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OPPORTUNITIES FOR GLASS FIBRE REINFORCED PLASTICS IN DEVELOPING COUNTRIES[1/]

by

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I. INTRODUCTION

1. Glass fiber reinforced plastic is a material which consists of flexible strands of fibrous glass imbedded in a plastic matrix. It has become almost synonomous with such well-known products as boats, sports cars, translucent building panels, vaulting poles and fish rods. Perhaps lesser known to the consumer, but of greater significance to the product designer, are such industrial applications as automobile body components, appliance and equipment parts, storage tanks and electrical equipment components.

2. Today we find the annual per capita consumption of reinforced plastics to be about 2.2 kilos in the United States, 1.1 kilos in Japan, 0.7 kilo in Europe, and 0.1 kilo in Latin America. In these areas and other major commercial areas of the world, estimated consumption figures through the 1970's are impressive. For example, United States production totalled 445 million kilos in 1971 and is projected to be 1 billion kilos by 1976*.

3. In the relatively labor intensive economies of Latin America, the versatility and design flexibility of reinforced plastic is especially attractive. The low capital investment and basic simplicity of open-mold processes and low pressure closed-mold processes are ideally suited for the variety of small and moderate-size product markets in developing countries. On the other hand, certain industrial segments in Latin America show evidence that they may soon require more sophisticated process technology. Examples are the market areas of transportation, construction, and corrosion-resistant products. These areas have high volume production potentials which may soon demand semi-mechanized or mechanized high-speed production to satisfy the growing Latin American markets.

*Data based in information supplied by Society of the Plastics Industry, Inc., 250 Park Avenue, New York, New York.

II. THE NATURE OF REINFORCED PLASTICS

4. The term glass fiber reinforced plastic includes a whole family of basic design materials made from a wide range of thermoset or thermoplastic resins, combined with glass reinforcements in many forms and produced by a wide variety of manufacturing processes.

Basic Characteristics

5. Glass fibers have greater tensile strength than structural steel at one-third the weight. In reinforced plastic, glass fibers act to reinforce plastics much as steel reinforces concrete. Neither the plastic nor the fibers alone can serve as a load bearing structure. However, when the fibers are embedded in the plastic, the resulting composite has impressive properties including high strength-to-weight ratio and impact resistance plus improved temperature resistance and stiffness. These properties serve to give reinforced plastics its basic characteristics which provide the favorable cost/performance relationships necessary for commercial success. These basic characteristics of reinforced plastics are listed in Table I.

TABLE I

BASIC CHARACTERISTICS OF REINFORCED PLASTICS

Design Flexibility
High Strength
Low Specific Gravity
Corrosion Resistance
Dimensional Stability
Parts Consolidation
Low Tooling Cost
Low Finishing Cost

The Plastics and Reinforcements

6. The first plastics to be reinforced with glass fibers were the thermoset resins which cure to permanent shape and hardness. Thermosets can be molded to finished form with or without heat or pressure. Thermoset resins include polyesters, epoxies, phenolics, silicones, melamines, and diallyl phthalates. Today, polyester resins are used in 80% of the reinforced plastics produced.

7. During the past few years thermoplastic resins have been successful in capturing a share of reinforced plastics markets. Thermoplastics are resins which soften when heated and cool to rigid shape. Thermoplastics include nylon, polycarbonate, styrene-acrylonitrile, polystyrene, acrylonitrile-butadiene-styrene, polypropylene, polyethylene, acetal, etc.

8. The specific chemical and physical properties of glass fibers are controlled by the composition and the processes by which the fibers are drawn. There are, however, several innate characteristics of glass fibers which make them ideal reinforcements. For example, glass fibers have high tensile strength, perfect elasticity, high temperature resistance, dimensional stability, moisture resistance, corrosion resistance, excellent electrical characteristics and relatively low cost for structural fibers. Glass fibers are the reinforcement for 85 to 90 percent of all reinforced plastics.

9. Glass fibers are commercially available in a variety of forms. These forms include roving (essentially parallel strands of fibers gathered into a continuous ribbon), chopped strand mat (a blanket of chopped or continuous strands), yarn, fabric and woven roving. Each form his its individual adaptability to molding processes and its individual performance characteristics when embedded in a resinous matrix.

