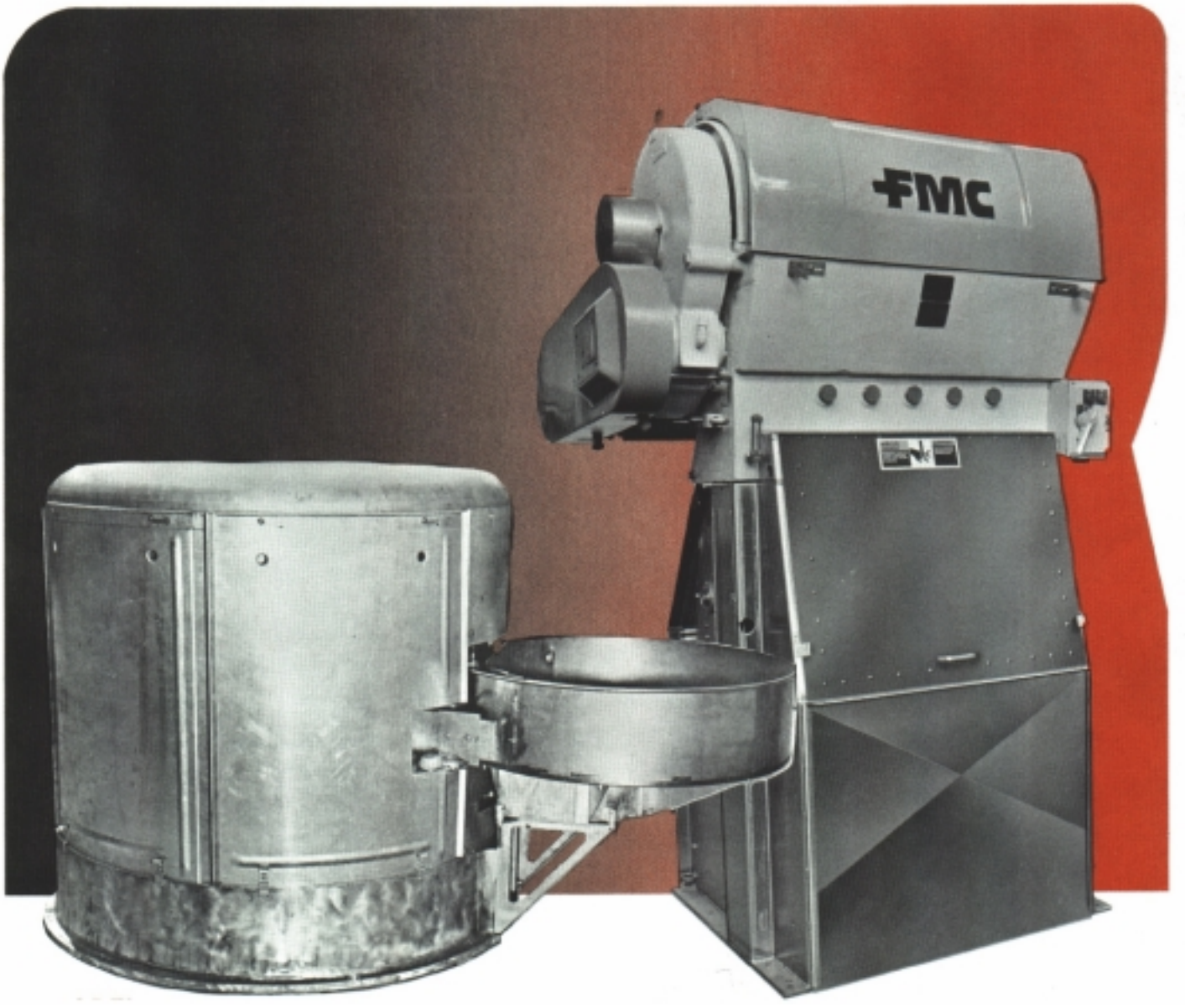
# The FMC Whole Citrus Juice Extractor

Designated
An International Historic Mechanical Engineering Landmark
by the
American Society of Mechanical Engineers - March 24, 1983




