Технічні науки

Jowett Chris

Senior SRE Architect

San Antonio, Texas, USA

DEVELOPMENT OF COMPLEX TECHNICAL SYSTEMS

Summary. *Development of Complex Technical Systems Using Computer-Aided Design Programs with Elements of Artificial Intelligence.*

Key words: *Complex Technical Systems, Computer-Aided Design Programs, Design Programs with Elements of Artificial Intelligence, Definitions and Laws of Development of Technical Systems, Machine Design Systems, Local Programmable Processors, Central Processor of a Complex Technical System of a Higher Level, Diagram of an Automated Robotic Manufacturing Assembly Complex, Technical Systems with a Rigid Production Cycle.*

Introduction. The nature of the construction and interaction of local technical solutions within each subsystem is fundamentally determined by the laws of developing technical systems, formulated in TRIZ (Theory of Inventive Problem Solving).

The work cycle of each module is coordinated with the step (work cycle) of the assembly module – the conveyor; This applies to both traditional complex modules of vibrational bunkers (in the Fig. - on the left), and fundamentally new modules for stamping contacts and feeding them onto the assembly and control conveyor (in the Fig. – in the center);

Such a diagram of an automated robotic manufacturing assembly complex can be attributed to technical systems with a rigid production cycle, with all technological modules of the complex tied to the step of the assembly module - the conveyor;

In this diagram, the technological modules perform the functions of subsystems, and the assembly module - the conveyor performs the tasks of leading supersystems under the production cycle of which the subsystem modules are adjusted;

Here's the English translation of the table of contents:

Development of Complex Technical Systems Using Computer-Aided Design Programs with Elements of Artificial Intelligence

In order to form complexes of specialized technological equipment in accordance with modern requirements and at the same time preserve the possibility of applying TRIZ and ARIZ, it is necessary to analyze, at a minimum, the definitions and laws of the development of technical systems in combination with machine design systems with elements of artificial intelligence.

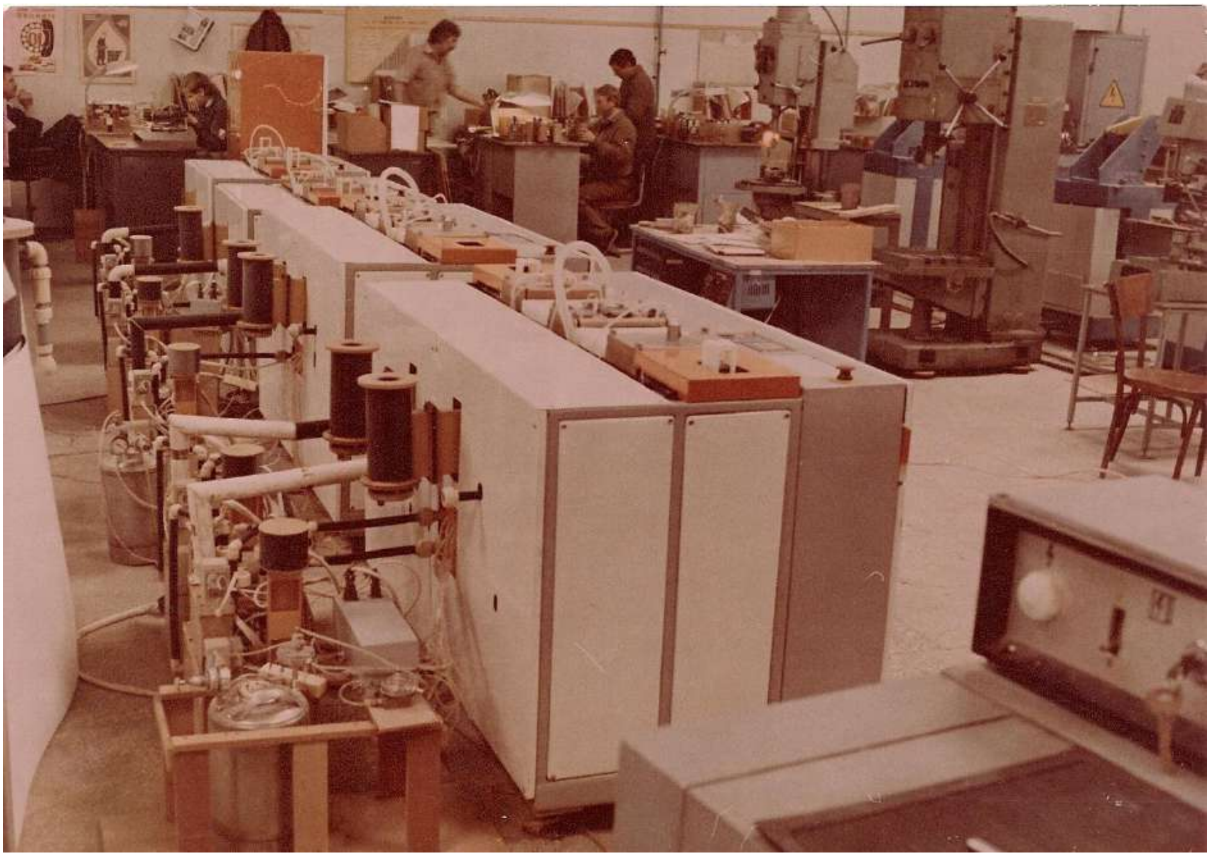

Fig. 01. The Fig. shows an automated line for applying galvanic coatings to thin-film micro assemblies; This is a complex technical system of a higher level, including a series of interconnected technical systems according to the technological cycle, which are in the status of dual parallel local supersystems, each including two lines - chemical and mechanical - in combination with galvanic

Accordingly, each of these dual parallel local supersystems consists of a multitude of local technical systems - subsystems - connected with local programmable processors to the central processor of the complex technical system of a higher level.

The nature of the construction and interaction of local technical solutions within each subsystem is fundamentally determined by the laws of the development of technical systems, formulated in TRIZ.

