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F O R E W O R D

This report covers the activities and accomplishments of the Research Department for the last six months of 1966. Since this is the year-end, some results will also be reported for the full year of 1966.

\$210,000 was budgeted for research in 1966. The total expenditures were \$166,777. The lower expenditure is a result of abandoning projects on acoustical tile and synthetic gypsum for which \$37,700 had been budgeted. Due to a transition in Accounting personnel, we do not have a distribution of the 1966 research expenditures. \$235,000 has been budgeted for research in 1967. The projected distribution of these expenditures is shown on page two.

The market performance of new products on pages three and four show the sales and profits emanating from products developed through research. The charts on page five show the growth of sales and profits from new products. In 1966, the sales from new products were 3.9% of the Division total and the profits were 2.7% of the total.

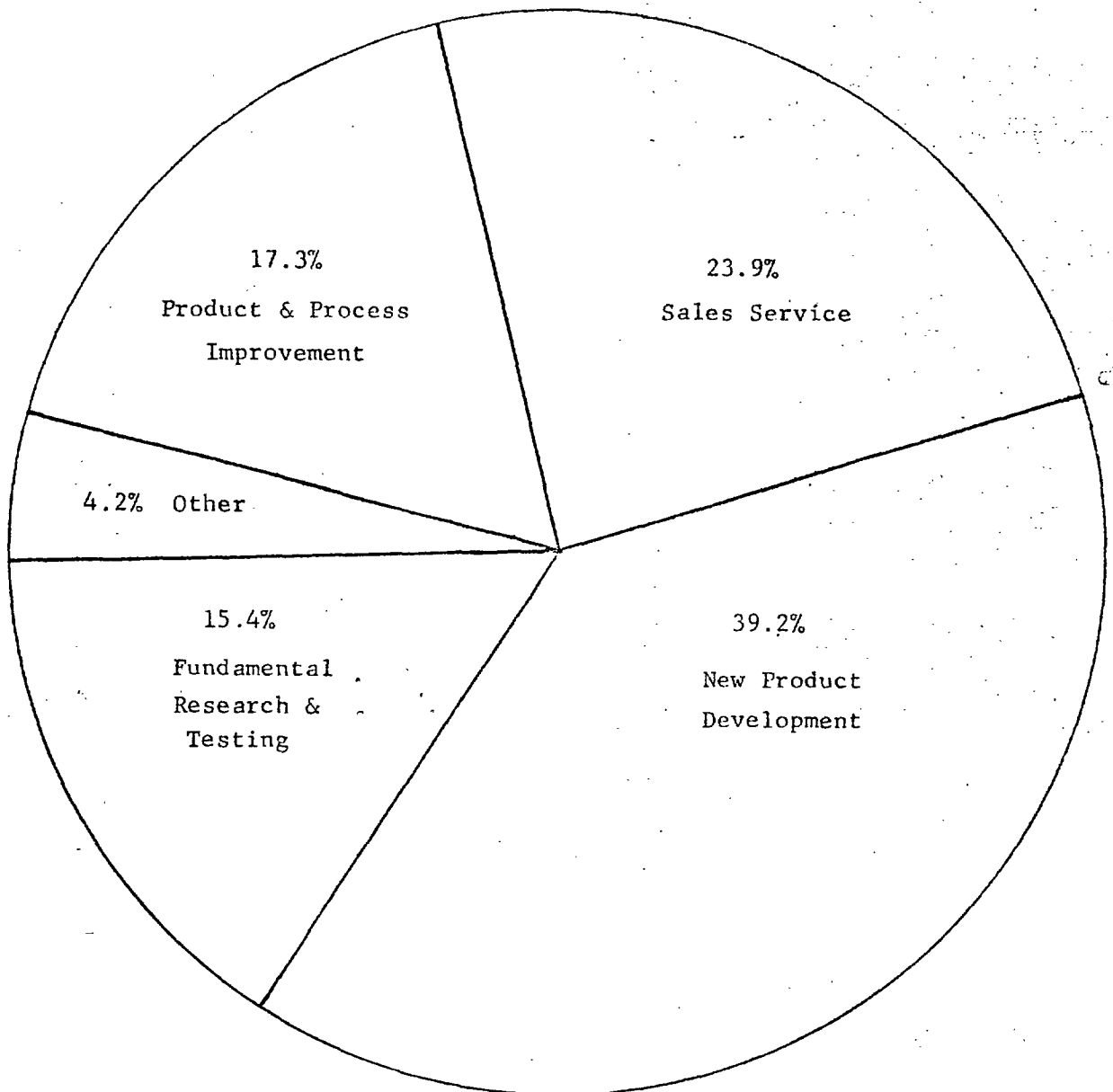
Product improvements or services to Sales can not be measured directly in terms of sales. About \$30,000 was spent for fire testing in 1966. The fact that our 1/2" Firestop sales increased 83% and our 5/8" Firestop sales increased 17% compared to 1965, is an indicated that our money for fire testing is well spent. The graph on page six shows the growth in Firestop sales since 1964.

Some organizational changes have been made during this period. Mr. Matruo was transferred to Blue Rapids to assist in getting the Denscal operation underway. Arrangements were made to get two students from Drexel Institute as technicians through their co-op program. Each six months replacements are furnished. This program has help immensely with the project work and it was hoped that this would be the basis for future hiring of technical personnel. We plan to investigate the possibility of starting a similar program in Portland. We are still seeking another permanent research engineer and will direct our search to the West Coast.

