Engineering

# CONSIDERATIONS ON THE EVOLUTION OF MUSHROOMS HARVESTING SYSTEMS*

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**ABSTRACT:**

*IN ORDER TO IMPROVE THE ECONOMIC AND ENERGY WORKS IN INTENSIVE FARMING SYSTEMS OF MUSHROOMS, TO COPE WITH THE ASIAN COMPETITORS, THE MECHANIZATION OF ALL OPERATIONS RELATED TO THE TECHNOLOGICAL FLOW OF THE CULTIVATION OF MUSHROOMS. OF ALL THE PHASES OF TECHNOLOGICAL FLOW, HARVESTING IS THE MOST EXPENSIVE AND LEAST DEVELOPED.*

*THIS PAPER AIMS TO PRESENT A BRIEF HISTORY OF THE EVOLUTION OF THE COLLECTION SYSTEMS AND TO HIGHLIGHT THE ADVANTAGES AND DISADVANTAGES OF MECHANIZED HARVEST OF MUSHROOMS.*

**KEY WORDS:** AGARICUS MUSHROOM, MUSHROOM PICKERS, SELECTIVE HARVESTING, HARVESTING ROBOTS, PRODUCTION COSTS.

## ECONOMIC CONSIDERATIONS

Mechanical harvesting of mushrooms has emerged as a must to reducing costs of mushroom farms. Because manual harvesting costs represent more than half of the total costs of production, have initiated and conducted experimental research with different systems designed to replace at least partially manual harvesting.

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In order to obtain a high-quality harvests, the mushrooms harvesting should be carried out as soon as they have reached full maturity. In this phase, the himenian veil is stretched and intact, the size of mushroom being maximum, depending on the variety grown. Selective assembly of mature mushroom is usually done manually, using a simple technique which consists of separation through a twisting combined with a slight pressing with the right hand and with the other hand to fix of the bouquet to avoid dislodging it from the layer of culture. If in a bunch there are more mushrooms, harvesting is done by stages, detaching carefully mature mushrooms without being disturbed the rest of the bouquet.

For preservation and industrialization, mushroom harvesting is done in phase of cufflinks with a diameter of 1-2 cm.

Mushroom industry requires intensive labour force and it is difficult for EU countries and for the United States of America to compete with Asian competitors due to the significant difference in labour costs. To stay competitive in the production of mushrooms, the efforts were channeled to mechanized production. At present, from the technological stages, only the harvesting process is not fully mechanized. All producers used manual harvesting of mushrooms. The current level of the average salary for a selector (harvester) in the USA is 6.50$ per hour (Aviv 2004). Considering that a selector can efficiently harvest about 30 pounds of medium-size mushrooms per hour (Lou Summerfield, 2004), the harvesting cost is approximately 0.22$ per kilogram, or about 20% of the wholesale price. The differences in labour costs from different European countries are immense. Netherlands is in the top 5, while the Czech Republic, Poland, Hungary, Lithuania and Romania are at the bottom of the scale. In countries with low labour costs is an average of 2,00 € per hour, compared with an average of 16 € per hour in the Netherlands. In the Netherlands, for harvesting capacity of 32 kg/hour/man, harvesting costs amounted to 50 cents per kilogram, while in Eastern Europe the costs are 10 cents per kilogram for harvesting capacity of 20 kg/hour. This massive difference represents a very large competition for the fresh produce market in the Netherlands and in the countries around them. A study conducted in 1997 indicated that labour costs account for about 46% of the production costs of mushrooms for the fresh produce market in the EU (Farrar J., 1999)

## BRIEF REVIEW OF THE EVOLUTION OF HARVESTING SYSTEMS

In a first phase has adopted the harvesting mechanical non-selective method of mushrooms, the method consists in translating a particular knife on top of the compost cover layer to a height adjustable from it. The knife cut his foot mushrooms after which, the hats are pushed on a conveyor belt to the collection. Among the equipment designed to harvest mushrooms, is a machine proposed by Sverker Persson, P.E. in 1970, it forms a mecanico-pneumatic combination. He has devised a mushroom harvesting machine, shown in Figure 1, which is inside a tubular chassis with open end with a sharp blade, which act almost to the ground, cutting the stems of the mushrooms. The machine has provided by such devices targeting, using jets of air adjacent to the base of mushroom while cutting, and an absorbing device, mounted on the chassis for the transfer of the collection area cut without significant deterioration of it. At the same time is carry out a cross-section displacement system on the shelves.

