SVERIGES LANTBRUKSUNIVERSITET

Apparatus for Determination of Kernel Weight Distributions in Cereal Grains and for Sorting Kernels by Weight

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ABSTRACT

A system for automatic kernel weighing was developed in 1989 in order to facilitate determination of the kernel weight distribution in cereal grains. A device for sorting the weighed kernels was developed and added to the system in 1990. The capacity is approximately 500 kernels per hour.

CONTENTS

INTRODUCTION

The variation in kernel size is normally very large in cereal grains. However, the kernel size of a specific sample is usually only described by the 1000-kernel weight, which represents the average kernel weight. To make it practically possible to determine the kernel weight distribution and thereby get more information on the size of the kernels, an apparatus for automatic single kernel weighing was developed in 1989. A device for sorting of the weighed kernels was developed and added to the system in 1990.

The presentation of the apparatus is mainly an overview of the chosen and developed components. The changes made to the purchased major parts of the system are described in greater detail than the parts developed at the Department. Further information, computer codes and wiring diagrams can be obtained from the author.

A PC-program for analysis of the recorded weights provides an opportunity to compare different distributions by their average weight, standard deviation, skewness and kurtosis. The studied distribution is graphically presented in different frequency plots and calculations can be made on different parts of a distribution. External customers receive the program together with the data-file.

DESCRIPTION OF THE APPARATUS

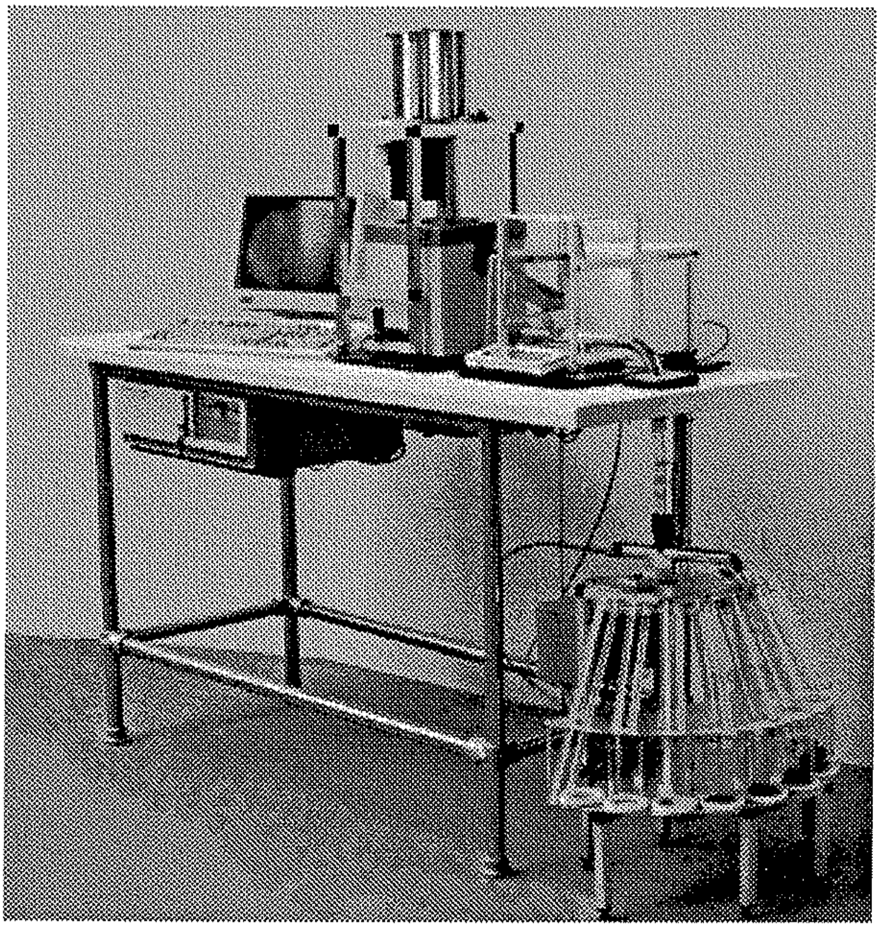

Fig 1. The system for sorting grain kernels by weight.