Molding Processes

10. The molding process, wherein glass fibers and resin are combined to form a structural material, is very important in the successful production of glass fiber reinforced plastics. Several processes are available to produce the desired combination of design, performance, and economics. The principal production processes are listed in Table II*.

TABLE II

PRODUCTION PROCESSES FOR REINFORCED PLASTICS

Hand Lay-up	Pressure Bagging
Spray-up	Autoclaving
Cold Press Molding	Centrifugal Casting
Matched Die Molding	Continuous Laminating
Filament Winding	Rotational Molding
Pultrusion	Injection Molding
Resinjection	Cold Stamping
Vacuum Bagging	Encapsulation

*It is beyond the objectives and intended scope of this paper to review reinforced plastics molding technology in detail. Such information is available from a variety of sources, such as:

Fiberglas Reinforced Plastics
Owens/Corning Fiberglas Corporation Publication 1-PI-1998-B
(Note that Fiberglas is the trademark (Reg. U. S. Pat. Off.) of Owens/Corning Fiberglas Corporation, Toledo, Ohio, for a variety of products made from glass fibers).

Reinforced Plastics
Owens/Corning Fiberglas Corporation Publication 5-PL-31-1-D

A comparison of basic characteristics of the more popular processes are indicated in Table III.

TABLE III

COMPARISON OF BASIC PROCESS CHARACTERISTICS

Process	Characteristics			
	Capital Investment	Tooling Cost	Production Rate	Technology Requirement
Hand Lay-up	Low	Low	Low	Low
Spray-up	Low	Low	Low	Low
Cold Press Molding	Moderate	Moderate	Moderate	Moderate
Filament Winding	Mod. to High	Mod. to High	Low to Mod.	Mod. to High
Matched Metal Die	High	High	High	High
Injection Molding	High	High	High	High

Principles of Production

11. There are four major principles which must be recognized for the successful production of glass fiber reinforced plastics. These principles are:

A. The mechanical properties of a glass fiber reinforced plastic part depend on the combined effect of the amount of glass fiber reinforcement used and its arrangement in the finished composite.

B. The chemical, electrical and thermal performance of a reinforced plastic part is influenced by the resin system used as a matrix.

C. Materials selection, plus design and production requirements, determine the proper production process to be used.

D. The cost-performance value achieved by a part is dependent upon good design and judicious selection of raw materials and processes.

III. MARKETS FOR REINFORCED PLASTICS IN DEVELOPED COUNTRIES

12. There are few, if any, other areas of business endeavor which can match the opportunities offered by reinforced plastics. There is reputed to be over 35,000 different products produced in reinforced plastics and there are untold thousands of new products being developed.

Market Areas

13. The markets for glass fiber reinforced plasticsare usually divided into the nine market areas as indicated in Table IV.

TABLE IV

REINFORCED PLASTICS MARKET AREAS

- Aircraft and Aerospace
- Appliances and Equipment
- Construction
- Consumer Goods
- Corrosion-Resistant Products
- Electrical
- Marine
- Transportation
- Other

14. The aircraft and aerospace market includes the market for aircraft parts and structures plus that for various rocket and missile parts including rocket motor cases. The confidence factors for reinforced plastics in airframe and structural components are continually improving. The Windecker 2-engine, 4-passenger airplane is all reinforced plastic; wings, fuselage, and tail. The Boeing 737 has 150 square meters of laminate including primary structure in the elevator and rudder sections. The Boeing 747 has 100 square meters of laminate,including variable camber flaps,which, due to their particular flexural and strength requirements,were impossible to

produce in metal. Aircraft applications will grow because reinforced plastics can provide a gain in strength plus an important savings in weight. Rocket and missile applications will also increase due to both the strength-to-weight ratio plus the high temperature resistance which can be achieved with reinforced plastics.

15. Although the appliance and equipment market has not been large in terms of consumption, it is expected to provide many new opportunities in the near future. Appliance manufacturers have accepted reinforced plastics in all its different forms, taking advantage of newer materials developments and mass production techniques. Applications include components of air conditioners, humidifiers, supermarket cases, refrigerators, calculator housings, and instrument covers, plus parts for dishwashers and garbage disposal units.