The main section of this report is devoted to the progress of the various projects. Each project is listed under one of the following categories:

1. Product and Process Improvement
2. Sales Service
3. New Product Development
4. Fundamental Research, Laboratory Service and Testing

BUDGETED DISTRIBUTION OF
1967 RESEARCH EXPENDITURES



Market Performance of New Products (Last 6 Months)

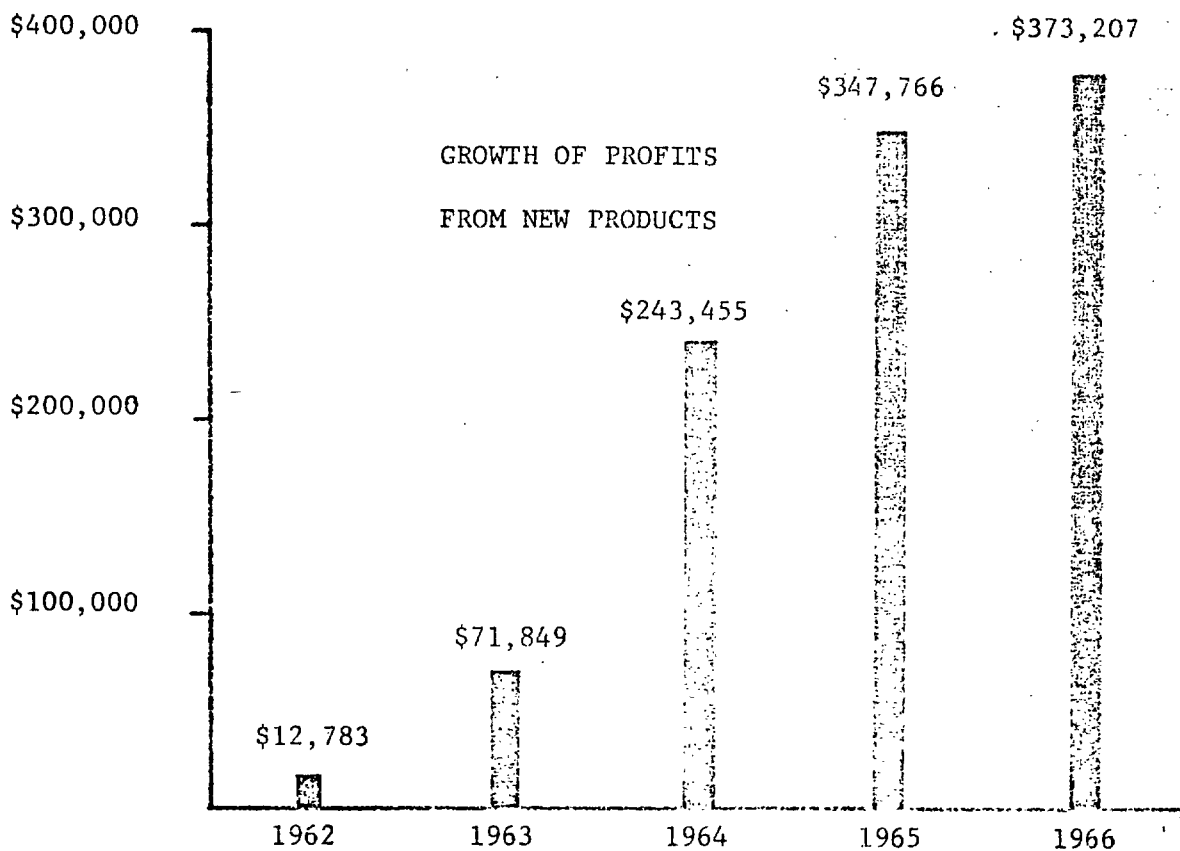
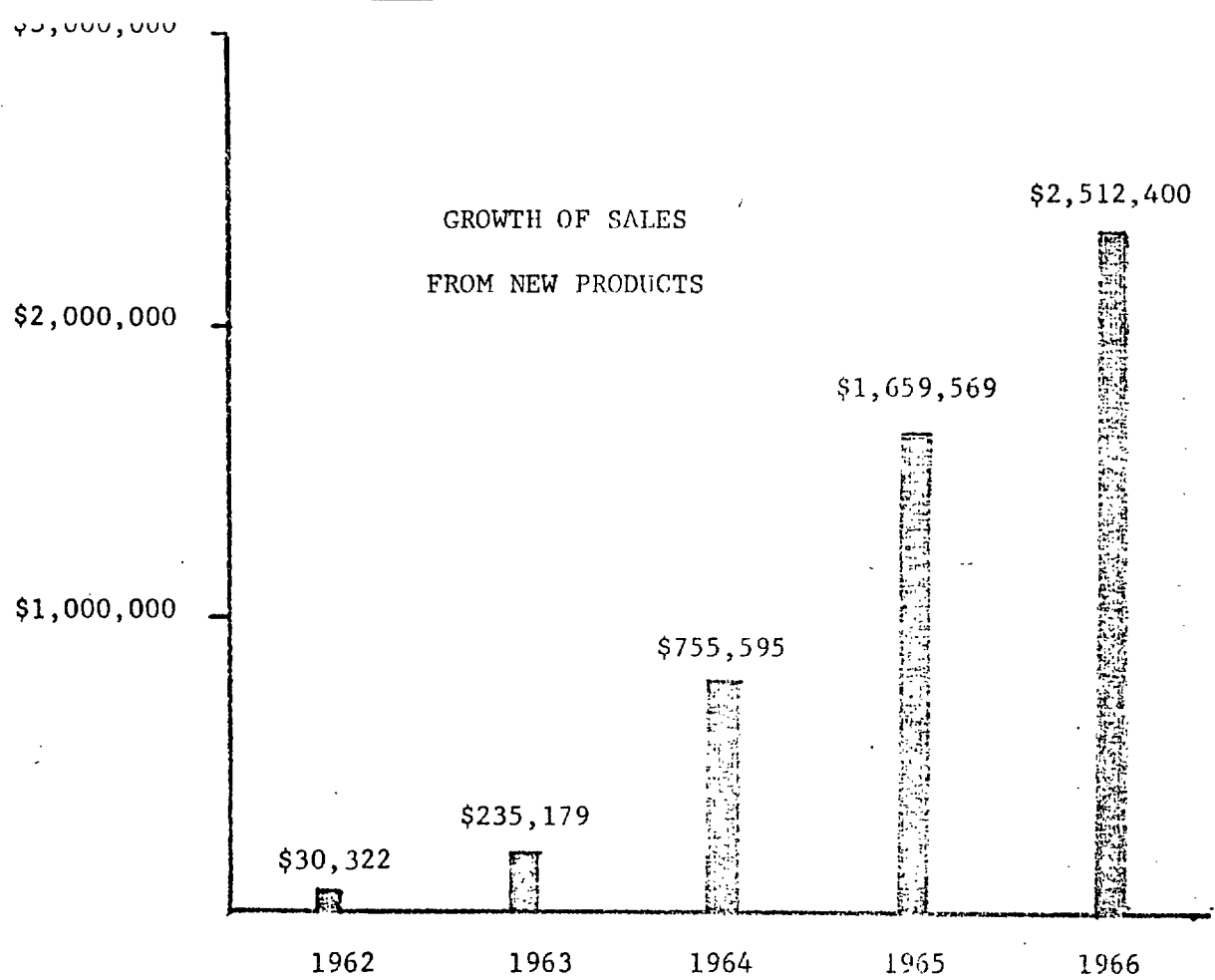
<u>Product</u>	<u>Sales Volume</u>	<u>List Sales</u>	<u>Estimated Gross Profit</u>
Denscote Base (all)	8,625 M sq. ft.	\$ 367,179	\$ 59,699
Tile Backer Board (all)	1,551 M sq. ft.	129,183	50,608
Firestop Tile Backer	30 M sq. ft.	3,034	1,326
Tru Grain Wallboard	178 M sq. ft.	12,632	1,427
One Day Jt. Compound	215 Tons	36,531	5,749
Ready Mix Jt. Compound	73,762 Pails	302,023	(3,059)
(5 gal.)	66,055 Pails		
(1 gal.)	7,707 Pails		
Triple Duty Jt. Compound	1,656 Tons	254,887	52,347
Grabit Adhesive	53 Tons	7,910	2,336
Bestex A	28,920 Bags	57,769	(2,222)
Bestex B	1,689 Bags	7,331	(127)
Bestex C	3,640 Bags	14,835	(1,785)
Denscote Plaster	1,426 Tons	81,813	9,086
Denscote Tape	3,707 Rolls	6,523	2,737
Vinyl Tape - Tile Backer	384 Rolls	379	80
Model Densite	1 Tons	47	16
Tooling Densite	2 Tons	204	89
High Expansion Plaster	2 Tons	138	21
Ram Process Plaster	8.8 Tons	924	424
 TOTAL		 \$1,283,342	 \$178,752