The apparatus has 5 major components: sample feeder, kernel feeder, scale, sorting device and computer.

Sample feeder

The sample feeder, developed and constructed at the Department, contains seven tubes, each with a volume of 100 cm^3, which corresponds to about 2000 wheat kernels. The feeder is rotated by a synchronous motor and one tube at the time is positioned over an emptying tube leading the sample to the kernel feeder. The positioning is performed by a read-element and a magnet mounted on each tube.

When a large amount of grain is to be sorted, a hopper is mounted on the sample feeder. After filling, the system can then be run for about 4 days without refilling.

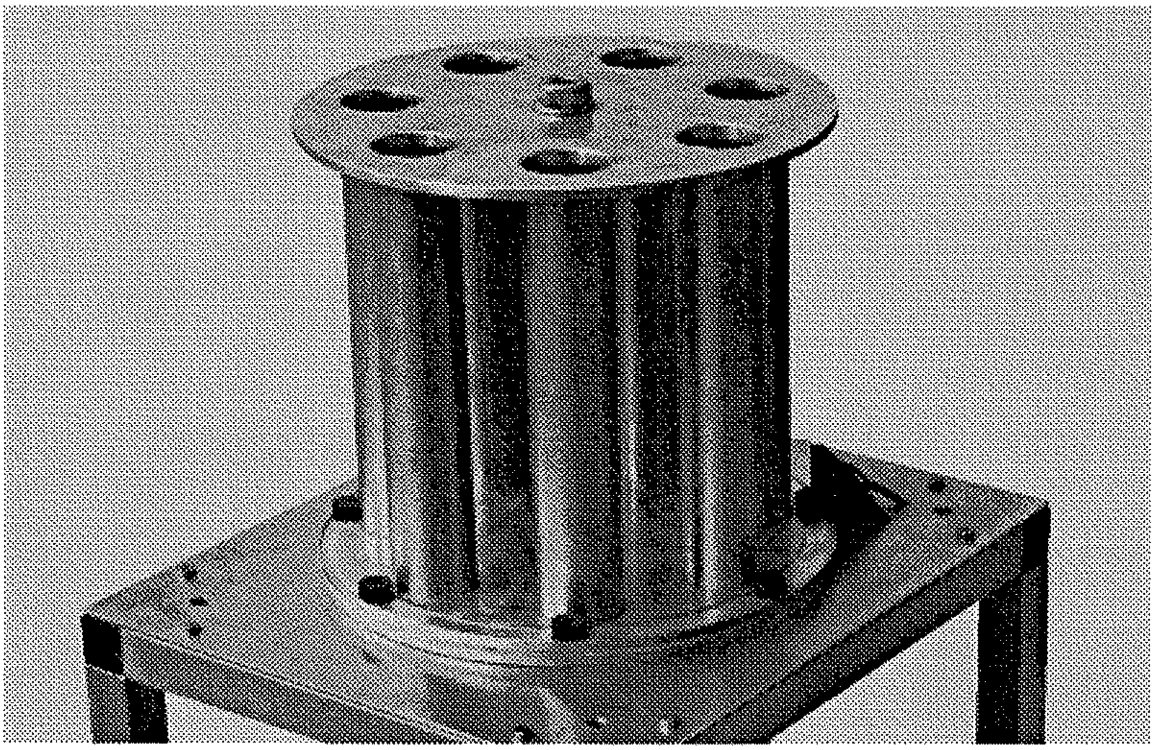

Fig 2. The sample feeder.

Kernel feeder

The kernel feeder, a Mettler-LV10 (Mettler Instrumente AG, Greifensee, Switzerland), transports the kernels by means of vibrations from the centre of the feeder to the end of a spiral groove. When a kernel reaches the end of the groove it falls down on the scale and passes through a beam of light which stops the feeder.

