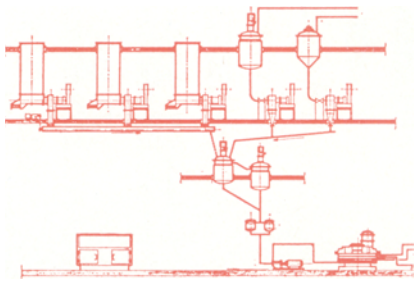
# Continuous Feeding, Mixing and Spray Drying of Detergent Formulations



S. J. SILVIS, Ing. Mario Ballestra & Co., Milan, Italy

EACH YEAR THE PUBLISHED FIGURES on detergent production in the United States show a steady increase. We are all aware that the liquid products and the specialty products have captured the attention of the manufacturers for the past few years, but it should not be forgotten that the spray dried detergents are still far and away the major item in this entire market. The total production is enormous. Figures for 1963 showed that 2.8 billion lb of spray dried detergents went to the consumer—just about 10 million lb/working day. When we consider the excellent quality and uniformity of the products on the market we would think that the spray drying operation has been thoroughly researched and that precise spray tower designs could be picked off the shelf. This is not the case. The mixing of detergent formulations and their spray drying is still largely an art and most of the larger organizations, who have been in the business for years have each developed their own techniques and know-how.

The spray drying of detergents started approx 20 years ago and a survey of the technical literature will show that only a very few articles have been published that really contribute to a quantitative understanding of the design variables. Therefore the larger organizations have jealously guarded their hard-earned and costly knowledge which they felt gave them significant quality and economic advantages over their competition and minimized the entrance of new competitors into the market. The immediate success of detergents in this country clearly demonstrated the advantages such products had over soap, and interest in the manufacture of detergents cropped up in many areas of the world. The major U.S. manufacturers built their detergent facilities in such countries where the market justified it; but if the local soap producers in these countries wanted to enter the detergent business they had to find engineering firms inexperienced in detergent spray drying to take on such projects. Now in the past ten years or so, firms such as the Ballestra Co. of Milan, Italy, have become thoroughly experienced in the manufacture of complete detergent plants (i.e. raw material handling facilities, sulfonation, mixing, spray drying and product handling) so that today anyone who wants to enter the detergent business can purchase the entire packaged plant, whether his needs are 500 lb/hr of sprayed product or 50,000 lb/hr.

Let us stop for a minute and ask ourselves just what a detergent plant is supposed to do. Its purpose is to economically produce a packaged product with: 1) the desired formulation; 2) the desired physical characteristics, such as particle size, non-caking, quick solubility, etc.; and 3) the desired density.

Because accurate formulation is so essential to ensuring consistent product performance when used by the consumer, most detergent mixing units were batch-type (i.e. each ingredient of the formula is weighed into the mixer with sufficient agitation at all times to insure homogeniety). When the batch is completed it is transferred to a holding tank and the next batch is begun. This batching operation has definite disadvantages because of difficulties in controlling product moisture and product density, but it does theoretically permit accurate formulation.

Product moisture is critical in that, for cost purposes, it should be at the maximum consistent with good product characteristics such as flowability, caking tendency, etc.

Product density is of utmost importance since a given wt of product must *fill* the carton at least to the maximum allowable outage. Since most high speed filling machines fill by volume, the precise control of density in the tower is essential for the efficient and steady operation of the filling machines.

The old batch plants served their purpose and permitted the manufacture of a good product, but the newer plants with continuous feeding and mixing offer the ultimate in efficient processing, accurate formulation and most important—excellent control over product moisture and density.

I would like to described a Ballestra Co. detergent plant which permits fully continuous feeding, mixing and spray drying of any desired detergent formulation, including the important feature of automatic control of density. In the course of this discussion we can review the key design features as well as the critical processing conditions, and compare it with batch operation where apropos.

[1] Presented at the AOCS Meeting, New Orleans, 1964.