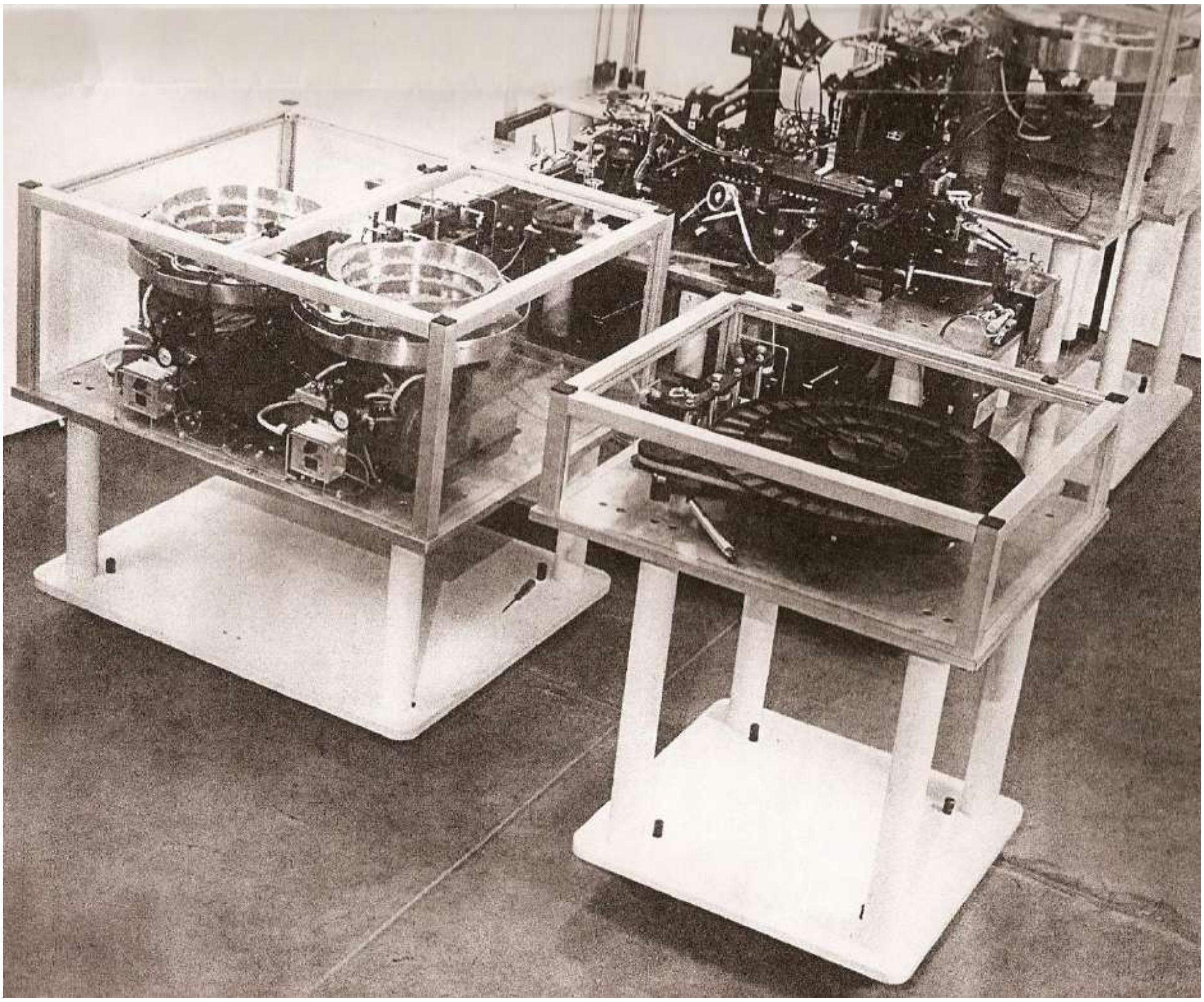

Fig. 1. The Fig. shows the technological modules of an automated robotic manufacturing assembly complex designed for the autonomous production of contact blocks for telephone lines; As can be seen in the photo, the complex contains 4 main technological modules, of which 3 are modules for preparing parts and elements for assembly and are located around the assembly module - the conveyor;

Now, for a more detailed analytical review, it makes sense to return to examples of specific modern developments, taking into account the provided comments on the laws of the development of technical systems and with a certain modification of the definitions and classifications of TRIZ, proposed in the well-known publications of Oleksii Hrachov;

The work cycle of each module is coordinated with the step (work cycle) of the assembly module - the conveyor; This applies to both traditional complex modules of vibrational bunkers (in the Fig. - on the left), and fundamentally new modules for stamping contacts and feeding them onto the assembly and control conveyor (in the Fig. - in the center);

Such a diagram of an automated robotic manufacturing assembly complex can be attributed to technical systems with a rigid production cycle, with all technological modules of the complex tied to the step of the assembly module - the conveyor;

In this diagram, the technological modules perform the functions of subsystems, and the assembly module - the conveyor performs the tasks of leading supersystems under the production cycle of which the subsystem modules are adjusted;

As can be seen from the figure, even though there are enough points of contact and requirements for coordinating production cycles in the assembly complex, there are no regulatory requirements for increasing the degree of flexibility and regulation of the production cycles of the modules;

This diagram is characteristic of complexes of technological solutions with a constant work cycle, which makes it pointless to correct or change the timing of the production cycle;

Logically, for such complexes, there are no initial requirements for computerization, and they can successfully operate under the conditions of an automated production cycle with the mass production of identical products.

For a Technical System performing tasks of this kind, all the definitions of a Classical Technical System remain unchanged; The definitions and classification methods of the components of this system - supersystems and subsystems - also remain unchanged.

For the specific structure and features of an automated robotic manufacturing complex, it is necessary to note the existing elements of fundamental novelty in the overall technological scheme of the complex and the features of the product manufactured on it.

This primarily relates to the specifics of the contacts in the contact blocks;

As can be seen from the figure, a ribbon of special bronze with a high beryllium content is not stamped immediately in the stamping module but is only formed with a notch along the contact contour, after which the ribbon is transferred to a module (located on the other side of the assembly module - the conveyor), where it is finally formed into paired contacts and inserted into the corresponding cells of the conveyor, into which pre-installed plastic parts of the contact block are already placed.

This is a fundamentally new solution for complexes of this kind, which allows maintaining a constant production rate of contact blocks and does not require intermediate real-time control.

For the classification of a modern automated robotic manufacturing assembly complex designed for the autonomous production of contact blocks for telephone lines, it is possible to use the updated definitions of Technical Systems and their constituent elements, developed and proposed by the well-known researcher and innovation specialist Oleksii Hrachov in his publications;

