An Installation for Automatic Data Transfer, Record and Process in Agricultural Field Experiments

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Installations for automatic data logging and processing may be of great concern of agricultural research workers. It is especially the case with breeding and genetical research works in field. An enormous amount of experimental materials are subjected to measurement with respect to different sorts of traits, which should successively be followed by recording and processing of the measured values. A great amount of labor efforts, time and cost have been laid out for such procedures.

In recent years, on one hand, the development and practical use of electronic computer has made it possible to process the data with high efficiency and accuracy. On the other hand, however, almost all of the procedures related to the measurement and data recording have been manually practiced as before in field experiments. The present equipment is designed to make efficient the procedures of transferring, recording and primary processing of the field data.

Planning of the equipment started in 1966 and a master plan was settled in April, 1967. The equipment was almost established in 1968 in cooperation of staff members of the National Institute of Agricultural Sciences with those of Oki Electric Company Ltd., Tokyo, Japan.

General description of the equipment

The equipment consists of three main parts; i.e. data-transfer, data-record and data-process parts. Schematic diagram is shown in Fig. 1.

Measuring is practiced while measurers are moving in the field. The measured values are sent by pushing micro-button-switches on portable operation board. The data are automatically converted from decimal numerics to binary codes and sent by the FS-FM wireless system. For measuring length an automatic reader with length-code converter can also be used.

The binary codes received in the receiver are transmitted to the recording system (typewriter and tape-punching machine) through the input regulator, interface and computer. The data are automatically typed out on the paper sheet in tabulated form and simultaneously punched on the paper tape in real time.

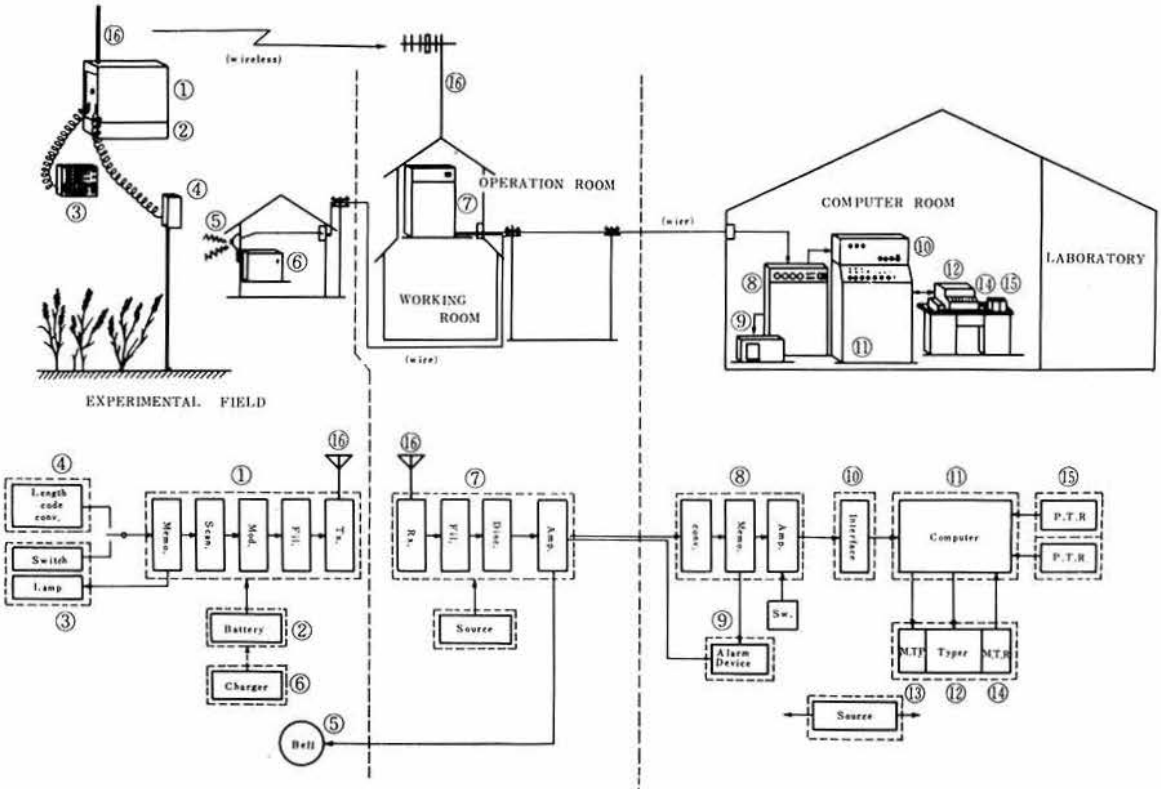
The original data transferred and recorded in tapes are compiled and subjected to primary statistical analyses with a small electronic computer of the system. The results of the analyses are recorded on the paper sheet and also on the paper tape. The tapes with the original and the primarily processed data can be subjected to further analyses by the computer of this system or any other high-power computers.