16. Opportunities for reinforced plastics in the construction market have been and are very good. This is in spite of the fact that the construction industry is notoriously slow in accepting change, not only in construction techniques, but in new products. Also, building codes are not changed quickly. The construction market includes corrugated sheet whose production consumes the greatest amount of glass fibers and resin of any single reinforced plastic product produced in Latin America today. This market area also includes flat panels, bathtubs, tub-showers, shower stalls, wash basins, kitchen sinks, concrete pouring forms, facades, doors, window frames, etc.

17. Reinforced plastics inroads into consumer products are diverse and imaginative. Products include campers, travel trailers, snowmobiles, all terrain vehicles, fishing rods, surf boards, water skis, snow skis, archery equipment, vaulting poles, playground equipment, swimming pools, luggage, trays, lamp shades, golf club shafts, decorative fountains, and furniture.

18. The corrosion-resistant market is an explosive market in terms of potential and sales opportunity. Corrosion engineers have found reinforced plastics to be the solution to tough corrosion problems. The cost performance advantages of reinforced plastics have been established and proven-in-use. Technological advances have made it possible for reinforced plastic pipe to be competitive with 60% of all the pipe used in oil fields and in the chemical process industry. Applications for corrosion-resistant products include pipe from diameters of 2.5 cm to 2 meters, tanks up to 280,000 liters, fume hoods, ducts, scrubbers and food processing equipment.

19. Market intelligence clearly indicates that engineers are developing increased confidence in the electrical applications of reinforced plastics. The electrical market includes such applications as poles and pole hardware, transformer tanks, switchgear, telephone equipment, printed circuits, computer parts, line-work booms and buckets and underground substations. The development of the market will be further motivated by the development of resin systems with improved weathering and track resistance and the development of new high performance reinforced thermoplastics.

20. Marine applications have been a leading market since glass fiber reinforced plastics reached commercial proportions. The pleasure boat market continues to grow and yachts, military craft and commercial boats are moving into reinforced plastics in greater quantities. The future for reinforced plastics in commercial fishing fleets looks especially promising. Today, 22.6 meter reinforced plastic shrimp trawlers are replacing wood boats in Gulf Coast fleets and 28.4 meter reinforced plastic seiners fish Peruvian waters.

21. The land transportation market offers one of the larger opportunities for reinforced plastics. Opportunities for end-use applications of this market are almost too numerous to mention. The proliferation of new reinforced plastic component applications can be found in automobiles, trucks,

trains, trailers, mobile homes, busses, subways, containers, and farm equipment. More specifically, there are such product applications as door panels, deck lids, roof panels, underbodies, instrument panels, head lamp housings, fender extensions, decorative parts, interior trim, trim rails, heater ducts, wiring shields, bumper closure panels, hoods, cowl assemblies, etc. Automobile and truck manufacturers in the United States are expected to use 94,000 metric tons of glass fiber reinforced plastics in the 1972 calendar year. The projected average growth rate in the U. S. transportation industry is 22 percent per year through 1977.

Market Growth

22. In the 1970's the growth of glass fiber reinforced plastics will be strong because:

A. Glass fiber reinforced plastic has gained acceptance in its own right as a material of quality, utility and beauty. It is no longer considered a cheap substitute for traditional materials.

B. Process technology has advanced to where reinforced plastics as a material can compete on a cost performance basis with the traditional design materials - wood, metal, ceramics, etc.

C. Glass fiber reinforced plastics have gained the support of reputable concerns who have the means and desire to grow and develop its potentials to the fullest.

23. A good indication of the market development possibilities for reinforced plastics in Latin America are the consumption and market distribution figures in the United States. In 1971, total production of reinforced plastics in the United States totalled 444,350 metric tons. Forecasts indicate the total volume will more than double by 1976 to reach a level of 989,200 metric tons.

Market distribution figures for 1971 with 1976 projections are given in Table V.

TABLE V

REINFORCED PLASTIC SHIPMENTS IN U. S.