Market Performance of New Products for 1966

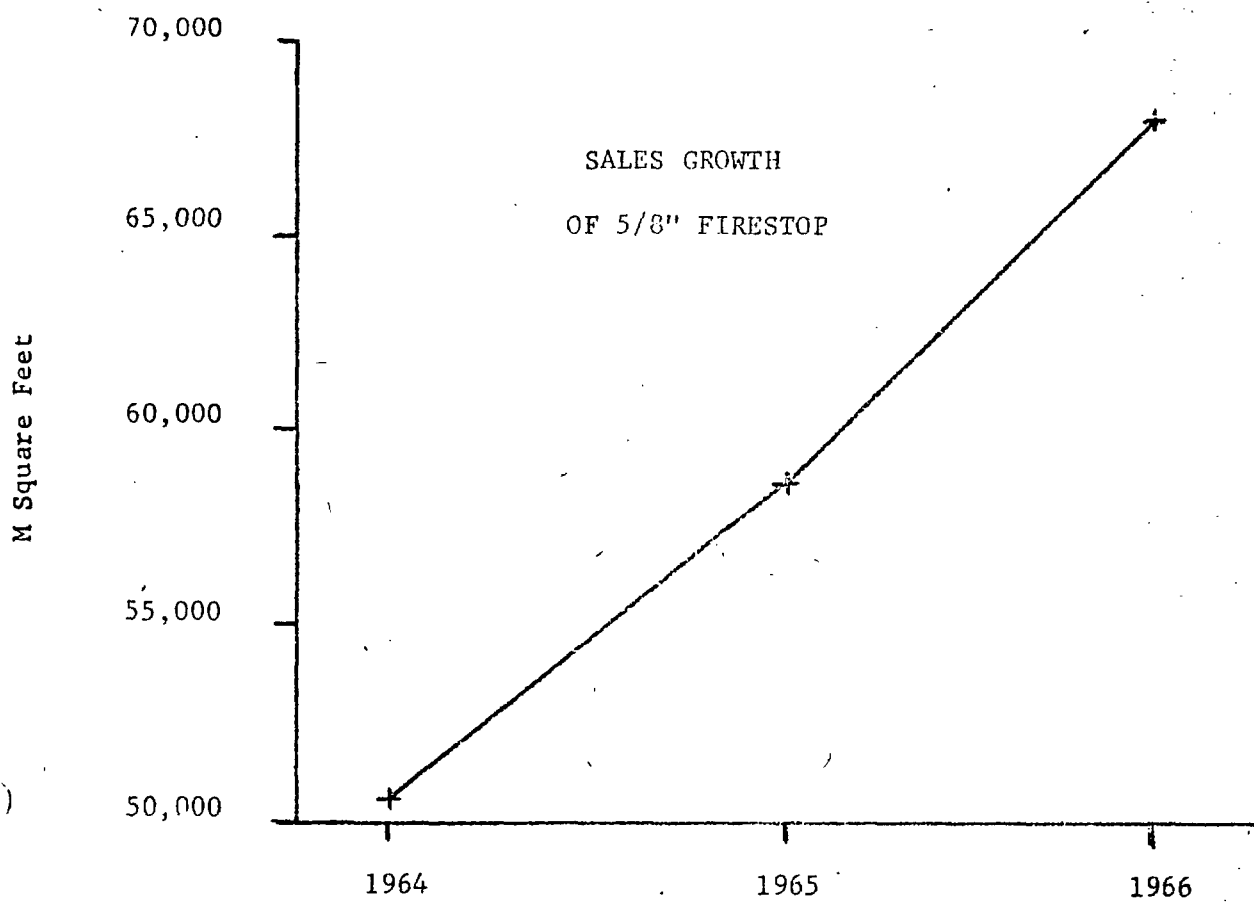
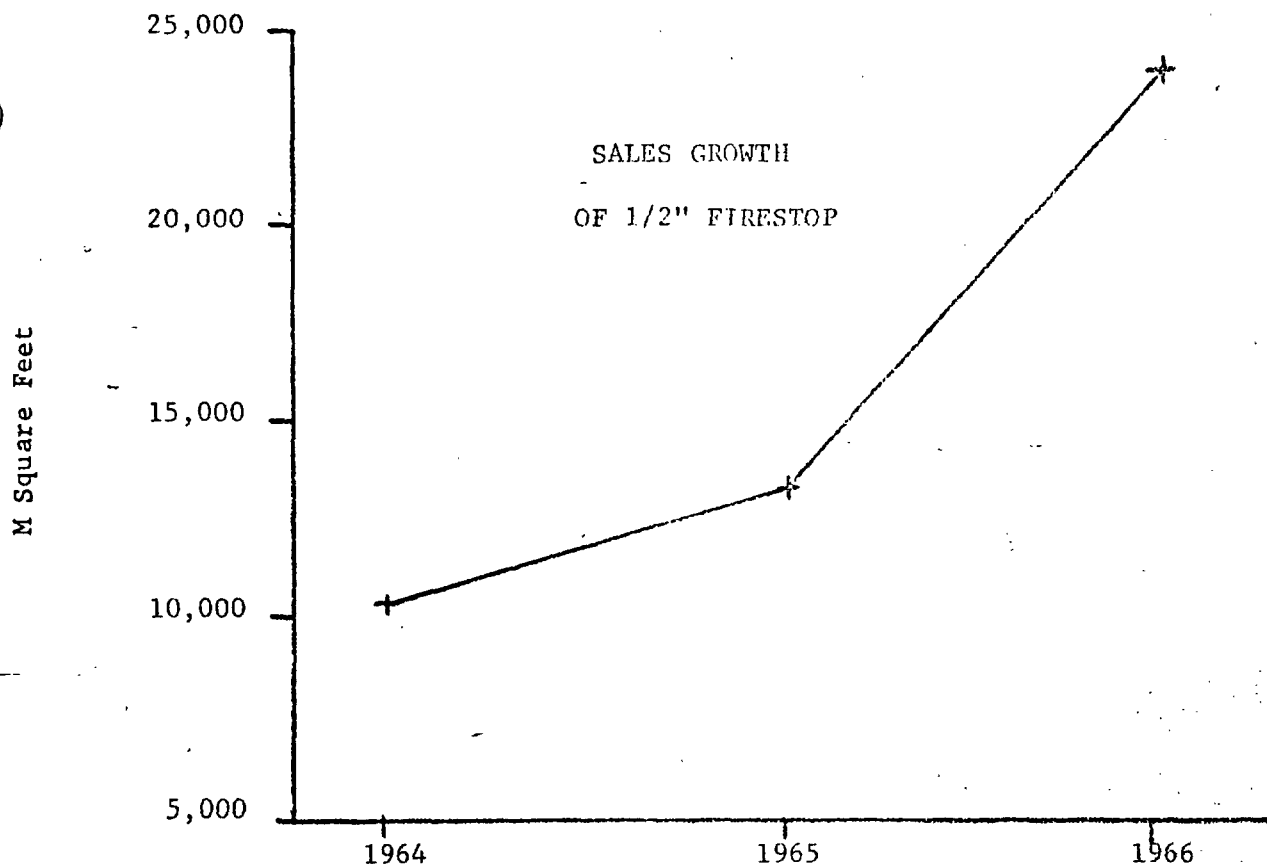
<u>Product</u>	<u>Sales Volume</u>	<u>List Sales</u>	<u>Estimated Gross Profit</u>
Denscote Base (all)	17,230 M sq. ft.	\$ 732,007	\$126,540
Tile Backer Board (all)	2,828 M sq. ft.	231,486	88,028
Firestop Tile Backer	30 M sq. ft.	3,034	1,326
Tru-Grain Wallboard	537 M sq. ft.	37,681	3,612
One Day Jt. Compound	495 Tons	83,426	13,725
Ready Mix Jt. Compound	138,718 Pails	567,021	** (3,018)
(5 gal.)	126,226 Pails		
(1 gal.)	12,492 Pails		
Triple Duty Jt. Compound	3,106 Tons	487,486	109,895
Grabit Adhesive	118 Tons	17,508	5,523
Bestex A	58,789 Bags	114,821	* (1,352)
Bestex B	2,482 Bags	10,600	* (10)
Bestex C	7,881 Bags	31,629	* (2,537)
Denscote Plaster	3,017 Tons	173,173	22,238
Denscote Tape	12,268 Rolls	17,475	7,205
Vinyl Tape-Tile Backer	548 Rolls	1,551	870
Model Densite	5 Tons	233	84
Tooling Densite	3.1 Tons	286	117
High Expansion Plaster	32 Tons	2,059	537
Ram Process Plaster	8.8 Tons	<u>924</u>	<u>424</u>
 TOTAL		 \$2,512,400	 \$373,207

