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Symposium on the Development of the Plastics
Fabrication Industry in Latin America

Bogotà, Colombia, 20 November - 1 December 1972

BLOW MOULDING [1]

by

Lars O. Philipson
Pan Amcel Co. Inc.
New York USA

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SUMMARY

BLOW MOULDING 1/

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Lars O. Philipson
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Modern Plastics defines blow moulding as a method of fabrication in which a hollow tube (parison) is forced into the shape of an enclosing mould cavity by internal pressure (usually air).

This technique is by no means a recent development as glass blowing has been known for 2,000 yaars. The first plastics blow moulding item was introduced in 1943: bottles for water purification tables (U.S. Army Medical Corps.) in polystyrene. Ever since the introduction of HDPE in the late 1950's, the plastics blow moulding industry growth has been explosive. Major reasons for this growth have been new technical advances in production techniques, more sophisticated blow moulding machinery and auxiliary equipment developments, resin formulation improvements and, of course, lower plastic resin prices. As a result, many old markets have been expanded and new ones created.

By 1971, the world plastics consumption for blow moulding was approximately 1.5 million tons. It is expected to triple over the next 10 years.

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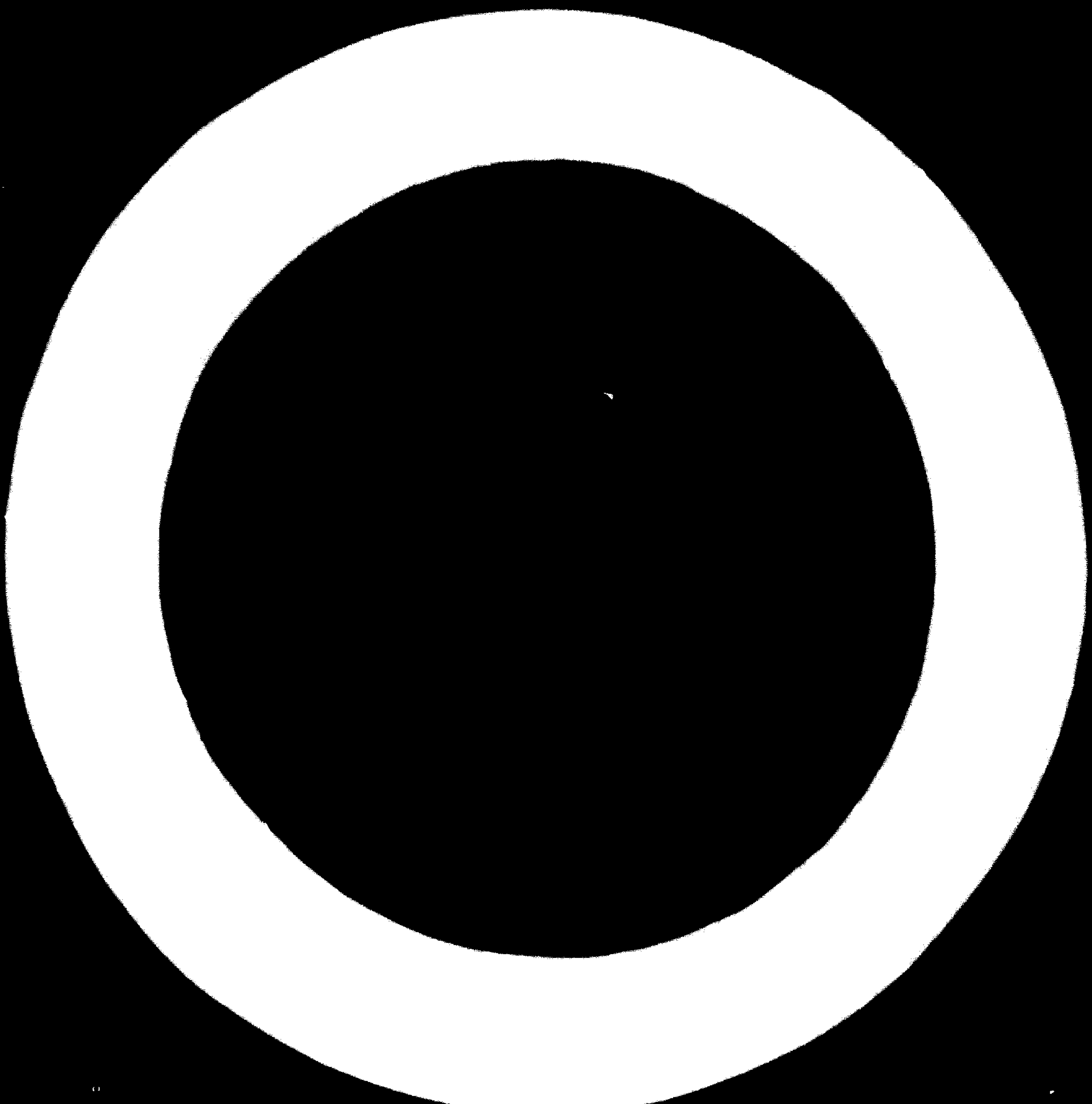


The distribution of [illegible] blow moulding differs [illegible]pending on container size, [illegible], and the country. The effects [illegible] these [illegible] over all [illegible]ariables, the following [illegible] moulding is considered to [illegible] most accurate for 19[illegible].

High Density Polyethylene (HDPE)	[illegible]
Polyvinyl Chloride (PVC)	[illegible]
Polypropylene (PP)	[illegible]
Others	[illegible]
(Low Density Polyethylene)	
(Polystyrene)	
(Polyacetal)	
(Polycarbonate)	

High density polyethylene is by far the most widely used for several reasons. [illegible]t has the best balance of properties, processability and economics of all the [illegible]aterials. Chemically, it is nearly inert. Advantages of other resins will be [illegible]iscussed.

The size and nature of the blow mould market varies very much from country [illegible]o country. As an example, the following table shows the consumption per capita [illegible]f HDPE blow moulded containers, by country.

HDPE CONSUMPTION [illegible] INHABITANTS

	USA	JAPAN	W. GER.	SCAN.	MEX.	CZECH.
Large Containers	3[illegible]	13[illegible]	[illegible]	[illegible]	20	[illegible]
Household Chemicals	11[illegible]	4[illegible]3	79[illegible]	[illegible]	74	5[illegible]
Food Containers	[illegible]35	27	[illegible]	3[illegible]	3	[illegible]

The blow moulding machine manufacturers have [illegible] major role in developing new markets in close co-operation with the [illegible]. For example, because of certain machine developments, ultra large containers in high density polyethylene, used for fuel tanks up to 2,000 liters can be [illegible].

