

# Innovative Solutions for Refrigerator Manufacturing

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## ABSTRACT

The introduction of innovative methods - Cannon's ROTOPLUG and Drum systems - for the production of foamed refrigerator cabinets and doors in the mid-'80s allowed for a radical change in the manufacture of domestic refrigerators and freezers. Following the wide commercial success which derived, Cannon have continued to improve their range of solutions to better fit the technical and economical needs of a larger number of producers. The paper describes the latest developments in this area, including a new version of the ROTOPLUG - a multi-plug fixture allowing for zero-time-plug-change foaming cycle - and the latest versions of the Drum foaming machine for doors.

## BACKGROUND

The Cannon Group have always devoted significant resources to the development of dedicated foaming technologies for the refrigerator industry. Even its foundation - in the early '60s - was driven by the need to provide proper solutions for filling a refrigerator cabinet's walls with a reactive formulation of Polyurethane; in those days the operation was done using low-pressure dispensers, manually filling the cabinets, which were pre-assembled and locked in jigs mounted on carousels or turning tables. One of the earliest Cannon successes was the development of mixing heads and low-pressure machines specifically devoted to this rising sector of the house-holdings industry.

When the cleaner high-pressure technology, based on self-cleaning mixing heads, progressively replaced the low-pressure heads and machines, Cannon introduced first the HPFP head, with high-pressure recirculation circuit up the injection nozzles, followed in 1979 by the well-known FPL\* head.

This "L"-shaped, compact-mixing tool quickly gained the favours of all the foam producers, because of its intrinsic advantages:

- A compact design, making it easy to handle manually or to fit it in tight spots for automatic injection

- A fast operation, shortening the injection cycle and allowing for its use on multiple foaming jigs
- A very high mixing efficiency, providing a laminar flow of reacting blend at reasonable high output
- An easy adjustment of pouring pressures, for quick adaptation of injection's output when switching from small to large models.

After several years of co-operation with another manufacturer of industrial plants, Cannon decided in the early '80s to start their own Refrigerator Plant Division, devoted to the manufacturing of all sorts of special equipment required by refrigerator manufacturers to fill with Polyurethane foams their refrigerator cabinets, doors and small panels. The new Division - named Crios - started immediately introducing new manufacturing concepts in this industry, quickly gaining respect and loyalty throughout Cannon's old and new customers.

## EARLY INNOVATION

By this time - in the early 1980's - most of the World's producers had switched their foaming methods to high-pressure technology. Advantages included higher automatization of the foaming process, a solvent-free working environment, the possibility to lay in a static row various foaming jigs and to feed them with several mixing heads fixed on the foaming jig. This tool had a new design, too, if compared with the locked jigs that were used on carousels and turning tables. The outside components of the mould (generally composed by two flat sides, a flat top and a stepped bottom) were not anymore hinged and swivelling on the four sides of a flat back mounted on wheels: they could be mounted on four sides of the rigid structure holding the plug.

### Cabinet foaming

The process had gained significantly from the change, but problems remained. One of the most costly and time-consuming operations was still the change of the tool on the static jigs. At that time, when a change of model was required in production numerous operations had to be manually performed. After the last cured cabinet was extracted, a slave cabinet had to be manually introduced in the jig and the plug had to be seated in it. The operators had to loosen the bolts holding the jig, leaving it loose in the slave cabinet, then had to remove it from the jig and replace it with the new model. The reverse operation (fixing and centring) had to be performed, and - after some time required to heat the new plug - the line was ready to accept the new model for the foam injection.

A pretty long task, which was sometimes forcing the producers to extend their production runs: they

used to foam more cabinets than those really required by the sales programmes, just to optimise the minimum economic lots. They were working for the stock, with materials and warehousing costs chopping their already thin margins.

One of the first Crios projects aimed at the development of a new method for manufacturing cabinets with a very short interruption of the foaming cycle. During 1984 the concept was put into practice, and the first industrial plant was delivered to a subsidiary of Philips in Spain in 1985.

This was a direct evolution of a new system, introduced by Crios in its first single-model jigs - where the male mould, the plug, was fixed on the upper part of the fixture and the outer walls were left on the lower part. In this way the male plug - the heavy part of a refrigerator mould - was left on a solid structure while the sides (either slightly swinging or moving by a parallel stroke) were brought up and down with the cabinet, to fit the male plug. Having a free-standing plug on the upper side would have helped a lot all cleaning and versioning operations. Moving the lighter components would have reduced the energy consumption and the size of all the structural components.