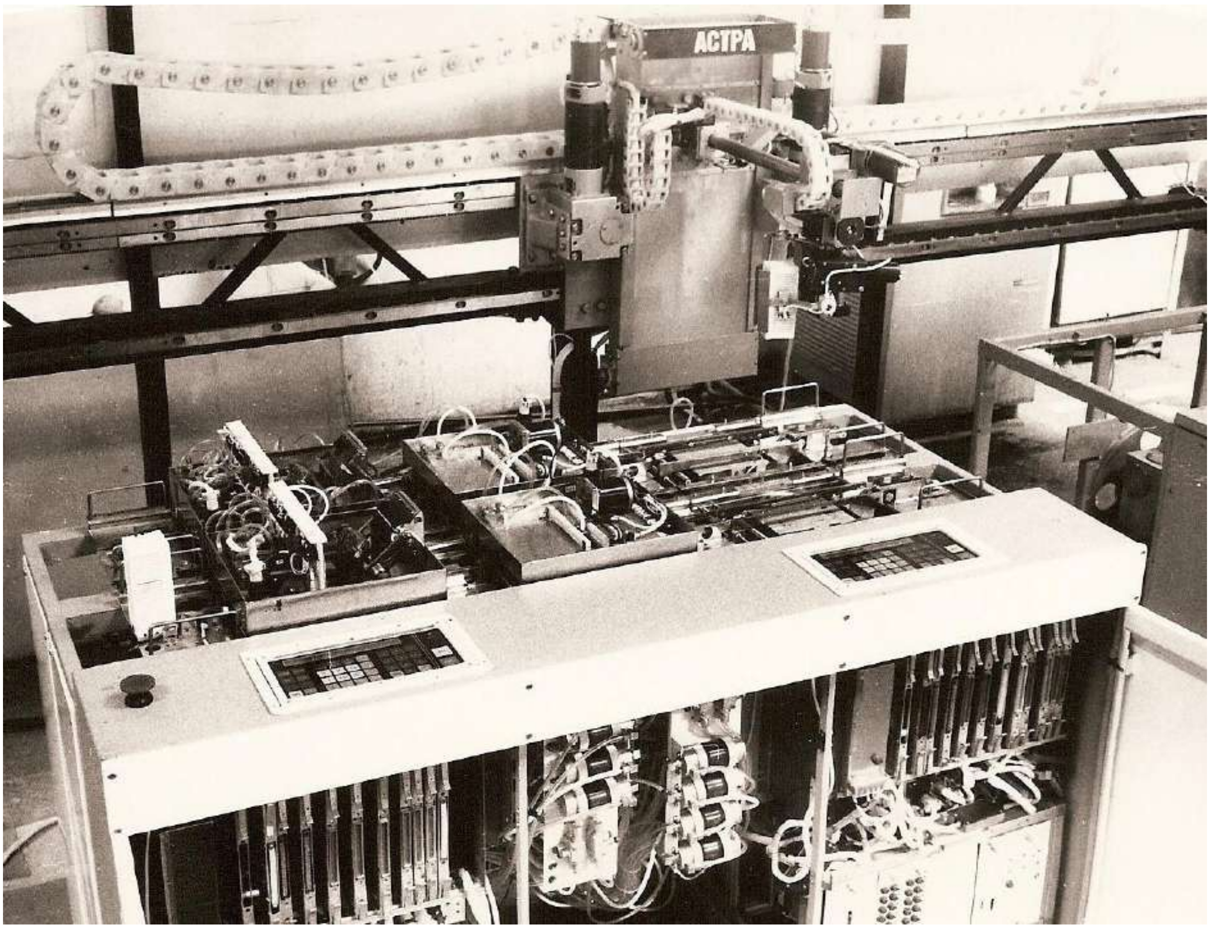

Fig. 2. The Fig. shows a variant of a Flexible Technological Module for photolithography on thin-film microassemblies; The module includes two parallel technological flows, and it is necessary to note the complete autonomy of each of the flows, including independence from each other for the controlling complex computer systems; In addition to these systems, the module also includes a computer control system and a robot-operator, functionally connected to the controlling complex computer systems

The specified module includes several closely related functional technical systems, each of which can be qualified as a supersystem.

The totality of these systems includes - loading and unloading modules, local loading and unloading units, tracks, centrifuges, dosing and feeding units for chemical reagents and photoresist onto the centrifuge table, control systems, etc.

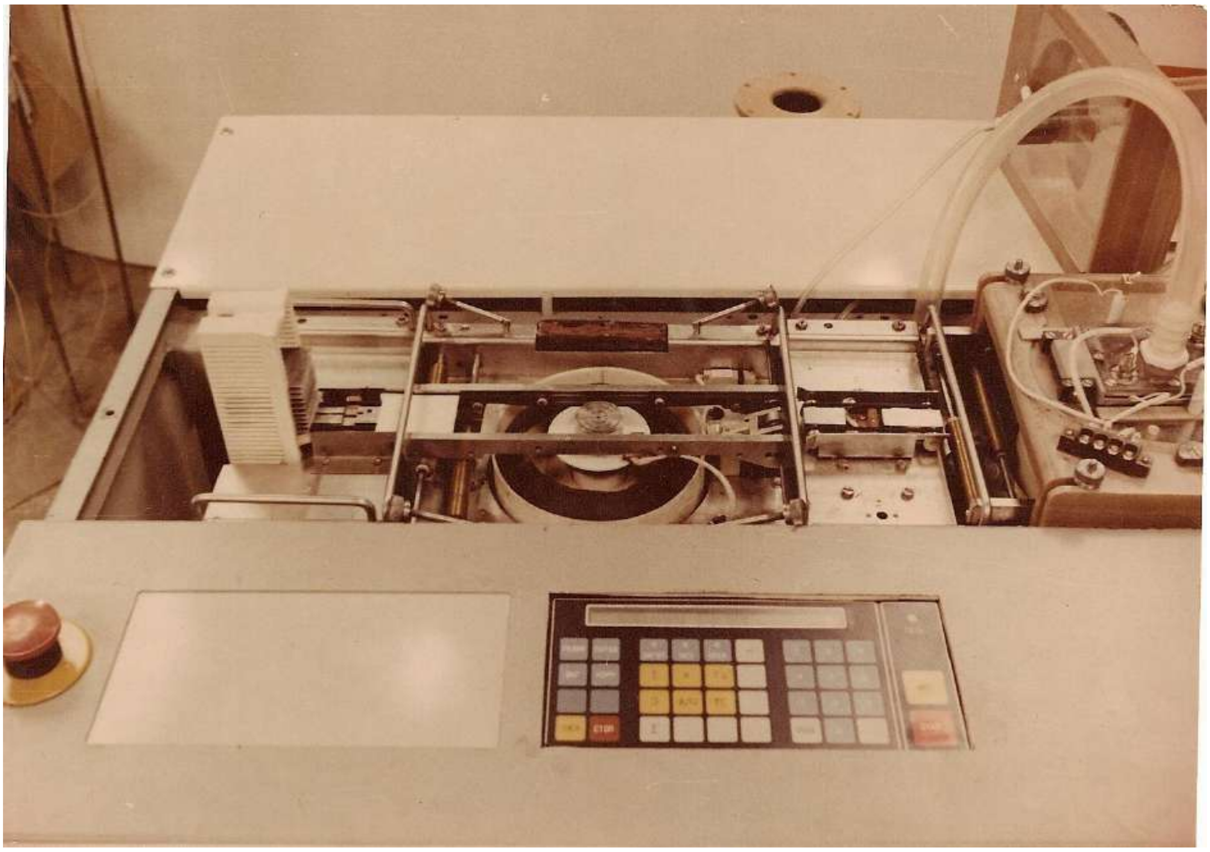

Fig. 3. The Fig. shows the working track of an installation for galvanic coatings on thin-film micro assemblies; The working track includes an autonomous device for loading and unloading plates, installed at the input and output of the process

The track includes several centrifuges - a working position for preparing surfaces for coating, a working position for galvanic coating, and a working position for final processing of the plates after coating;

The system is fully automated and is operated and controlled by programmable processors connected to a power source for the galvanic process, with flexible regulation of current density depending on the area and thickness of the coating;

The system has two working flows, of which only one is shown in the figure; The system is operated, configured, and controlled using several programmable controllers, information, programs, and commands which are entered via a touchscreen;

It is important to note that each local technical system, even in the status of a low-level subsystem, due to the high level of unification and standardization, possesses a high potential for integrative adaptation in the technical systems of the entire hierarchy, determining the composition and functional characteristics of the leading hierarchy supersystems.

Due to the fact that in specific production situations, the development of prototypes of such equipment is usually carried out at the level of invention, the correct definition and systematic qualification and classification of all new technical solutions and their combinations in technical systems of all levels of the hierarchy are extremely important.