Machinery manufacturers have produced high speed equipment. These have played a major role in the success of the HDPE milk container in the U.S. Although the market outside of the U.S. for plastic milk bottles is still in the embryonic stage, dairies in many nations are displaying an active interest in the plastic package. Typical economics for establishing production for milk containers will be reviewed. A 16 mm. film produced by Celanese Plastics Co. on HDPE milk bottles will be shown during the presentation of the paper.

New blow moulding machines capable of high speed production with close parison control are responsible for the rebirth of the plastic aerosol container market. Celcon acetal */ copolymer is a most promising thermoplastic resin candidate for this market. It possesses chemical and creep resistance in addition to strength and toughness required to satisfy the strict demands of the pharmaceutical and cosmetic industries. The paper will cite cost and property analysis for Celcon aerosol containers.

Blow moulding plant proposals will be presented in conjunction with this paper by machinery manufacturers. They will outline machinery and auxiliary equipment requirements, costs, operating economics, etc.

*/ made by Celanese Plastics Co (USA) and distributed outside the United States by Amcel Co. Inc., and Pan Amcel Company.

CONTENTS

INTRODUCTION

1. Modern Plastics defines blow molding as a method of fabrication in which a hollow tube (parison) is forced into the shape of an enclosing mold cavity by internal pressure (usually air).

2. This technique is by no means a recent development as it was used by the ancient glass blowers who used to sit in market places making bottles and other hollow items for sale to passersby.

3. Since the time of primitive glass blowing, the technique of blow molding has progressed considerably from "the art" of glass blowing to the highly complex science of blow molding of plastics materials.

4. The proceeding definition of blow molding is, as are most definitions, much over-simplified. There are uncountable independent and dependent variables which affect the blow molding process of today. To effectively and efficiently operate a blow molding operation, one must have a good understanding of all these variables and the effect they have on the total operation.

5. Unfortunately, there is certainly not time here today to discuss all of these details in depth. I will attempt to cover, in as much detail as possible, the following topics:

WHY BLOW MOLDING?

6. Someone contemplating entering the plastics fabrication business might ask himself this question.

7. The answers, versatility, economics, present demand for blow molded articles and, of course, future prospects in blow molding; they are all favorable.

8. Versatility

There is virtually no hollow shape that cannot be blow molded! The shape can be round, square, flat, necked, short and fat, tall and thin, etc. The only limitation is the cleverness of the mold maker.

9. As far as size is concerned, the sky is the limit in both directions; presently containers are being blow molded from less than one milliliter to about 2000 liters. The upper limit on size is only an equipment limitation.

10. From a material standpoint, virtually any plastic material that can be melted and made to flow can be blow molded. Some of the materials

TABLE I

PLASTICS THAT HAVE BEEN BLOW MOLDED

- POLYETHYLENE - HIGH AND LOW DENSITY
- POLYPROPYLENE
- POLY VINYL CHLORIDE
- POLYSTYRENE
- A. B. S. POLYMERS
- CELLULOSICS
- IONOMERS
- MODIFIED ACRYLICS
- POLY ACETALES
- POLYAMIDES - NYLON
- PHENOXIES
- POLY CARBONATES
- FOAMED POLYSTYRENE

that have been successfully blow molded are shown in Table I. Each different material has its own set of physical and chemical properties which may qualify its use for a particular end use application. Of these materials, polyethylene enjoys about a 77% share of the blow molding market. We will discuss this more completely when we discuss the choice of material

11. Today, blow molded items of every description are being produced and used in literally millions of applications.

12. Packaging is by far the largest end use. A partial list of products packaged in blow molded containers is shown in Table II. For nearly any product that needs to be put in a container, there is a plastic that can be blow molded to hold it.

13. Blow molded items are not entirely used for packaging, however. Table III lists some of the non-packaging blow molding applications.

14. Thus, within the realm of the blow molding process you have more flexibility in size and shape choice and end use, than with any plastic molding technique, be it injection molding, rotational molding or what have you. This is versatility!

<u>Economics</u>

15. A second major advantage and one that we are all interested in, is the favorable economic aspect of the blow molding process. With blow molding, depending on your choice of equipment, a relatively low investment is required to give you a highly productive operation; and because

TABLE II

ITEMS PACKAGED IN BLOW MOLDED CONTAINERS

- FOODS
- MILK
- HONEY
- MUSTARD
- KETCHUP
- EDIBLE OIL
- SALAD DRESSINGS
- FRUIT JUICE

  ETC., ETC., ETC.

- TOILETRIES AND COSMETICS
- SHAMPOO
- DEODORANT
- SUN TAN LOTION
- PERFUME
- BABY POWDER

  ETC., ETC., ETC.

- PHARMACEUTICALS
- MEDICINE
- MOUTH WASH
- ALCOHOL
- LAXITIVES

TABLE II - Cont'd

- **HOUSEHOLD CHEMICALS**
- BLEACH
- DETERGENT
- FABRIC SOFTENER
- SHOE POLISH
- GLUE
- SWIMMING POOL CHEMICALS

ETC., ETC., ETC.

- **INDUSTRIAL CONTAINERS**
- ACIDS
- PAINTS
- MOTOR OIL
- PHOTOGRAPHIC CHEMICALS
- SOLVENTS

ETC., ETC., ETC.

- **MISC.**
- AEROSOL BOTTLES
- SQUEEZE BOTTLES
- TOYS

TABLE III

NON-PACKAGING BLOW MOLDING APPLICATIONS

- AUTOMOTIVE HEATER DUCTS
- AUTOMOTIVE GASOLINE TANKS
- LUGGAGE, SUITCASES, BRIEFCASES
- BEVERAGE CRATES
- FURNITURE
- FUEL OIL TANKS
- WATER STORAGE TANKS
- FLEXIBLE CONNECTOR TUBES
- DYNAMITE TUBES

ETC., ETC., ETC.

of low mold costs, you can have an array of different size and shape blow molded items, without prohibitive investment. This, for instance, would be impossible in injection molding where mold costs can be as high as $80-90,000. Also, with blow molding production, costs are lower than with other fabrication techniques as minimal secondary operations are required. As a matter of fact, if the mold and part are properly designed, there may be no secondary operation required at all. Operations as trimming, degating, deflashing, drilling tabs, etc., require extra hands and this adds to expense.

16. Thus, if you were to blow and injection mold the same article, the production cost, exclusive of the material cost, would be less for the blow molded article. The only other possibility is rotational casting and for items less than 50 liters. The long cycle times almost completely remove this process from consideration.

17. The present demand for blow molded items is obvious, but what about the future? Often the past sheds light on the future. In less than 30 years, the worldwide consumption of plastics for blow molded items has gone from 0 to 1.3 million tons per year (see Table IV) and this rate is not expected to slow down in the foreseeable future.