* Losses shown reflect standard costs based on the highest purchase price for casein. Based on the present casein price, the Bestex A sales would generate a profit of \$11,757 for the year.

** New Ready Mix plant when completed should permit savings of \$.50/5 gallon pail.



M Sq. Ft.



PRODUCT AND PROCESS IMPROVEMENT

WALLBOARD

1. Wallboard Weight Reduction - R&D 255

We have continued to seek the optimum particle gradation for our board plant stucco. Hammermills installed in the plants have enabled lighter weights to be achieved by virtue of finer grinds. Our tests indicate the Entoleter, which grinds finer than a Hammermill, will make further reductions in weight possible. Our studies show that too fine a grind is detrimental and therefore, we conclude that there must be an optimum particle size range. A technical report covering the results to date will be submitted shortly and further work will be done to investigate how the optimum particle gradation can be achieved.

2. Improve Scoring and Breaking Properties of Gypsum Wallboard - R&D 298

After a detailed study which included devising a method for measuring score and break properties, it was found that at least one cubic foot of expanded perlite fines/M sq. ft. of board offered the best opportunity to improve the scoring and breaking. The Sigurd plant used perlite in their board for a short period and had good success. However, quality considerations induced the plant to "play safe" and discontinue the use of perlite. This project has proved that scoring and breaking can be improved with the addition of perlite. It has also resulted in a better means for evaluating score and break properties.

3. Hydration Studies by the Temperature Rise Method - R&D 296

Using the instrument which was built for this purpose, a series of tests were conducted to determine the effect of soluble anhydrite, stucco particle size, accelerators, retarders, and dispersing agents on the hydration rate. More work needs to be done, but thus far indications are that soluble anhydrite, and dispersing agents adversely affect hydration. Also, it was found that finer particle size improves hydration until it becomes exceedingly fine. This reinforces other work which also supports an optimum particle size range. A technical report containing all of the data is being prepared.

4. Improve Grainboard Line - R&D 268

All of the testing of coatings and coating application equipment was completed. As a result of this investigation, a Gasway Curtain Coater will be purchased and installed at Fort Dodge. This equipment will

be used to apply a clear, abrasion resistant, washable coating to our grainboard. This will permit the purchase of a variety of more appealing grain patterns than we now have. The coater will also be used to help develop a vapor barrier wallboard and pre-decorated products.

JOINT SYSTEM

1. Improve Texture Products - R&D 275

A new basic texture formula has been adopted after a successful series of field trials. The estimated raw material savings are \$7 per ton of texture.

A new vermiculite aggregate texture is being market tested after several successful field trials. This texture gives a different appearance (very coarse) and would be competitive with other similar products which are available.

INDUSTRIAL

1. Denscal Plant - R&D 308

We have been providing assistance in the preparation of the start-up of the Denscal operation. An operating plan and a product specification have been submitted. Below is a photomicrograph of Hydrocal crystals which will be used for comparison with Denscal since both are manufactured by the same process.



200 X Magnifica
of Hydrocal

2. Pelletizing of Gypsum - R&D 29

After some exploratory work with Komarek-Greaves, who manufacture pelletizing equipment, it has been decided to pursue it on a larger scale. We are arranging to have ten tons of gypsum fines pelletized and sent to one of the Portland Cement companies to try as a substitute for rock gypsum. Our objectives are to make use of all the fines from the Densite and Denscal operation and to expand the scale or rock to Portland Cement companies.

PLASTER

1. Improve Dens-Cote Smooth Finish Plaster - R&D 219

In response to a request from Sales that U.S.G.'s Imperial veneer plaster had better working properties than Dens-Cote, a new formulation was developed. Field trials are currently in progress. In addition to the improved application properties, the raw material costs have been reduced by \$2.80 per ton, so this is another reason for our interest in making a formula change.

Some testing has been done to determine the possibility of substituting Denscal for Densite in Dens-Cote veneer plaster. These experiments were conducted using U.S.G.'s Hydrocal and indicate that substitution of 20% more Denscal than Densite will result in the same physical properties. An investigation of the effect on application properties will be launched as soon as the Denscal is available.