### Continuous Feeding and Mixing

A typical heavy duty detergent formula would require: 1) active ingredient (as sulfonic acid or in slurry form or as nonionic); 2) tripoly phosphate (TPP); 3) silicate; 4) carboxymethyl cellulose (CMC); 5) optical brightener; 6) sodium sulfate; and 7) other ingredients. Let us assume we want to spray dry such a formulation to a density of 0.35 and with a moisture content of 10%.

The accuracy of formulation is strictly dependent upon the precision of weighting each ingredient. We assume here that the chemical analysis of each raw material is known. Excellent control over product composition can pay off handsomely in two areas. First, uniform product composition means uniform product performance which in due course leads to real confidence in the product by the consumer; and secondly, reducing the variation of a particular ingredient in the formulation actually allows the reduction of that ingredient. For example, let us assume the specification for the Active Ingredient level is 30% ± 1.0%. Usually this means that the product is considered satisfactory at 29% AI, the lower limit permitted to be shipped from the plant. If you could reduce the variation to ±0.5%, then the average AI level could be reduced to 29.5%. Thus significant cost savings can be realized by the more accurate feeding systems. The proportioning of the ingredients in the Ballestra Dosex system (Fig. 1) is carried out in the following manner:

The raw materials are placed into specially designed hoppers or tanks depending upon whether they are solids or liquids. From here they are fed, within a fixed time interval, into recepticals (let's call them small drums) which are mounted on precise dial scales. The raw material feeders to the weighing scales are conveyers for the solid materials and pneumatic valves for the liquid materials.

The scales used for the weighing are equipped with photo electric cells and amplifiers to stop the feed of each raw material when the desired wt has been fed to the drums (Fig. 2). When each raw material has been fed into its individual weighing drum, then all are automatically and simultaneously inverted and discharged. After discharging, the drums return to their initial position and the cycle is repeated. The Dosex system of feeding is designed so that, at the full design rate of the plant, there will be three cycles/min. Thus every 20 sec each raw material is simultaneously weighed and discharged. To give some idea of the amts involved, assume a rate of 3600 lb/hour of tripoly phosphate is required. Then it would be necessary to weigh 20 lb during each 20-sec cycle.

The cycle, then, consists of two steps: 1) feeding and weighing; and 2) discharging and feeding reset.

Microswitches operate control contacts of the screw conveyors for the solid material and the coils of the solenoids for the valves for the liquid materials, and the feed materials fall into their respective drums on the scales and the weighing starts. The moving pointers of the dial scales rotate and as soon as they reach the position of the photoelectric cells (which have been preset) cut off the circuit, stopping the feed unit.

When each raw material is in its drum (and remember, the feeding of each raw material requires less than 20 sec), and all feed units are stopped, a relay operates the solenoids of the pneumatic cyclinders which causes complete turning over of the drums and effects the discharge of each material. The rotation of the drum operates another microswitch and automatically all drums are returned to their upright position to accept more feed. And the cycle is repeated. The liquid materials drop into a manifold pipe which allows for some mixing prior to their entrance into the mixer. The solid materials drop into a common screw conveyor which also provides adequate premixing prior to their continuous flow into the mixer.

#### Continuous Mixing

The continuous mixer (Fig. 3) is specifically designed to give a thoroughly homogeneous slurry and to provide excellent shear which minimizes any tendency for lumping. Also the design is such to avoid excessive incorporation of air into the slurry, since aeration leads to lower finished product densities and higher slurry viscosities.

It is well to point out now that the conditions and characteristics of the mixing operation regulate to a great extent 1) the density of the finished product that may be obtained; 2) the efficiency of pumping and atomization; 3) the spraying pressures required to obtain the desired density; and 4) the physical characteristics of the finished product.