TABLE IV

PLASTIC BLOW MOLDING HISTORY

1930	- NOTHING
1943	- FIRST BLOW MOLDED ITEMS - BOTTLES FOR WATER PURIFICATION TABLETS (ARMY MEDICAL CORPS) - STYRENE
1945	- CHRISTMAS TREE DECORATIONS ACETATE - STYRENE
1945 (LATE)	- LOW DENSITY - ACID CONTAINERS TOILET TANK FLOATS
1946	- THE FIRST LOW DENSITY SQUEEZE BOTTLE STOPETTE DEODORANT TOTAL MARKET FOR BLOW MOLDING MAXIMUM 500 TONS
1972	- 1.3 MILLION TONS PLASTICS FOR BLOW MOLDING

18. The Latin American blow molding industry is estimated to consume 22,000 tons plastics in 1972, which is less than 2% of the mentioned 1.3 million tons world total. Due to the rapid industrialization of the Latin American countries, we expect to see the Latin America's share increased to 4.5% of the world total by 1990 as shown in Figure 1.

19. With increased use of blow molded containers for food stuff, industrial applications, automotive, household and personal items, we can see nothing but an increased growth rate and demand for blow molded items.

20. Now that we have decided that blow molding is a processing technique that is versatile, profitable and has a tremendous future, let us return to the process.

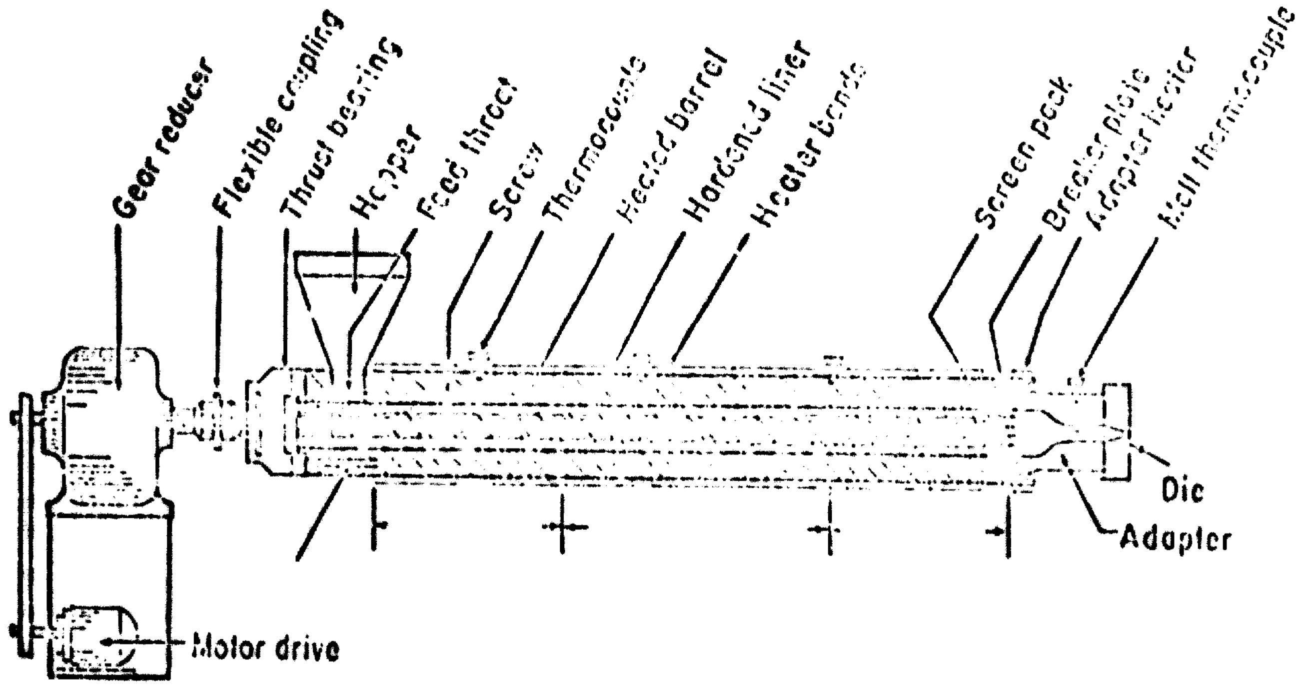
BLOW MOLDING PROCESS

21. Blow molding is a method of fabrication. As already mentioned, this definition is an over-simplification of a relatively complicated processing technique. Unfortunately, these hollow plastic tubes do not just appear out of the sky in a melted state, insert themselves in the molds and blow themselves up. They must be produced, placed between the molds and blown up - thus, the blow molding process and blow molding machine.

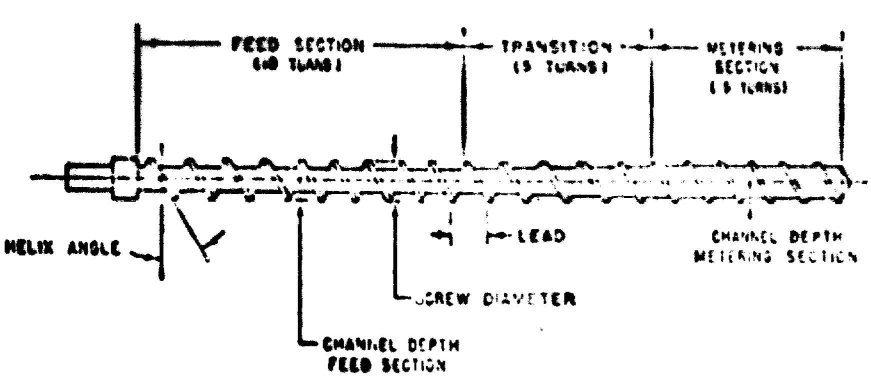
22. The blow molding process can be conveniently broken down into three major areas plus post molding finishing, if necessary.

FIGURE 2

EXTRUDER + SCREW



FEED TRANSITION METERING



TYPICAL SCREW

23. As time is limited, I will discuss only the most basic principles of each step. Hopefully, this will give you a feel for each step in the blow molding process and for the interaction between the steps.

24. In the blow molding process, the prime objective is to present a tube of molten plastic of the proper consistency in the molds, close the molds, blow the tube into the shape of the molds and then remove the bottle.

25. The first step to this end is the extrusion or melting of the plastic material.

Extrusion

26. Figure 2 shows a sketch of an extruder barrel and screw. The primary function as you are probably well aware is to take the cold pellet feed, compress and melt it into a physically and thermally homogeneous melt and force it through a die. The extruder is commonly made up of three sections, Feed Zone, Transition Zone and Metering Zone (see Figure 2). The exact length of each of these zones and their relative depth is primarily dependent upon the material being extruded - but, that is a complete topic in itself.

