A Study Extracting Information on Ground Objects from Characteristics of Space Thermal Distribution

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Abstract

It is necessary to gather many pieces of information and put them together to superimpose precisely in order to analyze the thermal characteristics of ground objects from thermal infrared date which were obtained from LANDSAT or airborne MSS. The thermal characteristics of objects are presumed from the observation date and space models of thermal distribution, especialy the thermal gradient of plane, in order to extract the useful information on vegetation, soil, geological data and so forth. This result of experiments showed as having high correlation between thermal characteristics of Temporal axis and Spatial axis directions and temperature fluctuation on the ground is affected by meteorological items, soil and vegetation conditions on the ground.

1.Intoduction

The Earth Resources Technology with Satellite and Airborne are required to extract the characteristics such as specific heat and thermal conductivity of the objects to get the more detail results by analyzing the thermal infrared information from MSS data. These analysis is geneally carried out to estimate the heat conditions from the thermal inertia in relation to the temporal factors. In this case, it is necessary to gather the temporal data within the several hours, but there is practically few chances to gather them from the points of weather conditions and satellite orbits. This study proposes to presume the thermal characteristics of objects from the special models of heat distribution with only single observation data and to extract the useful information on vegetation, soil, geology and so forth. This is the interim report of the fundamental experiment done up to now.

2.Background of the Studies

The information of heat distribution on the objects are not only the signals of temperature values, but also simpton of the object conditions. Therefore, From the analysis of these heat distribution our study aims to estimate the thermal characteristics and present status of the object characteristics. Table-1 shows the relationship between the ground surface conditions and thermal characteristic from a view of qualitative point.In these items shown in the table-1, the temperatures in a day time and the temperature gradients are mostly eligible to measure by remote sensing technique. There are a few insufficient cases to estimate the object characteristic by the item which is plain temperature gradient,proposed here in this paper.

In general, the temporal gradient by method of thermal inertia have been used. But in analyzing these factors in connection with time, it is required to acquire the data of the dual time intervals and to superimpose them precisely. Therefore the authors have investigated about the method using

the date of only single time which can save the time. From our fundamental survey, the objects which the rise and fall of temperature drastically are changeable in relation to the temporal axis, that means, they are having the lower specific heat conduction, as a result, we assume are eligible to cause the temperature fluctuation. As indicated in Fig.1, when the 3 X 3 matrix data of temperature have been acquired the standard deviation of temperature this paper aims to survey and to verify under what conditions the plane temperature gradient rises and falls in relation to the ground surface conditions and heat characteristic, especially here stresses to study the relationship with plane temperature gradient. In order to simplify of the field measurement, the measurement were dealt with only one dimensional direction.

As the additional experiment, the responding characteristic and the conditions of temperature , vegetation growth density and so forth have been investigated and observed the characteristic of temperature stability as the fundamental characteristic of the heat.

3.The experiments and the test species

The test plantation species were prepared in several planting boxes and under the several conditions of moisture and weather, the fluctuations of plane and temporal temperature were observed and the data were summed up.

3.1 Observed species (see photo-1,2)

(1) The lawn cultivated in planting boxes
(six species changed the soil moisture conditions and growth density)

*Sparsely planted lawn(5%)
*Standard soil(5%)
*Damp soil(9%)
*Dried soil
*Trimmed lawn
*Withered lawn

(2) Soil in the planting box
(two species changed the moisture condition)

*Damp soil(9%)
*Dried soil(1%)

The number in the parenthesis shows mean value of moisture contents every day.

(3) Water poured into the planting boxes
The surface temperature of water poured into the planting boxes was measured its deviated values each 100 seconds as the stable standard.

(4) The mean moisture contents was estimated from the water quantity given each species.