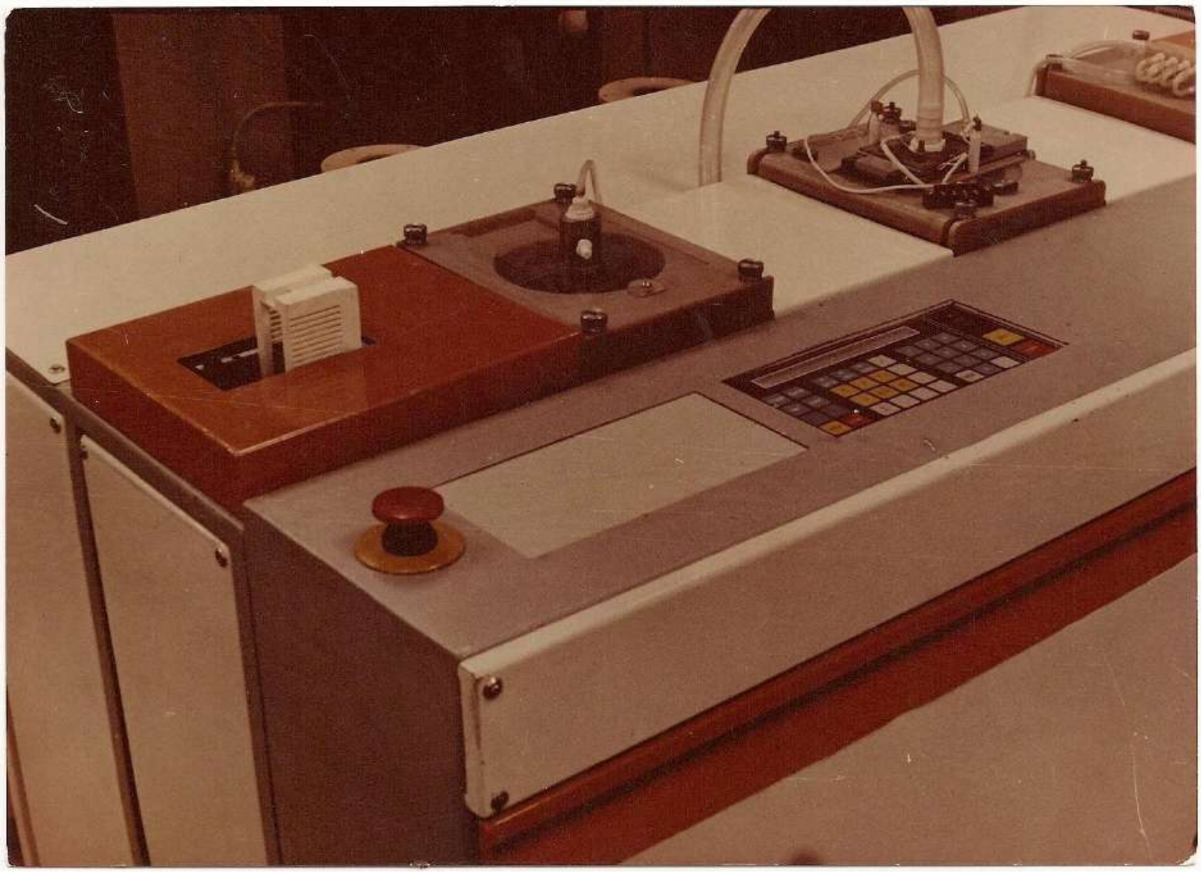

Fig. 4. The Fig. shows an automated installation, consisting of two technological flows, with a flexible and independent control and monitoring option, for applying galvanic coatings to thin-film micro assemblies in semiconductor manufacturing conditions; This installation can be integrated into flow-type flexible technological modules, which in turn can be integrated into higher-level systems

As can be seen from the figure, the workpieces of thin-film micro assemblies, made of special ceramics (size 48 X 60 mm), are contained in cassettes that are installed at the beginning and end of the technological flow;

Thus, the participation of an operator in the process is not required, as all loading and unloading operations are performed with the help of a robot operator, and the control of all operations and the sequence of executing control commands are carried out by a programmable processor, contact with which is made through a touchscreen control panel.

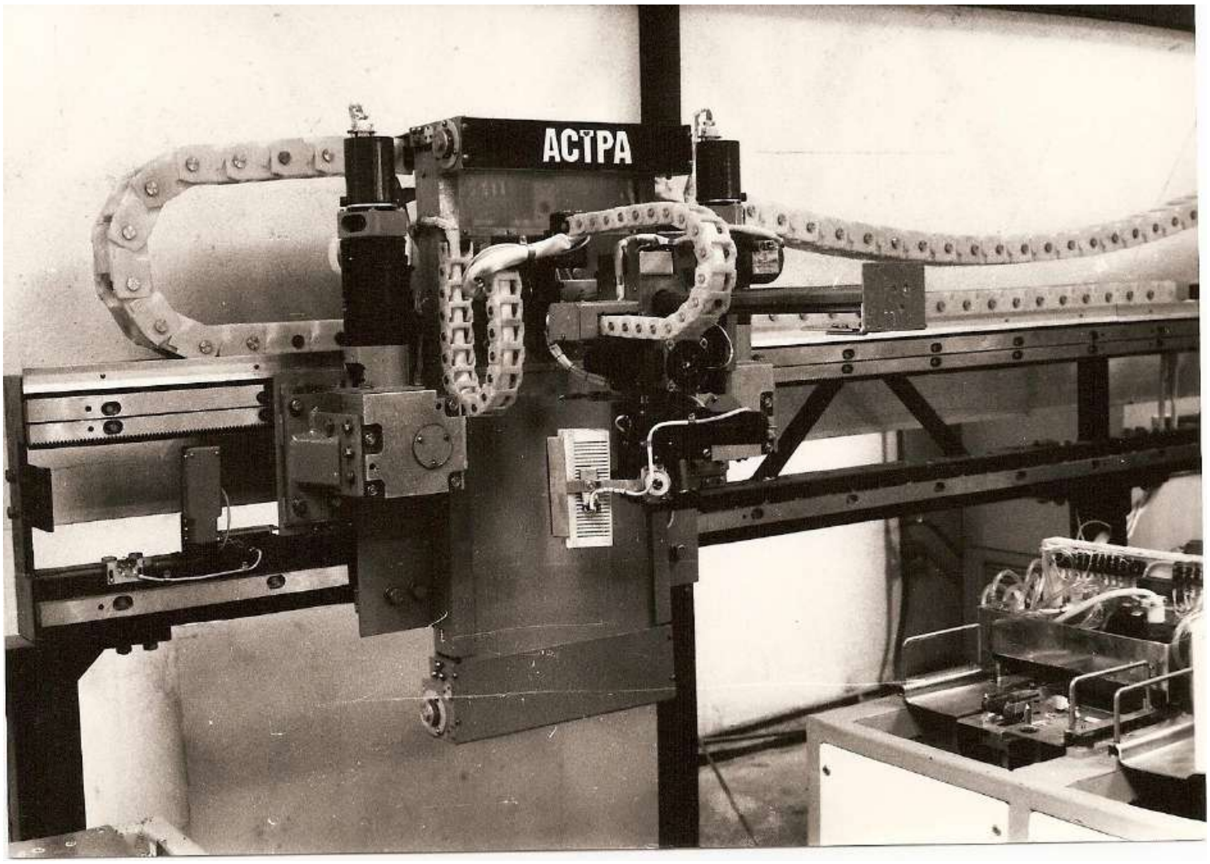

Fig. 5. The Fig. shows a flexible automated technological module from the side of the input devices, onto which a loading-unloading robot installs a cassette with workpieces for thin-film microassemblies

The robot manipulator picks up a cassette from a storage cell and moves it to a position aligned with the table of the input device, after which it lowers the cassette into contact with the table and fixes its position.

The shown combination of local technical systems is qualified as a combination of subsystems, connected into a local, but - a supersystem, due to a specific flexible algorithm of the entire complex and sequential process - searching for cassettes, identifying and gripping cassettes, moving cassettes, orienting the position of cassettes in three dimensions, orienting cassettes vertically, identifying cassettes on the table of the loading-unloading input device, and finally fixing cassettes on the table with the subsequent transfer of functions to the conveyor track.

All the specified operations are simultaneously a technical task for the development of the corresponding software.

