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Current Trends in the Development of Fruit Sorters in Japan

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ABSTRACT

In the 90 years or so since the beginning of the 20th century, orchard growing and agricultural fields in Japan have undergone considerable change in terms of production volume, as seen in Fig.1. As this change in volume progressed, sorting and packing machines have also grown from the first wooden tools, almost too simple to be called "machines", into sophisticated devices that bring together diverse technologies such as machinery, electronics, and optics.

Nowadays, Japan's agricultural industry is facing unprecedentedly serious labor shortages and the rapid aging of its experienced growers and producers. In addition, Japan has changed from a society oriented towards high-volume production and consumption to a more selective society which prefers smaller volume with the taste of naturally ripened produce. With consumer trends changing, there is a new demand on the part of growers for equipment that can not only measure the external quality of produce, but can measure internal quality as well.

Key Words : History, Fruit Sorter, Free tray system

INTRODUCTION

Japan's present-day agricultural industry is faced with problems which are both numerous and serious. One of the fundamental problems challenging the industry is that agricultural labor is much more strenuous than that in other industries, and that young people have been leaving the agricultural fields in great numbers for less demanding occupations. This trend has been in evidence since the end of World War II and is still continuing today. According to 1990 statistics, the number of people involved in the agricultural industries in that year was 5,650,000; of these, 3,126,000 people, or 2.58% of the total population, could boast special expertise. In a breakdown by age, 11.6% were between the ages of 16 and 39, 40.2% are between 40 and 59 years of age, and 48.2% are 60 or older.

According to estimates, the number of people involved in agricultural occupations will decrease another 22% by the year 2000. As agricultural distribution becomes more and more international-oriented, increasingly intense competition can be expected in terms of production cost between domestically grown fruits and vegetables and low-priced products imported from overseas. In addition to the uncertain outcome of this economic struggle, the number of young people leaving the agricultural industry and the decrease in the number of those engaged in this kind of work are acceleration steadily.

