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STUDY OF DETECTING METHODS FOR VOLUME OF DROPLET

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Abstract

This study is done to develop some new methods of detecting volume of spraying droplets. The volume of droplet can be usually obtained to calculate each diameter of droplets with a microscope. Two measuring devices developed to detect the volume of droplets directly. One of these devices is a sensor detecting impact forces of droplets flying from nozzle, and the other is a sensor detecting a change of illuminance according to varying the color density of chemicals by a chemical reaction. As these sensors have an effective characteristic which their outputs are in proportion to the volumetric change of droplets, so it is clear that these sensors are suitable for detecting volume of droplet.

1. Introduction

Many conditions of weather, soil, weeds, and noxious insects or virus do damages to the plant in its growing. Among these damages, the noxious insects or the virus cause the most serious damage. There are some pest control methods for protecting the damages. They are shown as follows.

1. Cultivation and control for burying weeds and rotating crops.
2. Trapping and killing insects by a nets or a fluorescent lamp trap or using an equipment that takes advantage of the insect's instinct and the sensory organ or a sexual incentive material.
3. Evasive chemicals or smoke for repelling insects.
4. Physiological and morphological control of plant disease and insects by breeding varieties with a resistant characteristics, grafting, fertilizing, and competition between living organisms.
5. Chemicals by spraying, dusting, fumigating, painting, dipping, etc.
6. Using a natural enemy or sterilized insects.

A chemical application method, that is a direct method, is an ordinary use, because the method can control the damages conveniently, effectively, and economically.

The agricultural chemicals divide into insec-

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ticides, fungicides, acaricides, herbicides, etc. according to its usage and divide into a liquid type, a powder type, and a granule type according to the spreading shapes. It needs to cover and to spread the chemicals on a target as insects, fungus, and plants with atomizing. According to atomizing the chemicals, a covering characteristic becomes good, but an adhesive characteristic goes down, and a drift of particles by an atmospheric current increases. So it needs to keep a range of the diameter of particles properly and to spread a proper quantity of agricultural chemicals on the required point of target in order to improve the adhesive effect of chemicals.

This study is done to develop some new methods of detecting volume of spraying droplets using a liquid type agricultural chemicals. Two measuring devices developed to detect the volume of droplets directly. One of these devices is a sensor detecting impact forces of droplets flying trom a nozzle, and the other is a sensor detecting a change of illuminance accoding to varying the color density of chemicals by a chemical reaction.

2. Experimental equipment and results

(1) Generator of droplets

As it needs to vary volume of droplet and its colliding speed on this study, so a trial construction of the equipment that generates droplets with a variable height is done. The droplets generate by a precision air displacement micro pipette (made by GILSON Co.) that can vary volume of droplet at intervals of 0.1 micro liters ($=0.1*10^{-6}$ liters) and fall vertically. The height from the detecting device of droplet to the pipette is a maximum of 2 m and can set at any height freely.

(2) Application of impact force sensor

At first, an application of sensor detecting the impact force of droplets is dealt with. An acceleration pickup detects the impact force. There are two types of the acceleration pickup constructed with four strain gages or a piezoelectric element. The acceleration pickup with strain gages uses together with a dynamic type strain amplifier usually. The pickup converts the acceleration into the strain. The units of acceleration and strain is G ($=9.80665 m/s^2$) and micro meter (10^{-6} m) respectively. The piezoelectric type acceleration pickup converts the acceleration into voltage directly. So its output unit is volt. The outline of the sensor and the relation between the acceleration as input and the out-

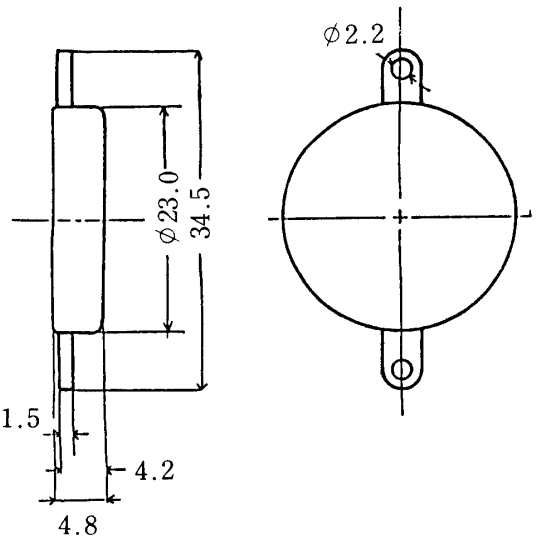


Fig. 1 shape of impact force sensor.