SALES SERVICE

WALLBOARD

1. Sound Test Program - R&D 276

Our 1966 sound transmission program was completed when several partitions with a 1/4" gypsum "sound" board were tested at Geiger & Hamme. The 1/4" board performed comparable to 1/2" wood fiber or glass fiber sound deadening board on metal stud partitions, but not as well as the fiber boards on wood stud partitions. The 1/4" board offers better economics and more fire protection, so it was approved to be added to our wallboard line.

2. Fire Test of Metal Stud Partition with 1/4" Gypsum Sound Board and 1/2" Firestop - R&D 306

A one hour rating was easily achieved. This construction was fire tested to gain the fire rating to go along with the good sound barrier properties.

3. Weight Reduction of 5/8" Type X Board - R&D 307

After considerable correspondence and discussion, we were able to convince Underwriters' to extend a lower weight for our old Firestop formula with 6 lbs. of glass fiber/M instead of 4 lbs./M. The purpose was to have the lower weight to offer our licensees who still manufacture the old formula and for us to consider shipping "unlabeled" board in certain areas.

4. Weight Reduction for 1/2" Firestop - R&D 303

A test was held at Underwriters' to reduce the minimum weight on 1/2" Firestop from 1940 lbs. to 1750 lbs. We were indeed unfortunate as the deck exploded at 1 hour and 58 minutes. This occurrence plus slightly higher bar joist and plenum temperatures caused Underwriters' to refuse to extend a lower weight. We will re-apply for another test which will be preceded by a thorough evaluation of possible formula alterations.

5. Three Hour Rating for Concrete Floor with New 5/8" Firestop - R&D 305

After a careful evaluation of construction details, a test was conducted at Underwriters'. After two hours and 32 minutes, every piece of board was still intact, but the top side temperature exceeded the allowable. The board performed better than board in any previous test and as well as we had hoped. We do not understand how National Gypsum was able to attain this rating and are attempting to obtain a copy of their test report. No re-test of this construction is planned at the present time.

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6. Flamespread Rating for Eternawall - R&D 215

A flamespread rating of 30 was obtained in an Underwriters' test of our Eternawall with 8 mil vinyl and each of two different flame retardant laminating adhesives. We had hoped for a rating of 25, but 30 is as good or better than our competitors have been able to do with their vinyl covered wallboard

7. Fire and Sound Test Data - R&D 249

A new system is being set up to handle the increasing amount of data which is being collected. We are continually receiving more requests from Sales for test results and estimates for constructions which have not been tested.

INDUSTRIAL

1. Ram Process Plaster - R&D 132

The field trials held to evaluate a new Ram Process formula were all favorable and the new formula is being furnished to customers who use the Ram Pottery making process.

NEW PRODUCT DEVELOPMENT

WALLBOARD

1. Molded Grainboard - R&D 304

On September 30, 1966, a one year option (extendable to 18 months) was signed with U. S. Mold Coatings, Inc. for an exclusive right to develop a commercial process for making molded grainboard. A sample of the molded grainboard coating is shown on the first page of this report. The process involves casting a specially formulated gypsum coating onto a rubber belt which has a wood grained impression molded into it's surface. The coating is then contacted to a piece of gypsum wallboard and after the gypsum sets, it breaks away from the belt and remains adhered to the wallboard. Subsequent stains and sealers are applied to reproduce the color desired and to fully reveal the grain configuration. Based on an exhibit of the molded grainboard at the Homebuilders Show in Chicago and a questionnaire distributed by our Marketing Department, it appears that there is an excellent demand for this product if it can be sold for about \$.15 per square foot. The feasibility is dependent on our ability to manufacture the product on a continuous basis, and this is our objective.

A program for pursuing the grainboard development has been put into effect. A belt specification was prepared and submitted to U. S. Mold Coating, Inc. who will deliver the belt as a part of the option agreement. The pattern for the belt is completed and arrangements have been made to have Goodrich Rubber Company fabricate the belt. We expect to have the belt in February 1967. A pilot plant operation will be located at Brunswick in place of the tile operation which is being discontinued. It is hoped that the pilot plant equipment will be available no later than March, so that the trial runs can be commenced. In the meantime, some experiments will be conducted in Paoli to give us some preliminary information regarding the mixing and forming operations which we deem to be critical to the success of the process.

The picture on the following page shows the belt pattern being made.



Fabrication of Belt Pattern

2. Radiant Heating Panel - R&D 235

After an exploratory evaluation of several types of radiant heating panels, it was decided that a type having Armstrong's conductive "Temsheet" as one of the cover papers of the wallboard offers the most potential. The "Temsheet" is based on specifications which we furnished after having previous samples of their conductive paper. It consists of carbon black dispersed in the fibers of the paper and adhered with butadiene-styrene latex. When copper conductor strips or bus bars are attached to the surface at a specified distance apart and are energized, the resistance of the conductive sheet provides a uniformly heated surface. Laboratory wallboard specimens were made with the "Temsheet" then a full scale plant run was made at Wilmington. The "Temsheet" was used as the back paper on 1/2" square edge board. There were no unusual problems in manufacturing this board and the end product appears to be quite satisfactory. The next phase of this project will involve planning the installation procedure and getting Underwriters' approval for the product and it's installation.