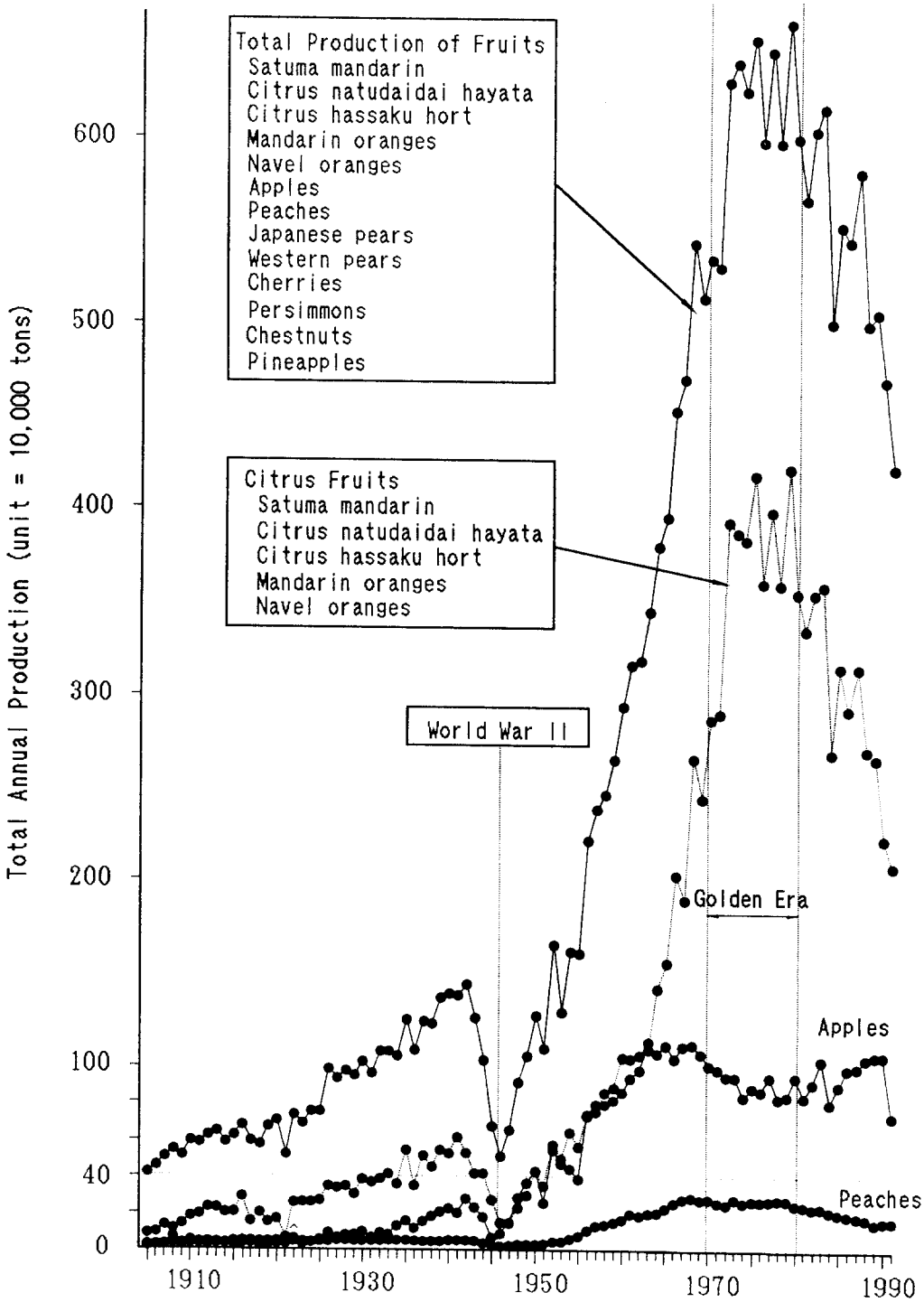

Fig.1 Total Production Volume of Main Types of Fruits

In an effort to combat these problems, we are seeing a growing trend to exploit the advantages of labor-intensive agriculture in fruits and vegetables such as rice, one of Japan's main agricultural staples, and to produce lower quantities bet higher quality. Production groups are called on to supply fresh produce ripened in the field, and better-tasting produce, though techniques such as reducing the amounts of pesticides and using safer organic farming methods.

Despite these developments, however, agricultural work still does not appeal to young people. For this reason, regions which depend on the production of fruits and vegetables for their livelihood are facing a state of crisis because of labor shortages and aging population, and the operation of sorting and packing machinery is growing increasingly problematic which every passing year.

Sorting and packing machinery which has been collectively purchased by manufacturers who then operate it on a cooperative basis plays a very important role in bringing farmers produce together and preparing it for the market, as well as providing a central place where market information can be collected; at times, it even serves as a center where proceeds collected from market sales are distributed. Any hindrance to these functions, or, in the worst case, the possible loss altogether, would pose a critical problem for producers.

For this reason, the following needs have been in identified:

(1) Finding a means of reducing the labor involved in operating sorting and packing equipment

(2) The development of handling techniques using transportation and classification equipment which would allow non-destructive sorting and packing of high-grade and fragile produce

(3) There is a strong need for development of automated technology to be used in grading and sorting produce; in particular, there is a demand for technological developments which will allow measurements pertaining to the taste of fruits and vegetables, including the measurement of sweetness and sugar content.

THE HISTORY OF SORTING AND PACKING EQUIPMENT

The Early Years (1880 - 1940)

In Japan, the first cooperative growers' association for the shipping and marketing of produce was formed in 1906, in an area where tangerines are produced. The facilities used collectively by this cooperative became the first fruit selection plant. At first, the facilities consisted merely of a sinlge building where the produce was spread out on the floor and sorted and packed by large numbers of people. The work proved very difficult, however, and discrepancies in quality were a constant problem. In order to solve these difficulties, the cooperative manufactured its first machinery, designed to sort produce by size. In 1924, the first Japanese model, the Fujita power-driven sizer, was developed, and in 1925, the first Parker power-driven grading and sorting machine was imported from the U.S. Production capacity at this time, however, was limited to a mere 200,000 to 250,000 tons, and there was no need for the large-volume facilities that we have today (see Fig.5).

