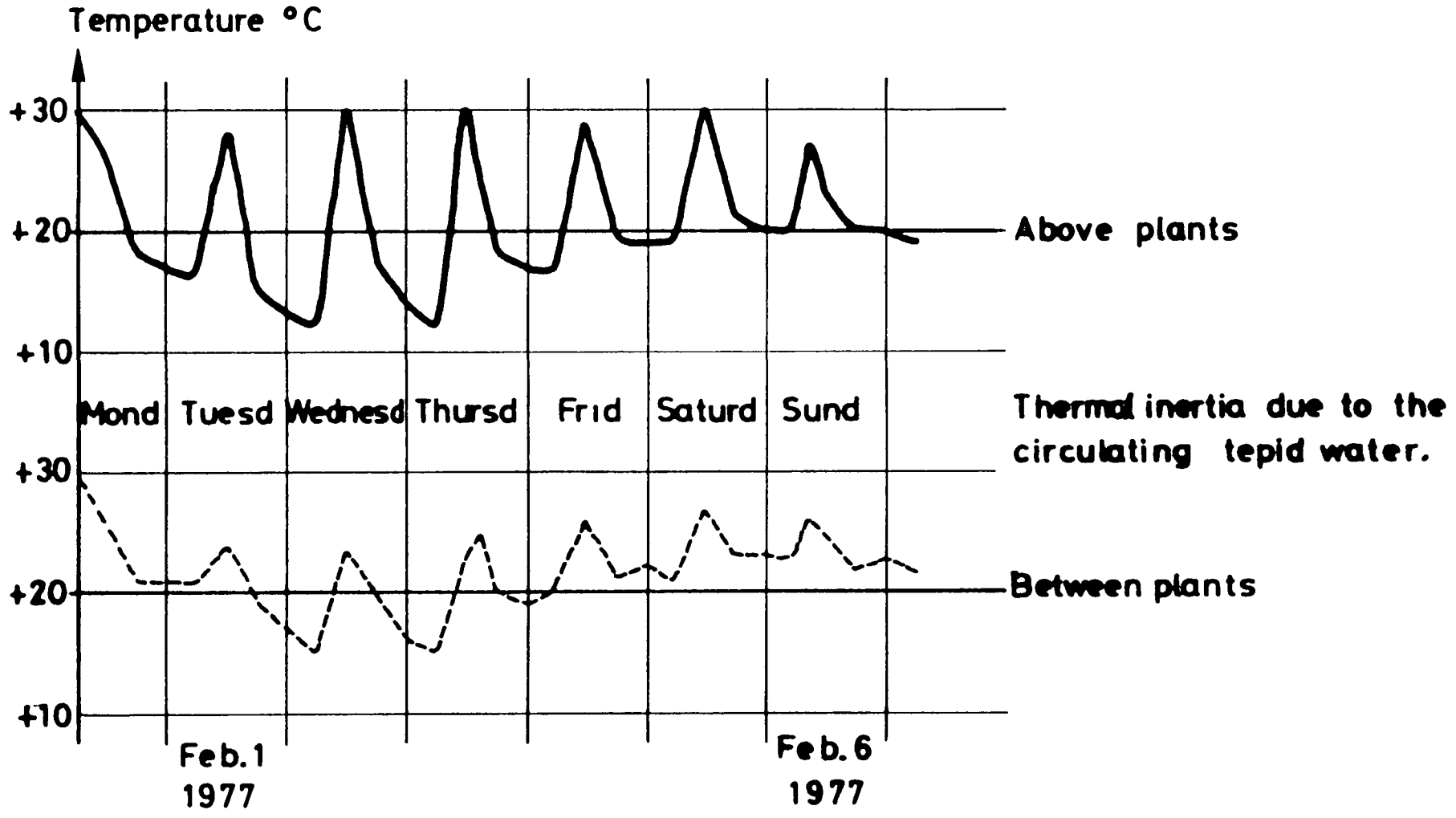

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Fig. 4 COMPARED TEMPERATURES ABOVE PLANTS (h=1.50 m) AND BETWEEN PLANTS_