3. Gypsum/Plywood Studs - R&D 209

Favorable comments have been received from the field trials of the gypsum/plywood studs. The cost of producing these studs has been estimated at \$.04 per linear foot F.O.B. Fort Dodge. We would

anticipate selling these studs at \$.08 to \$.10 per foot. It has been recommended that we make these studs available in areas serviced by Fort Dodge in order to obtain a better evaluation of their performance and acceptance. A picture from one of the field trials is shown below.



Field Installation of
Gypsum Plywood Studs

4. Predecorated Products - R&D 215

At the request of Sales, several different ideas for predecorated board for walls or ceilings are being evaluated. The object is to develop products and systems which will eliminate joint treatment and if possible, the decoration. The ceiling systems would be particularly adaptable for use with wood paneling where acoustical tile is commonly used. Some of these ideas are:

- a. A pre-grooved wallboard which could be pre-painted and applied without further decoration. This was suggested by Sales.
- b. Two foot wide pre-painted panels supported on suspended wood members to give a wood beamed ceiling effect. A picture illustrating this ceiling is shown on the following page. A similar idea is to suspend the 2 foot wide gypsum boards on metal channels which are nailed to the joists.

- c. Another idea is to nail regular board on the ceilings and conceal the joints and nail-heads with a rigid plastic tape to provide a grid-system effect.



Predecorated
Beam Ceiling

5. Pre-Fabricated Panel - R&D 223

Two pre-fab panel systems are being investigated, one which is a horizontal stud system using the gypsum/plywood studs and another which is a take off from U.S.G.'s demountable Easywall System. The various aspects of both of these partitions will be evaluated.

PLASTER

1. Dens-Cote Radiant Heat Plaster - R&D 219

We are testing a special calcination resistant plaster in the small test house constructed for testing radiant systems. The house is heated to 70° F with various radiant systems, including this one.

The special plaster has been applied over cables 1-1/2" apart and is operating at surface temperatures of 125 - 130° F. Regular Dens-Cote calcines under these conditions. We hope to determine whether the new product will withstand these temperatures without calcining. U.S.G. is selling a special calcination resistant veneer plaster at a premium price.

INDUSTRIAL

1. Gypsum Firedoor Filler - R&D 295

After encountering one obstacle after another, it appears that we may finally be able to have a door made with our gypsum filler for a full scale fire test. General Plywood, with whom we have been working, is currently purchasing calcium silicate at \$.44 per square foot for their firedoors. Our raw material cost is less than \$.10 per square foot and we estimate that the total F.O.B. cost would not exceed \$.15 per square foot, so the product appears to be quite profitable. If the fire test is successful, we may try to manufacture the gypsum filler block on one of our wallboard machines. If this were possible, we could use existing capacity and limit the capital expenditure required to manufacture this new product.

2. 1/8" Gypsum Board Core for Plywood Grainboard - R&D 308

During a visit to our Savannah plywood plant, an inquiry was made concerning the possibility of us furnishing a thin (1/8") gypsum wallboard to be used as the core in the manufacturing of plywood. An investigation was commenced to look into the problems involved and to determine whether this would be feasible. Some small samples were prepared which looked reasonably satisfactory. It was decided that we would have to have some full size sheets of plywood with a gypsum core, laminated in the large plywood press in order to fully evaluate this proposition. It was, therefore, necessary to manufacture some 1/8" gypsum wallboard. The 1/8" wallboard was manufactured at Brunswick and it is planned to laminate some plywood panels at Savannah with this board as the core material.

The objective is to improve the fire resistance and lower the costs of the plywood while simultaneously expanding the market for gypsum wallboard.

3. Gypsum - Steel Roofdeck System - R&D 294

A small roofdeck consisting of corrugated steel sheets with perforations in the valleys (Bethlehem Steel Slabform) and a 2" thick perlited gypsum fill over the steel was previously installed

in the rear of our shop building. Another deck was installed at Bethlehem Steel's Lackawanna plant. This second deck differed in that a foamed gypsum mix was poured over the steel. The advantage of the foamed deck is one of economics. The foaming can be difficult to control, but in this case no insurmountable difficulties were encountered. The gypsum and foam were mixed and metered from apparatus furnished by The Mearle Corporation. The next step would be to install a large deck of about 3,000 - 5,000 square feet.

The objective of this project was to work with Bethlehem in evaluating a roofdeck system which could compete with lightweight concrete and steel roofdecks. Bethlehem has been making the slabform by hand and are currently investigating the equipment to mass produce this material. Until they decide whether they will manufacture the steel, there is nothing further for us to do. We have discussed the possibility of another trial job, but they seem to feel they have enough information.

FUNDAMENTAL RESEARCH, LABORATORY SERVICE AND TESTING

1. ASTM and Gypsum Association Work - R&D 4

During the past six months we have been working on the following Gypsum Association and ASTM projects:

- A. Develop a test to distinguish between regular and type X wallboard.
- B. Develop a performance specification for gypsum wallboard including test methods.
- C. Develop a performance specification for water resistant backer board.

The above tests, particularly A and B are a result of controversies regarding proposals to eliminate Label Service and to reduce the ASTM minimum wallboard weights. We are objecting to the proposal to do away with Label Service. In spite of its limitations and complications, the Underwriters' Laboratories Label Service is the only way of assuring what board passes what fire rating in a given construction. Underwriters' is the only test agency whose ratings are universally accepted by all code authorities. The U. L. Label Service Procedure is our way of controlling our Firestop licensees and of extending their licenses to cover Firestop improvements.