Constituents and functions of parts

1) Transmitter and receiver

The operation board of the transmitting part is carried by hand, and the transmitter and batteries are shouldered on back. They are connected by sealed cables (Fig. 2 and 3).

In transferring measured values, a measurer pushes micro-switches on the panel of the



① Portable device with memory and transmitter ② Battery ③ Operation board ④ Measuring tape with length-code converter ⑤ Alarm bell ⑥ Battery charger ⑦ Receiver ⑧ Input regulator ⑨ Alarm ⑩ Interface ⑪ Computer ⑫ Typewriter ⑬ Mechanical tape-reader ⑭ Mechanical tape-reader ⑮ Photo-electric tape-reader ⑯ Antenna

Fig. 1. Equipment for field plot data recording, transferring and processing.

operation board. The panel has thirteen micro-switches, ten of which are for sending numerics of 0 to 9. Each measured value is expressed by three figures. Three sets of ten micro-lamps are also fitted up to the panel, which are used for checking the measurer's operation with lamps lighting. Each set of three figures of a measured value is converted to binary codes and transmitted by wireless in pushing one of the micro-switches to start transmission. The figures can be cleared, if needed, in pushing the other switch for resetting.

Sliding scale is available for measuring length, and a value measured with it is automatically transferred to the transmission system without manual operations of pushing the micro-switches for sending individual figures.

For wireless transmission the FS-FM system with a wave band of 365.35 MC is adapted.

The memory device, scanner, modulator and transmitter are housed in the shouldered case. Batteries, supplying electric current to the above mentioned whole system, are also housed there.

The receiver system is installed in a working room which is about 1,000 meters apart from the experimental field (Fig. 1). The FM wave carrying the data from the field is filtered and discriminated here. Then the codes and signals are transferred by wire to the input regulator and record system.

Table 1. An example of data recorded on a paper sheet

(Original data)

(EXPERIMENT ON WHEAT ADAPTATION)

```
A 1  B 1  C 1  D 1  E 105  F 18  G 20
               D 2  E  92  F 13  G 18
               D 3  E  85  F 12  G 24
               D 4  E 114  F 20  G 16
               D 5  E  97  F 15  G 21  /
A 1  B 1  C 2  D 1  E  75  F 14  G 25
               D 2  E   0  F  0  G  0
               D 3  E  76  F 12  G 19
               D 4  E  70  F 14  G 27
               D 5  E  74  F 15  G 20  /
     ...            ...
     ...            ...
S
```

(Primary data-process)

(Sum, sum of squares and mean of individuals within line for each trait)

```
A 1  B 1  C 1  D 5
               E   493  F   78  G   99
               E 49119  F 1392  G 1997
               E    98  F   15  G   19  /
A 1  B 1  C 2  D 4
               E   295  F   55  G   91
               E 21777  F 1392  G 2115
               E    73  F   13  G   22  /
     ...            ...
     ...            ...
S
```

(Total sum, sum of squares and mean of individuals for replications)

```
B 1  C 1  D 20
          E  238934  F 4417  G 8899
          E    1925  F  287  G  413
          E      96  F   14  G   20  /
     ...            ...
     ...            ...
```

(Total sum, sum of squares and mean of individuals within family for each trait)

```
B 1  D 97  E   8439  F 1360  G  2039
           E 713564  F 18995  G 42239
           E     87  F   14  G    21  /
     ...            ...
     ...            ...
S
```

Note: 1. A 1, 2, ... — Replication and its number.
B 1, 2, ... — Family, population or main plot and its number.
C 1, 2, ... — Line or sub-subplot and its number.
D 1, 2, ... — Individual and its number.
E, F and G — Trait.
2. O for E, F and G — Missing lot. S and / — End mark.
3. The items in parentheses are not automatically recorded.