(In metric tons)

Market	1971	1976
Aircraft and Aerospace	11,350	18,200
Appliances and Equipment	19,500	56,000
Construction	61,000	144,000
Consumer Goods	36,400	56,500
Corrosion-Resistant	40,500	109,500
Electrical	25,400	46,400
Marine	118,000	197,000
Transportation	99,500	294,000
Other	32,700	67,600
	444,350	989,200

IV. REINFORCED PLASTICS IN LATIN AMERICA

24. The production and use of reinforced plastics in the developing countries of Latin America has increased markedly during the last 3 or 4 years. Latin American production is expected to be 25,000 metric tons in 1972.

Typical Products

25. The larger share of Latin American production is for the construction market. Major items include corrugated sheet and sanitary fixtures. The second ranking production area is for consumer goods. Common consumer items are furniture, helmets, trays and face shields. A list of specific reinforced plastics items currently produced is given in Table VI.

TABLE VI

TYPICAL REINFORCED PLASTICS PRODUCTS
CURRENTLY PRODUCED IN LATIN AMERICA

Automotive
- Bodies (total)
- Fan shrouds
- Fenders
- Gasoline tanks
- Grills
- Heater housings
- Hoods
- Instrument panels
- Jeep tops
- Kick panels

Bus and Truck Parts
- Bus bodies (total)
- Passenger seating
- Truck cabs
- Refrigerated boxes

Construction
- Concrete forms
- Corrugated sheet
- Domes (decorative)
- Domes (structural)
- Doors
- Facades
- Flat sheet
- House modules
- Kitchen sinks
- Roofs
- Shower bases
- Shower stalls
- Sun shades
- Tubs
- Tub-showers
- Ventilators
- Wash basins
- Windows (decorative)
- Window frames

Electrical
- Pole extensions
- Service booms
- Service baskets
- Street lamp housings

Furniture
- Chairs
- Chair bases
- Cocktail tables
- Dining tables
- Lockers
- Lounge chairs
- Magazine racks
- School chairs
- School desks
- Sofa bases

Marine
- Canoes
- Fishing trawlers
- Outboard-motor boats
- Pedal-pontoon boats
- Sailboats

Pipe
- Chemical
- Oil
- Sewage
- Water

Tanks and Tank Linings
- Chemical
- Oil
- Water

Miscellaneous
- Display cases
- Face shields
- Feed troughs (cattle)
- Helmets
- Lampshades
- Manikins
- Playground equipment
- Swimming pools
- Telephone booths
- Tote boxes
- Toys
- Trays
- -
- -

Potential Growth Areas

26. With problems of increasing consumer population, incomplete industrialization and limited capital availability, Latin America will find advantage in the variety and flexibility of reinforced plastics processing methods. Depending on prevailing conditions, manufacturing may be geared to low, intermediate or high volume production with corresponding technical and capital investment requirements. For example, a small product market of a few hundred or few thousand parts per year might be satisfied by a simple hand lay-up or spray-up operation started with an investment of a few thousand dollars. On the other hand, the demands of a large volume sophisticated product market might justify a complex, more capital intensive process such as matched-metal-die compression molding. This variety of processing methods, with different technical and capital investment requirements makes reinforced plastics production adaptable to a variety of industrial and economic situations. The break-even chart in Figure 1 indicates the adaptability of reinforced plastics processing to market potentials and economic requirements.

27. There are several market areas, in Latin America, which have better than average growth potential for reinforced plastics. An example is the construction market. In many areas of Latin America, as in most of the world, housing is desperately needed. The inherent advantages of reinforced plastics - light weight, ease and speed of fabrication, etc., are all important to anyone trying to develop mass, low income housing. There are several exploratory projects underway and the key to this huge potential market is expected to be found in the reasonably near future. Mexico already produces a reinforced plastics house (see Figure 2), Colombia has developed a preliminary design module for houses and school rooms, Chile is developing a filament wound module (see Figure 3) and Venezuela is becoming increasingly active in reinforced plastic housing. Although a great deal of work remains to be done before reinforced plastic houses become a practical reality, progress is being made. The potential exists and the possibilities excite the imagination.