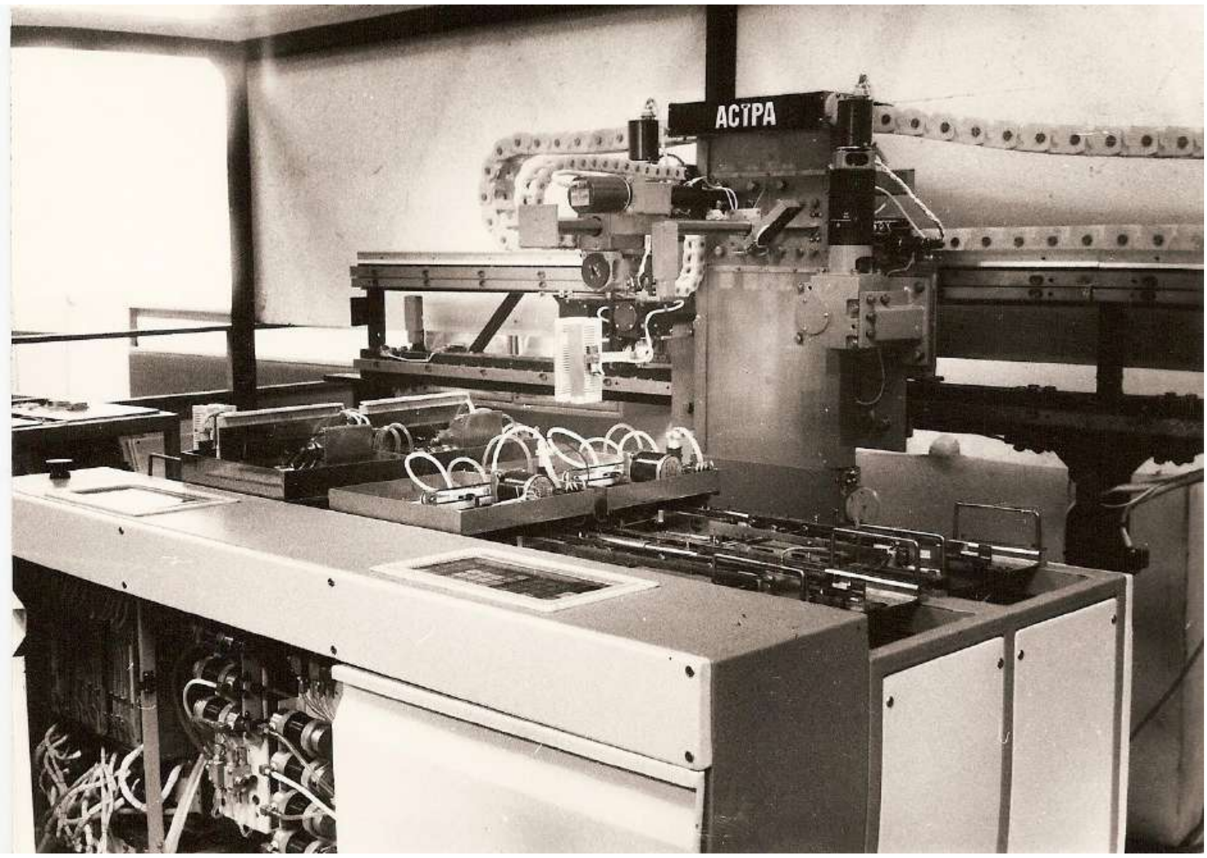

Fig. 6. The Fig. shows the technical solutions that are part of and form the transport technical systems of all levels of a flexible automated technological module, starting from the transportation of workpieces of thin-film microassemblies from the loading-unloading module to the working positions and ending with a complex transport technical system of a robot manipulator, capable of being adapted to installations of another technological direction and to computerized control and dispatching regulation systems

As a rule, systems of this kind have quite diverse variants of basic technical solutions, the combinations of which with technical solutions possessing global novelty allow qualifying specifically complex variants of technical solutions in various combinations and configurations as inventions.

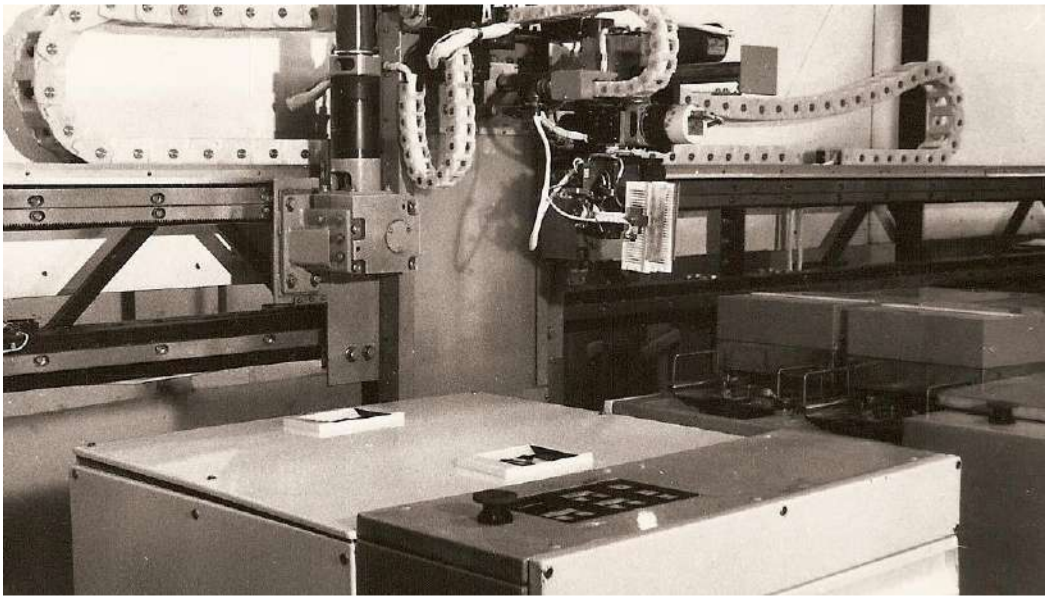

Fig. 7. The Fig. shows the combination of complex transport technical systems of a flexible automated technological module with transport-orienting systems of the storage module - as universal supersystems

The strategy of patent (technical) and licensing (legal) protection in such a configuration of ascending and descending flows in the scale of hierarchies of higher-level supersystems - technical solutions is very dependent on a clear and (technically correct) qualification of the entire indicated complex of technical systems and their functional connections among themselves, which is much more important than their connections with the definitions and formalized varieties and types of technical solutions - entering higher-level systems - subsystems and connecting links in supersystems - technical solutions at the junctions of local and sufficiently autonomous technical systems.

Finally, the presence of controlling and monitoring programmable controllers and processors increases the level of technical systems from a local technical system to a smart technical system.

All of the above shows how substantial the analytical work performed by Alexei Grachev in his pioneering analytical research is; his developments on fundamental issues of classification and systematization of types and characteristics of technical systems, defined for each level of technical systems, are important for the systematic continuation and further optimization of machine design processes using new design computer programs in combination with new principles and methods of digital technologies and their combinations with the terminology and laws of development of technical systems available in TRIZ and ARIZ.