In batch mixing the aeration of the mix is generally quite high and it is impossible to control from batch to batch. Therefore, in practically every case a slurry deaeration unit is required. With continuous mixing, aeration of the mix is minimized and what little aeration does occur is constant hr after hr. The key factor here is the design of the mixer and how the incoming raw materials are introduced into the mix. As a result, no deaeration equipment is necessary.

The temp at which mixing is done is extremely important and effects the slurry consistency, solubility and, most important, hydration rate of the TPP. The temp of mixing has a great effect on the density of the sprayed product, with lower temps yielding the lower densities. Also, if the mixing temps are too high, the finished product will become extremely tacky, with poor flowability and poor filling characteristics, and will have a tendency to cake in the finished package. The exact temp of mixing will depend upon the formula and the type of TPP used.

#### Aging

The thoroughly mixed slurry overflows from the mixer into the holding vessel where it is given a definite aging time during which certain phase changes are permitted to occur, such as the hydration of the TPP.

The mixing that occurs in the aging vessel is gentle and the internals of this unit are such as to prevent mixing from top to bottom. Thus there is a constant holding time of the slurry and this insures that every lb of slurry pumped to the spray nozzles has exactly the same history. With such uniform slurry being sprayed into the spray tower, excellent control of moisture and density is easily attainable.

#### Automatic Capacity Control

Since the demands of the spray tower can vary, a unique device automatically ties the continuous feeding system to the rate at which slurry is being pumped to the tower. The aging vessel contains a float which will rise or fall depending upon the level of slurry. This float is connected to a potentiometer which in turn controls the cycles/min of the continuous feeding system. As the level in the aging vessel decreases, the float falls and the number of cycles/min of the feeding units increases. Conversely, as the level increases, the feeding rate of the raw materials decreases until, if the level reaches the maximum permissable, the continuous feeding system stops completely.

This "Feed Control" device thus insures uninterrupted and controlled flow of slurry to the spray tower regardless of the changing demands of the tower. The major advantages of continuous feeding are:

*Uniformly aged slurry to the spray nozzles.* This condition assures consistent atomization of the slurry which in turn results in excellent density and moisture control of the sprayed product.

Such an advantage cannot be obtained with batch mixing. Batch sizes can vary depending upon design, so that one batch may require anywhere from 15–30 min to spray out. If we assume that we have a 20-min batch time, then there

(Continued on page 36)