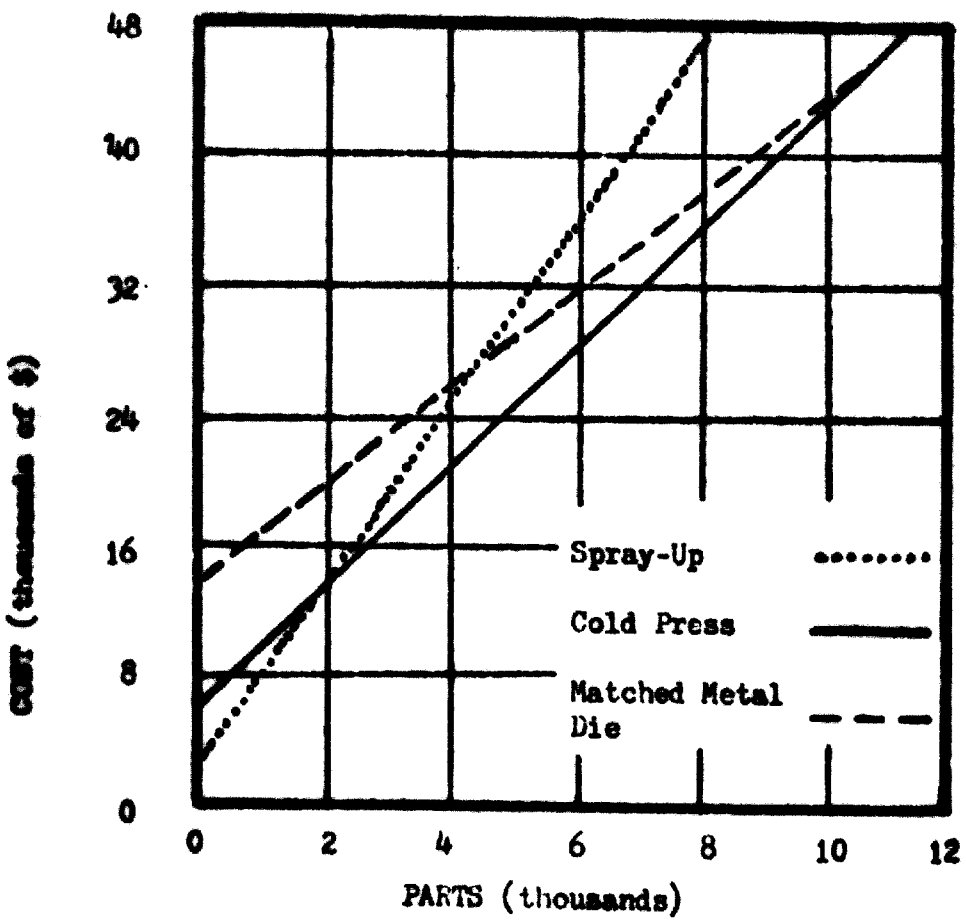


Figure 1. Break-even chart for molding a particular .52 square meter chair

Costs are U. S. costs for tooling, labor, and material.

Figure 2. Glass fiber reinforced plastic house produced in Mexico (Courtesy Vitro-Fibras S. A.)

Figure 3. Glass fiber reinforced plastic house module filament wound in Chile (Courtesy of Sylleros S. A.)

28. Another key opportunity for reinforced plastics is in the market for corrosion resistant products (see Figure 4). There is a large Latin American potential for water and sewage pipes as well as for anti-corrosive piper. The shortage of cast iron and steel pipe in some areas has created a demand for pipe, especially for water supply in new communities. The petroleum industry which is growing at an accelerated rate in many areas of Latin America, offers several new opportunities for both pipes and tanks. Also the repair market for large oil storage tanks is a good one, with hundreds of tanks in need of repair in Latin America. A repair with reinforced plastic is good for an estimated 20 years service life and costs only about 1/2 the cost of repair with steel. With the adoption of more sophisticated agriculture methods and techniques, the possibilities for fertilizer tanks and irrigation pipes provides other opportunities in the corrosion resistant market.