27. Each zone of the extruder has its own specific function.

28. The main function of the feed zone is to move the pellets forward and compact them - it is important that minimal melting takes place here as the interstitial air must have an escape route - if melting occurs too soon, air will be entrapped and will be conveyed all the way through the extruder and out of the die resulting in bubbles in the parison.

29. Only in the last few slights of the feed zone should melting start to occur.

30. The transition zone is the real work area. This is where the material is severely compressed, churned and melted. Any remaining air is driven out here.

31. The melted material is then conveyed to the metering zone which is very shallow. Here, it is smeared between the screw root and the barrel surface. Because the material film is very thin, thermal equilibrium is reached rapidly - thermal consistency of the melt is essential to successful blow molding.

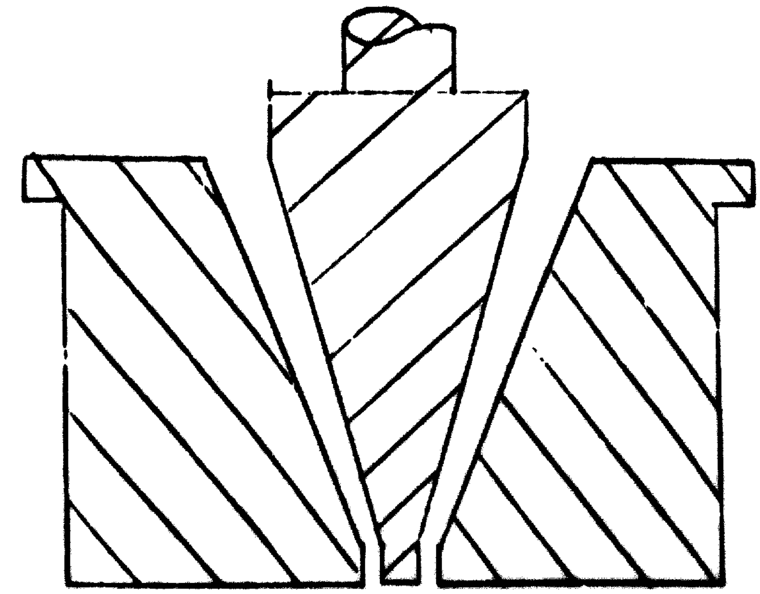
32. The metering zone also acts as a pump to force the melt at a uniform rate to the die.

<u>The Die</u>

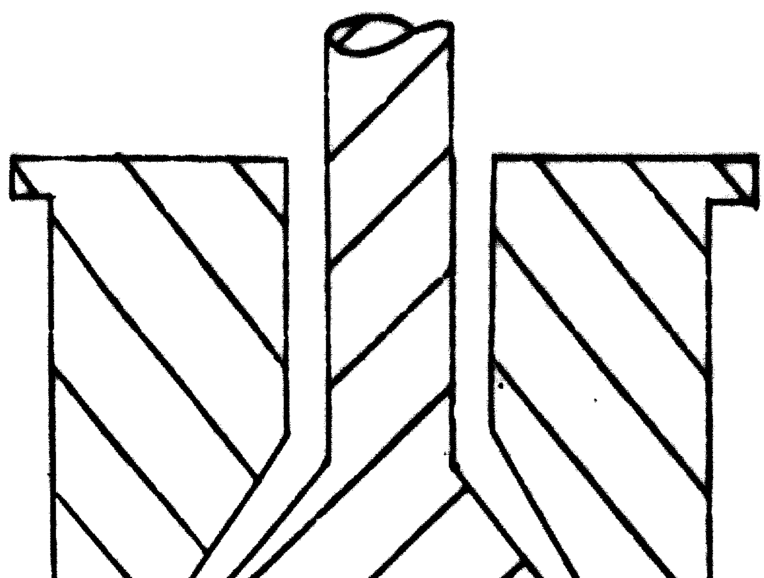
33. The purpose of the die is to form the parison. It receives the melt from the extruder and is designed so that molten plastic will flow around the die pin and form a tube (parison) when it emerges from the die.

BLOW MOLDING DIES

FIGURE 3



CONVERGENT



DIVERGENT

34. These are diagrams of a couple of typical die designs, 1) convergent and 2) divergent (large bottles).

35. The size of the die, the angles of convergence or divergence, the land length, material of construction, surface finish, etc., are all dependent on the material being molded, the design of the container and the machine type. Die design is, again, an extremely important but complicated subject which could be the topic for a weeks' worth of discussion. It will have to suffice to say here that the die has formed, hopefully, a decent parison which is now ready to be blown into a bottle. The above description is over-simplified as there are many phenomena which occur affecting the parison after it emerges from the die, but before the molds close and it is blown, that make this part of the process quite complex. Factors such as swell, draw down and snap back vary from polymer type to polymer type and also vary within each polymer type depending on the flow characteristics and molecular structure of the particular grade.

36. The next and final major step is blowing the bottle into the mold to form the final shape.

37. The mold closes on the parison, closing off one end and air is introduced usually through the mandril or pin, thus inflating the molten

plastic tube against the mold surface. This part of the process is highly critical as the mold design and mold modifications can severely affect just how the molten material fills the mold. This, in turn, will have a great deal of affect on the final properties of the blow molded article.

Part Mold Finishing

38. This operation may or may not be required depending on the machine and mold design. It is usually a relatively simple mechanical operation where "Tail" or neck flash is removed. Regardless how simple it is, it is usually the most neglected area in the whole operation and is the source of more lost production than all the other problems added together. It is not how many bottles are produced, it is how many get out the back door that counts - moneywise. A bottle lost is a bottle lost whether the good fairy steals it or the trimmer crunches it.