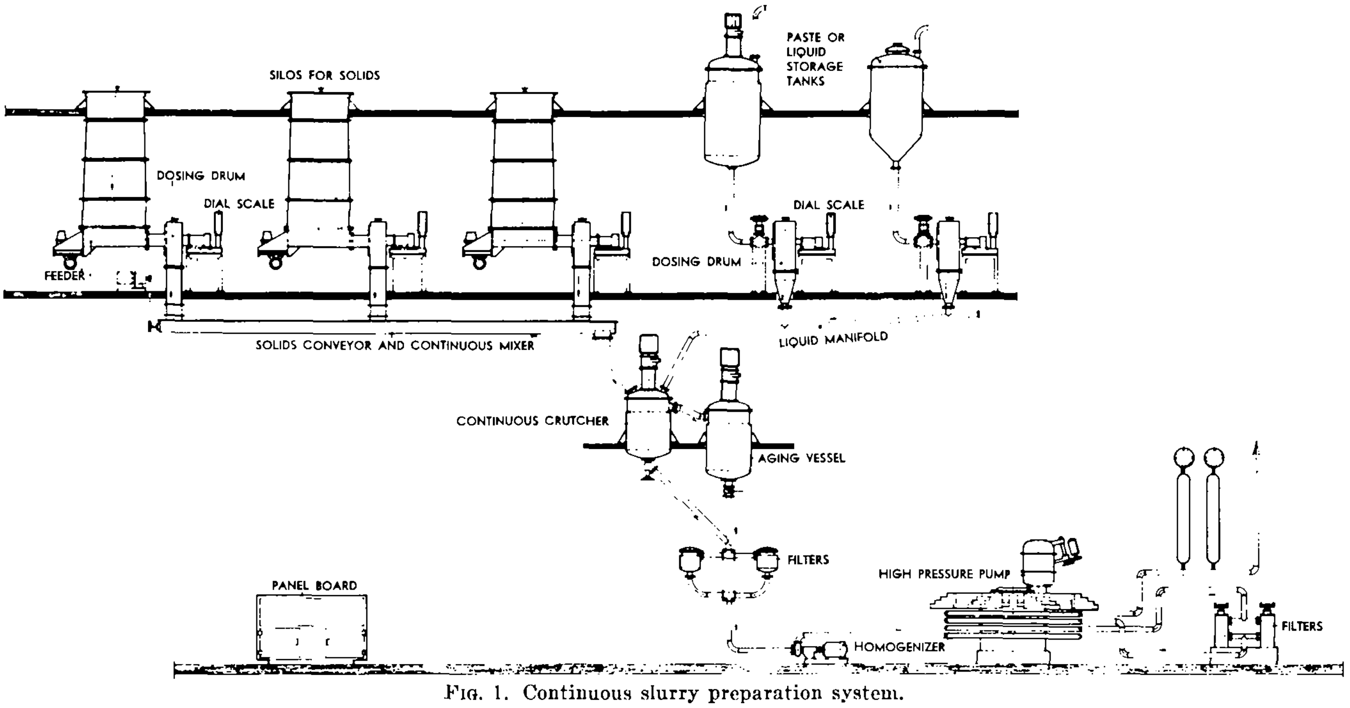



FIG. 1. Continuous slurry preparation system.