From this new starting point, a foaming fixture with a plug suspended on its upper part, the idea for an improvement came out quite quickly. The new derived concept - the ROTOPLUG fixture - (*Picture 1*) was "revolutionary": in fact a revolution was involved, that of a moving platform - hinged on the upper part of the foaming jig - holding two plugs instead of one, mounted back to back. This rectangular platform, hinged to the structure on its shorter side, was revolved by 180° in a few seconds when the new model was required. The two moulds were constantly kept warm, so that no heating time was wasted prior to foaming the first new cabinet. The upper side of the platform was safe to work on when the rotation was done, so the operators could easily remove those plugs that were not to be used in a short future and replace them with other more required models. Doing so, the ROTOPLUG fixture was at the same time a good tool for both those producers which required frequent model changes, and for those who simply hated to move plugs all the time.

The revolutionary effects of ROTOPLUG immediately appealed the manufacturers: being able to change models without any loss of production means that - as far as the foaming station is concerned - the minimum economic lot of production is one piece! Short runs, pre-series, tool trials, next-day-shipping orders were all made now on the same foaming lines that were churning out the thousands of standard models. It was not anymore necessary to foam some more models for the stock, because "...it's a pity to foam only 20 cabinets" or "...just in case a small rush order comes in..." The possibility

to work almost "just in time" allowed the producers to reduce their stocks, the pass-through time of raw materials and the storage area for finished refrigerators reduced significantly, and the book-keeper was much happier.

ROTOPLUG-2, i.e. with two plugs on the platform, quickly developed into two more versions, with three and four different plugs hanging on a rotating structure, having a triangular or square cross section.

ROTOPLUG-4, in particular, is now in operation in places where the plug change nightmare has become a remainder of the past (*Picture 2*). Once the plugs for the whole catalogue are fixed on the foaming lines, they stay there until the design of those model changes. Easy adjustment of their length is carried on the upper platform simply inserting modular aluminium spacers

By now the system has been widely proven on a world-wide basis, and fit with models and sizes used in the five continents. More than 250 ROTOPLUG foaming fixtures of all models are in operation today. Wide side-by-side models are produced in North America with ROTOPLUG machines because, as a customer stated "...it's so convenient to leave those huge plugs there and have them ready in seconds..." Small companies - producing special design refrigerators in small lots - find very convenient to organise manufacture and deliveries on the basis of the incoming orders rather than on their stock, saving substantial sums in storage and raw material inventories.

A number of similar solutions have been proposed in the meantime, with technical alternatives that would more or less bypass the existing Cannon patent.

### **Door foaming**

The foaming technologies available in the early 80's for the production of refrigerator doors relied either in open-mould pouring in moulds mounted on Paternoster systems and carousels, or in closed-mould injection in moulds fixed in an arc in front of a low-pressure dosing unit. Crios developed in 1983 and installed in early 1984 their first development in this area, the DRUM unit. (*Picture 3*) This new carrier was designed around a hexagonal structure, step-by-step rotating by means of a hydraulic piston. On the six faces of the structure a clamping unit was installed, able to hold two standard door's moulds or a very long one. At each 60° -rotation of the structure one clamping unit was automatically opened, to allow for the demoulding of two cured doors. At the same time the next one was closed, allowing for the side injection of Polyurethane in closed moulds. Another alternative allowed for open-mould pouring before the rotation.

The DRUM is a simple solution, very compact and economic, easy to be installed and maintained, energy-conscious, requiring only one operator for a

productivity of two doors every 60 seconds. Two units can be placed side-by-side, fed by the same dosing machine, for an increased use of the available foaming resources.

Also this concept was very soon imitated by other manufacturers, and is now a very popular production tool. The 6-unit model was very soon followed by a whole range of similar solutions for different production requirements: Crios has produced until now more than 200 DRUM units, in models from 2 to 10 clamping units, for a total curing capacity of more than 1000 polymerisation cavities. The machine is suitable for all the flat and curved doors for domestic and commercial refrigerators, and has successfully been used for foaming small insulation panels used in cold rooms and walk-in coolers.