MODEL 402X 1947

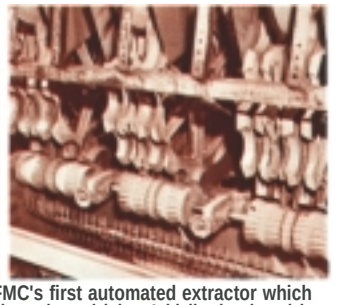
PRESENT MODEL 291B

## The story of its conception and evolution

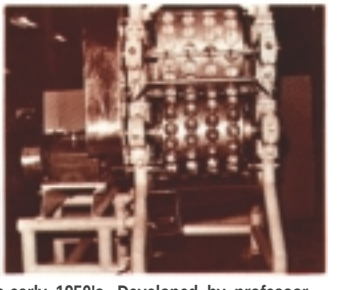
# Whole citrus fruit juice extraction

## PREFACE

This revolutionary concept coupled with high yields and excellent quality juice had a major impact on the citrus industry. Despite favorable acceptance of the 24-head rotary whole fruit extractor, FMC Technical personnel recognized certain features which could be improved. As a result of this forward thinking, the FMC Inline Extractor was developed and introduced to the industry. This extractor, which also prefinishes the juice, quickly replaced the FMC rotary extractor and many of the less efficient competitive machines. There were 30 FMC Inline Extractors in the field during the 1949-50 season and over units operating in the 1950-51 season. Today, approximately 2400 FMC Citrus Juice Extractors annually "squeeze" and simultaneously prefinish 70% of the citrus juice production in 30 countries worldwide.



**POLK EXTRACTORS 1930's-1940's FMC's first automated extractor which quartered the fruit and then removed the pulp and juice. Initially developed by Ralph Polk, Sr. & Jr. POLK EXT. CLOSE-UP showing pulp and juice removing devices.**



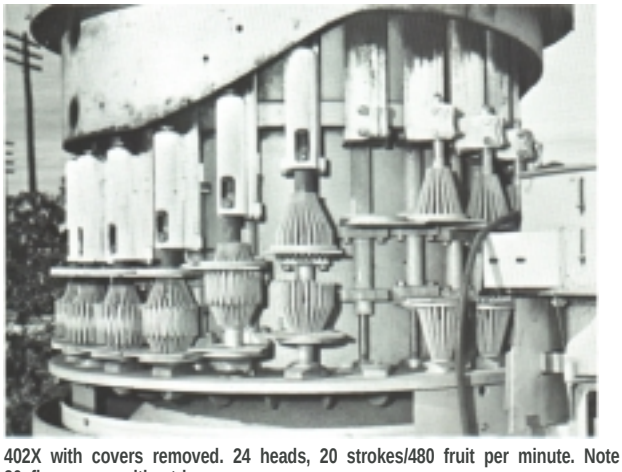
**"SKINNER" ROTARY PRESSES. 1930's-early 1950's. Developed by professor Faulds, Clearwater, Fla. and manufactured by Skinner Machinery Co.**

**CLOSE-UP OF "SKINNER" PRESS showing male/female features which pressed pulp and juice from fruit halves.**

## EARLY 1940's

Introduction of the whole citrus fruit juice extraction principle was started just prior to World II, however completion of development work was delayed due to the war.

Immediately after World War II, development was taken over by the Central Engineering Laboratories of FMC Corporation with the first 24-head rotary whole fruit extractor being completed in mid-1946. This first unit was operated experimentally on grapefruit at the Sunkist Exchange plant in Tempe, Arizona during late May and June of 1946. While many operating problems were encountered, overall performance of this machine and the success of the whole fruit principle involved were most encouraging.



**402X with covers removed. 24 heads, 20 strokes/480 fruit per minute. Note 20 finger cup with strippers.**

## 1947

Based on this encouraging performance, three more units were manufactured and operated commercially on oranges at the Sunkist Ontario, California plant during the spring of 1947. Performance of these units was quite satisfactory and sufficiently encouraging to cause FMC to proceed with the manufacture of additional machines for both Texas and Florida.

Sixteen machines were manufactured for operation on grapefruit in Texas in late 1947 and early 1948.

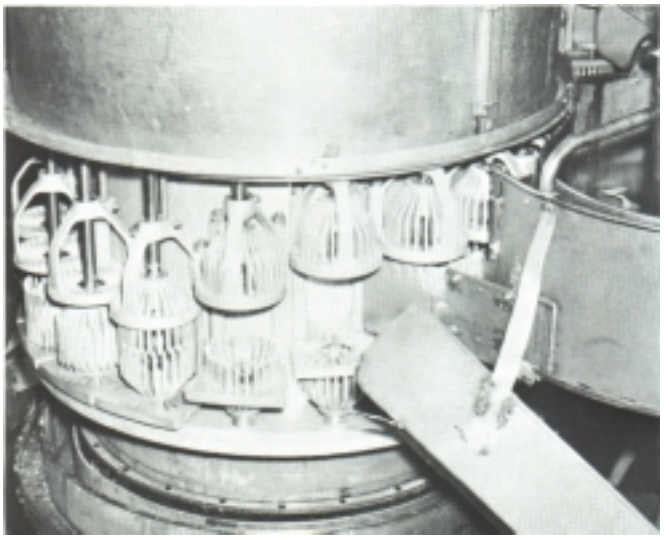
Simultaneously, ten machines were being manufactured for operation on oranges in Florida. These machines were installed in time to begin operation during the latter part of the 1947-48 season.