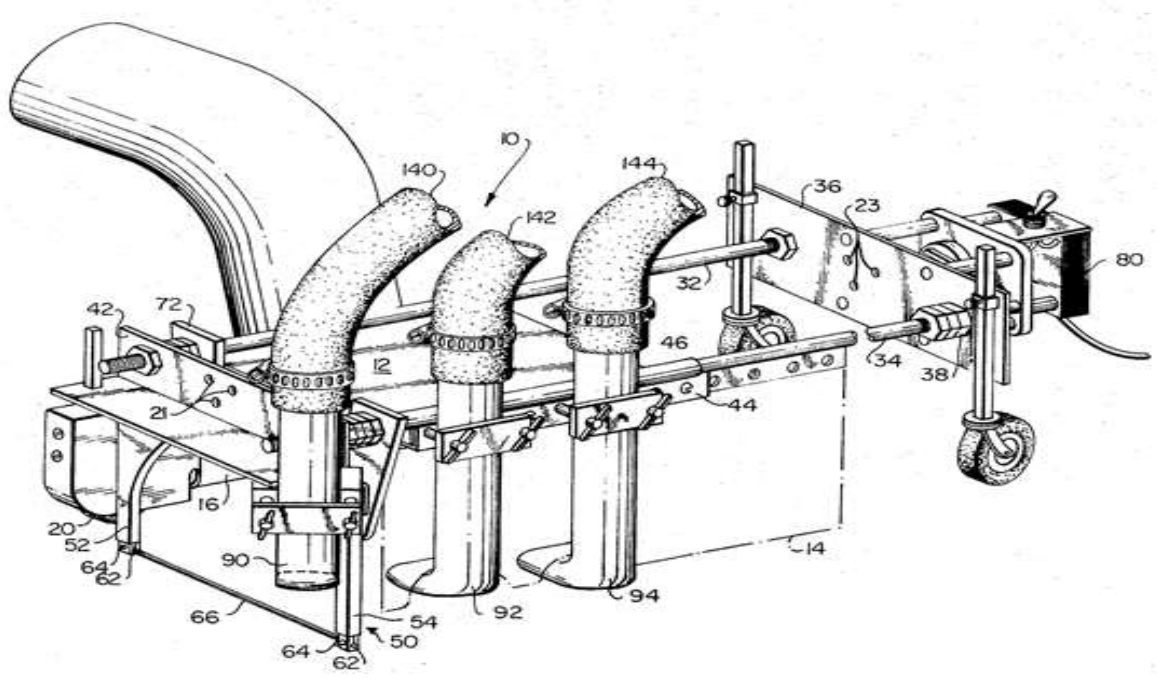
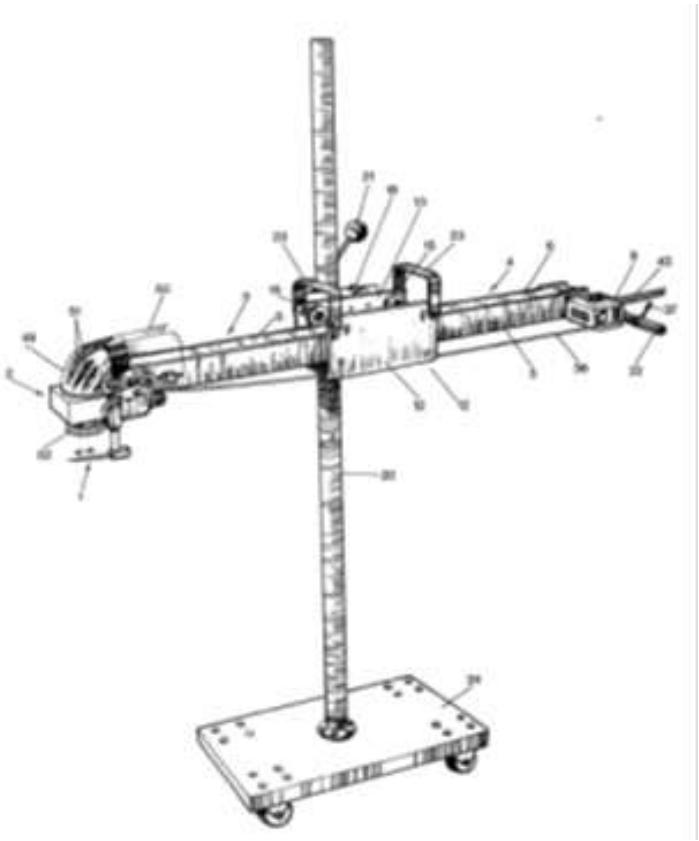