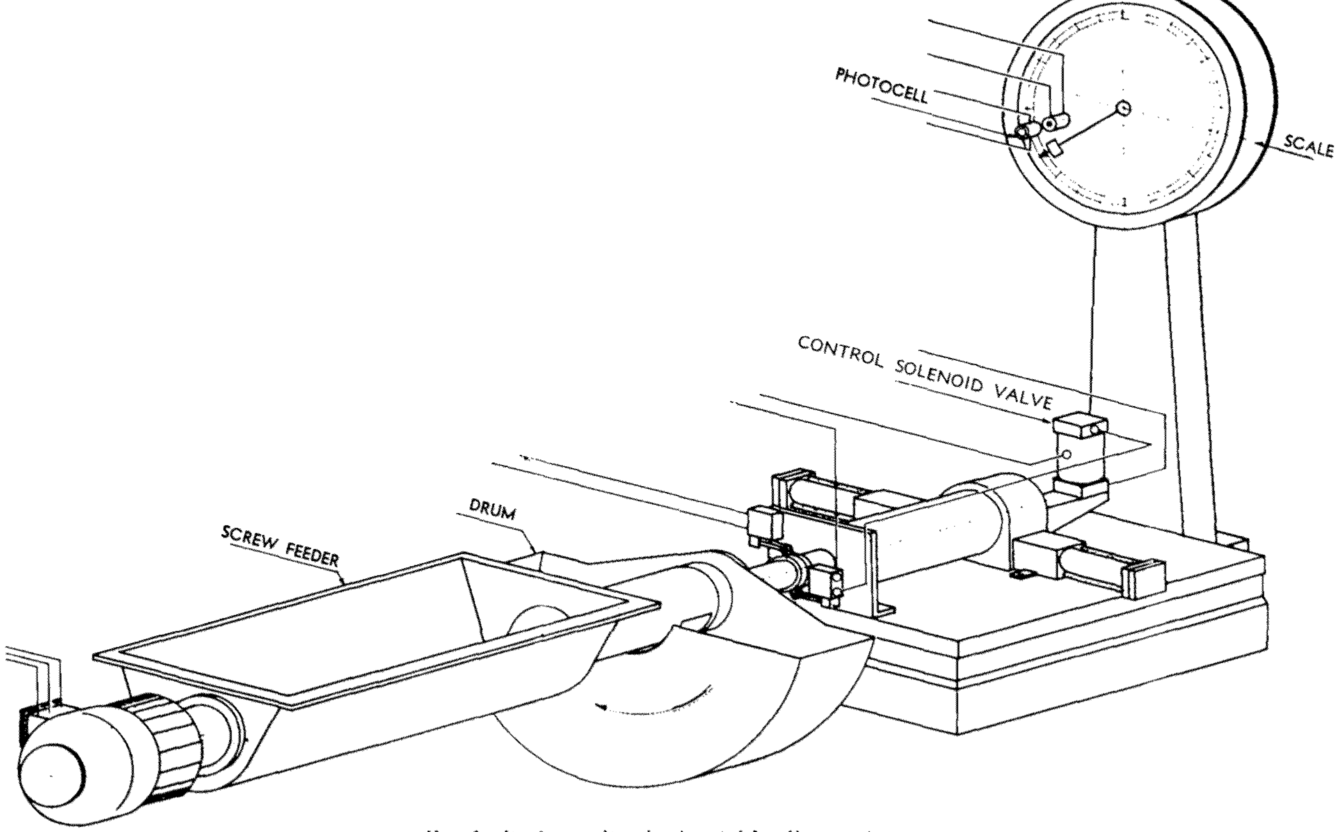



FIG. 2. Dosing units; horizontal loading system.

## Continuous Feeding . . . .

(Continued from page 6)

will always be a 20-min difference in the aging time between the beginning of the spraying of that batch and the end. There is a further complication. The aging time of a batch in the aging vessel will vary depending upon how full the vessel was prior to the dropping of the batch. If the aging vessel is nearly empty, it may be only a matter of a few min before the new batch begins to reach the spray nozzles; if there is still one full batch in the aging vessel and the fresh batch is discharged on top of this, then it may be 20 min before the fresh batch beings to reach the nozzles, and, of course, 40 min before the end of the batch is sprayed. Thus you can see the wide variation of holding time experienced in batch mixing—a variation which is inherent in this type of operation and also dependent upon the attention of the operators.

*Elimination of operator errors.* Although batch mixing theoretically should be accurate, errors by operators continually exist, either through inattention by over-adding a particular ingredient, or incorrect setting of the scale, etc.—even to the point of forgetting to add a certain component of the formula. It should be remembered that with batch mixing operations, when the plant is running at, or near, capacity, the operators are extremely busy keeping up with the tower, and in their haste are prone to make many more errors.

*Minimum aeration of the slurry mix since the mixer remains full all the time.* With a full mixer the agitators and baffles can be placed in their most effective positions to give maximum shear and insure complete homogeneity, while at the same time avoid vortexing and surface agitation—both of which would result in excessive aeration of the mix. Thus there is no need for a deaeration unit.

*Higher allowable solids content of the slurry.* Because of low aeration, and because of premixing of the solid feeds and the liquid feeds, it has been found that for a given formula it is possible to increase the solids content of the mix by ca. 3–6%. For example, where batch mixing might permit a maximum solids content of 62%, continuous mixing might permit a solids content of 68% with the exact same formula used in both cases. Such an increase in the solids content of the slurry would yield a 30–40% increase in the tower output without any additional heat input for the drying. The very significant cost savings involved here are obvious.

#### Pumping of the Slurry

The slurry discharges from the aging vessel and passes through one of two coarse filters in parallel. Any foreign materials that might damage the pump or the homogenizer are removed. Two filters are used so that, if one requires cleaning the other can be placed on stream and there will be no interruption of production.