39. Thus, the blow molding process consists of four essential parts:

A. Melting the plastic

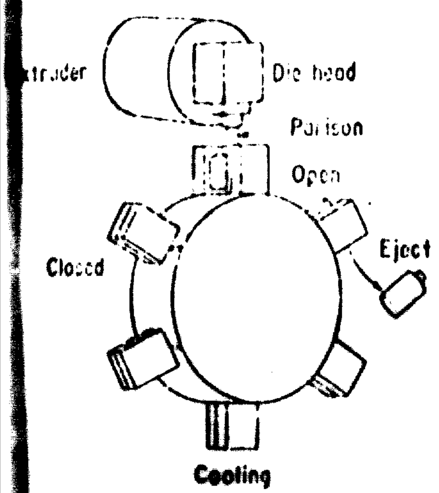
B. Forming the parison

C. Blowing the bottle

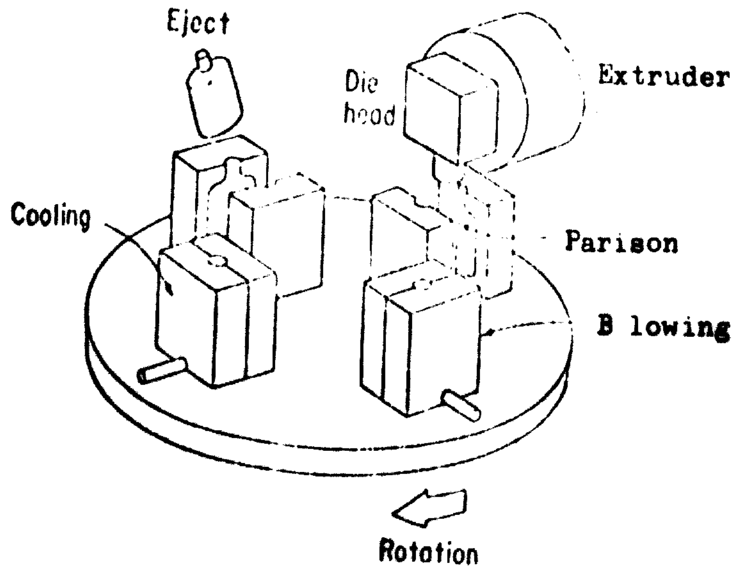
D. Part mold finishing (if necessary)

Every blow molding machine must have A, B and C.

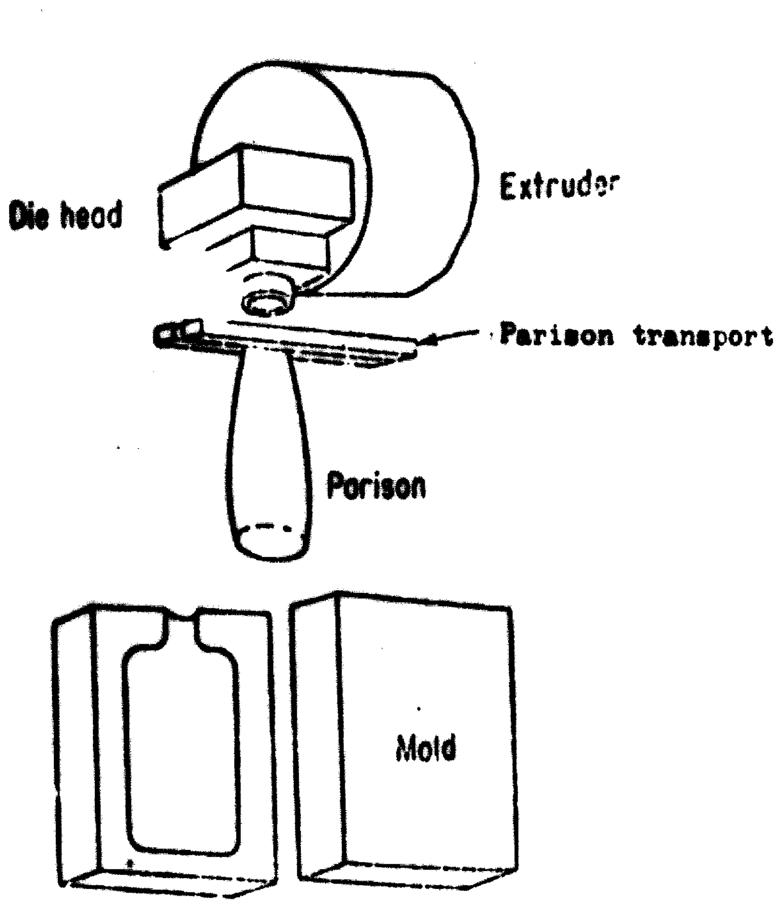
FIGURE 4
CONTINOUS EXTRUSION



VERTICAL WHEEL



HORIZONTAL WHEEL



PARISON TRANSFER

BLOW MOLDING EQUIPMENT TYPES

40. From this basic schematic, a wide variety of blow molding equipment has evolved. Each was developed with a specific purpose in mind, some were developed to produce specialized items, some were developed for specific materials.

41. We will basically describe each type and give an indication of the polymers that can be used on them and the items they are best suited to produce. We have purposely avoided discussing injection blow molding, as a separate paper on this subject will be delivered by a machine manufacturer during the Symposium.

42. Blow molding equipment can be classified by two methods:

A. Method of parison extrusion

B. Mold action

43. Although any combination of A and B is possible, continuous extrusion is almost always used in conjunction with: (See Figure 4)

A. Vertical wheel

B. Horizontal wheel

C. Vertical, horizontal or diagonal moving molds

D. Parison transfer

where the accumulation and reciprocating screw use the single or double platten open-shut type mold arrangement.

TABLE V

CONTINUOUS EXTRUSION

ADVANTAGES

- CAN BE USED FOR ALL MATERIALS
- CONTINUOUS STEADY STATE FLOW OF MATERIAL
- SLOW MATERIAL FLOW RATE - NO FLOW INSTABILITY PROBLEMS - MELT FRACTURE
- FEW SWELL PROBLEMS - CONSTANT PARISON WALL THICKNESS AND DIAMETER
- RAPID PRODUCTION - ESPECIALLY WHEEL
- EASILY PROGRAMMED

DISADVANTAGES

- WHEEL TYPE

  1) MULTIPLE MOLDS (2-15) - HIGH COST
  2) COMPLEX HYDRAULIC CONNECTION
  3) LARGE AMOUNT OF SCRAP - VERTICAL
  4) LIMITED PART SIZE - 4 LITRE
  5) HIGH SAG OR DRAW DOWN
  6) TEMPERATURE VARIATION ALONG PARISON