3.2 The insturments used for experiments

*Thermal radiometer
*Solar radiometer
*Wet and Dry bulb Hydrometer
*Thermo-couple thermometer
*Wind gauge
*Recorder
*Umbrella(white color)

3.3 The observed items

*Distribution of Surface Temperature(Thermal Radiometer)
*Solar Radiation(Lawbich Solar Radiation)
*Distribution of ground Temperature
(Thermo-Couple Thermometer)
*Radiation Reflectance (Portable Photometer)
*Air Temperature/Moisture contents(Wind Hydrometer)
*Wind Velocity(Wind gauge)
*Responce Characteristic for temperature
by cut-off of the solar irradiation

3.4 Metheological conditions

*Existing or not of Natural Wind
(Use of the protection frame)
*Fractuation of Direct solar irradiation
(Use of white umbrella)

3.5 Experiment date

July.20 - Oct.30,1985

3.6 Place

Campus Ground (Hosei University,Faculty of Engineering
Koganei-City,Tokyo,Japan)

3.7 Process of Experiments

Fig.2 shows the instruments and their arrangement used for measurement in the field experiment. The thermal radiometer, radio refrector and the surrounding metheological data were measured each 100 seconds by scanning and one fixed pointing method on the planting box.

To observe the thermal response characteristic under the direct solar irradiation, we measured the fluctuation of the surface temperature during the time flow from the case of opening and shutting out the direct solar irradiation to the objects. The switching of sunny and shadow is using the white shelter (umbrella). The items for measurement are as followss; thee fluctuation for surface temperature, such as its maximum value, minimum value and itss duration for temperature variation.

4. Results and Consideration for experiments

The followings are the results and consideration for experiments.

(1) The result of experiments showed as having the correalation between the observation of one fixed pointing and scanning (Fig.3). In this case, the correlation value was 0.86 at the maximum, which shows to have high correlation between the fluctuation of temperature in temporal progress and special extension.

(2) The fluctuation for special and temporal temperature shows the constant deviation of temperature in both lawn and naked land. From this phenomena, it is estimated that the specific relative characteristic between each object are maintained with constant relationship but the absolute value for the

fluctuation in this characteristic used to change depending upon the surrounding conditions such as the meteorology and the others.(fig.4 and Fig.5)

(3) The discrimination of various kinds of lawn is too hard only from measurement of temperature distribution, but it is eligible to judge its work of discriminating by considering the temperature fluctuation(Fig.6). In case of having been intercepted the wind effect, withered lawn and dry naked land shows the phenomena of small temperature deviation in spite of being the big temperature difference between objects and air. This proves, these is fairly large effect of the wind to the surface temperature(fig.7).

(4) Fig.8 shows the spectral refractance of the several species. It clearly shows us that the growth condition of lawn and water contents are closely connected with the wave length and refractance coefficient of the vegetation.

(5) The response characteristic of temperature cutting off the wind is sensible for the time difference between rising and falling of temperature, that means, the gradient of rising is bigger than the one of falling. This tendency appears, the more being vegetation distribution dense, the more being land wet. In case of dense vegetation condition and wet land, as the time consuming of temperature rising and falling, is needed much quantity and there is few difference between the max and min temperature, the species containing small quantity of water varies in short period of time and also the difference between the maximum and minimum temperature appears big. This cause of phenomena comes mainly from the automatic control function of temperature in physiological action which are closely related to the temperature equibrium and evaporation function of vegetation.

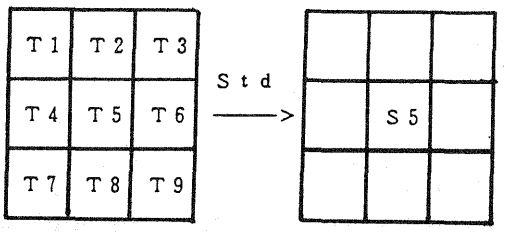
5. Conclusion

This result of experiment showed us having high correlation between thermal characteristics of temporal axis and special axis directions and also the special factors of thermal characteristic are closely connected to the various parameters such as weather conditions, soil and vegetation factors with the data fluctuation gained from observation of the land surface temperature and so on. But in this present stage, as the affect for the relative change pattern of each parameter is rather difficult to digitize, its works have not been realized.