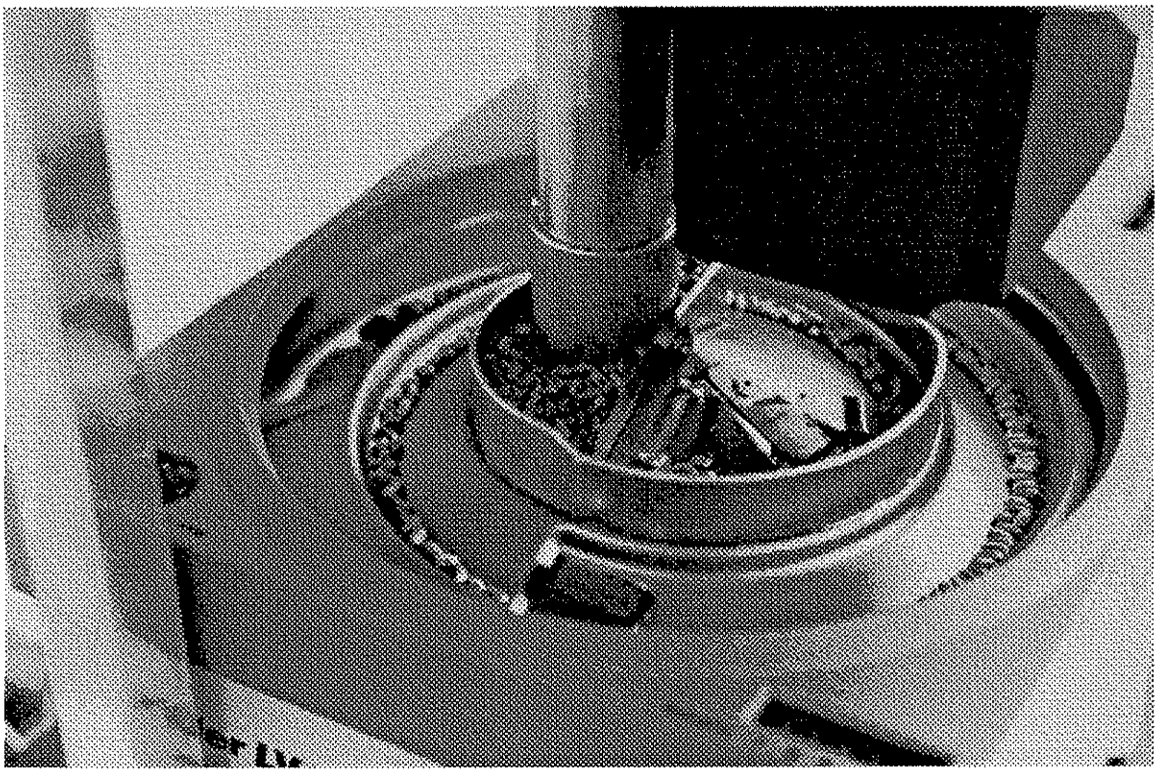

Fig 3. The kernel feeder.

Obstacles were mounted on one side of, and close to the centre of, the spiral groove in order to give the desired flow of kernels.

The LV10 is normally controlled either manually or by a micro-processor attached to the Mettler scale used by the system. Signals to the micro-processor are transmitted through an RS-232 interface. The feeder has 4 vibration intensities and an emptying mode with extremely intensive vibrations. If no kernel is detected within one minute after the start of the feeder the feeder stops. The feeder cannot be stopped unless it is in its emptying mode. The vibration intensity cannot electronically be changed by the micro-processor without restarting the feeder. This is possible only during manual operation.

To provide information on whether a kernel had passed or not, a flip-flop circuit was inserted in the light beam circuit. To make it possible to change the intensity electronically without restarting the feeder, a relay was mounted in parallel to the manual intensity switch. A restart while the feeder is running may otherwise lead to a kernel falling down in between the check of the flip-flop and the accomplishment of the intensity change, even though the time elapsed is very small.

The feeder is always started at the lowest intensity and thereafter the intensity changes in accordance to a schedule which gives an even flow of kernels.

Scale

The scale in the system, a Mettler AT-20, has a readability of 10^{-4} gram. The scale can be fully controlled through its RS-232 interface. The micro-processor in the scale can also control the standard features of the Mettler LV-10 vibrator.