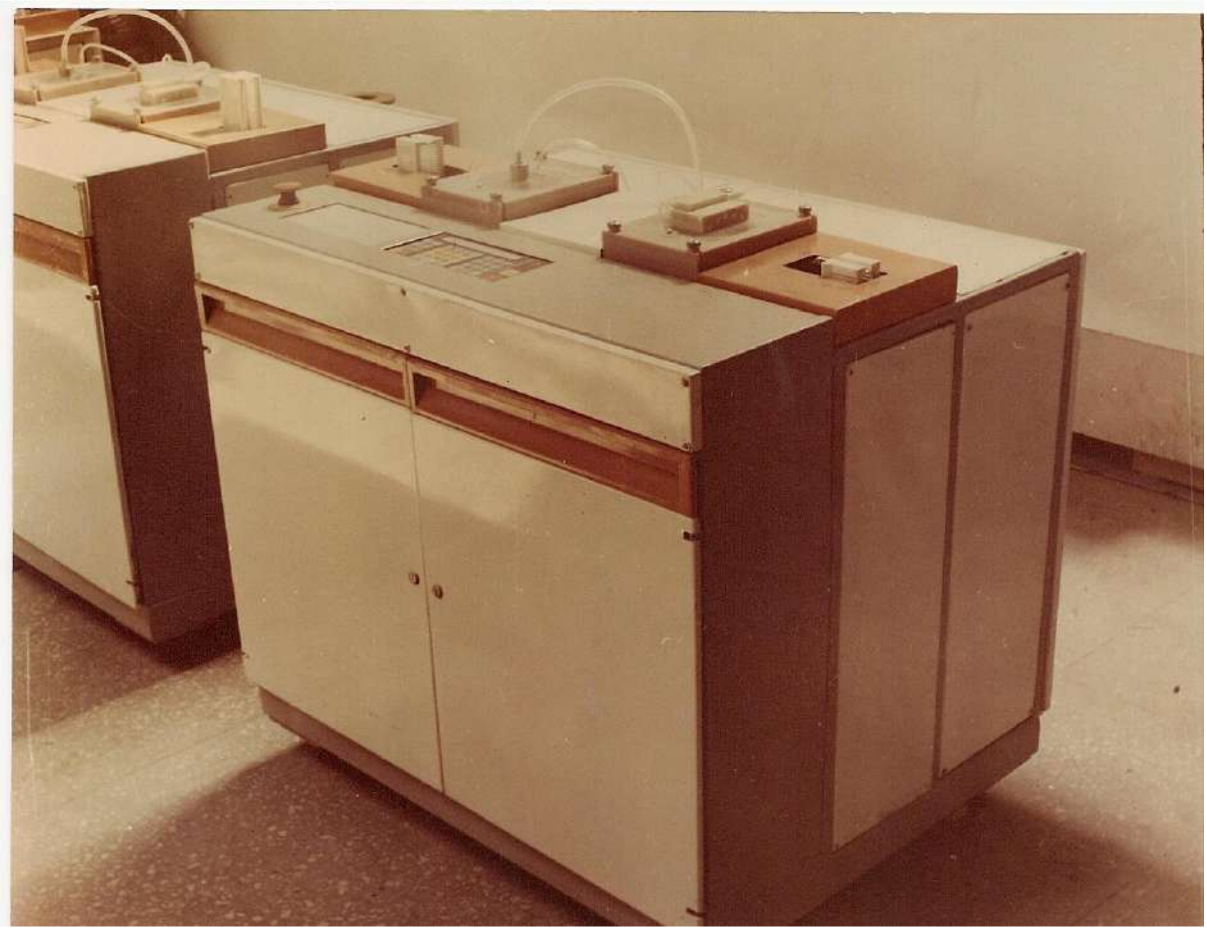

Fig. 8. The Fig. shows a flow-type automated production line for a full cycle of photolithography and chemical-mechanical processing on thin-film micro assemblies with a flexible organization of the local technological process within each unit included in the line; According to the TRIZ classification, the line is a technical system of a higher level of the hierarchy - a supersystem, each unit within the line is a technical system of a medium level of the hierarchy - a supersystem, and each working position is a technical system of a lower level of the hierarchy - a subsystem

In turn, in the order of increasing the level of the system in the hierarchy, each subsequent ascending system is a supersystem, and each preceding system in the hierarchy is a subsystem.

Such a strict classification to a significant extent unifies the logical and technological interrelation between technical systems of all levels and allows for the extreme unification of program and system interconnections between processors and programmable controllers of all constituent parts of automated installations and modular technical systems included in the line of auxiliary elements.

When transitioning from a system flow-type automated line to a system-flexible automated technological module, all classification definitions and formulations retain their meaning.

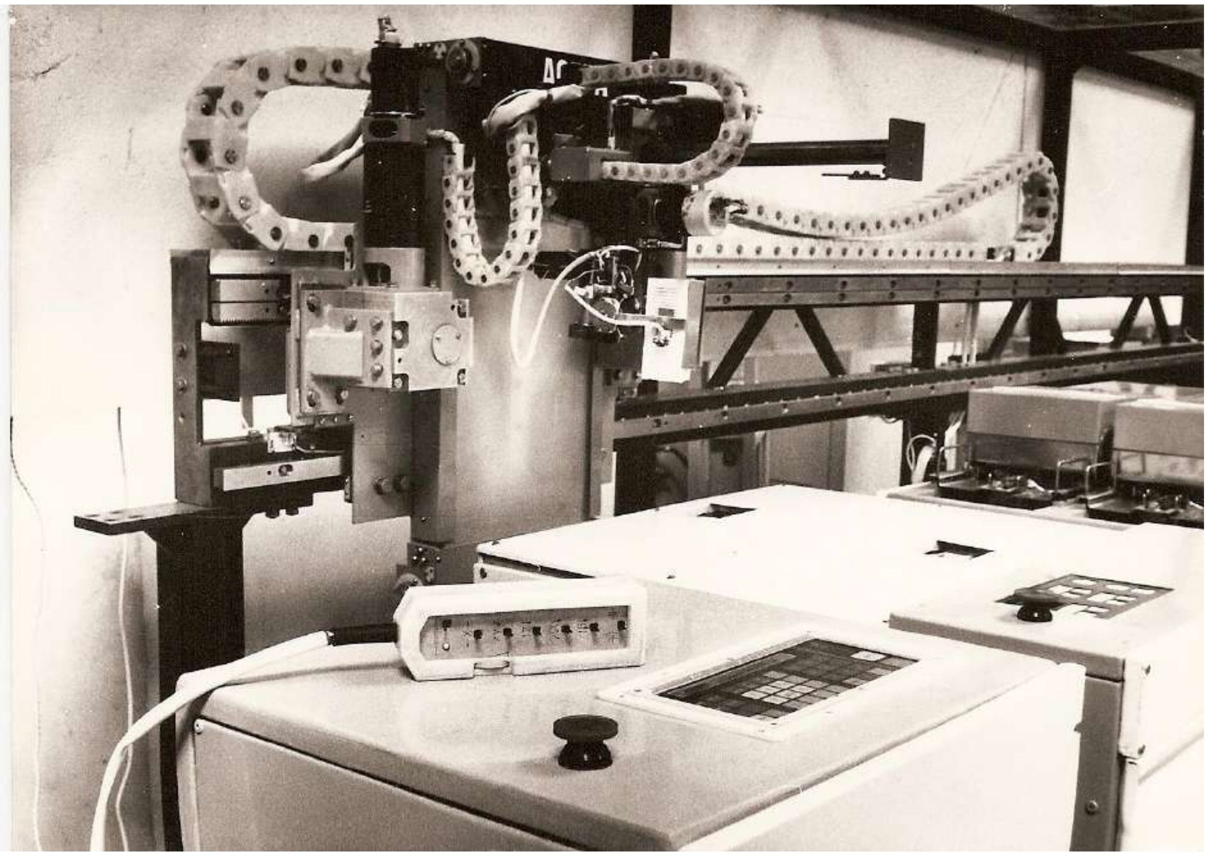

Fig. 9. The Fig. shows a fragment of a flexible technological module for photolithography on thin-film micro assemblies, illustrating the fundamental solution to the issues of loading and unloading working positions with the help of a robot operator, which picks up a cassette with wafers from the storage module and installs this cassette on the table of the loading device of the technological flow; The same process occurs in the reverse scenario - picking up a cassette with processed wafers and installing it in the storage module

As can be seen from the figure, the storage modules have sealed cells for cassettes and contain controlling programming processors that monitor the processing and send signals to the conveyor of the storage module regarding cells to be filled or emptied of cassettes.