Consequently, most of the sorting machines from this era were compact machines made of wood, as shown in Fig.2 and 3. These machines developed eventually to the

point where they were power-driven, but the basic operating principle consisted of holes and gaps through which the produce was fitted to sort it by size. Most of these initial sorting machines were manufactured not by specialists in mechanical design, as today's machines are, but by carpenters in the area where the produce was grown. Delicate fruits such as apples, persimmons, and peaches which are easily bruised, continued to be sorted and packed by hand, as always.

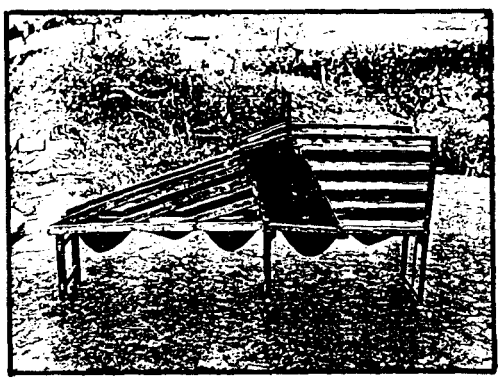

Fig.2 Mizusaki-A Type

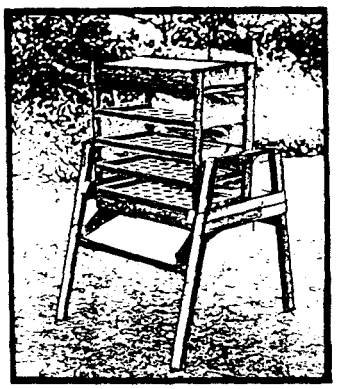

Fig.3 Fujita-A Type

Recovery Period Following World War II: An Era of Prosperity (1941-1975)

World War II proved disastrous to the agricultural industry, with production of fruits and vegetables falling by half, to the level of 510,000 tons, as can be seen in Fig.1. With democratization of the government through measures such as the newly revised Constitution and liberalization of agricultural lands, however, legislation promoting agriculture began to be implemented, resulting in a rapid comeback in agricultural production. Within 30 years after the end of the war, between 1946 and 1976, the volume of production had reached 6.5 million tons, far exceeding the pre-war level of 1.4 million tons. The progress in hothouse-grown tangerines was particularly striking, growing from 400,000 tons to 3.5 million tons.

The decade from 1970 to 1980 was a golden era for orchard growers, and development of sorting and packing equipment escalated accordingly. During this era, many different types of mechanical sorters were manufactured, but the basic principle of operation varied little from that used with older models, shown in Fig.2 and 3. Most pre-war models, however, had only a compact, simple construction, while those built after the war were designed by specialists in mechanical design and were built for full-scale plant operation. Features such as conveyor belts and automated machinery which fed the produce through all of the processes from intake to shipping were designed to streamline the work and make it more efficient, while the machines themselves were bigger and could handle larger capacities. Wax was also introduced in order to assure the quality of the tangerines as they passed through the machines.

Two sorting machines typical of this period are the drum-type sizer used for citrus fruits, shown in Fig.4, and the weight sizer designed for deciduous fruits, shown in Fig.5. The drum-type sizer, used for citrus fruits, spread quickly to most areas where tangerines were grown, because of its ability to process large volumes of fruit, while the weight sizer contributed greatly to cooperative ventures in areas where deciduous fruits were grown, as well as to increases in production quantities.

