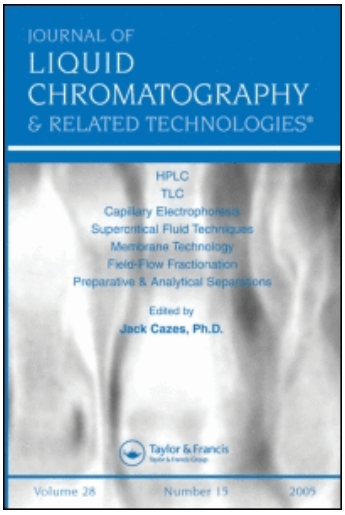

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Laboratory Robotics—An Overview

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LABORATORY ROBOTICS - AN OVERVIEW

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In recent years the word robot has become a well known laboratory 'buzz word'. What is it that makes Robots such a fascinating piece of hardware in today's laboratories? Is it the Star Wars humanized behavior that attracts so much attention? Or perhaps, the consistency and accuracy with which they perform those repetitive tasks such as sample preparations, titrations, assaying and dissolution testing? Whatever the case may be, robotics in the laboratory are here to stay and represents a growth area for robot suppliers worldwide.

As a member of the Robotic Industries Association (RIA), and a robotics supplier, I have been privileged to participate as both an exhibitor and visitor at several recent robotic trade show expos. Industrial robotics have been most prevalent in these shows.

Enter: Josco Smart-Arm Lab Robotics

Although Johnson/Josco is not the only lab robotics supplier in the marketplace, there are currently less than a half dozen that we are aware of that are presently focusing on this market. At

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the most recent Achema Show in Frankfurt, Germany, I was surprised to find there were little or no robotics systems on display. Apparently, the European laboratories are not yet desirous of this approach to lab automation, or perhaps lack the exposure. The U.S. obviously is pioneering the robot approach for handling materials and information in the lab. Today, lab Robotics is dominated by relatively few suppliers with both knowledge of robotics/systems and knowledge of laboratory requirements, and procedure. Zymark, Perkin-Elmer and Johnson/Josco satisfy the major market share at this time. The Josco® Smart Arm™ robot appears in Figure 1.

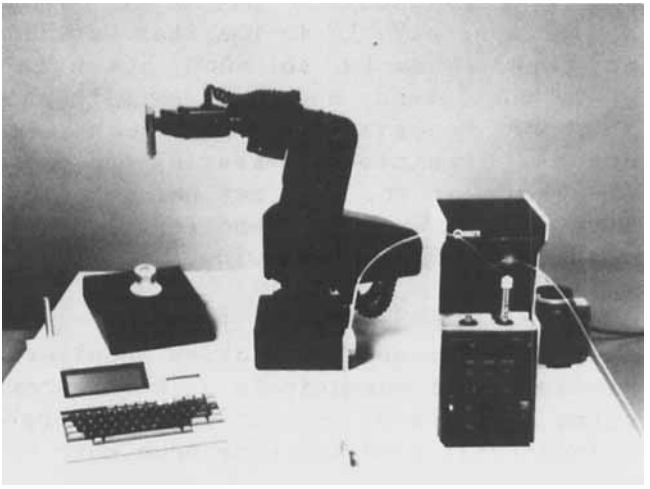

Figure 1. Josco® Smart Arm™ Robot.

What do lab robot suppliers have in common?

Applications remain similar:

Sample Preparation
Liquid dispensing
Dissolution testing
Titrations
Assays
Tablet Q.C. testing/hardness/wt., thickness, etc.
Liquid extraction
Dilution
Filtering
Micro-Batching

Robot Hardware: Remains similar in capacity, size, design, functionality, degrees of freedom, work envelope, etc.

Software: Most robots are programmed by use of a teaching pendant or computer controlled XYZ coordinates which brings the so-called "arm" to a desired location or "position." These positions are stored in computer chip memory (PROMS). A system controller such as the IBM PC, H/P, Apple, DEC, or Epson, etc. are generally provided to control the robot and place its "positions" in the proper sequence of events. Most suppliers use "Basic," a universal programming language, while others provide a custom language developed specifically for their systems. There are advantages and disadvantages to both approaches.