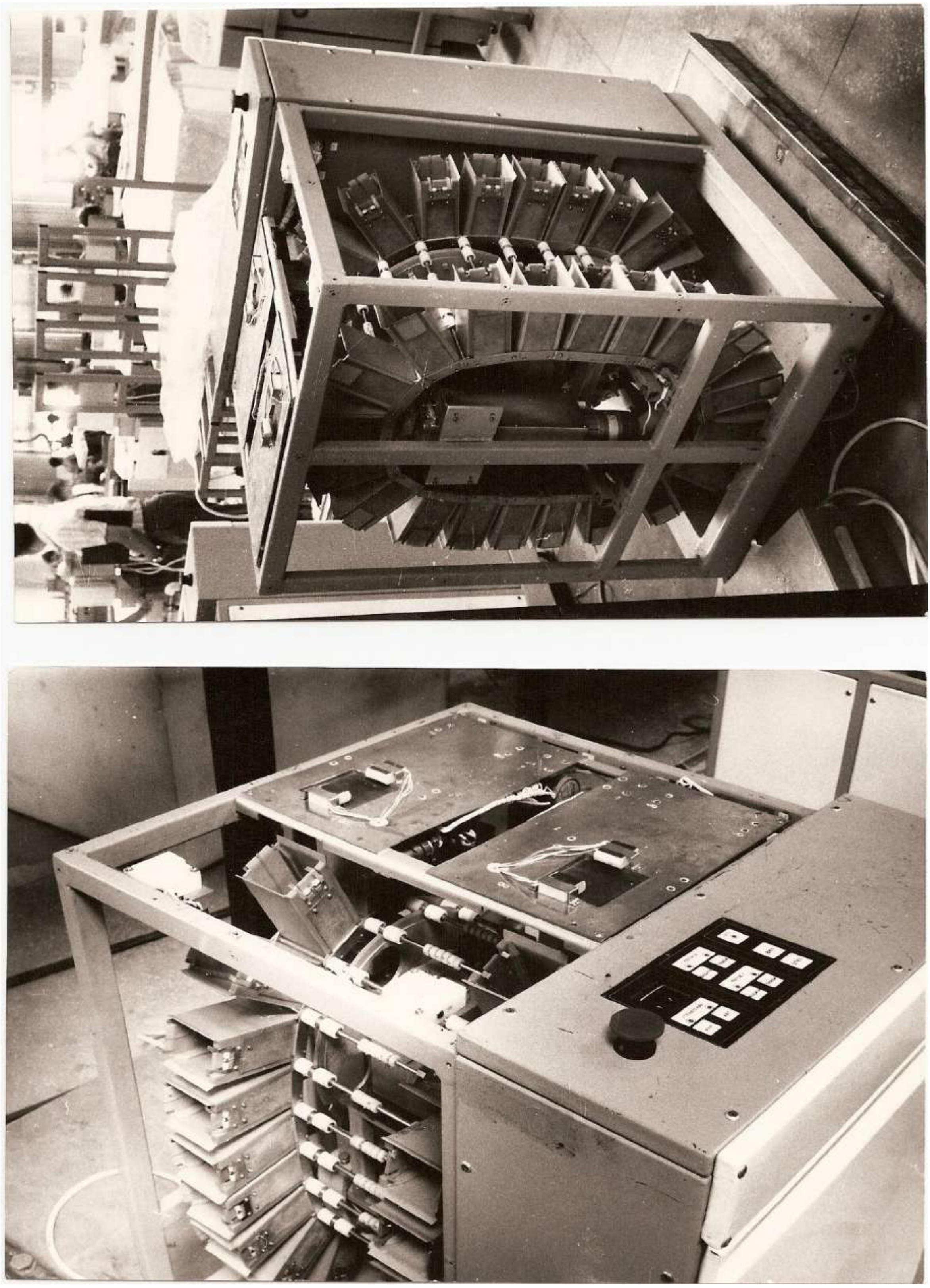

Fig. 10. The Fig. shows the internal structure of a storage module; As can be seen from the figures, the storage module has a vertical conveyor in which cells are fixed, where cassettes with workpieces are installed or from which they are removed

This technical system has been repeatedly tested, and upon its detailed analysis, it can be seen that, in principle, all compositional, schematic, and constructive technical solutions of the constituent parts of the flexible automated production technological module, in terms of their design, functions, composition, and operation methods, practically correspond to the classifications and terminology, as well as the structure of modified technical systems and their definitions, formulated in the works and publications of Oleksii Hrachov.

The analysis will not be complete if we do not follow the standard process of developing a new technical solution that is part of a higher-level compositional and component technical system and consider the corresponding formulations and definitions with the modified formulations and definitions of technical systems of all levels proposed by Oleksii Hrachov;

List of References and Patent Information Used:

Appendix 1

20180321666

United States Patent Application
Kind Code **A1**
Cella; Charles Howard ; et al. **November 8, 2018**

METHODS AND SYSTEMS FOR EQUIPMENT MONITORING IN AN INTERNET OF THINGS MINING ENVIRONMENT

Abstract

An apparatus, methods, and systems for data collection in a ***production*** environment are described. The system may include a data collector communicatively coupled to a plurality of input channels, wherein a first subset of the plurality of input channels are connected to a first set of sensors measuring operational parameters from a ***production*** component, a data storage structured to store a plurality of collector routes and collected data, a data acquisition circuit structured to interpret a plurality of detection values from the collected data of the ***production*** component, and a data analysis circuit structured to analyze the collected data and evaluate a first collection routine of

the data collector based on the analyzed collected data, wherein based on the analyzed collected data the data collector makes a collection routine change.

Appendix 2

United States Patent Application	**20180284753**
Kind Code	**A1**
Cella; Charles Howard ; et al.	**October 4, 2018**

METHODS AND SYSTEMS FOR DATA STORAGE AND COMMUNICATION IN AN INTERNET OF THINGS CHEMICAL PRODUCTION PROCESS

Abstract

A system, method and apparatus for data collection related to a chemical ***production*** process are described. The system may include a cross point switch including a plurality of inputs and a plurality of outputs, a plurality of sensors operatively coupled to at least one of a plurality of components of the chemical ***production*** process, a sensor data storage profile circuit structured to determine a data storage profile, wherein the cross point switch is responsive to the data storage profile to selectively couple at least one of the plurality of inputs to at least one of the plurality of outputs, a sensor communication circuit communicatively coupled to the plurality of outputs of the cross point switch, and a sensor data storage implementation circuit structured to store at least a portion of the plurality of sensor data values in response to the data storage profile.