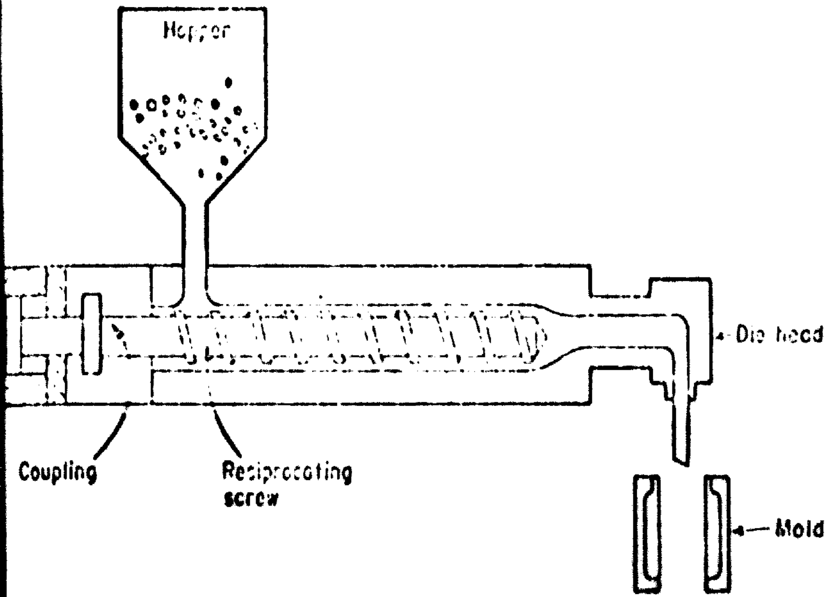
TABLE V - Cont'd

DISADVANTAGES - Cont'd

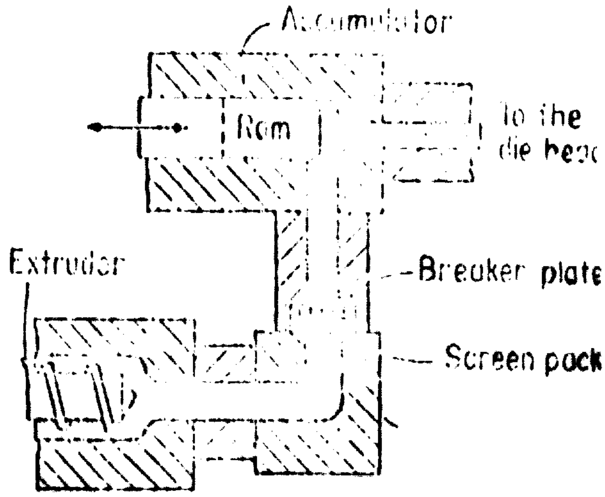
- MOVING MOLD - PARISON TRANSFER
  1) LIMITED PART SIZE 4 LITRE
  2) SLOWER PRODUCTION RATE
  3) HIGH SAG OR DRAW DOWN
  4) TEMPERATURE VARIATION ALONG PARISON

INTERMITTENT

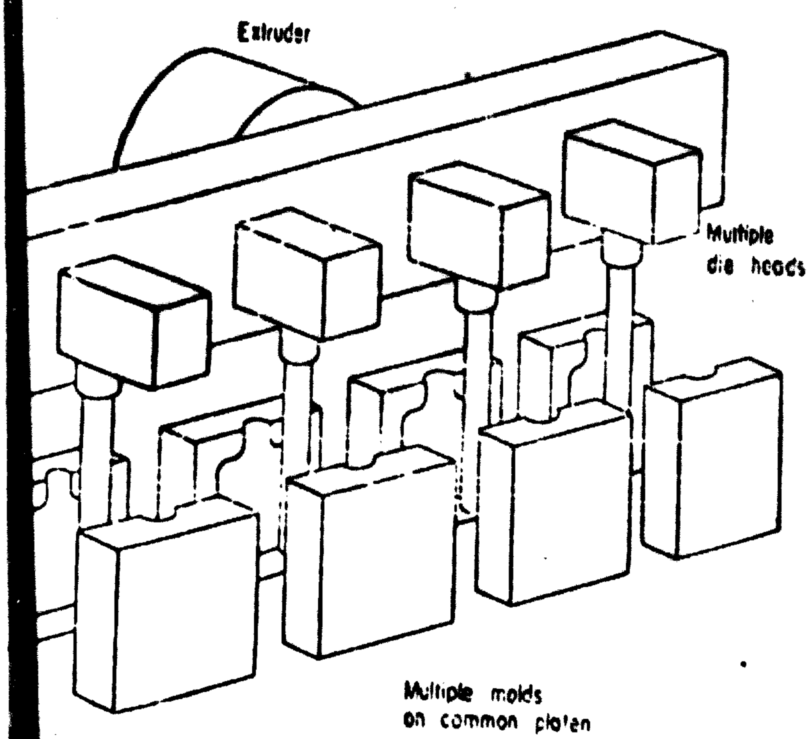
FIGURE 5

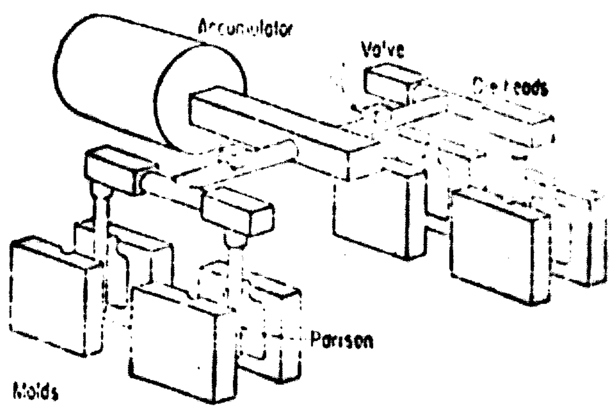


CIPROCATING SCREW



ACCUMULATOR





DOUBLE PLATEN
ALTERNATE FLOW

TABLE VI

INTERMITTENT EXTRUSION

ADVANTAGES

ACCUMULATOR

1) VERY HIGH PRODUCTION RATES
2) UNLIMITED PART SIZE
3) RAPID PARISON EXTRUSION
4) MINIMUM TEMPERATURE VARIATION ALONG PARISON
5) LOW SAG
6) MINIMIZES MOLD OPEN TIME
7) CONTINUOUS EXTRUSION TO ACCUMULATOR

RECIPROCATING SCREW

SAME AS ACCUMULATOR EXCEPT FOR 2

DISADVANTAGES

1) CANNOT BE USED WITH PLASTICS SENSITIVE TO THERMOL DEGRADATIONS (PVC)
2) DIFFICULT TO PROGRAM BECAUSE OF RAPID EXTRUSION RATE
3) OFTEN MELT INSTABILITY PROBLEMS
4) CAN CAUSE SWELL PROBLEMS