In case of digitizing the relation between water contents and standard deviation of land surface temperature, there are many parameters besides them under natural circumstances which cannot neglect. The authors confirmed from the experiment that by combining the both informations, such as results of field experiments and data of thermal infrared images, the production potentiality of vegetation and soil factors in certain places might be estimated. In future, there are a few image processing ways which could be useful for planning of civil enginnering projects, they are connection with thermal conduction model by Fourier series or image processing of the feature extraction of each parameter in experimental thermal infrared images and so foth.

Table-1 Ground surface and thermal properties

	Ground moisture contents less ⟷ much	Vegitation grawth potentiality low ⟷ high
Thermal conduction coefficient	low ⟷ high	
Specific heat	low ⟷ high	(low⟷high)
Temporal temperature radient	high ⟷ low	steep⟷gentle
Plane temperature radient	high ⟷ low	steep⟷gentle
Daytime temperature	high ⟷ low	high ⟷ low



T1-T9:measured temp. at each designated points
Std :The standard deviation
S5:Folding value at T5 point from the standrad deviation values of 3X3 matrics

Fig.1 Variable quantity of mean-value temperature

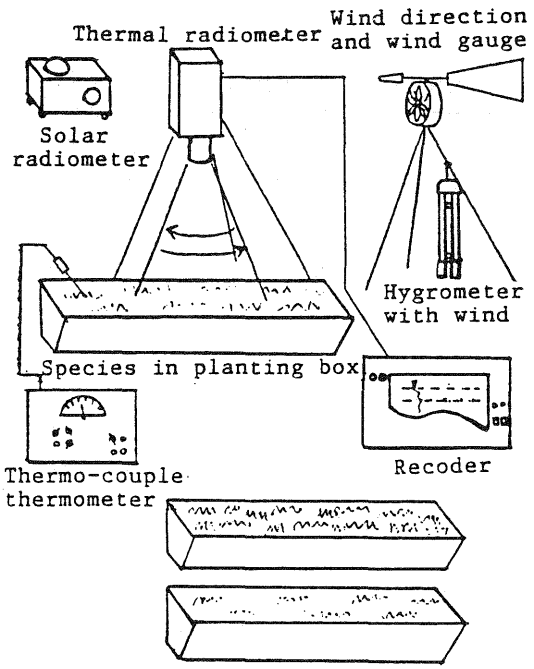


Fig.2 Ground trouth instruments

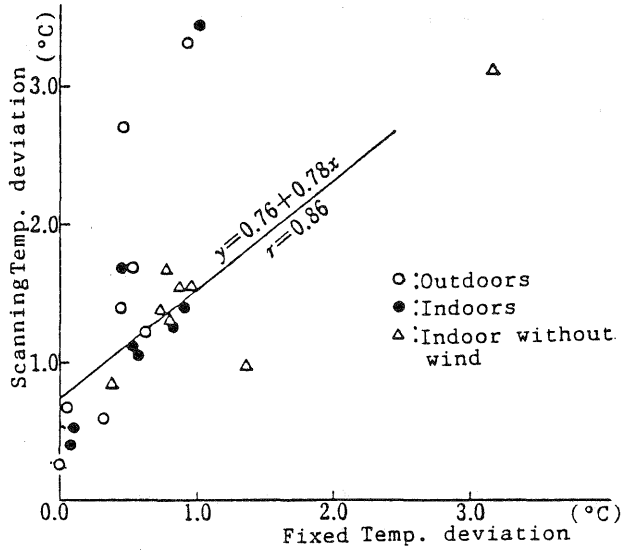


Fig.3 Correlation of radiation temp. deviation between single and scanning measurment