Appendix 3

United States Patent Application	**20060036394**
Kind Code	**A1**
Chen; Wen-Ling ; et al.	**February 16, 2006**

Universal and integrated ***wafer*** testing real-time monitoring software system and its open system architecture

Abstract

A ***wafer*** testing real-time monitoring software system and its unique open software architecture which achieves real-time monitoring of ***wafer*** test results and on-***line*** changing of externally hooked software to satisfy customer needs without changing its main program. The software structure receives and processes binary files from different probers and converts these into readable ASCII files. The system consists of four software programs that can operate independently. These programs are an ***automatic*** transfer program, a program which converts ***wafer*** test results from a binary file to an ASCII file, a program which receives the ASCII files and performs ***wafer*** map editing, and an auto-ftp program which automatically scans data and sends data to remote locations. Additionally, multiple workstations can process data from probers simultaneously. The on-***line*** monitor on a ***production line*** can see ***production*** results from multiple major workstations through the network drive and drive mapping functions.

Appendix 4

United States Patent Application	**20070156272**
Kind Code	**A1**
Winstead; Charles H. ; et al.	**July 5, 2007**

Integrated configuration, flow and execution system for ***semiconductor*** device experimental flows and production flows

Abstract

According to embodiments of the invention, an integrated configuration, flow and execution systems (ICFES) may be used to specify, control and record a history of processing of both ***semiconductor*** device experimental lots and ***production*** lots of wafers. Moreover, the system allows combining of one or more partial flows of pre-existing flow blocks, and special processing into another processing flow block. A lot plan can be created that includes the flow block, and the lot plan can be updated to include partial flows and special processing before or during processing of the lot plan.

Appendix 5

United States Patent Application	**20060064188**
Kind Code	**A1**
Ushiku; Yukihiro ; et al.	**March 23, 2006**

Process-state management system, management server and control server adapted for the system, method for managing process-states, method for manufacturing a product, and computer program product for the management server

Abstract

A process-state management system encompasses: a plurality of ***production*** machines; a control server configured to collectively control at least part of the ***production*** machines; a management server including a data-linking module configured to link operation-management data of the ***production*** machines with corresponding management information transmitted from the control server, respectively, the management server analyze the operation-management data linked with the management information with a common analysis application; and a management database configured to store the operation-management data linked with the management information.

Appendix 6

United States Patent Application	**20170004985**
Kind Code	**A1**
NISHI; Shinichi ; et al.	**January 5, 2017**

PRODUCTION SYSTEM FOR PRINTING ELECTRONIC DEVICES

Abstract

An object of the present invention is to provide a printing ***production line*** system for an electronic device, the printing ***production line*** system that can achieve prevention of defective products caused by dust generated by a printing method and increase electronic device productivity, and a transport chamber provided with a robot transport ***line*** 100 in which a self-traveling robot 111, 112 that transports a base material 15 in a sheet-fed manner in a free state travels is provided, a plurality of processing chambers 6 for forming an electronic device on the base material 15 by printing are provided on at least one side of the transport chamber, a base material transfer area 601 that performs loading of the base material 15 to the processing chamber 6 from the self-traveling robot 111, 112 and unloading of the base material to the self-traveling robot 111, 112 from the processing chamber 6 is provided between the transport chamber and each processing chamber 6, the transport chamber and the base material transfer area 601 communicate with each other through an opening 602 in which a one-way air flow moving to the side where the processing chamber 6 is located from the side where the transport chamber is located is formed, and the one-way air flow in the opening 602 is formed by making an adjustment such that the air pressure in the transport chamber becomes higher than the air pressure in the base material transfer area 601.

Appendix 7

United States Patent Application	**20180133677**
Kind Code	**A1**
KIM; Ju Hee	**May 17, 2018**

APPARATUS FOR A MASS PRODUCTION OF MONODISPERSE BIODEGRADEABLE POLYMER-BASED MICROSPHERES AND A MULTI-CHANNEL FORMING DEVICE INCORPORATABLE THEREIN

Abstract

Provided is an apparatus for a mass ***production*** of microspheres and a multichannel forming device incorporatable therein. The apparatus comprises a multi-channel microsphere forming unit, a first source material reservoir containing the first source material and in fluid communication with the plurality of first microchannels, a second source material reservoir containing the second source material and in fluid communication with the plurality of second microchannels, a flow control unit configured to supply a first gas to the first source material reservoir at a first source material flow rate and to supply a second gas to a second source material reservoir at a second source material flow rate and a product reservoir for accommodating the microspheres formed from the multi-channel forming unit.

Appendix 8

United States Patent Application	**20150066592**
Kind Code	**A1**
Ehm; Hans ; et al.	**March 5, 2015**

METHODS OF ***SEMICONDUCTOR*** MANUFACTURING AND SUPPLY CHAIN MANAGEMENT SYSTEMS

Abstract

In various embodiments, a method of ***semiconductor*** manufacturing is provided. The method may include: gathering information impacting ***production of semiconductor*** goods via a computer network platform; gathering information from a social networking platform via an interface of the computer network platform to the social networking platform; modelling at least one agent of a manufacturing entity in carrying out its tasks to manufacture ***semiconductor*** goods; and determining manufacturing capacity of the manufacturing entity as a function of at least the gathered information impacting the ***production of semiconductor*** goods, the gathered information from the social networking platform and the modelled agent.

Appendix 9

United States Patent Application	**20080008837**
Kind Code	**A1**
SHIBA; Yasuhiro ; et al.	**January 10, 2008**

SUBSTRATE PROCESSING APPARATUS AND SUBSTRATE PROCESSING METHOD FOR HEAT-TREATING SUBSTRATE

Abstract

A substrate coated with a coating solution for an anti-reflective film is placed on a heat treatment plate and is heated. Nitrogen gas flows near the periphery of the heat treatment plate into a heat treatment space. An exhaust outlet is formed in an upper central portion of an inner cover, and the inner cover has an inner wall surface configured in the form of a tapered surface. This produces a smooth flow of nitrogen gas along the tapered surface to smoothly discharge a sublimate produced from the coating solution together with the gas flow

outwardly through the exhaust outlet. After the heating process for a predetermined period of time is completed, the cover moves upwardly, and support pins move upwardly to thrust up the substrate from the heat treatment plate, thereby spacing the substrate apart from the heat treatment plate. This gradually decreases the temperature of the substrate. The substrate is placed in a standby condition within a hot plate in this state until the substrate temperature is decreased down to at least a temperature at which the ***production*** of the sublimate from the anti-reflective film after firing stops, and thereafter a transport robot transports the substrate out of the hot plate.

Appendix 10

United States Patent Application	**20050264777**
Kind Code	**A1**
Gardner, Steven D. ; et al.	**December 1, 2005**

High speed lithography machine and method

Abstract

A machine and method for high speed ***production*** of circuit patterns on silicon wafers or similar substrates may be used for applications including printing Integrated Circuit (IC) packaging patterns onto wafers prior to separating IC chips. Projection camera(s) simultaneously project image(s) onto substrate(s) carried on an X, Y, .theta. stage. The projection camera(s) may include independent alignment systems, light sources, and control of focus, image placement, image size, and dose. In one embodiment, each camera inlcudes a 6-axis reticle chuck that moves a reticle to correct image-to-substrate overlay errors. In-stage metrology sensors and machine software establish and maintain the correct relationship among the machine's coordinate systems. Thus, two or more projection cameras can print simultaneously even when substrates are slightly misplaced on the X, Y, .theta. stage.