The second controversy concerns the ASTM limits on board weight. We are supporting the reduction of the weights of 1/2" board from 1800 lbs./M to 1700 lbs./M and of 5/8" board from 2250 lbs./M to 2100 lbs./M. The performance specifications were proposed as a result of objections to making these weight reductions. The companies opposing the lower weights are asking for the performance standards, but this is merely a stall. Their real reason, in our opinion, is their inability to manufacture lightweight board. Our interest in performance tests is defensive, so that we can intelligently oppose any unacceptable specification that may be proposed.

2. Patent Data - R&D 6

A. Status of Present Patent Applications

- Synthetic Gypsum - Both American and Canadian applications revised and re-submitted to patent office.
- Dens-Cote Base - No action has been received on this application which was submitted in July of 1964.

Dens-Cote Plaster - No action has been received on this application which was submitted in July of 1964.

B. New Patent Applications

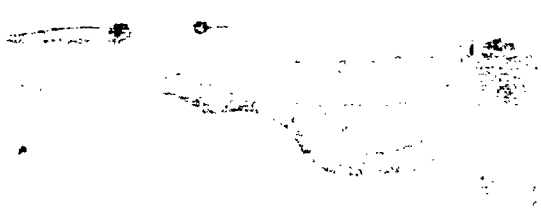
Considerable time has been spent devising test methods and developing information to use in the preparation of an improvement patent on Firestop. The improvement involves an addition of clay to the formula. The data compiled thus far shows that clays provide improved fire resistance by reducing the shrinkage and by increasing the strength of the Firestop during exposure to high temperatures. A number of different clays are currently being evaluated to compare their effects. This work may lead us to better or less expensive sources for clay, as well as defining the general types of clay which can be used to improve fire resistance.

C. Licensing

We have been sending formulas and general specifications on the new Firestop formula to licensees who have accepted our offer to provide the additional coverage for a fee of \$2,000.

3. Differential Thermal Analysis - R&D 299

We are in the process of calibrating the DTA equipment. We will endeavor to set up a method for determining the dihydrate contained in our calcined products. If a satisfactory procedure can be developed, it will be presented to Manufacturing for consideration as a quality control test method. The DTA is also being used to compare different types of clay in the Firestop patent improvement. A photograph showing the DTA apparatus is shown below.



DTA Equipment

4. Microscopic Studies - R&D 293

The effect of various additives on the hydration and crystal growth has been observed by means of the microscope. This work is far from complete, but has shown that some additives do effect the size and shape of the crystals. The next step would be to determine the significance of this variation.

The microscope has been used to compare two different types of glass fiber, to take photomicrographs of Hydrocal for use in the Denscal specifications, and to take photomicrographs of different stucco grinds which we were comparing. Mr. Green attended a seminar on photomicrography at McCrone Institute in Chicago. We are using photomicrographs more and more, so we decided to take advantage of this seminar to improve our technique.

5. Maintenance of Research Equipment and Facilities - R&D 15

Assistance was furnished to prepare the Laboratory and pilot plant facilities for the Resin Research group. This group, under the supervision of Dr. Leopold Bornstein, moved here in September.

The major capital expenditure item purchased during the past six months was a pilot wall furnace for testing partitions. This furnace will be delivered shortly after the first of the year, but will probably not be installed in view of the impending relocation of the Laboratory. This new furnace will enable us to test sections in a vertical position (as a wall) as well as our present horizontal method of testing (as a ceiling).

S U M M A R Y

Sales of products developed through research have climbed to a new high of \$2,512,400 in 1966. Profits from new products were only slightly higher than last year because of the unprofitable status of ready mix. The large ready mix facility being installed at Akron and the smaller facility at Acme will put ready mix on a profitable basis.

A 1/4" gypsum sound deadening board was added to the line during the past six months. This board will be sold in competition with wood fiber and mineral fiber sound deadening boards. A new vermiculite texture and an improved Dens-Cote plaster are being market tested and should be ready for release shortly.

Improvements in stucco grind will help make weight reductions possible and therefore reduce costs. Lower Underwriters' minimum weights will also result in cost savings. Reformulation of our entire texture line will save on raw material costs.

Fire and sound testing continue to give impetus to the sale of Firestop. In 1965 6.7% of our wallboard (not lath) sales were Firestop. In 1966 Firestop represented 9.1% of our wallboard sales. In addition, Firestop improvements during the first six months of 1966 enabled us to offer additional coverage to our Firestop licensees for a fee of \$2,000. Thus far, five licensees have accepted the additional coverage.

The year of 1967 promises to be a year of great challenge to the Research Department. The objectives we will be concentrating of during 1967 are:

1. To develop a process for manufacturing gypsum grainboard.
2. To develop a gypsum wallboard radiant heating panel and a system of installation.
3. To achieve a 150 to 200 lbs./M square foot reduction in the Underwriters' minimum weight for 1/2" Firestop.
4. To determine the optimum grind for wallboard stucco to pave the way for further weight reductions in wallboard.
5. To find less expensive clays for use in Firestop. This could save \$25,000 annually based on last year's Firestop sales.
6. To continue the development of a gypsum filler for firedoors.
7. To conduct fire and sound test programs to provide Sales with the ratings needed in the promotion of wallboard products.

We have provided for more new product development in our budget for 1967. The basic reason for this is that we have more promising new product possibilities than ever before. We believe this is a good indication of progress since it is new products which will make it possible to expand sales without the present market for gypsum products increasing.

In the coming months we will be preparing for the move to Portland. We expect to have some temporary frustrations, but will be looking forward to the long term benefits of this relocation.