Fig. 1. Sectioned perspective mushroom harvesting machine Persson[2] (http://worldwide.espacenet.com)

2 MUSHROOM HARVESTER; Inventor: Sverker P.E. Persson, University Park, Pa.; Assigne: Research Corporation, New York, N.Y., United States Patent 3,635,005 Jan. 18, 1972

In 1982, the inventor MacCanna ,offers a combined mechanical and pneumatic system for selective harvesting of mushrooms, shown in Figure 2, similar to the one devised by P.E. Sverker Persson. The device is equipped with cutting devices, (a knife blade), which it travels on the surface of the shelf mushrooms to carve the feet mushrooms, combined with a lifting device of hats (2), for extracting mushrooms cut in and transfer them to the bands collection (3). The lifting mechanism (2) includes an air engine consists of a cylindrical chamber with a hole cut above the cutting devices (1) and an outlet connection with the collection devices (3).

The compressed air is directed into the housing through an annular orifice which is profiling to direct the air flow towards the exit. An area of low pressure is created adjacent to the inlet chamber, aspiring ambience air in the housing. Cutted mushrooms are absorbed into the housing, driven by the airflow passing through the housing, and delivered to the collection device (3), (6). In an ideal variant , the knife (1) and the lifting mechanism (2) are mounted on the end of a long frame of the conveyor belt (4), that can be moved horizontally and vertically on a support column (20), so print them maximum maneuverability.



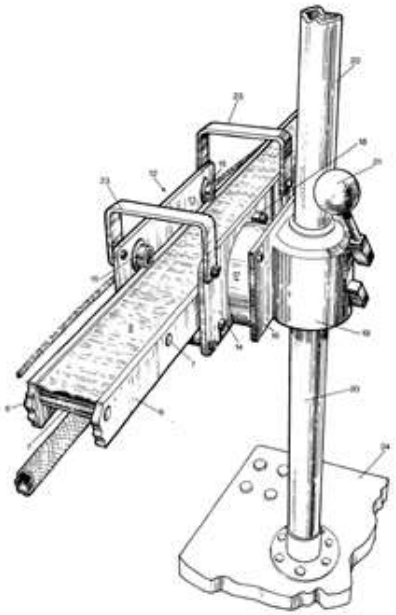
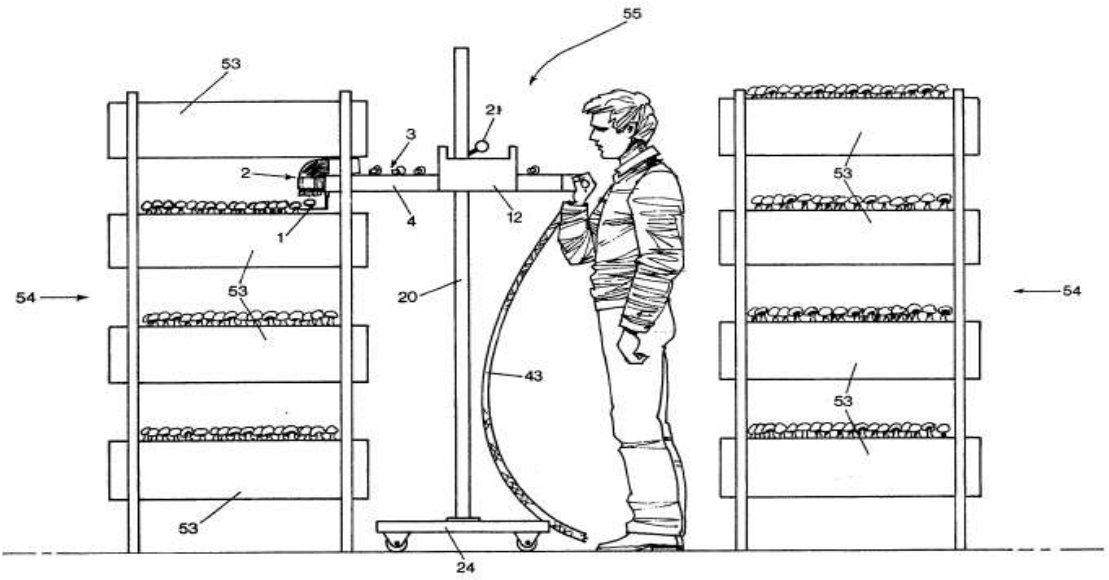


Fig. 2. Overall views of the MacCanna collector[3]
(http://brevets-patents.ic.gc.ca)

This device involves the presence of a human operator, who must conduct the appliance during the operation of harvesting, as shown in Figure 4.