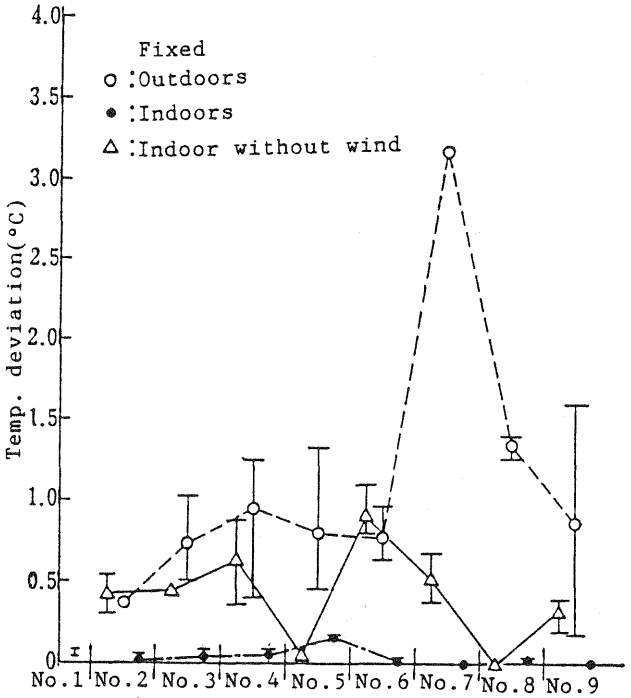


Fig.4 Vaiable temp. fluctuation (fixed thermal radiometer)

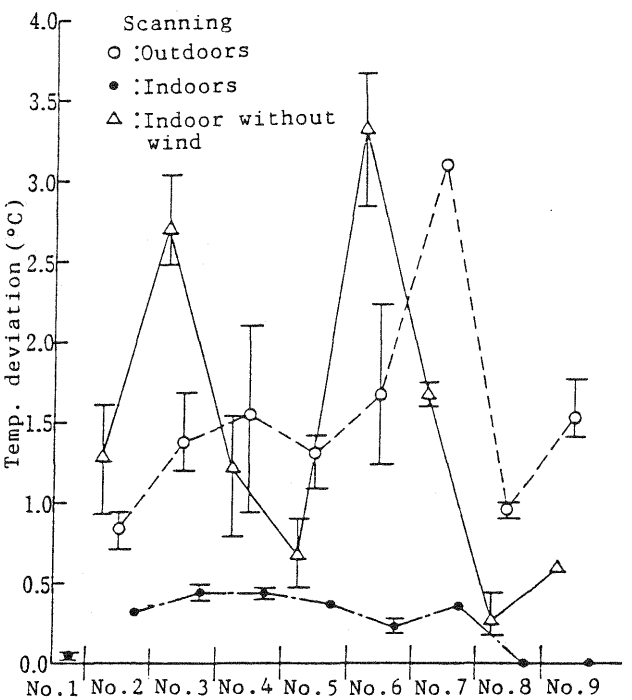


Fig.5 Vaiable temp. fluctuation (scanning thermal radiometer)

No.1 water
No.2 damped lawn
No.3 standard lawn
No.4 trimed lawn
No.5 sparaely planted lawn
No.6 dried lawn
No.7 withered lawn
No.8 damped soil
No.9 dried soil