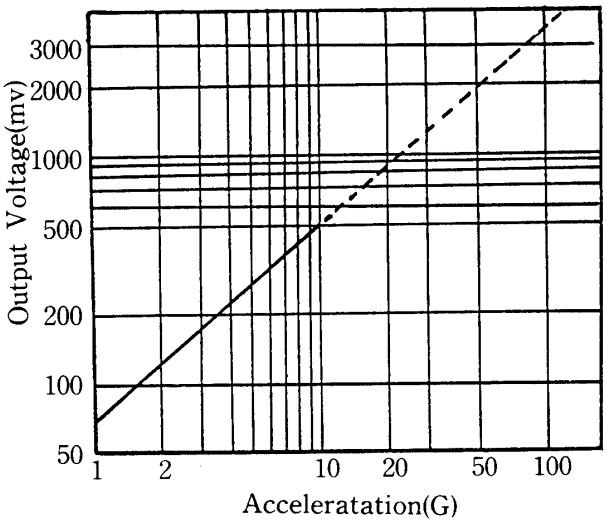


Fig. 2 Relation between acceleration and output voltage of sensor.

put voltage are shown in Fig. 1 and Fig. 2 respectively.

As the sensor is very small for the target of falling droplet, so two types of collision plate are made by way of trial. One, type A, is made by a rectangular alminium plate of 250mm in width by 280mm in depth and by 2 mm in thickness. The other, type B, is made by a phosphor bronze disk of 180mm in diameter by 0.5mm in thickness. Both plates fixed at their flanges.

As the output signal from the sensor shows a impulsive wave form, so the A/D conversion of the signal is done by a digital memory and the digital memory holds the converted signal. Then the read-out of the stored signal from the digital memory is done slowly and the wave form appears on the surface of an oscilloscope. The measuring data is a maximum amplitude of wave form.

(3) Experimental result and consideration

The experiments were done to vary a falling height and volume of droplets and distance from a center of sensor to a falling point. The number of repetition of the experiment is five at any experimental condition.

An example of measuring data is shown in Fig. 3 and its experimental conditions are as follows. Volume of droplet are 8 and 18 micro liters and a distance from the center of sensor to the falling point is 20mm. The solid line and the dotted line show the case using the phosphor bronze disk and the aluminium rectangular plate respectively. It is clear that the output voltage of measuring device made of phosphor bronze is larger than the device made of alminium and its single correlation coefficient is higher, too. So it is thought that the disk type collision plate made of phosphor bronze is suitable for detecting the collision of droplet because it has a higher sensitivity. A relation between the output voltage of device and the drop height is almost linear, so it is clear that the output voltage is proportional to the collision speed of droplet, and that the output voltage of device is proportional to the volume of droplet.

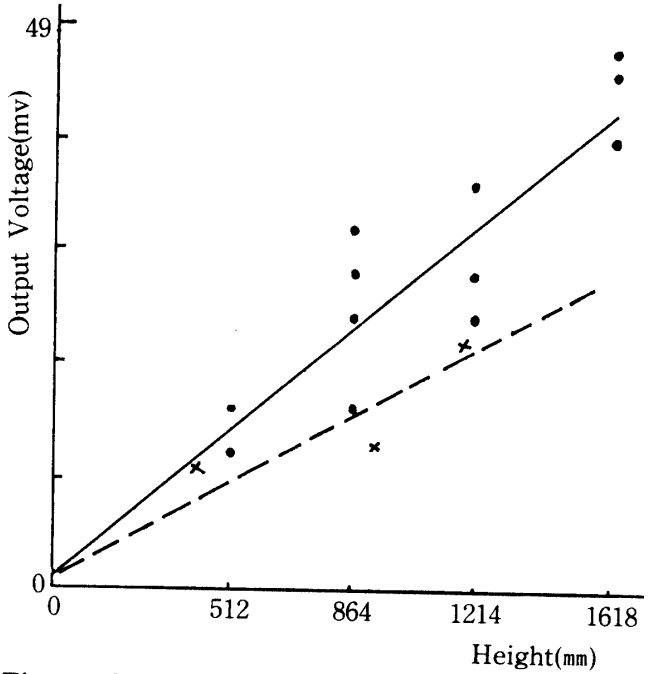


Fig. 3 Experimental result of impact force sensor.

(4) Application of illuminance sensor

Next, an application of the Bromophenol Blue solution is dealt with. The Bromophenol Blue solution colors from extra light pink

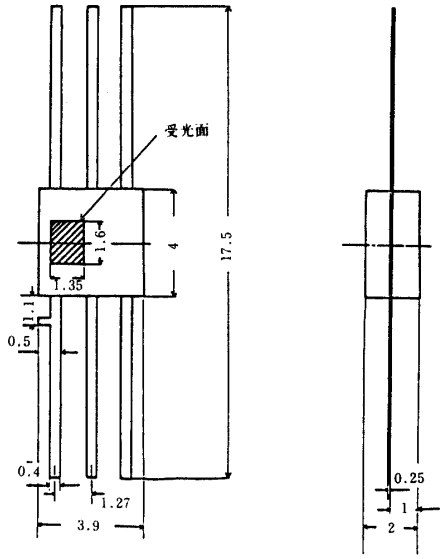


Fig. 4 Outline of illuminance sensor.

through dark red to dark blue accoding as it reacts to the water. When the droplets of a regulation volume drop on a petri dish coating the Bromophenol Blue solution, the illuminance under the petri dish alters according to the coloring of the Bromophenol Blue solution.