Peripherals: Although system suppliers and/or integrators provide similar types of peripheral hardware to perform specific tasks, today's lab robot purchasers are already in a position to be more selective and more demanding when it comes to accuracy, repeatability, quality, features, benefits

and performance. For example, several systems integrators may supply pipetting instruments for liquid dispensing. Some may also offer robot friendly centrifuging whereby the centrifuge always stops at an exact location which represents a common Robot 'position'. The question, however, is are all robot systems suppliers all offering the same performance? Is one supplier's pipetting as accurate as another? If not, then why not? Does the robot change hands/fingers, or does the robot provide special stations instead? One approach may be better than another in certain applications. The prospective user should investigate these approaches. Are we comparing apples with apples?

When purchasing a system it would be wise for the user to provide an accurate set of specifications, noting the required accuracies and results. In some instances it would also be wise to specify the peripheral devices required or preferred.

How Are Robot Stations Provided?

Generally speaking, the typical system consists of a table with a center-mounted robot surrounded with the required peripheral partners and trays and racks situated within its work envelope. Recent techniques also include mounting the robot arm on a lead screw track which is motor driven to transport the arm from one peripheral to another. This approach provides increased flexibility and is ideal in the lab counter-top. Additionally, it's advisable when only one robot is required to perform one task 60% of the time and another 40% of the time.

Figure 2 shows a typical robot layout as provided by our company. Peripheral placement is critical in that all 'work stations' must be

accessible by the robot/arm. Since 'arm-reach' and 'work envelopes' are restricted, peripherals are often clustered very closely together in order to accommodate all that are required.

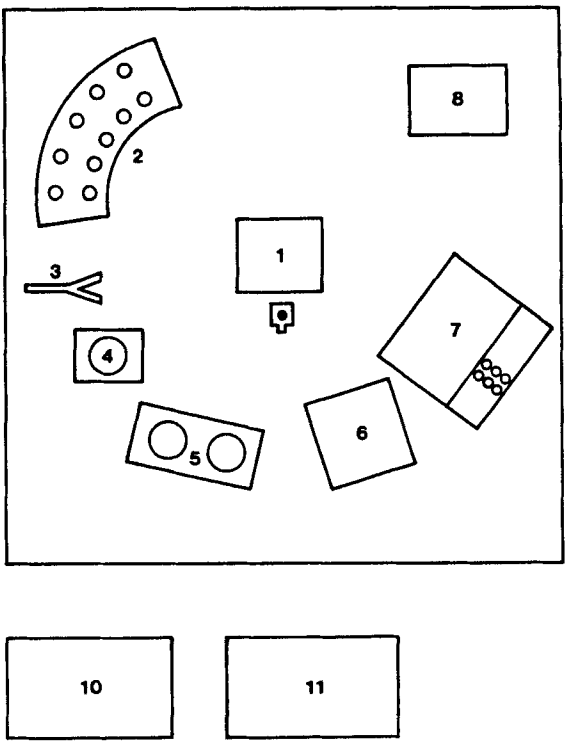

Figure. 2. Typical Robotic layout as provided by Johnson Scale. 1. Josco Smart-Arm laboratory robot; 2. Sample bottle rack; 3. Pipette tip wipe; 4. Waste hole (bottle); 5. Pipette tip wash; 6. Titration cell; 7. Titration controller/computer; 8. Digiflex pipette; 9. Modified custom hand with hypodermic injector; 10. Smart-arm Robot controller with I.O. 11. Epson HX-40 computer.

Devices such as capping or de-capping stations, test tube carousels, etc. must, often be custom fabricated for robot applications. More often than not these items are one-of-a-kind and not commercially available off the shelf. Increased use of pneumatics (air cylinders) is becoming important for maintenance free operation. Applications include gripping or holding stations, and opening and closing analytical and precision balance air shield doors. Bar coding/printing and laser scanners are also gaining popularity amongst lab robotic applications.

Networking and distributive control; methods borrowed from industrial and process control technology are now being employed in lab robotic applications. In some instances some peripherals are individually controlled by their own dedicated computers which in turn are networked to a host computer via an interface terminal and the I/O (input/output) programmable controller section of the robot's control console. This makes it possible to turn devices on and off while positioning the robot, while logging data from other devices, simultaneously. Whenever possible, peripherals with Bi-directional RS-232 AScii data I/O are selected so that they can be interfaced with computers and other devices to both send and receive information.

Where Found

Pharmaceutical, cosmetic, chemical, energy, food and biotechnology industries are now employing lab robotic systems for research and Q.C. applications. Applications include those where, safety, efficiency, accuracy and documentation (statistical analysis, archival data storage, etc.) are of concern; where repetitive tasks are required or in hazardous

environments, such as in the research of Hepatitus or AIDS, or the handling of carcinogens or radioactive materials.