Additionally, because grapefruit being processed in Texas were larger than could be accommodated by the 402X machine, which would accept either three or four inch cups, a larger machine, an 18-head Model 532B, was designed and the first units manufactured in late 1948. They operated in Texas during the 1948-49 season.

Based on early operation of these extractors, it was evident that maintenance difficulties were greater than could be tolerated. Further, the rotary machines, both Model 402X and 532B, mixed core, membrane, pulp and seeds with the juice stream. With this material in the juice it was difficult to effect transfer from the extractor to finisher. Further, it was felt that the quality could be improved if cores, membrane, seeds and some portion of the pulp were eliminated at the extractor rather than at the finisher.

With these deficiencies in mind, design of the Inline was begun in late 1947. A prototype known as Model 659 (6" machine) was manufactured and tested in Florida late in the spring and summer of 1948.

In addition to the whole fruit extraction principle, this machine included a unique prefinishing system to remove undesirables from the juice as part of the extraction operation. Thus, only juice and juice sacs are a part of the juice stream which made possible the use of a completely enclosed juice handling system. This assures improved sanitation and makes possible effective cleanup by back-flushing, which is not possible with covered type juice troughs.



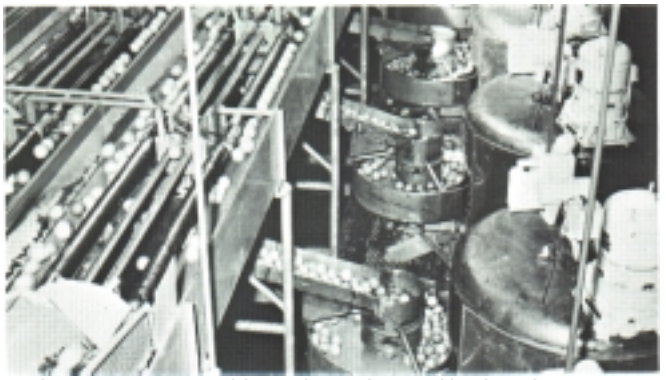
**532B for extracting fruit 4" to 6" in diameter, 18 head. Approx. 16½ strokes/ 300 fruit per minute.**

The performance of this test unit met expectations and justified the manufacture of two additional units. These machines with the original prototype, were tested extensively during the 1948-49 season. During this period it was possible to improve reliability to such a level that it was decided to design limited manufacturing tooling so that 30 machines could be manufactured for commercial operation during the 1949-50 season. Very satisfactory results were obtained with these 30 units and, on the basis of this operation, it was decided to build a substantial quantity for operation during the 1950-51 season.

## 1950

More than 400 commercial units were manufactured and installed at various plants and operated during the 1950-51 season.

There were 2 models of this machine, a 5-head machine known as a Model 718, suitable for two cup sizes; a 3" cup for fruit 3" and smaller and 4" cup for fruit between 3" and 4" in diameter. A second extractor, a 3-head unit known as a Model 659, was equipped with 6" cups suitable for handling fruit from 4" to 6" in diameter. It should be noted that the Model 718 extractor would handle all oranges and approximately two-thirds of the grapefruit, with the Model 659 handling the remaining third of the grapefruit crop.

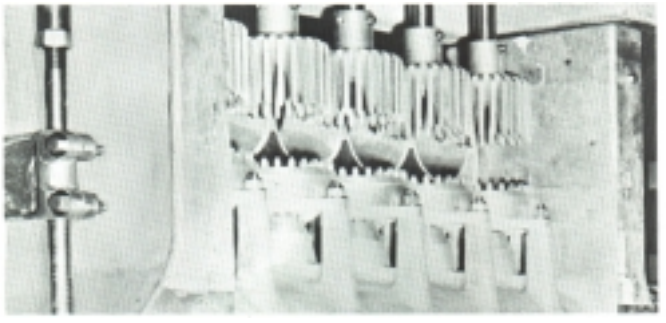


Six 402's—1948 commercial operation at Citrus World, Lake Wales.

The initial Model 718's operated at 40 strokes per minute or a theoretical total of 200 fruit per minute, whereas the 3-head Model 659 operated at 33 strokes with a theoretical through-put capacity of 99 fruit per minute.

These machines performed in line with expectations and received excellent customer acceptance. However, despite these very satisfactory results and in line with company policy which has prevailed through the years, an ongoing program was implemented to further improve reliability and efficiency of these machines.

Improvements resulting from this continuing program follow in chronological order along with limited comments concerning the improved features.