2) Input regulator and recorder

The input regulator consists of a converter, memory, controller for recording the proper number of measured values, alarm device and an amplifier (Fig. 1 and 4). It is placed in a room where the computer is housed, and connects receiver with computer.

For some disturbances or faults of electricity supply, such as interruption, abnormal voltage or current, the circuit for electric current supply is automatically interrupted. This abnormal situation is instantly and automatically informed to the measurer in the field by the alarm device attached to the system (Fig. 1).

The recorder part consists of a typewriter and a punching machine (Fig. 4). The original data transferred from the field are recorded on the paper sheet by the typewriter in a tabulated form and on the paper tape by the punching machine in real time. The measurer sends only the numerical values of individual samples. Recording of the data is done for every three traits of each sample. The proper marks and numbers which identify the individual recorded figures are automatically (without signals from measurer) recorded with the data. An example of the data recorded is shown in Table 1. As shown in the figure,

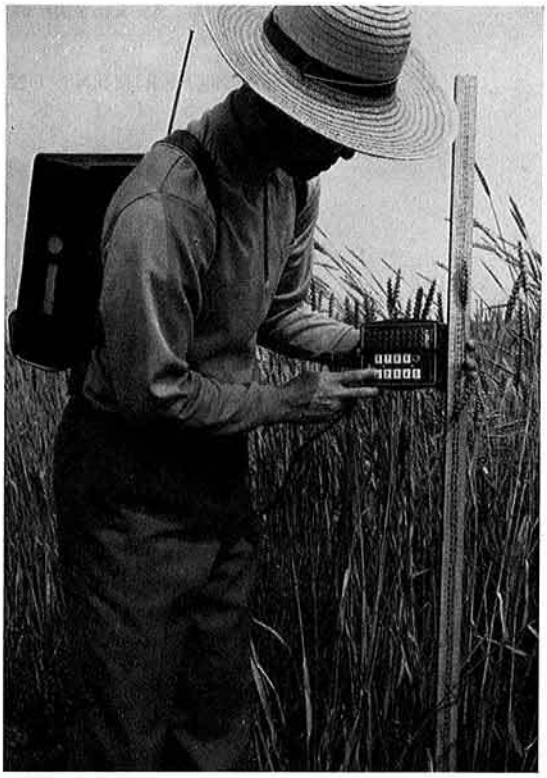


Fig. 2. Measuring with portable device for wireless transmission.

A, B, C and D indicate replication or block, family or main plot, line or sub-plot, and in-

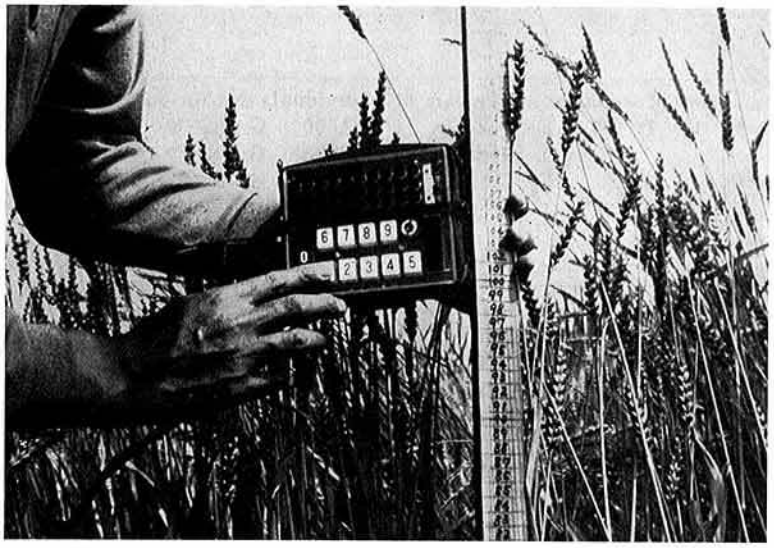


Fig. 3. Panel of operation board for data transmitting.

dividual or sub-subplot, respectively. The mark E, F and G represent three measured traits.