## RECENT DEVELOPMENTS

In order to satisfy the requirements of a larger number of end-users, Cannon have developed a number of new tools for both cabinet- and door-foaming applications. They have been supplied to the industry in the last two years, and currently in normal production in several countries.

### ROTOPLUG KIT

A new rotary plug-holder is now available at Cannon. This solution has been specifically designed to provide more mechanical stability when handling the largest models of refrigerators. The side-by-side models have sizes reaching 180 x 120 cm, with foaming plugs as heavy as 1000 - 1200 kg. With two jumbo-plugs like these on the platform, the rotation for the mould-change requires a proper structure to sustain the mechanical strain and avoid deflections.

Instead of adding weight to the structure another method for rotating the platform has been chosen: in this new type of ROTOPLUG (*Picture 4*) the rotation of the upper rectangular platform is performed on its longer side, rather than on the shorter one as previously described.

The rotating pinion is positioned in the middle of the fixture's longer side. An electric motor operates a driving chain and a proper combination of toothed wheels allows for a smooth rotation with limited torque on the drive.

The central point of rotation on the longer side provides a support right where the platform could deflect, allowing for a relatively light structure to hold and handle heavy plugs. The deflection of the tools - even for the heaviest ones - remains within the normal tolerances.

The design of the rotating top fits with the standard single-plug Crios fixtures, (*Picture 5*) so that existing Cannon foaming plants can be retrofitted with the required number of dual-plug fixtures, with limited investment and shorter delivery time.

The tighter cross-section of the fixture allows for the positioning of a higher number of foaming stations in a row, with higher plant's productivity per occupied space. (*Picture 6*)

This simpler structure also reflects in lower investment costs that become quite relevant for plants composed by dozens of foaming fixtures.

## COMMERCIAL REFRIGERATORS

The producers of commercial refrigerators – those used in shops, supermarkets, restaurants, ice-cream parlours and similar places – and of refrigerated vending machines have grown in number in the last ten years. The increasing level of competition in their market has generated finished products characterised by a very high level of quality. This reflects in a more sophisticated production, with more automated assembling and foaming lines. The use of low-pressure dosing machines and self-locking tools – where the cabinet is manually assembled prior to foaming – is progressively giving way to high-pressure machines and automatically operated tools.

It is now a common procedure to assemble these large, mostly irregular cabinets in a working island, and transfer them on conveyors to the foaming jig. Here they are automatically lifted and locked over standard aluminium plugs, that precisely match the inner liner or walls of the fridge. High-pressure injection is performed, with a more accurate control over the pouring parameters.

It goes without saying that these procedures are possible where the design of the cabinets has been standardised and the required production numbers are reasonable. In this case, then, the application of industrial manufacturing standards to special products allows for a further step of improvement. The dimensions and the complexity of these plugs are equivalent to that of the widest side-by-side refrigerators described before. Handling these large and heavy tools is a complex operation that has to be aided by forklifts and several men. This often leaves some surface damage on the plugs, and the unused tools take place anyway, so - if the production series are regular - why not leaving the most common plugs mounted on a ROTOPLUG?

Special versions have been designed, the latest being a ROTOPLUG-4 that guarantee smooth operations also in presence of the widest and heaviest tools. (*Picture 7*)

Some of the major manufacturers of commercial refrigerators have realised the advantages deriving from this concept, and are now in industrial production in Europe with these large units.

The main advantages for them include

- Production of more standard, quality parts
- Savings in mould-change cost
- Reduction of tool damages during handling
- Cleaner production
- Higher productivity

## **DRUM UNIT - AUTOMATED VERSIONS**

Since they have been introduced on the market, Cannon DRUM units have demonstrated a very high flexibility in design and use. Therefore they have been easily adapted to the various requests of the end users.

A part the already mentioned range of moulds that can be mounted on a DRUM (from two to ten, until now) several different versions have been designed, able to work

- in open or closed mould,
- with fixed or traversing head
- with manual or automatic loading and unloading
- with book-opening or parallel-stroke systems.