TABLE VII

Continuous Extrusion Transfer	Continuous Extrusion, Preform Transfer	Continuous Extrusion Ferris Wheel	Continuous Extrusion Rotary Table	Intermittent Extrusion Reciprocating Screw	Intermittent Extrusion Ram Accumulator
Very small to small containers (1 oz-1 qt)	Small parts (to 9 oz. & qt. size up to 1 gal)	Containers to 1 gal., includ'g all previously listed	Same as wheel	1/2 gal. -5 gal. containers	1/2 gal., 5 gal & containers to 300 gal. size
Aspirin bottles	Containers for; Eye lotion, Aerosols, Non-dairy cream, Bath oil, Shampoos, Motor Oil, Mustard, Milk, Photo chemicals	Not generally used for parts other than bottles		Acid bottles	Riding toys
Containers for: Nose spray, Deodorant, Sunburn cream, Glue, Hair Color'g	Hospital syringes	Handleware can be difficult to produce		Lab ware	Street light globes
Small toys, doll parts, etc.	Lab ware			Spec. liners	Water coolers
	Spec. liners			Bulk milk btls	Displays
	Water pitchers			Urinals	Lawn ornaments
	Urinals			Wax dispensers	Vaporizers
	Gas tank floats			Elec. coffee pots	Waste baskets
				Spec. dispos. containers, hospital syringes, etc.	Seat backs & bottoms
				Handleware quite easy to produce	Boats
					Under fender skirts
					Auto gas tanks
					Large figurines

44. The continuous extrusion blow molding offers some advantages and some disadvantages. The Primary advantage is that it can be used for all materials, PE to PVC. Thus, from a material standpoint, it is quite versatile.

45. Its' primary disadvantage is the limited container size and weight. This is due to the slow rate of extrusion and excessive draw down of the parison.

46. Other advantages and disadvantages are shown in Table V.

47. The intermittent extrusion machines (Figure 5) offer the advantage of larger parts, especially the accumulator machine because of the relatively fast parison drop. Also, because of this rapid drop, very high production rates are possible. Advantages and disadvantages of intermittent extrusion are listed in Table VI.

48. The primary disadvantage is their limited versatility from a material standpoint. If a material is sensitive to thermal degradation, the intermittent extrusion machine cannot be used, as storage for long periods of time at elevated temperatures can cause even explosive decomposition.

49. The moral of the story is, if you want a machine that is 100% versatile for smaller parts, continuous extrusion. If you want higher production rates or larger parts - intermittent extrusion - but don't try PVC.

TABLE VIII

SHARE OF BLOW MOLDING MARKET (APPROXIMATE)

POLYETHYLENE	77%
POLY VINYL CHLORIDE	13%
POLY PROPYLENE	4%
OTHERS:	6%
POLY STYRENE	
POLY ACETAL	
POLY CARBONATE	
ETC.	

50. Table VII gives you an idea of the common products produced on the various types of equipment.

BLOW MOLDING MATERIAL CHOICE

51. As already mentioned, nearly any plastic material that can be melted and made to flow, can be blow molded. Therefore, you may be confronted with making a choice of materials when considering producing a particular blow molded item. First, you can narrow the field by ruling out materials that will not do the job. Often many materials do not have the required chemical resistance, for example, one could not package acetone in polystyrene.

52. Of the remaining materials, many can probably be eliminated on the basis of physical properties.

53. Specific thermal properties may be required, as well as barrier properties and optical properties.

54. Once the field is narrowed to materials that will do the job satisfactorily, the next consideration is, of course, economics and which material will do the job at the lowest possible cost.

55. Here, one must carefully study the economics of each material. It is of no advantage to use a material that costs half as much if you must produce a part of three times the weight to produce a part that will be acceptable. On the other hand, don't overdesign from a material stand-point at extra cost - you gain no advantage.

56. • The material you choose will usually affect your production cost, cycle time and production efficiency.

57. Choose the easiest material to work with, if possible - one that you have used with success before.

58. Be sure the material is compatible with your operation. By this, I mean be sure your equipment is capable of running the material efficiently and that cross contamination with products you are already using will not be a problem.

59. As you can see, material choice can be a complex problem.

60. Generally, however, there will be one or two very specific requirements that will lead you directly to one material. If not, chances are about 90% that polyethylene will be your best choice.

61. Table VIII shows the approximate relative amounts of each plastic used for blow molding today.

62. High Density Polyethylene is, by far, the most widely used for several reasons. High Density Polyethylene has the best balance of properties, processability and economics of all blow molding materials. Chemically, it is nearly inert.

63. Physical properties such as tensile impact, elongation, stiffness, brittleness, etc., show a better average balance than any other single plastic. Thermal properties are good.

64. HDPE is the easiest plastic to blow mold and it can be blow molded on any equipment from the most ancient to the most sophisticated.

65. It runs at high rates and the raw material cost is relatively low compared to other materials.

66. In addition, HDPE is available in a large variety of grades which can be tailored to give the optimum balance of properties for a specific application.

67. Thus, for general blow molding, HDPE offers the best overall balance of properties, processability, economics and versatility.

NEW APPLICATIONS

68. The size and nature of the blow molding market varies very much from country to country. As an example, Table IX shows the current consumption per capita of high density polyethylene blow molded containers, by country.

	HDPE CONSUMPTION - GRAMS/CAPITA					
	USA	JAPAN	W. GER.	SCAN	MEX.	CZECH
Large Containers	38	136	396	320	20	64
Household Chemicals	1180	453	790	380	74	50
Food Containers	535	27	40	30	3	0

The blow molding machine manufacturers have played a major role in developing new markets in close cooperation with the plastics producers. For example, because of certain machine developments, ultra large containers in high density polyethylene, used for fuel tanks up to 2000 liters, can now be made. In West Germany, for example, the yearly production of such large containers account for approximately 24,000 tons HDPE. In the automobile industry, usage of fuel tanks will increase dramatically within a few years. Tanks made out of HDPE are approximately 50% lighter than those fabricated from metal and the production process is much simpler and cheaper. The important criterion is that the installation must not take up more of the luggage space in the car which has, up until now, been a favored site for the fuel tank.

69. The food container market is rapidly growing all over the world. Some of the products packaged in blow molded food containers are milk,

fruit juices, edible oil and drinking water.

70. The plastic dairy bottle is currently the consumer of over 100,000 tons/year of HDPE in the U. S. More than one billion plastic dairy containers/year are used primarily for milk and for juices.

71. The degree of adoption so far in different parts of the world varies quite widely due to economic and sociological reasons.

72. The trend is, however, very clear; the switch from traditional glass and paper based laminates to plastics containers is just a matter of time.

73. In "Paper Poor" countries, such as U. K., France, Greece and Japan, for example, the plastic milk bottle is conquering the market rapidly. In france, 30% of all liquid milk goes into HDPE bottles.

74. Sweden and Finland are two countries which have completely abandoned the use of glass bottles for milk distribution because of the enormous amount of polluted water produced during washing. They switched to carton packaging but, although these two countries are "Paper Rich", the trend is now plastic bottles. Cartons have to be made from wood, and the world consumption of paper and carton is so large the price increases are unavoidable in the future.