29. The land transportation market for reinforced plastics is destined to grow because plastics are standing the acid test on a cost/performance basis. As evidence of this, there are approximately 200 reinforced plastics components in the 1972 U. S. automobiles that are identical to or modifications of components used in 1971. In Latin America as vehicle sales increase and as more nations legislate periodic increases in the percentage of nationally produced materials in vehicles, the increased consumption of reinforced plastics is almost inevitable. Already reinforced plastics auto bodies are produced in Brazil and Uruguay, truck cabs are produced in Brazil and Mexico, and bus body parts and a variety of miscellaneous interior and exterior parts are produced in several Latin American countries (see Figures 5, 6, and 7). Major automobile producers are now working on designs for a family of vehicles suitable for major world markets including Latin America. Some of these will be in reinforced plastics.

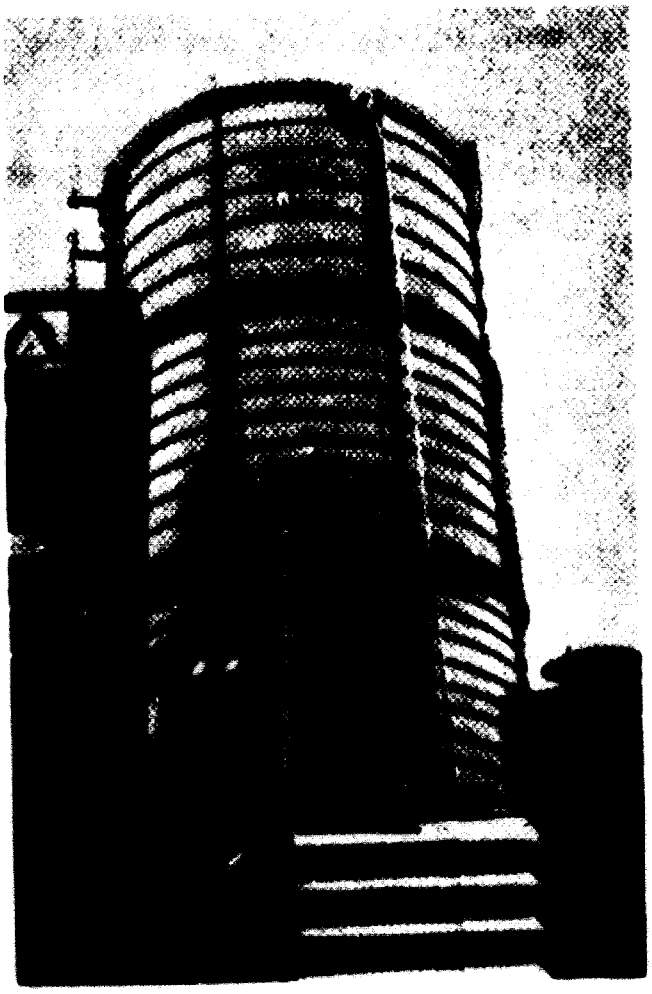


Figure 4. Glass fiber reinforced plastic tank produced in Brasil (Courtesy of Alpina S. A. Ind E Com.)

Figure 5. Glass fiber reinforced plastic truck cabs produced in Brasil (Courtesy of Heliogar S. A.).

Figure 6. Glass fiber reinforced plastic Jeep body produced in Brasil (Courtesy of Gurgel Ind. E. Com. de Veiculos)