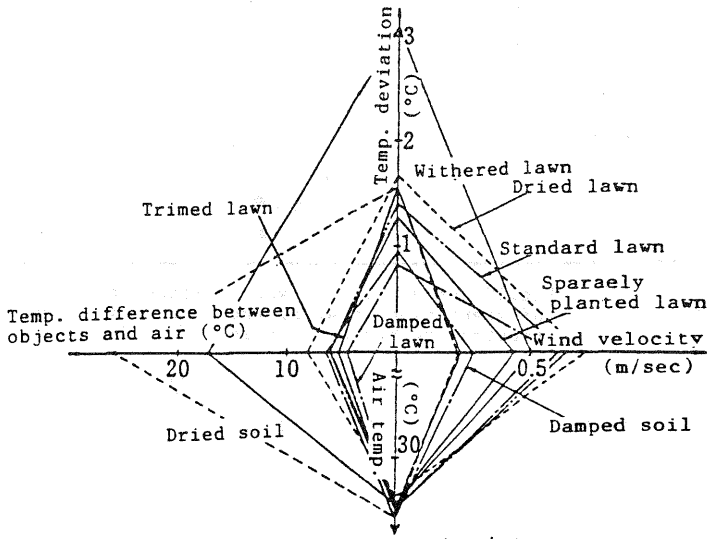


Fig.6 Comparison of properties between temp. deviation and weather conditions

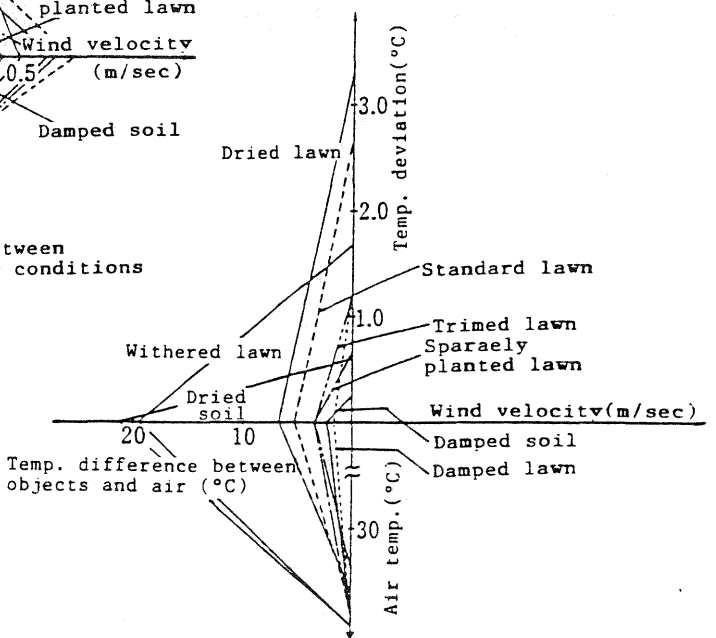


Fig.7 Comparison of properties between temp. deviation and weather conditions

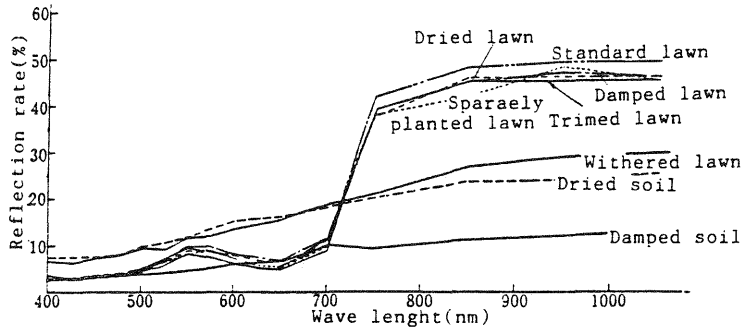


Fig.8 Spectral refractance properties of difference species

Table-2 Factors connecting with temp. responding property

Duration of rising and falling in temp.		Diff. of maximum minimum on the surface temperature	
Vegetation	much ⟷ less	Vegetation	less ⟷ much
Moisture	much ⟷ less	Moisture	less ⟷ much
Time	long ⟷ short	Diff. of temp.	much ⟷ less

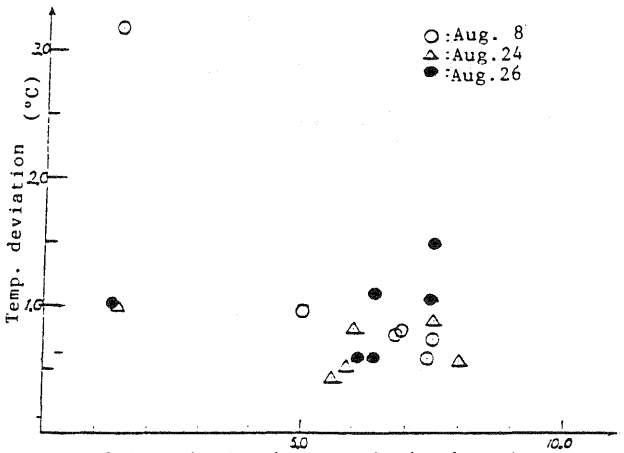


Fig.9 Correlation between By-band ratio of vegetation spectral and temp. deviation spectral refractance ratio 750/ 650