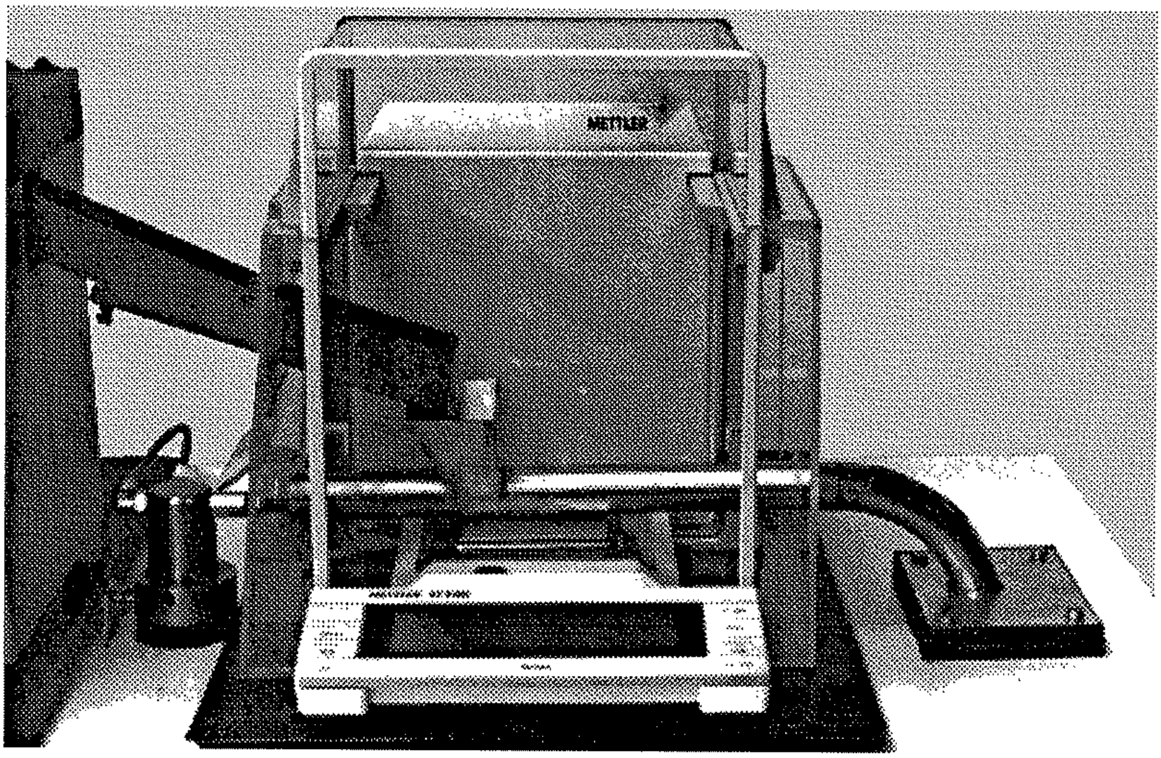

Fig 4. The scale used in the system.

New wind shields were constructed to enlarge the weighing chamber. In order to weigh and transport the kernels, a tube with an inner diameter of 22 mm, was mounted on a plate and placed on the weighing pan. Near the centre of the tube a hopper was mounted so that the kernels could fall from the feeder into the tube.

A nozzle for compressed air, placed outside the wind shield, blows air through an aperture in the wind shield and into one end of the tube. After a kernel has been weighed a valve opens and the kernel is pneumatically transported out of the weighing chamber and into another tube that leads it to the sorting device.

Sorting device

The kernels fall into a horizontal tube, mounted on a vertical axle. A step motor rotates the axle so that the end of the tube is positioned over one of the 10 tubes leading the kernels to the desired glass cup. A Hook element is used to regularly check the positioning. After the tube has been positioned, a valve opens and the kernel is pneumatically transported by air from a nozzle mounted in one end of the tube. The holding capacities of the glass cups are 300 ml. When large quantities are being sorted one of the cups may be replaced by a bucket for the undesired fractions.

If only the kernel weight distribution, and no sorting, is desired the device puts each of the samples in different cups.