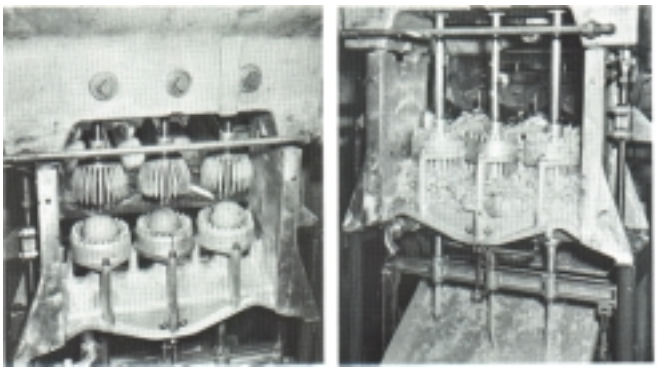
718, THE FIRST 5 HEAD. 40 strokes or 200 fruit per minute.

**1953** The 5-head Model 718 was increased in speed from 40 to 50 strokes per minute and the 3-head Model 659 was increased from 33 to 40 strokes per minute. This of course to increase throughput capacity of the machine.

**1958** In 1958, the prefinishing arrangement was further perfected. This improvement involved the addition of a "split ring" to be used with the orifice tube, which provided pressure in the prefinishing system. This improvement made possible use of reduced diameter strainer tube perforations which enhanced quality and minimized cleanup of strainer perforations. Also, the "split ring" provides self-cleaning of the strainer tube internal bore during each stroke of the extractor, assuring maximum efficiency under all operating conditions.

PARTIAL PRODUCTION OF THE MORE THAN 400 MODEL 718 EXTRACTORS manufactured for the 1950-51 season.

**1960** It became desirable to make major modifications to the 5-head Model 718. These changes were of sufficient magnitude to require a model designation change, the new line to be known as the "91" series. The Model 718, which accepted inter-changeably 3" or 4" cups, was split into two separate models - a 291 and a 391. The 291 accepted 3" cups only, whereas the 391 was essentially a 4" cup machine but could be set up with 3" components.



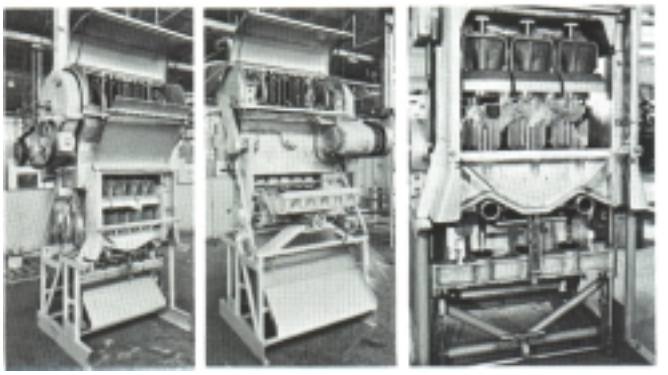
659 PROTOTYPE. Note the orifice discharge tubes at bottom which removed core, membrane and seeds from juice at the moment of extraction.

659 PROTOTYPE for grapefruit 4"-6" diameter.

This model change included the adoption of several other improvements, chief of which was a positive rotary feeder to improve feeding efficiency and reduce substantially the time necessary to feed fruit into the extractor. This feature allowed extractor modifications that again increased extractor speed. Operation of the Model 291 was increased to 75 strokes per minute, or 375 fruit per minute; whereas the 391 was increased to 65 strokes per minute, or a theoretical speed of 325 fruit per minute.

To improve sanitation, the cast aluminum juice manifold was changed to a fabricated stainless steel component and the aluminum lower main was cast with stainless steel inserts in the cone areas. With these changes, all juice contact surfaces were of stainless steel which were easier to clean and provided maximum sanitation, along with increased life.

In addition, the 3" and 4" size cups were changed from aluminum to stellite to improve strength, reliability and wear life.



291 FRONT VIEW. The first model with positive rotary feeder. 291 BACK VIEW. The rotary feeder permitted the operating speed to increase to 75 strokes/375 fruit per minute. 491, FIRST MODEL TO USE 5" OIL RECOVERY CUPS AND ROTARY FEED. 60 strokes/180 fruit per minute.

**1964** A Model 491,5" cup 3-head machine was produced to handle the major portion of the grapefruit which was too large for the 391 model 4" cup. Advantages of this new model were:

1. Inclusion of the positive rotary feed which improved feeding efficiency and allowed operation at 60 strokes per minute.
2. Aluminum oil recovery type cups were Included which permitted peel oil recovery.
3. All juice contact surfaces were stainless steel, as in Models 291 and 391, machines with the same advantages as this.