3 European Patent Application, 83304230.2/21.07.1983, Applicant: Garran Entreprise Limited, 36-39* Fenian Street, Dublin 2 (IE); Inventor: MacCanna, Cathal, 72 St. Columbia's Rise, Swords County Dublin (IE)

Fig. 4. The operating mode of the device MacCanna (http://brevets-patents.ic.gc.ca)

In 1990, the Dutch inventor Van den Top , proposes a non-harvesting machine based on the principle of cutting the legs with an oscillating knife, with adjustable height. The machine has a drive device of mushrooms, made from rabator with brushes, incorporating mushrooms from the culture, they push them on the oscillating knife cutting area and ascend on the conveyor belt. The distance between rabator brushes is chosen to wrap aged mushrooms, keeping them upright to get up to their release on the conveyor belt with the tape. The equipment presented in figures 5 and 6, is equipped with a drive motor of rabator, oscillating knife and belt conveyors. The horizontal movement of the machine is ensured either by a separate engine type winch, giving rise to a traction cable, or through an external fixed shelf winch that pulls the machine using an external cable.

If this type of harvest must follow strictly the cultivation technology, aiming to the development and growth of mushrooms to be more homogeneous. The machine harvested all the mushrooms on the layer of culture, and their sorting will be done with another machine. In the ideal cases, minimum 70-75% is intended for the market of mushrooms "fresh" and only 25-30% for processing. If you want the full processing of mushrooms, the harvesting can be done from the cufflinks to maturity phase.

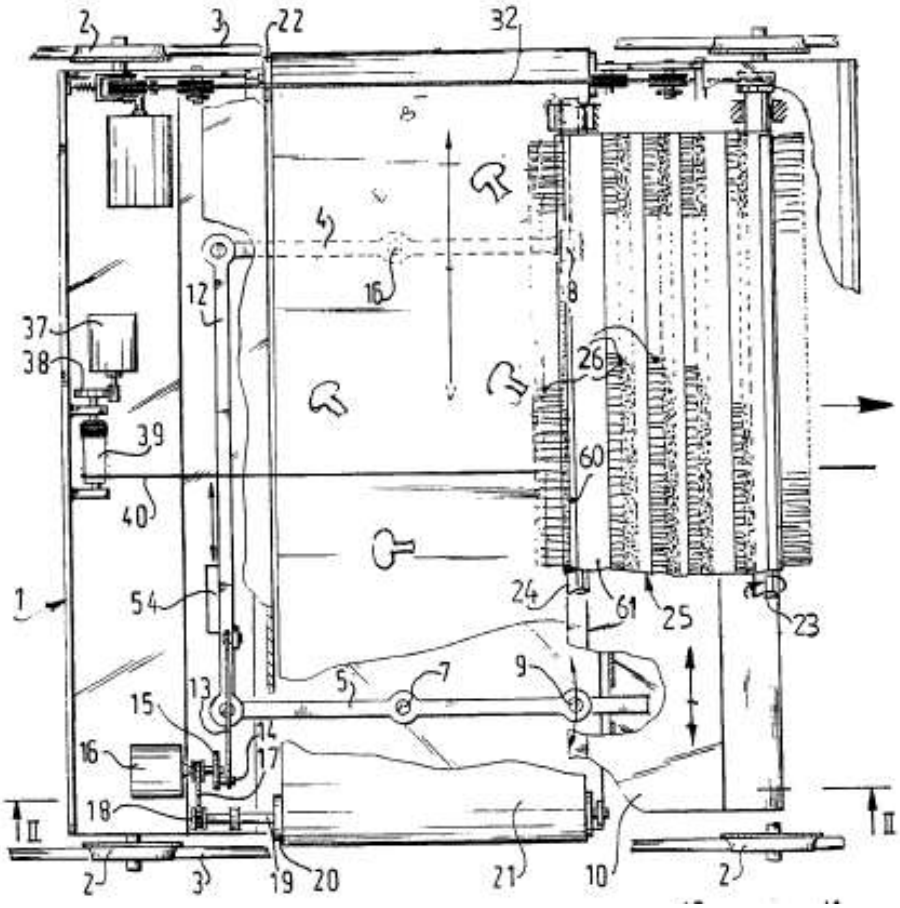



Fig. 5. Top view with partial section of the machine Van den Top (http://worldwide.espacenet.com).