The microprocessor used for controlling the sample feeder, the sorting device and the added features on the kernel feeder is mounted on the sorting unit. Communications with the micro-processor are performed by means of a RS-232 interface.

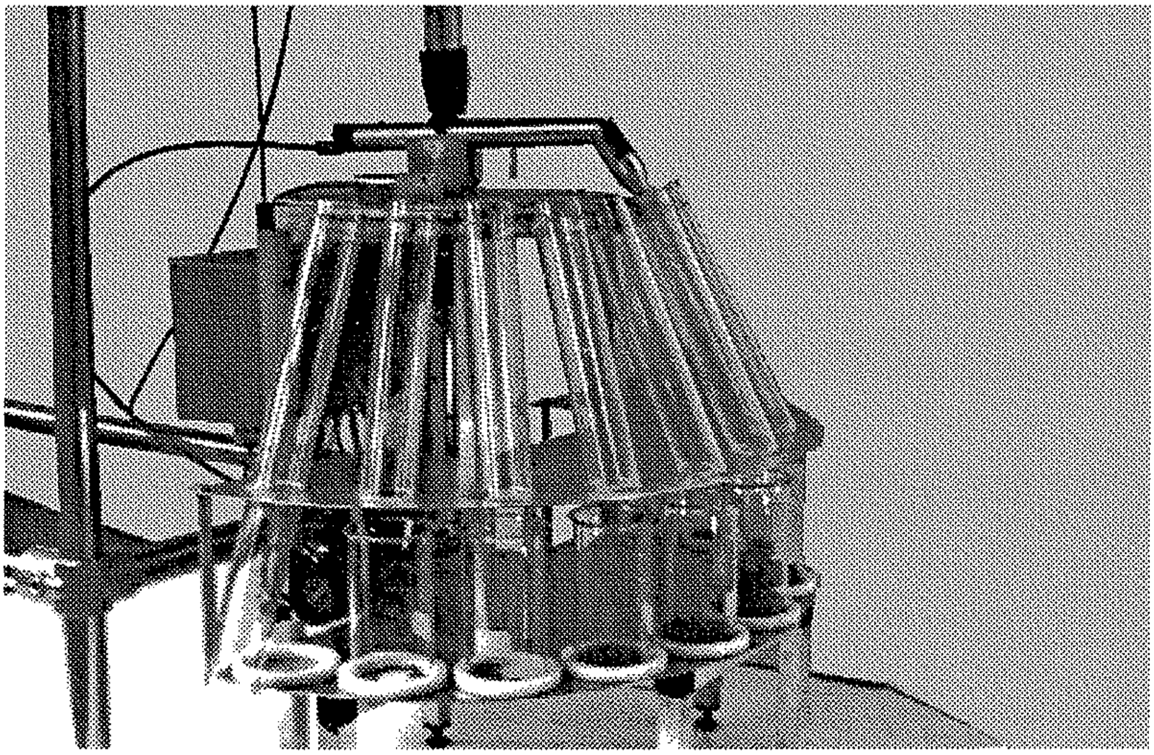

Fig 4. The sorting device.

Computer

An IBM PC-AT compatible computer controls the other parts of the system by means of 2 asynchronous ports and stores the kernel weights as ASCII-files. The program is written in Turbo Pascal (Borland International, Scotts Valley, USA) and uses Turbo Asynch (Borland International, Scotts Valley, USA) for the serial port communication.

The program can be run in two modes, with or without sorting of the kernels. If the kernels are to be sorted, only 1 sample can be loaded each time. The program will, in this mode, run until it finds an empty tube in the sample feeder. This means that the sample feeder may be refilled, without interrupting the program, until the entire sample has been sorted. In the non-sorting mode, up to 9 samples can be run without restarting the program. Since the sample feeder only holds 7 tubes the feeder must be refilled if the number of samples exceeds 7.

The program continuously graphically presents the frequency distribution, the number of weighed kernels, the average weight and the kernel weight standard deviation. An example of the information displayed during the kernel weighing process is presented in Figure 6.