The preceeding improvements were of substantial value, however, the ongoing product improvement policy of CMD continued with the following additional modifications:

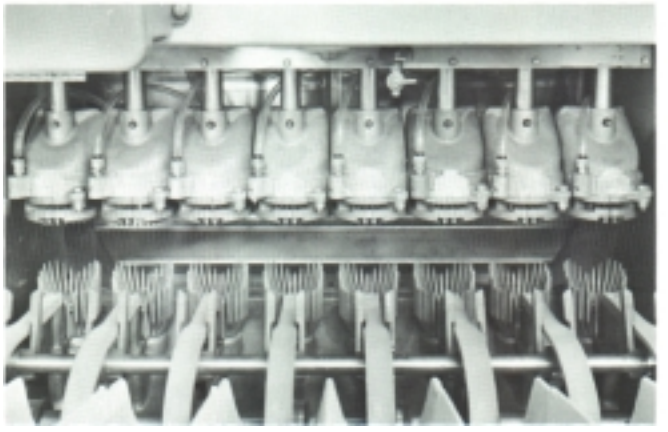
- In 1964 the orifice tube surface was changed from filled Teflon to a stellite coating. This not only improved considerably the life of the orifice tube, but of the companion strainer tube component. Operating life was extended from approximately 1,500 hours to 15,000-20,000 hours.
- In 1967 the cast aluminum orifice beam was changed to a fabricated stainless steel beam to improve reliability.

**1967** Another model extractor was introduced to the industry. This machine remained in the "91" series and was designated Model 091 (Florida) State Test extractor. It should be noted that this machine was competitively developed to provide the state a means of testing 45 pound random samples of fruit from each truck load as received by the processor. Juice characteristics of these samples were of sufficient accuracy to establish payment for the entire truck load.

Each machine basically was equipped with a 3", 4" and 5" cup to handle the appropriate fruit size. Also, these extractors were

equipped with .025" controlled hole strainer tubes to provide a sufficiently low pulp juice directly from the extractor to permit necessary laboratory evaluations.

Interestingly, this machine was selected over competitive equipment by the State because of superior reproductibility. Today, more than 70 of these same basic State Test extractors are being used by every processor in the State of Florida as means for evaluating fruit purchased. This method of purchasing fruit has proven to be satisfactory both to the grower and the processor.

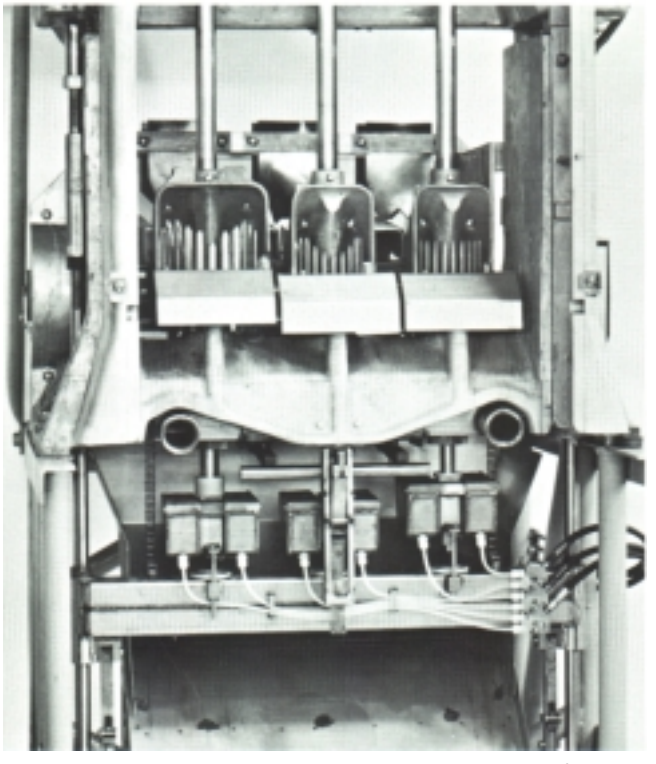


**191B. 8 HEAD FOR 2-3/8" DIA.-SMALLER FRUIT. 100 strokes/800 fruit/min.**

**1972** Another extractor in the "91" model series was introduced to the industry. This unit, known as Model 191, was equipped with eight 50mm (3-3/8") cups suitable for processing the smaller size limes, mandarin fruit, and lemons. It increased throughput of these small size fruit and further improved efficiency. This machine is used more widely in Japan than in other areas, but some are found in Florida, California and other locations throughout the world.

1972 was the year the FMC plant in Brazil built its 100th extractor. It also marked another refining program. The 291 and 391 model machines were changed to 291A and 391A to encompass the following changes:

1. A stainless steel frame and a cast stainless steel lower main which consisted of a bridge section and two side leg members. This change was made primarily to permit use of caustic cleaners to enhance cleaning and improve component life.
2. The adoption of top loading lower cutters to reduce the time required to change these components. This is of major benefit to service, but also reduces downtime which benefits the customer.
3. All exposed aluminum parts not changed to stainless steel or stellite were coated to permit the use of caustic cleaners. Caustic improves clean-up efficiency and reduces the time involved. This makes possible the addition of an automatic in-place clean-up system as an option.
4. Covers were changed to fiberglass or stainless steel.