The newest models, for instance, have been designed to work in a highly automated production cell, where one operator only loads manually the metal sandwich to be foamed. All the other operations are made automatically, including: mould unloading, door extraction and feed to the assembly line, mould loading, injection, mould change, mould pre-heat prior to mould change. (*Picture 8*)

Working with parallel-stroke opening clamps on the DRUM it is possible to position the pre-assembled steel-sheet sandwiches in the lower mould-half, while the upper mould is constituted by the flat surface of the clamp. This mould-half can circulate around the plant carrying its door through the different steps of the cycle (pre-heating, foam injection, curing, demoulding) and then return to the loading station for the next cycle. In this way the polymerisation clamps are not dedicated to one or another model: they optically recognise and accept the incoming mould-half - whatever model it contains - and start a foaming program according to the door that must be produced.

This "first-come first-serve" approach allows for a total freedom in using the door-foaming plant. In this case we cannot even talk of "fast mould change" simply because the moulds are circulating around the foaming station and enter it only at the very last moment prior to foaming.

## **Conclusions**

Since their very early days Cannon have contributed to the development of innovative manufacturing solutions for the refrigerator industry. With developments like the ROTOPLUG KIT, the solutions for commercial models and the newest automated DRUM units Cannon have improved significantly their range of solutions to better fit the technical and economical needs of a larger number of producers. Their network of offices is available to examine with the interested parties any standard or special project related with the production of all types of domestic and commercial refrigerator cabinets and doors.

## **BIOGRAPHY**

### **Max Taverna**

Max was born in Buenos Aires, Argentina, in 1949 and has an education background in Industrial Chemistry. He worked five years for Upjohn's Polyurethanes Division in Italy and joined Cannon Afros as the European Sales Manager in 1982. Since 1986, he has co-ordinated the Group's communications activities and currently serves as the Director of Communications.

*\* FPL = Cannon patents*



*Picture 1 - Patented by Cannon in the early 1980's the ROTOPLUG fixture guarantees zero-time-plug-change with numerous advantages in production and in economics.*



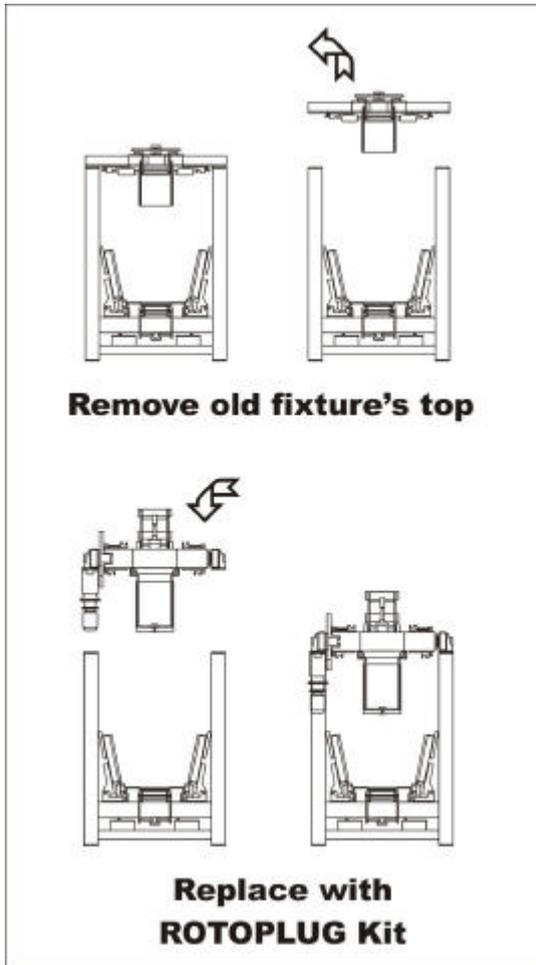
*Picture 2 - ROTOPLUG-4, here shown in a configuration of four units, allows four different plugs to be always available for immediate foaming*



*Picture 3 - DRUM-6, a Cannon Crios development, is a compact production tool for refrigerator doors and small panels.*



*Picture 4 - This new version of ROTOPLUG - rotating on the longer fixture's side - is very adapt to the longer and heavier plugs.*



Picture 5 - The new ROTOPLUG can be used to update most of the existing conventional Cannon Crios foaming fixtures.



Picture 6 - The new ROTOPLUG's compact size allows for a better use of the available space.



Picture 7 - ROTOPLUG-4 is now currently used in production of large commercial refrigerators.



Picture 8 - New fully-automated door plants like this are built around Cannon Crios DRUM-4 units.