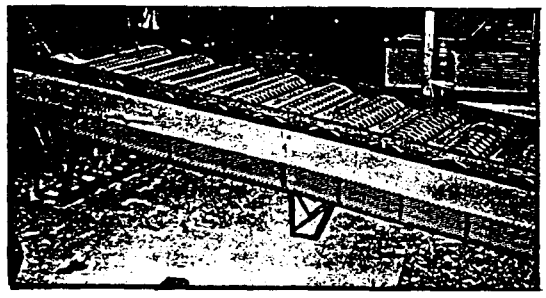

Fig.4 Shiroyanagi drum-type sizer(1950)

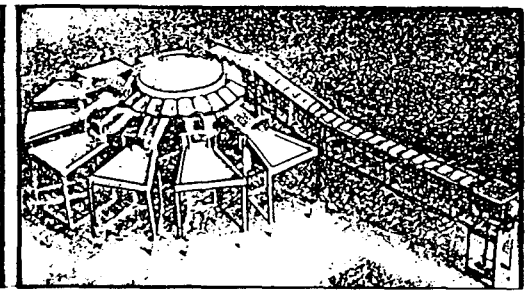

Fig.5 Maki weight sizer(1955)

Years of Contracted Equilibrium and High-Quality Competition (1976-1990)

Around 1975, industrial development began drawing large numbers of young people into the big cities, while increasing stability in the lives of young people into the big cities, while increasing stability in the lives of the Japanese people led to greater diversity in diet and individual preference.

Gradually, the Japanese people began turning towards luxury items, high-quality goods, and gourmet and fresh foods, rather than processed foods. A new era began in which large-scale production and large-volume consumption gave way to a preference for high-quality goods produced in small numbers and in a variety of models. This was accompanied by an increase in the amount of produce imported from overseas, which led in turn to new policies emphasizing scaling down and cutbacks in production. In sorting and packing equipment, factors such as labor shortages, the need to reduce sorting costs, and the necessity of sorting and packing fruit in a non-destructive manner, in order to preserve the high quality when the produce was shipped, led to the development of photoelectric sorting machines combining optical technology with electronic engineering. The first photoelectric sorting machine was manufactured in 1975, and used photodiodes. In 1977, the first photoelectric sorting machine to use a black-and-white camera was developed. This model was extremely simple, but it paved the way for an advanced sorter developed in 1985 employing image processing technology that used color cameras. Where the original machines had sorted fruit based only on size, the new machines were able to measure the color, size, any existing cuts or damage, and the shape of the fruit, and were thus used for both sorting and grading by size. These latest developments took place in a remarkably short period of only 15 years, between 1975 and 1990. During this time, the volume of fruit produced fell below 5 million tons, from its peak level of 6.5 million tons to 4.69 million tons in 1990.

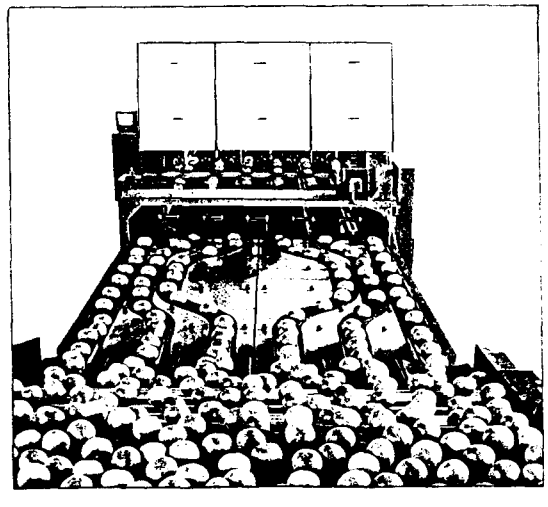

Fig.6 Maki-R.G.B. color grader

The High-Quality Era (1990 -)

The current era is clearly one of culinary enjoyment. Families are smaller nowadays, consisting of 2 or 3 people, and in many cases, both husband and wife are working. This enables the family to enjoy more affluent lifestyle and to indulge in luxuries such as fruit and vegetables which have been ripened naturally and taste freshly picked, even if the prices are somewhat higher. This has led to more emphasis being placed on quality inspections where the produce is grown, and recent demands on the part of growers include color cameras which can measure the exterior quality of the produce, as well as machines which measure ripeness and sweetness or sugar content using near infrared rays.