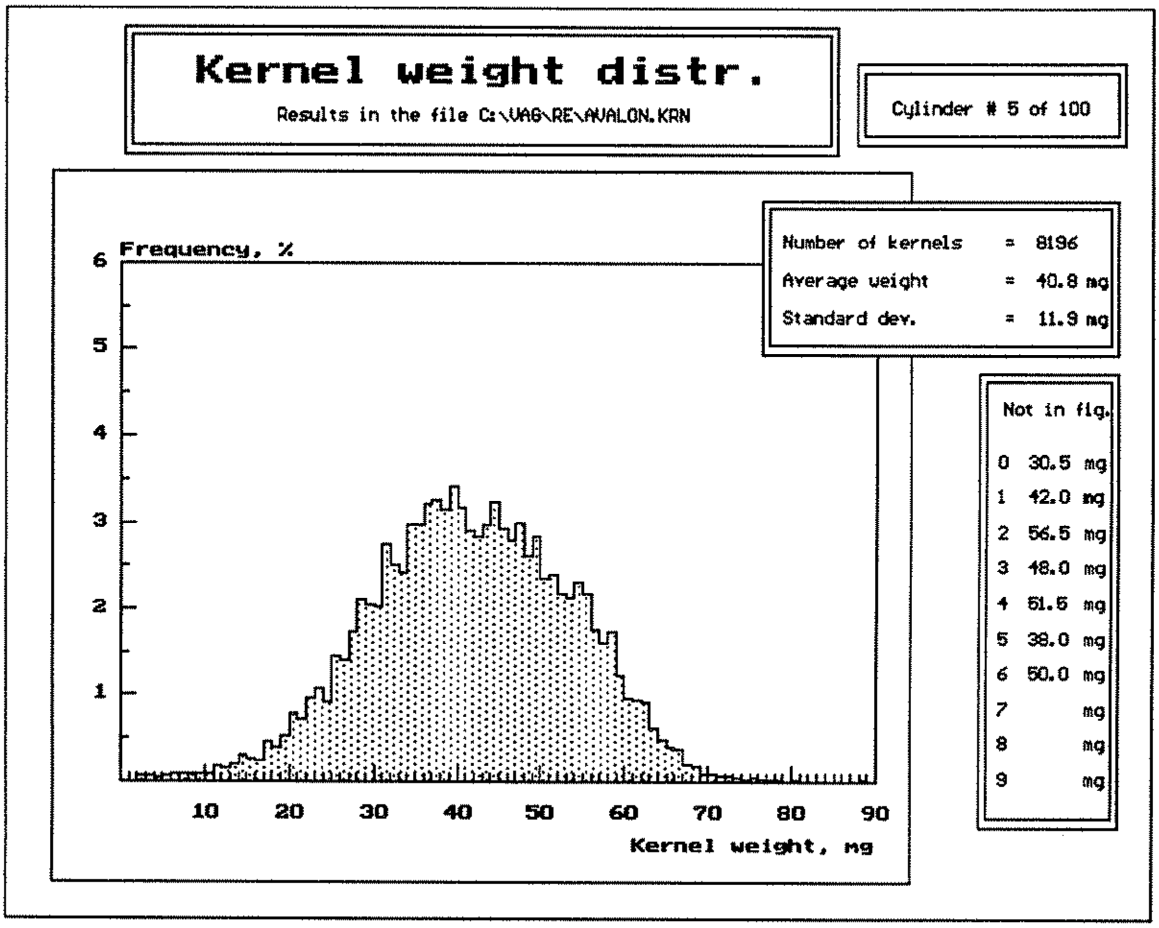

Fig 6. Information displayed during the kernel weighing process.

CAPACITY AND ACCURACY

The capacity of the system is about 500 kernels per hour independently of whether the sample is to be sorted or not. This means that about 6 samples of 2000 kernels each can be weighed daily.

In some cases two kernels can be fed to the scale at the same time. In a test where the same sample (about 1000 kernels) was loaded over and over again the standard deviation of the number of kernels calculated by the apparatus was about 1. In between each run the number of kernels was calculated with a conventional apparatus for thousand kernel weight determination (Numigral, Tripette et Renaud, Paris, France). The result of these calculations was similar to those made with the other apparatus.

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