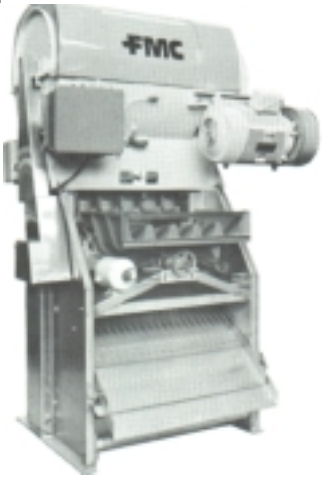
**091. THE OFFICIAL STATE OF FLORIDA FRUIT TESTING EXTRACTOR for measuring fruit characteristics to determine truck load prices.**

**1974** The model designations of the 291A and 391A were changed to 291B and 391B. Changes identified with these model changes were:

1. Fabricated stainless steel lower main side members to facilitate manufacture.
2. Improved feeder drive to improve reliability.
3. Complete new electrical system.

**1975** The following additional changes were made to the "B" series extractors:

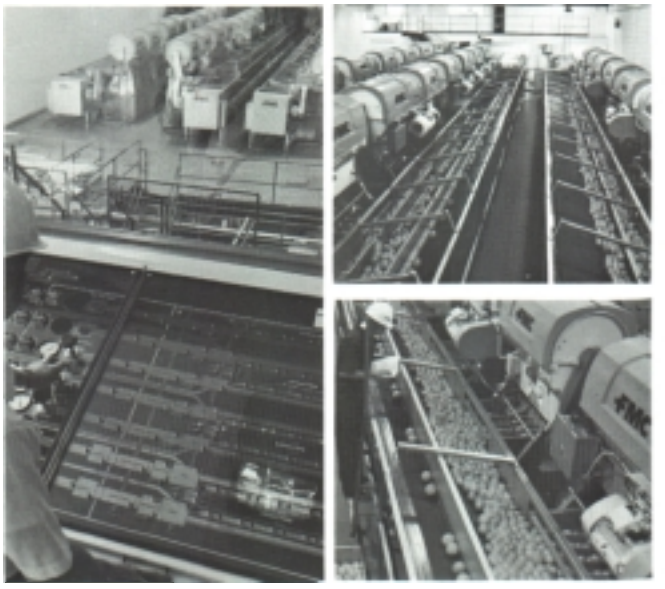
1. All Model 291 "B" models were increased in speed from 75 to 100 strokes per minute, or a total of 500 fruit per minute; with the Model 391B being increased in speed from 65 to 88 strokes per minute, or a total of 440 fruit per minute. The 491B remained at 60 strokes per minute.
2. The coil return springs were changed to pneumatic springs to permit higher speeds.
3. The plunger type piston oil pump was changed to a rotary gear pump to support the increased speed.
4. Spur gears in the gear box were changed to helical type to reduce noise and improve gear life at the higher speeds.
5. The double pickup finger arrangement was changed to triple finger to reduce juice contact speed and thereby retain maximum feeding efficiency with the higher speed.
6. A recycle peel oil recovery system was developed and adopted as an option. This permitted screening and reuse of the liquid phase from the centrifuge as part of the liquid requirement in the maximum recovery of peel oil from the extractors. This system reduced water requirements as much as 75 to 80% and reduced waste proportionately.