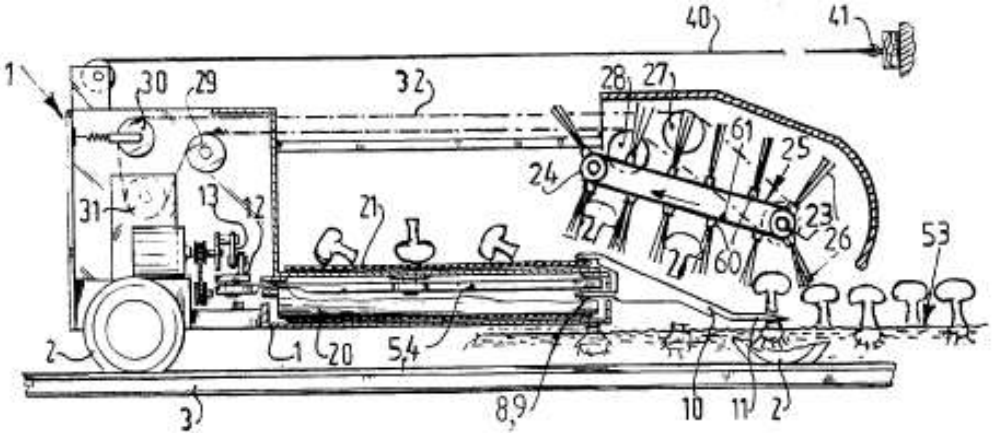



Fig. 6. Graphics section of harvesting machine Van den Top[4] (http://worldwide.espacenet.com).

4 European Patent Application, 90202566.7/27.09.90; Applicant/Inventor: Van den Top, Hendrik, Bellstraat 19, NL-3771 AH Barneveld (NL)

In both cases, after the harvest it takes a further operation of the remaining stems and coverage with peat of affected areas. In 2005, the same inventor, Van den Top presents a modernised harvested mushrooms machine , derived from the previous patent, with major improvements to the system of swing (9), of the system of adjustment of working height (5) and with a revolutionary retrieval system of mushrooms (90). The operating speed is increased significantly reaching 1800 kg/h, the percentage of damaged mushrooms significantly reduced (3-5%) and thanks to retractable collection system, it can be used in the most intensive farming systems. Currently this is the most used machine in modern mushrooms farms in Europe.