In 1990, a system designed to measure the ripeness of apples was first put to practical use, followed in 1991 by equipment designed to measure the sweetness of peaches. By now, these machines are beginning to enjoy fairly extensive use in inspections of peaches, pears, and apples. Fruits and vegetables Which are susceptible to damage can now be sorted and classified more efficiently, without being touched by human hands and development is progressing on transport and classification technology to be used in packing, and on automated packing technology. Already a "free tray" system exists which allows produce to be sorted and transported without ever leaving the bucket it arrives in.

In order to maintain freshness, equipment which can pre-cool produce and keep it cool, along with systems which remove ethylene from the produce, are in the process of being developed. Most recent systems also use film, trays, and other means of guaranteeing freshness.

Fig.7 Maki-suger dilector (1991)

Fig.8 Maki-free tray system (1990)

RECENT TECHNOLOGY IN SORTING AND PACKING EQUIPMENT

As mentioned previously, the main demands in fruit selection machinery currently concern the development of various measurement sensors which can reduce the labor involved in sorting and packing, and can guarantee product quality; in short, automated sorting and shipping systems. The different classifications of machinery which fall under this heading are shown in Fig.9. With many of these types of machinery, technological research is still in process, and none of the systems listed

below offer complete online capabilities or completely accurate measurement ability. However, these machines are currently in use at produce growing and processing sites.