**LATEST MODEL 291B. In-place clean-up & recycle peel oil recovery systems. 100 strokes/500 fruit per minute.**

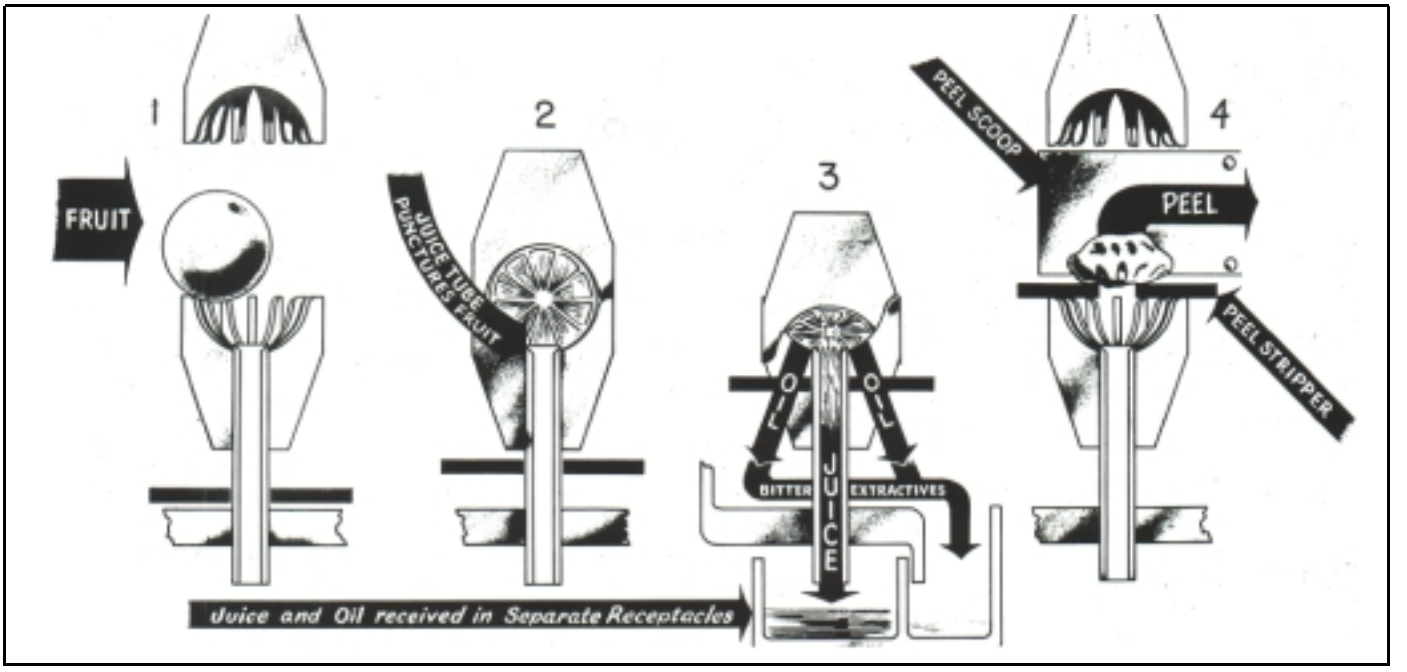
**1976** The feed hopper design was improved to more efficiently transfer fruit from the tilted feed belt to the feed hopper. While this modification was of importance to all model extractors, it was of greater value to the efficiency of the high speed machines because of the greater volume of fruit being processed.

As can be seen from the preceeding, the intital Inline underwent three major model changes which were designated as the "91" series, then the "91A" series, and finally the "91B" series. Even though some similarity in appearance to the original machine remains, it is obvious from the many mechanical changes that this extractor has been substantially improved from the date it was introduced to the industry.

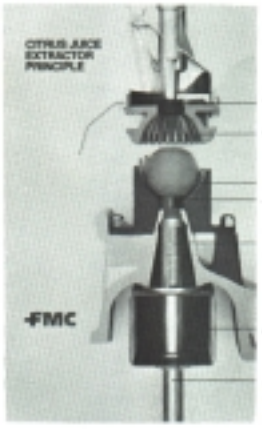


**PRESENT DAY COMMERICAL EXTRACTOR INSTALLATIONS**

# principle



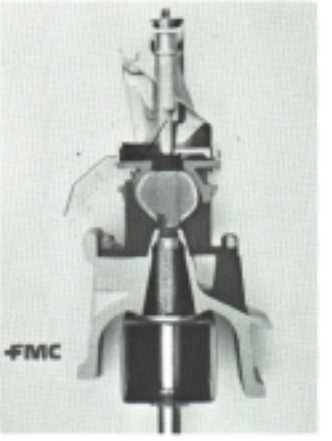

**1948 art for the 402X**




**CRITICAL COMPONENTS**

**1. FUNCTION**

| | |
|---|---|
| Upper Cutter | Cuts a plug In the top of the citrus to permit the separation of the peel from the internal portions of the fruit. |
| Upper Cup | Supports the exterior of the citrus throughout the squeeze cycle to prevent bursting. |
| Lower Cup | |
| Lower Cutter | Cuts a plug in the bottom of the citrus to allow the internal portions of the fruit access to the prefinisher tube. |
| Prefinisher Tube | Separates, based on particle size, the internal elements of the citrus. |
| Juice Manifold | Collects juice and juice sacs. |
| Orifice Tube | Generates pressure inside the prefinisher tube and collects and discharges membrane and seeds. |



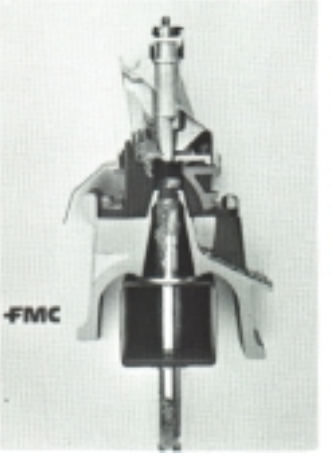

**2. IMPLEMENTATION**

In this early phase of the extraction cycle, the upper cup moves downward to cause pressure on the citrus so that the top and bottom plugs begin to be cut.