The detecting device of droplet's volume mentioned here is an use of illuminance sensor which converts the illuminance under the petri dish into the DC current. The outline of illuminance sensor is shown in Fig. 4. The sensor is constructed by a photo diode and a bipolar integrated circuit and its name is TFA1001W made by General Electric. A relation between the illuminance and the output current of the sensor is shown in Fig. 5. A practical circuit is shown in Fig. 6. The circuit have two detecting circuits and a differential amplifier in order to eliminate an influence of circumferential illuminance. One of detecting circuit measures the illuminance of the transmitted light through the petri dish coating the Bromophenol Blue solution. The other measures the illuminance of the transmitted light through the plain petri dish. The differential amplifier using a high speed type operational amplifier detects a difference of two illuminance.

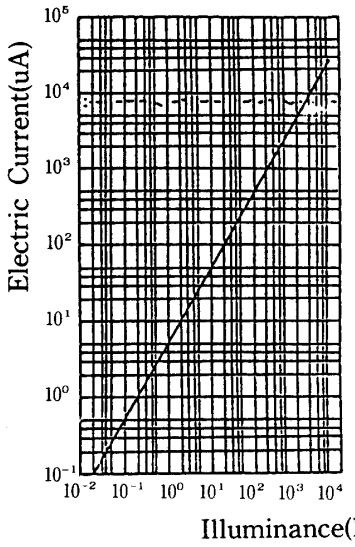


Fig. 5 Relation between the illuminance and output current of sensor.

(5) Experimental result and consideration

The experiments were done to vary both volume of droplet with the precision air displacement micro pipett and the circumferential illuminance with some fluorescent lamps. A digital illumination meter calibrates the illuminance. A number of droplet is 13 and a number of repetition is 10 about one experiment.

An example of results is shown in Fig. 7. The detecting voltage becomes higher according to increase the number of droplet, but the

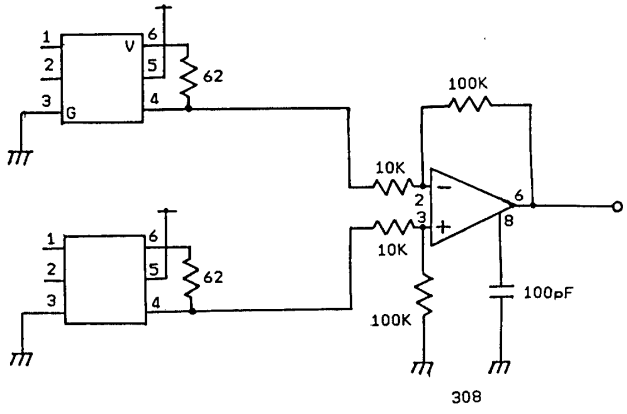


Fig. 6 Practical circuit for illuminance sensor.

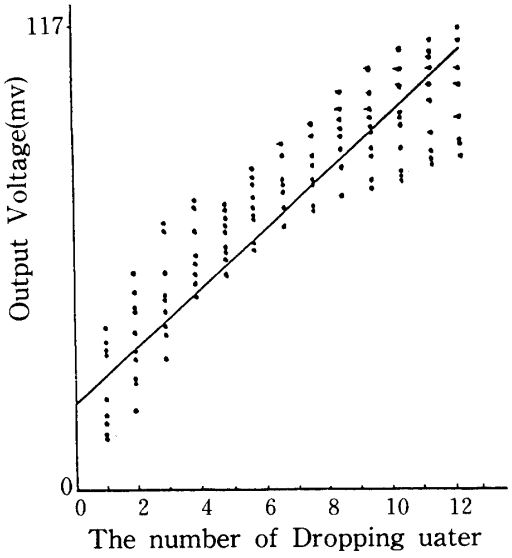


Fig. 7 Experimental result of illuminance sensor.

circumferential illuminance has an influence upon the output voltage of the sensor. When the circumferential illuminance is low, the output voltage of the sensor scattered in a wide range. So it needs to calibrate the circumferential illuminance ahead of starting the measurement and to estimate the output voltage of the sensor with the absolute value of the calibrated circumferential illuminance.

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液滴の体積検出法に関する研究

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要　　約

防除用農薬, 特に液剤の噴霧量を正確に測定することを目的として, 噴霧液滴の体積を測定する方法について研究を行った。噴霧液滴の体積は, 一般的には, スライドグラス上の油滴中に噴霧粒子を捕集し, 顕微鏡下で直接に, 或は, 写真撮影を行った後, 拡大投影して測定した粒子の直径から, 計算によって求める方式が使用されている。本研究では, 噴霧液滴の体積を直接検出する二つの方式を開発し, 比較・検討を行った。検出方式のうちの一つは, ノズルから飛来する液滴の衝突を検出する方式であり, もう一つは, 淡紅色透明のブロム・フェノール・ブルー溶液が水に出会うと深紅色から濃青色に変化することを用いて, 照度の変化として捉える方式である。両方式とも噴霧液滴の体積を直接検出する事が可能であったが, 照度の変化を捉える方式の方が可能性が高いと考えられる。