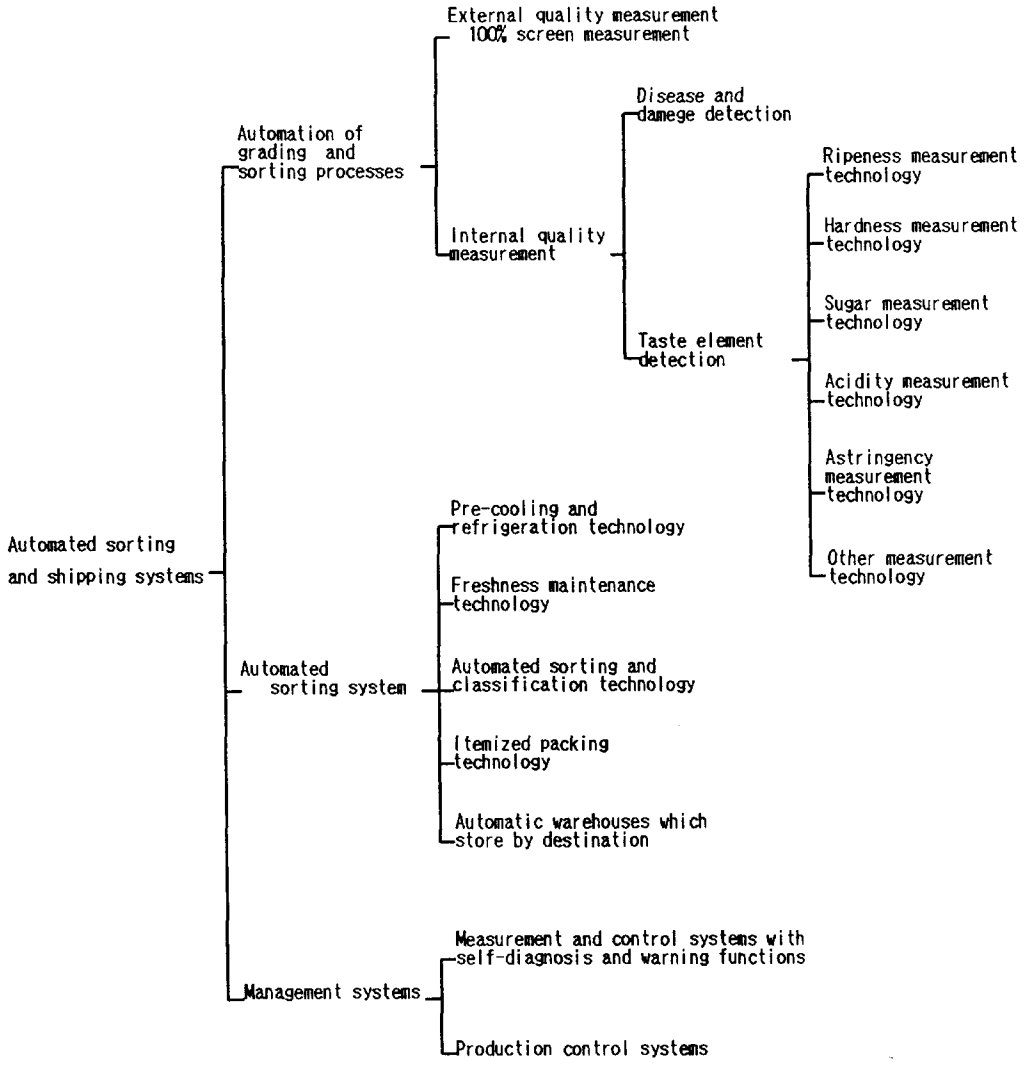

Fig.9 Technology Required in the Development of Automated Sorting and Shipping System

The following shows an example of the new sorting and packing equipment first introduced in Japan in 1992 for with peaches, pears, and apples. The equipment shown in this example consists of a color sorter and sugar measurement unit, along with a free tray system. The main specifications are also listed below.

Table 1 Main Specifications of the Equipment

Daily processing capability (8 hour shift):	8,000 cases
(1) Free tray model sorter	Conveyor system (4 lines)
(2) Color sorter	Color camera and ALU (4)
(3) Sugar measurement unit	NIR analyzer (4)
(4) Automated packing machine	Vacuum packer (10)
(5) Hand packers	(34)
(6) Automated product warehouse system	1 unit