Due to the profile of the cups, the citrus is totally supported, and thus will not burst but will get an even squeeze.


**3.**

As the extractor cycle Continues, pressure increases on the citrus causing the internal portions of the fruit to be forced through the bottom plug and into the prefinisher tube. The peel is now being discharged between the upper cup and cutter.




**4.**

Upon completion of the extraction cycle, the internal portions of the citrus are located in the prefinisher tube. At this time, the orifice tube moves upward, placing pressure on the contents of the prefinisher tube. This causes the juice and juice sacs, due to their small particle size. to flow through the holes of the prefinisher tube and into the juice manifold.

Those internal portions of the citrus, whose particle sizes are larger than the holes in the prefinisher tube, are forced through an opening in the orifice tube and are discharged out the bottom.

**Present-day photography.**

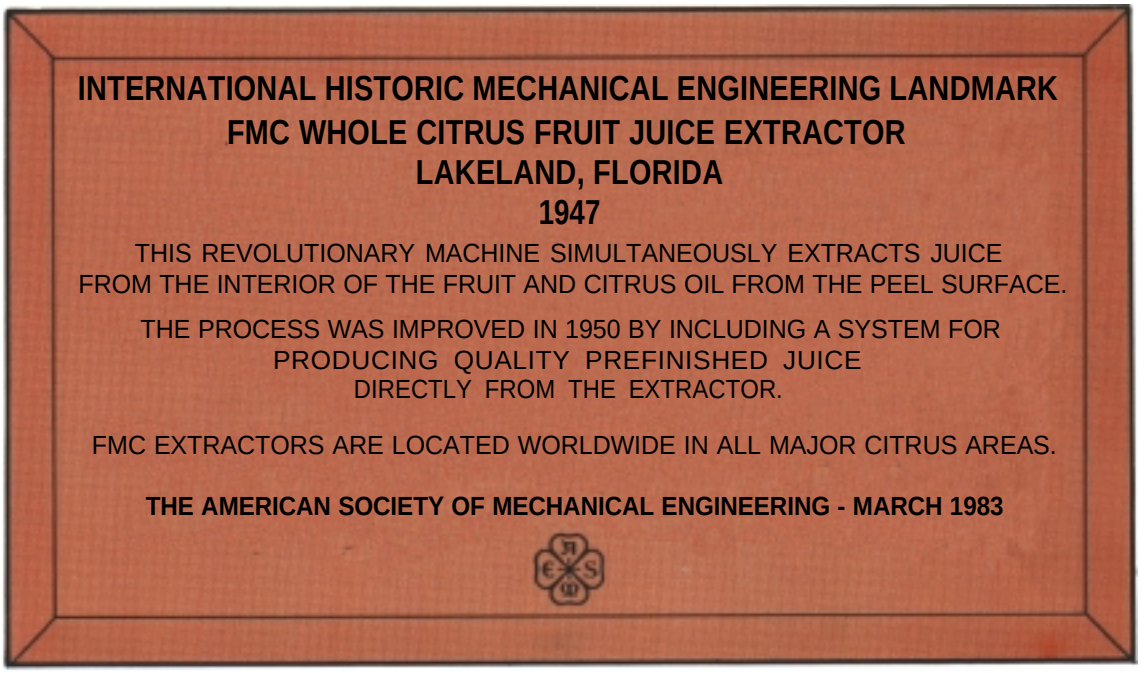
# The American Society of Mechanical Engineers
# Historic Mechanical Engineering Landmark Program

A National History and Heritage Committee was formed in 1971 by the ASME Council to promote a general awareness of our technological heritage. The committee gathers data on all works and artifacts with a mechanical engineering connection which are historically significant to the profession.

The committee's national, and international landmark program is a demarcation of sites which are of national or international significance—people or events which have contributed to the general development of mankind.

The Society also cooperates with the Smithsonian Institution to provide contributions of historical material to the National Museum of American History in Washington, D.C.

The FMC Whole Juice Extractor is the 11th International Landmark to be designated since the program began in 1973. Since then, 64 National and 5 Regional Landmarks have been recognized by the Society. Each represents a progressive step in the evolution of mechanical engineering and each reflects its influence on society, whether it is of significance in its immediate locale, in the country, or throughout the world. For more information about this and other programs sponsored by the ASME History and Heritage Committee, please contact the ASME Public Information Department, 345 E. 47th St., New York, NY 10017 (212-705-7740).




# ACKNOWLEDGEMENTS

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