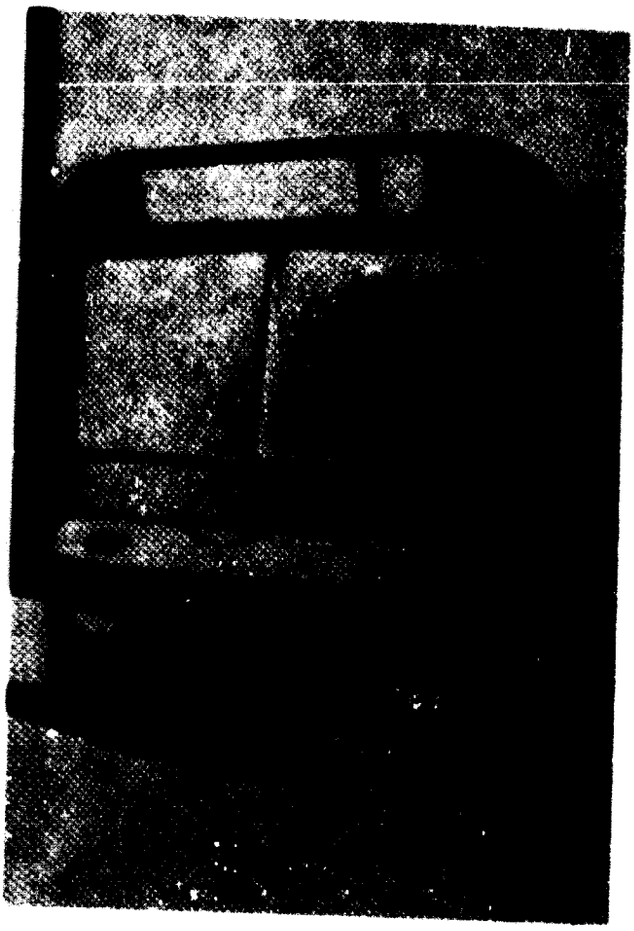


Figure 7. Glass fiber reinforced plastic bus body components produced in Mexico (Courtesy of Vitro-Fibras S. A.)

30. The marine market is another potentially good growth area. The pleasure boat market is growing and there is serious interest on the part of governments and industries to produce large fishing trawlers and other types of large fishing craft. With suitable design and adequate technology and financial backing, the production of large boats may soon prove to be an important business in Latin America.

31. Four specific items which seem to have good opportunities for market development are water tanks, bus seats, refrigerator truck boxes, and poles. Tanks for reserve water supply are commonplace for urban homes. Most of these tanks are now made from cement-asbestos and are rather unsightly although economical. In competing with cement-asbestos, reinforced plastic tanks offer design variety and beauty plus the other conventional properties of reinforced plastics. As a result they are now successfully produced and marketed in Chile, Costa Rica, and Mexico (see Figures 8 and 9). Because of the huge market for water tanks in Latin America, a small percentage market penetration could result in a very good business for reinforced plastics.

32. Bus seating with its longevity, vandal resistance, beauty and mechanical performance, has good market potential in many areas. Thousands upon thousands of busses are used for public conveyance in Latin America but the use of reinforced plastics for bus seating is not yet widespread. In most cases this is due to passenger complaints that reinforced plastic seats are "hard" and uncomfortable. These complaints stem from the fact that the simplicity of bus construction does not provide sufficient isolation of passenger seating from chassis vibration and shock. With newer bus and seat-base design, passenger resistance will undoubtedly be minimized and the cost/performance of reinforced plastics seating will prevail.

Figure 8. Glass fiber reinforced plastic water tanks produced in Costa Rica (Courtesy of Plastikart S. A.).

Figure 9. Glass fiber reinforced plastic water tank produced in Mexico (Courtesy of Vitro-Fibras S. A.)

33. The market for refrigerator truck boxes has been a profitable and rapidly growing one in Latin America. These boxes are usually constructed of reinforced plastics interior and exterior skins on a urethane foam core. As such they provide low heat transfer, light weight, eye appeal, low maintenance cost and a sanitary surface for contact with consumer food products. Seemingly only a small part of the market potential for refrigerator boxes has been developed.