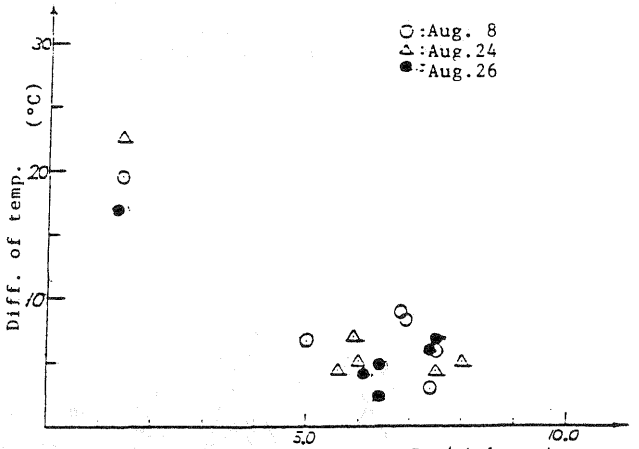


Fig.10 Correlation between By-band ratio of vegetation speatral and temp. deviation spectral refractance ratio 750/ 650

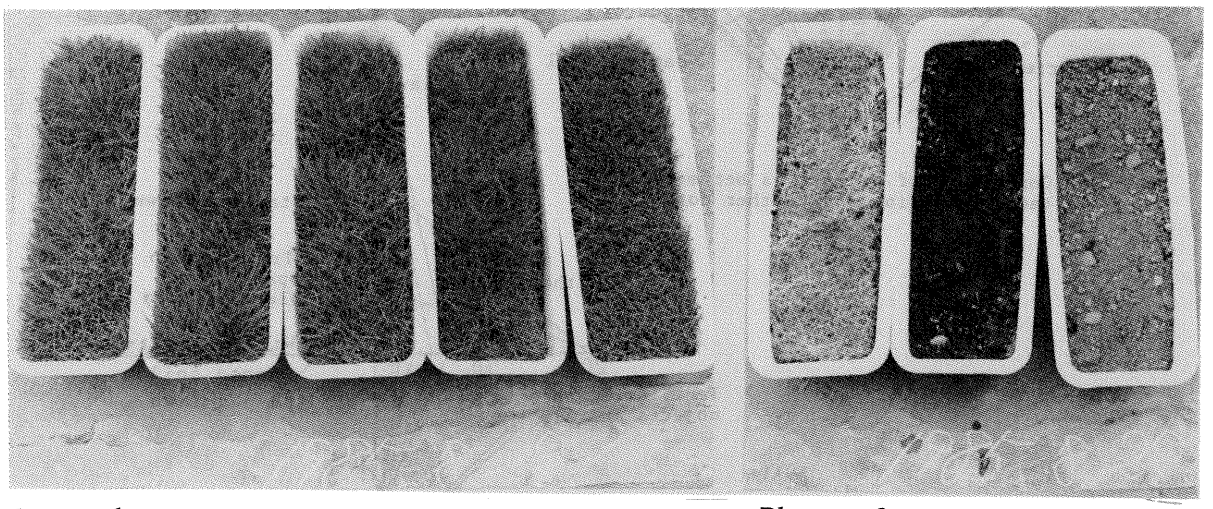


Photo-1
(From left side: Sparsely planted, Standerd,Damped,Dried,Trimed lawn)

Photo-2
(From left:Witherd lawn, Damped and Dried soil)