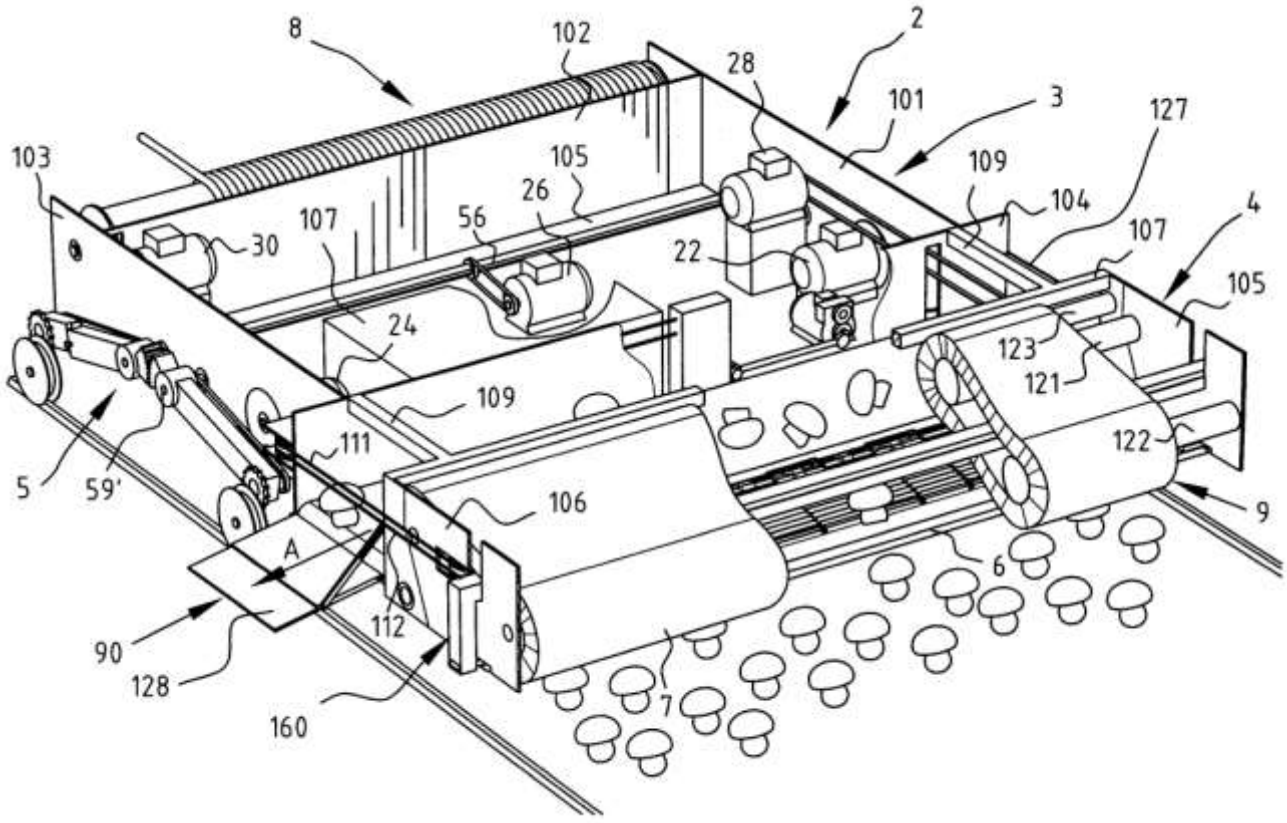



Figure 7. Sectioned perspective of the harvesting machine Van den Top[5] (2005) (https://data.epo.org/publication-server).

5 European Patent Application, 05075466.2/25.02.2005; Applicant/Inventor: Van den Top, Hendrik, Bellstraat 19, NL-3771 AH Barneveld (NL)

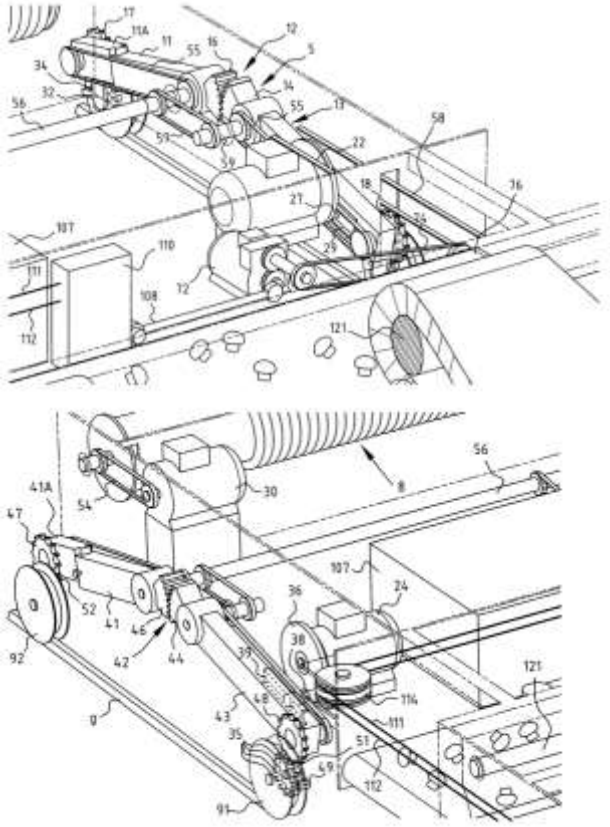


Figure 8. Detail of sectioned perspective of the harvesting machine Van den Top (2005) (https://data.epo.org/publication-server)

Based on this patent, the company VAN DEN TOP MACHINEBOUW BV of the Netherlands, has developed a performing machine called harvesting machine BQ 1045, shown in Figure 9. This machine, combined with a system of shelves in "zig-zag", also patented by the same firm, reaching a rate of harvest of up to 2000 kg/HR.