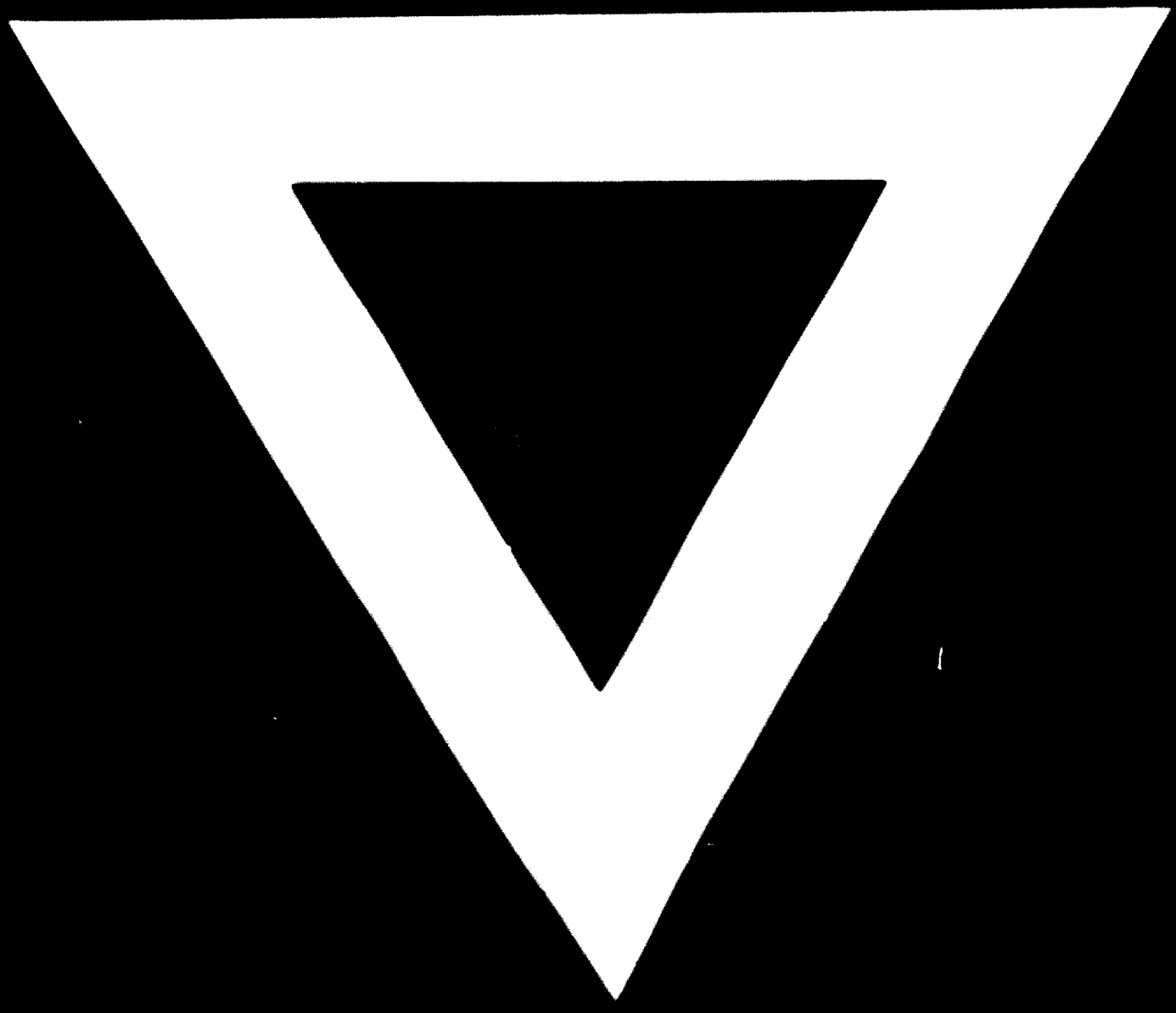
34. As the utility pole market is being developed, the lighting pole market seems to have some immediate opportunities. In most areas, aesthetics and safety are principal factors in pole selection; but in some Latin American coastal areas, deterioration rate becomes the principal criterion. The corrosion-deterioration resistance and longevity of reinforced plastics gives it a very good cost/performance.

The Challenge

35. The aforementioned opportunities offer a challenge to Latin American businessmen and officials. The materials and technology exist - the challenge is one of translating the technology into productive efforts in the Latin environment.

36. Problem areas include a shortage of trained technical personnel and limited supply of managers experienced in the business techniques unique to reinforced plastics. These problems, however, are being solved. Instrumental in their solution is the technical and marketing support provided by material suppliers in the more developed countries. Also of noticeable value is the establishment of joint ventures with experienced molders from Europe or the United States and the outright purchase of proven technology and know-how.

37. As a modern versatile, high-performance material, reinforced plastics is now establishing some impressive production growth rates in Latin America. Indications are that the 1970's will prove to be a period of major development and expansion. Increased production is expected in all of the Latin American reinforced plastics market areas.



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