These procedures for recording data, including typewriter operation, are controlled by signals from the measurer and mechanical device for automatic record of proper numbers and by a program memorized in the computer as well.

Some specific values which are calculated from the original data through arithmetic operations by the computer are recorded in real time, too. The data after primary and secondary processes are also recorded on the tape and paper sheet in tabulated form, as shown in Table 1.

The maximum speed needed for both typewriting and punching is 450 characters per minute.

3) Data processor

The processor system consists of a computer and two photo-electric tape-readers (Fig. 4). A

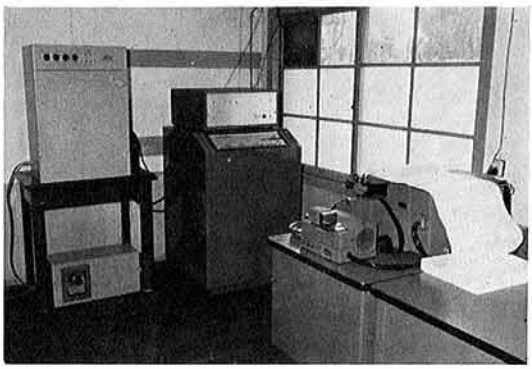


Fig. 4. Input regulator, data processor and typewriter. From left to right: Input regulator, alarm device (below), interface (upper), computer, photo-electric tape-reader and typewriter with mechanical tape-reader and tape-puncher.

rather small type of computer, which has magnetic cores of 4,096 words, is adopted because of its suitable rate of data processing, reasonable cost and lenient limit of environmental conditions.

The recorded data are subjected to primary data processes; i.e. calculations of sum, sum of squares and mean of sub-subplot, by the computer. Missing lots are automatically discarded in calculating mean value. Two photo-electric tape-readers and a mechanical reader set up in the typewriter are used for compilation and calculation of the data recorded in tapes. These primarily processed data are used for more advanced processing by the computer of this system with other appropriate programs.

Time needed for the data process and record is restrained by the printing speed of the typewriter. It takes about 10 hours to complete primary data processes of about 10,000 measured values, which are usually obtained by the manual procedures of measuring and recording by a party of two measurers and one recorder in a daytime. In other words, the primary data processes are completed during a night after measuring by this system.

Advantages of the equipment

The advantages which are expected to be obtained by using this device are as follows:

1) The manual practice for the measurer is only to push the micro-switches corresponding to measured values. Therefore, saving labor for data recording on field notes is expected, which might also ensure the decrease of errors, since the recorded data can be directly subjected to processes by computer.
2) The results of running tests have shown that the speed needed for data transfer, record and primary process by this device is lower than that by the conventional manual methods by two or three persons. This has been attributed to high-speed data processing.
3) The trial tests so far have shown that there were no serious troubles due to noises from outside the system.
4) The equipment concerned is expected to be used as a basic or common parts of the full set of installations for automatic data logging and processing system in field experiments.

Improvement of the system

The present equipment was manufactured for trial. Improvement of the system is needed in several points as follows:

1) Weight of the portable part including the transmitter and batteries should be lighter than that of the present system (5.5 kg).
2) Any type of system for checking or monitoring mistakes in data transfer should be attached, with which the measurer can confirm the accuracy of the recorded data after his transmitting.
3) Automatic system for measuring should be developed. It would make it possible to simplify the transmitting system, to eliminate or decrease incidental misoperations in sending measured values, and furthermore to reduce mental and physical loads on the measurer in the field.

Reference

1) Okabe, S., Kawai, T. and Akemine, H.: Equipment for automatic field plot data recording, transferring and processing. The Second International Conference on Mechanization of Field Experiments. Paper 5, 68 (1968).