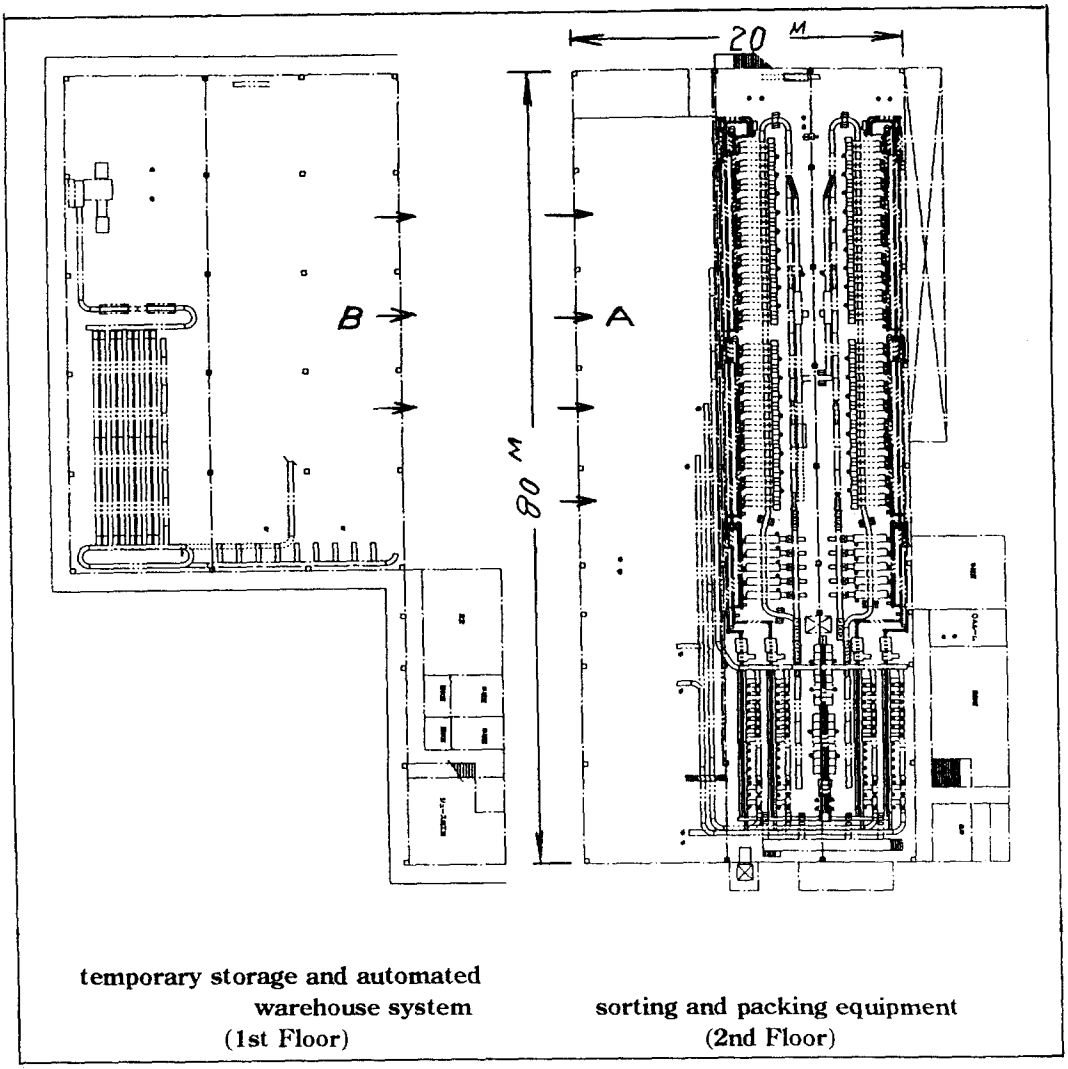

Fig.10 Sorting and Packing Equipment Using Free Tray System
(SHINSU-IIDA-JA-1992)

Most of the processes between Point A in the diagram, which shows the intake process, and Point B, which is the product shipping process, are mechanized and labor-saving. This particular equipment was designed with the objective of combining five small processing plants form five different growing regions into one centralized and streamlined processing location.

The equipment used in these five plants was outmoded equipment which consisted of a total of 9 unit with 47 lanes of sorting equipment, with 576 employees working there. Plans for this renovation included modernizing the plant into 2 units with 4 lanes, with the staff streamlined down to 115 people. The results of a local productivity study carried out after the equipment was introduced are as follows:

a) The number of employees varies somewhat depending on he type of fruit being processed (peaches, pears and apples), but the average number is 120 people, with 105 working in apples and 135 in pears. The total number of employees has been reduced from 576 to approximately 456.

b) According to a practical application study conducted during the season when bagged pears are produced, the operation rate of the equipment totalled 1,100 cases per hour, with 135 employees working during that period. The packing capability per person, per day amounted to 83.8 boxes. In a straightforward comparison, it took 576 people, with each person packing 13.9 boxes a day, to operate the system before the equipment was introduced, which means that production efficiency has been increased six-fold.

c) Because the effort involved in the work has been lightened, work can now be handled by workers in the higher age groups, making it easier to assure adequate numbers of personnel for the work. This is another primary advantage of the new equipment.

In addition to the above advantages, measurement data obtained when fruit is sorted, such as size, sugar content, ripeness, and coloration is used as personal management data, and after the day's sorting work has been finished in the sorting plant, the measurement data for each individual person working in the plant is sent to that person by fax. Employees can make use of this data to keep track of their own work results, and this has proved to be closely tied to improvements in the overall production level.

CONCLUSION

Sorting machines have evolved from the very simple types used in former times to those using optical engineering and computerized systems, with great progress currently being made in the development of technology which can measure internal quality. Today's sorting and packing facilities employ comprehensive technology drawing on the latest development in scientific fields such as mechanics, electronics, optics, and control, and are changing the way that modern food processing plants operate. They have not yet replaced those experts with long experience in cultivation, however, who have the ability to gauge all elements of the produce merely by looking at it.

The skill to judge produce comes from long years of close involvement and experience with fruits and vegetables, while our sensor technology has yet to even

approach this level. In many developed countries, however, agricultural industries are facing a great crisis as their young people move to big cities and their producers are gradually aging and dying out. Agriculture plays a vital role, not only in our food production, but in our lifestyle and our living environment. If we are to keep agriculture alive and thriving, we need to guarantee adequate incomes for those involved in the industry, and furthermore, to make sure that those incomes will continue to grow annually. The technology we are developing today is a critical component in that aim.

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