Figure 9. Mushroom harvesting machine Van den Top BQ 1046 (http://eng.topmachinebouw.nl/harvestingmachinebq.html)

In 1993 the European Union has provided funding from the Silsoe Research Institute United Kingdom to develop an automatic system of mushroom harvesting. A group of bio-engineers has developed a robotic harvesting system, able to automatically locate, develop, select, collect, trimming hedges, carry, and to carry out the transfer of mushrooms in boxes. Since 1995 the performance tests for this robot pilot project of harvesting were conducted at two different locations: the Research Institute for horticulture, Wellesbourne, United Kingdom and on a growing mushrooms farm in Netherlands. . In the two locations was performed a total of 2975 harvesting tests and in 2427 cases have met the conditions of the harvest (a rate of efficiency of 80%). During the agricultural trade studies, 75.7% of the harvest was carried out with this robot. The percentage of damaged mushrooms robotic harvested, was significantly lower than those collected manually. The overall success of the agricultural studies, clearly demonstrates that the technology of robotic picker is now possible (Reed, 2001).


Fig. 10. The robotic picker
http://www2.warwick.ac.uk

After taking over the London laboratories University of Warwick, researchers from the engineering section of the horticultural production, Warwick HRI, Warwick Manufacturing Group, are working on a series of robotics and automation products, that will substantially reduce the costs of the farmers, including upgrading the robotic arm of harvested mushrooms.

The robot, shown in Figure 10, uses a camera that scans the area of cultivation and selects only the mushrooms according to the size of the set. The mushrooms are then taken over by a suction cup on a robotic arm. While picking up speed is currently just over half of that of a man, the robot can be set to operate 24 hours a day. Researchers also hope to increase the speed of picking the nearest to that of a human worker.

## CONCLUSION

Mechanization and automation of work of harvesting in the modern mushrooms farms are the main solutions to reduce expenditure from this branch of agriculture. Of course that should be a relevant financial analysis, for each country, taking into account the hourly rates charged and the level of investment. Robotic systems will enable the improvement of working conditions for gatherers and will eliminate most of the currently security problems existing in the present (Ex: working at height, allergies, handling of the heavy buckets ). Since the robots can work 24 hours a day, it will increase the flexibility of delay, especially in the peak period of the first waves and will eliminate or significantly reduce the overtime work.

The quality of mushrooms harvested using machines is superior to those harvested manually due to damage during handling.

## REFERENCES


1. **Azoyan, Areg**, *Feasibility analysis of an automated mushroom harvesting system,* ATHENS, GEORGIA 2004 http: //athenaeum.libs. uga.edu/bitstream
2. Economic Research Service Data, *Mushroom Statistics, 5/20/03*, Washington DC, web source (http://www.ers.usda.gov/catalog/)
3. **Farrar, J.** *Economics of mushroom production crop year 1997. Farm business Unit*, CAFRE School of economic studies, The University of Manchester, Manchester, UK, 1997.
4. **Flegg, P. B., Spenser, D. M., Wood, D. A.** *The biology and technology of the cultivated mushroom.* Oxford, Oxford Press, 1985.
5. **Lucier, G., Allshouse J., and Lin, Biing-Hwan**, *Factors Affecting U.S. Mushroom Consumption*, Outlook Report No. (VGS295-01), March, 2003, web source (http://www.ers.usda.gov/publications/VGS/mar03/vgs29501/)
6. **Noble, R., Burton, K.S.** *Postharvest storage and handling of mushrooms: physiology and technology.* Postharvest News and Information, 4(1993):125-129.
7. **Reed, J.N., Crook, S.** *Harvesting mushrooms by robot*. Proceedings of the 14th International Congress on the Science and Cultivation of Edible Fungi, Oxford, 1995, Vol. 1, pp. 85-391
8. **Reed, J.N.; Tillett R.D.** *Initial experiments in robotic mushroom harvesting*. Mechatronics 4(1998):65-279
9. **USDA**, *National Agricultural Statistics Service, Mushrooms 1995 –2003,* Washington DC, 2003 web source (http://jan.mannlib.cornell.edu/reports/)
10. ***http://brevets-patents.ic.gc.ca
11. ***http://data.epo.org/publication-server
12. ***http://eng.topmachinebouw.nl/harvestingmachinebq.html
13. ***http://global.soopat.com/
14. ***http://www.freepatentsonline.com
15. ***http://patent.ipexl.com
16. ***http://worldwide.espacenet.com