75. As far as the food container market in Latin America is concerned, the switch from glass and paper has just begun. As an example of the potential market, we can mention Venezuela where over 2,000 tons/year of HDPE will be used for milk and juice packaging within a few years. A 16MM film produced by Celanese Plastics Company on HDPE milk bottles will be shown during the presentation of this paper.

76. New blow molding machines capable of high speed production with close parison controls are responsible for the rebirth of the plastics aerosol container market. Celcon^{R} acetal copolymer made by Celanese Plastics Company and distributed outside the U.S. by Amcel Company, Inc., and in Latin America, by Pan-Amcel Company, Inc., is the most promising thermoplastic resin candidate for this market*. The design inflexibility inherent in metal, glass and aluminum have limited the size and shape of aerosol packages. With the introduction of Celcon, new design flexibility becomes possible, new aesthetics, new valving systems, improved safety. Celcon can be processed easily into a wide variety of sizes and shapes with

^{R}Registered Trademark

*Celcon is an engineering thermoplastic with high mechanical strength, and with excellent chemical, creep and permeation resistance.

molded-in color. Unlike metal or glass containers which can explode when heated, properly designed and molded Celcon aerosols soften, expand, pinhole and thus, release the pressures safely.

77. The blow molded Celcon aerosol container has a bright future in Latin American countries. Those who are familiar with this industry, know that the Latin American countries have two major problems in common in the aerosol industry, namely, poor container quality and the high cost of metal and vinyl coated glass containers. By using Celcon, the quality problem can be eliminated. As far as economics are concerned, Celcon can today successfully compete with aluminum up to 6 oz. containers in the U. S. However, as metal prices are bound to increase, Celcon will soon be competitive in the larger size containers. Compared to the U. S., the container size distribution in most Latin American countries differs considerably inasmuch as the smaller containers are the most popular.

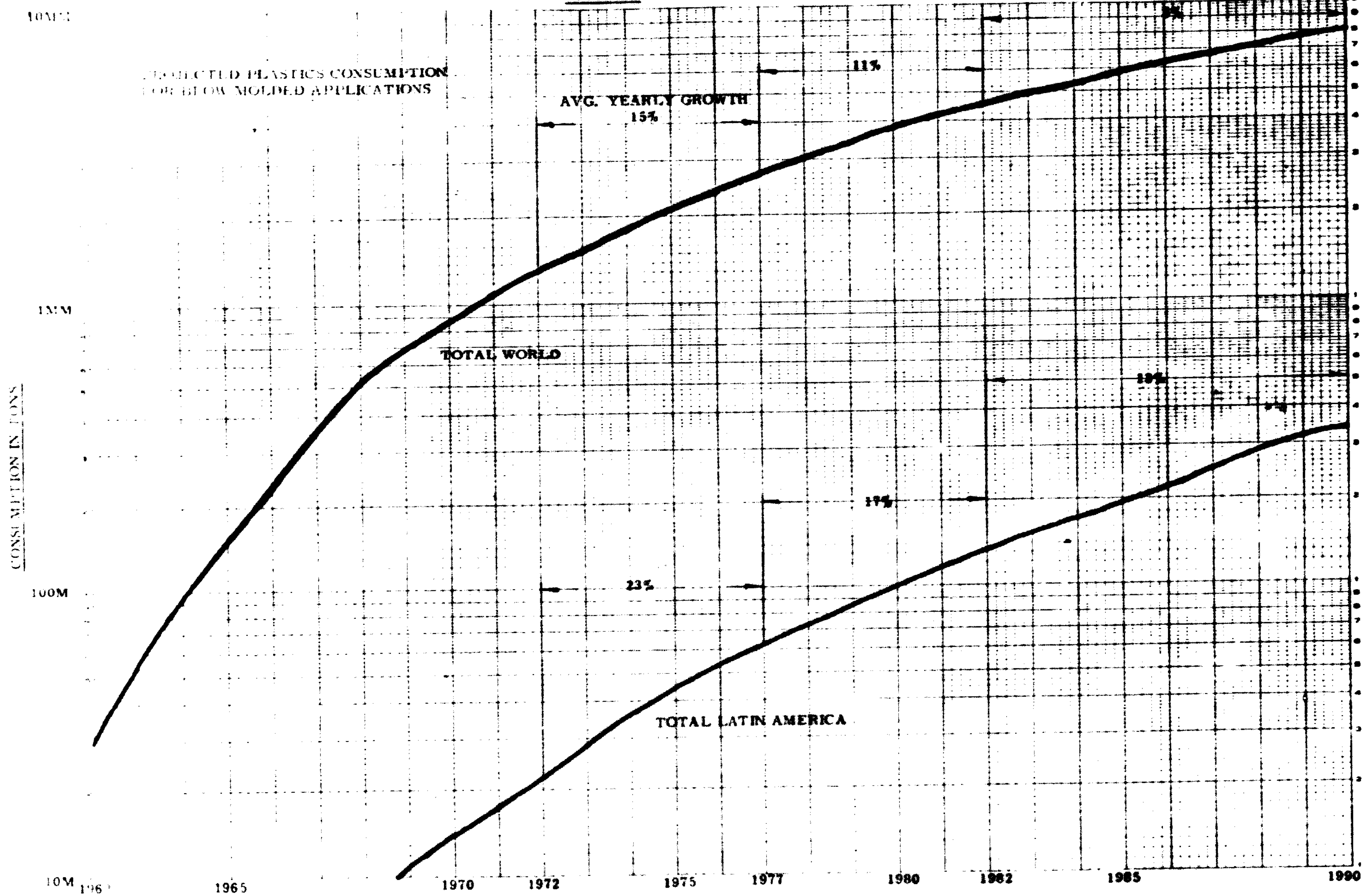
78. The total Latin American aerosol market is estimated to be 200 million containers/year and is growing at an average rate of 30%/year, which gives you an idea about the potential business that can be done in blow molded plastic containers.

Conclusion

79. To summarize, we have discussed the advantages of blow molding, the basic equipment involved, and the advantages and the advantages and disadvantages of various types of equipment, the different materials that can be blow molded, the basic requirements for selecting a material for a specific application. We have also discussed the future aspects of blow molding and some of the new applications that can be blow molded.

80. Obviously, we touched only lightly on each topic and many were left out - such topics as machine choice, die design, mold design, plant layout, etc., are topics which are extremely complicated and are different for each case.

FIGURE 1


PROJECTED PLASTICS CONSUMPTION
FOR BLOW MOLDED APPLICATIONS
CONSUMPTION IN TONS
10MM
1MM
100M
10M
1965
1970
1972
1975
1977
1980
1982
1985
1990
AVG. YEARLY GROWTH
15%
11%
TOTAL WORLD
23%
17%
TOTAL LATIN AMERICA

13. 8. 74