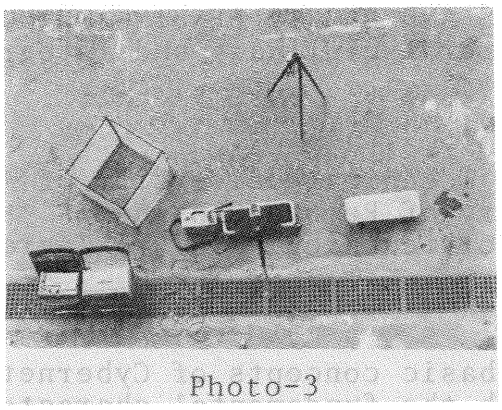


Photo-3

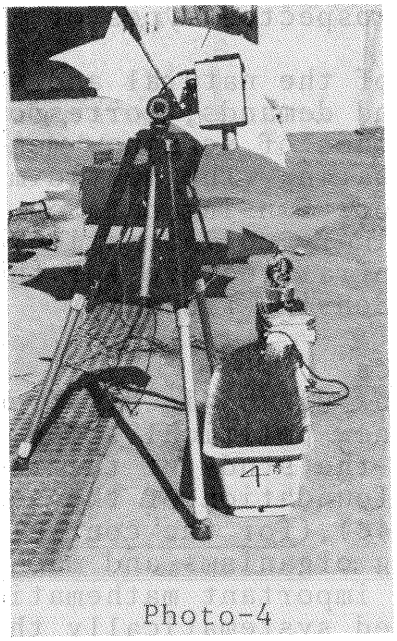


Photo-4

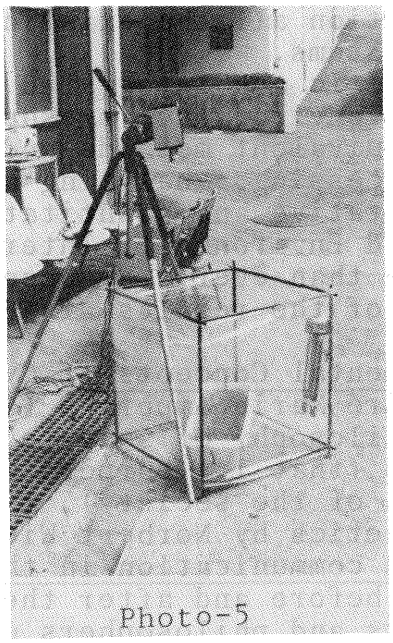


Photo-5

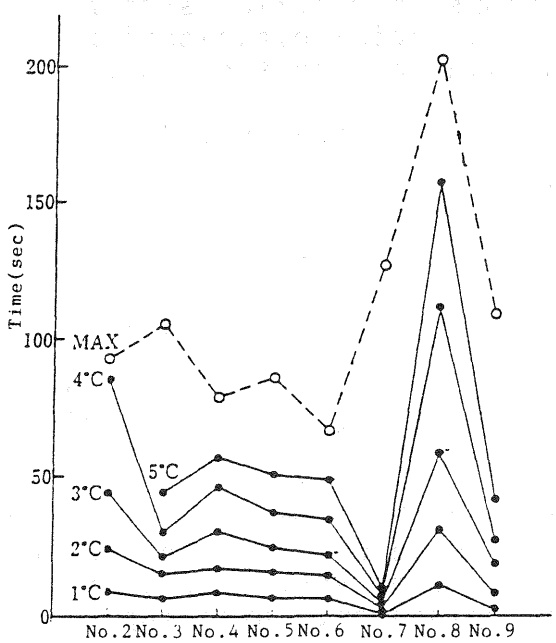


Fig.11 Temp. response property by cuting off direct light(in case of rising)

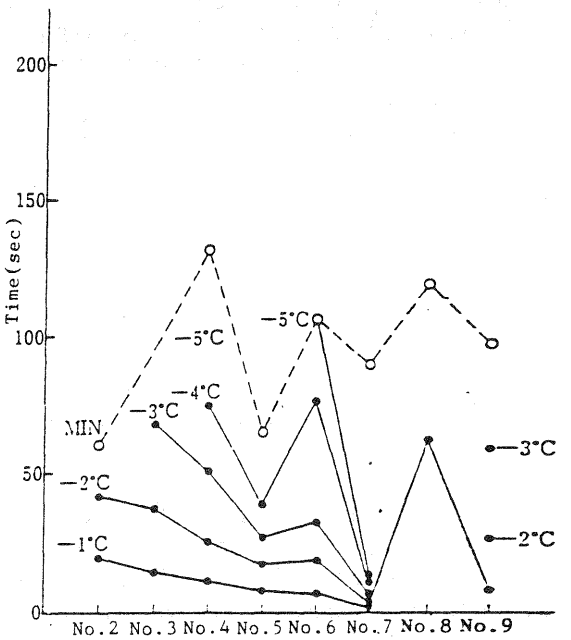


Fig.12 Temp. response property by cuting off direct light(in case of falling)