From the filter, the slurry then enters an homogenizer where it is further reduced to a smooth creamy consisteny. The milling removes all grit and small hard lumps that may have resulted from the sodium sulfate, the TPP or other ingredients. From the homogenizer the slurry is again passed through filters which are fine, self-cleaning units. This filter provides insurance that no particle larger than the opening of the spray nozzle orifice will remain in the slurry stream, and this eliminates any possibility of nozzles blocking, After the self-cleaning filters the slurry passes into the high pressure pump and from there it goes directly to the spray nozzles. The slurry lines are all jacketed and insulated to maintain the desired slurry temperature and to prevent any crystallization.

This slurry-handling system incorporates all the necessary features to insure, smooth, uninterrupted flow. Filters remove lumps that may cause nozzles blockage. The homogenizer smoothes and mills the slurry to remove gritty particles and other lumps that would be undesireable in the finished product. It is easy to determine which manufacturers homogenize their slurry and which do not. Dissolve a detergent powder in warm water and feel the particles that settle to the bottom. Some of these particles feel like bits of sand, and such a condition is considered detrimental wherever the product will be used by hand, for example, dishwashing, special hand washing, etc. In many areas of

# Summary of Governing Board Action

## October 11, 1964

THE IMMEDIATE BUSINESS of the Society was conducted between the hours of 1:00 and 3:00 in the afternoon, with all of the members of the Governing Board present with the exception of A. R. Baldwin and J. C. Cowan. Both of these individuals were in Europe attending the ISF Conference.

The meeting was called to order at 1:08 p.m. The minutes of the April 19 and 20, 1964, meetings were approved.

It was reported that two meetings of the Executive Committee had been held since the last regular Governing Board meeting, and that this committee was finding itself useful in such matters as handling the constitutional changes which were approved at the general session on Monday, October 17. Through this committee it was also possible to expedite business with the Chicago office, and since this committee normally has met in Chicago, it was possible for the Executive Secretary to discuss immediate problems with more than one or two individuals.

**R. C. Stillman**

C. H. Hauber delivered the report of the Executive Secretary, including a brief summary of current activities.

The Secretary of the Society, C. W. Hoerr, reported on the results of the Advertising Committee program for the 1964 year. He reported that the advertising rate increase, coupled with considerably improved sales efforts, would lead to a significant increase in both gross revenue and advertising pages to be published in 1965.

The Treasurer of the Society, A. F. Kapecki, introduced the proposed 1965 Society budget. Due to the increase in dues, subscription rates and advertising rates, the 1965 budget is in balance.

J. C. Harris, President-elect of the Society and Chairman of the Membership Committee, reported the Society total membership as 3,150 on September 30. He pointed out that membership drives at the convention, at the Short Course, and by the committee generally, has increased the membership considerably during the past two years. He pointed out that much of the above-normal gain has been in the biochemical fields. It should be noted that much of the Short Course Course work in the past few years has been along these lines.

R. W. Bates, Chairman of the Emeritus Membership Committee, recommended J. B. Brown ('37) and M. F. Lauro ('27) for Emeritus Membership. These recommendations were approved by the Governing Board. It was announced that the election of V. C. Mehlenbacher to honorary membership has been approved by the Society and that the presentation would take place at the business meeting on Monday.

Future meetings of the Society were discussed. It was announced that dates through 1968 had been completed and that the Secretary should examine possibilities for 1969. It was decided to hold the Spring Meeting in 1970 in New Orleans, and the Fall Meting in 1970 in Chicago.

W. O. Lundberg, Chairman of the Lipids Award Committee, reported that the By-Laws for this award had been carefully drawn up by the committee. Each section of these By-Laws was reviewed by the Board and several minor changes were agreed upon. Dr. Lundberg was approved as Chairman of the Nominating Committee for 1965 Lipid Award and a committee to determine the award winner itself was approved but remains anonymous.

C. W. Hoerr, Chairman of the Local Section Liaison Committee, pointed out that interest in this committtee has been lacking in the past, and that attendance at the workshop meeting in Chicago would determine whether future meetings of this committee would be desirable.

For some time there has been a need to define the function and the scope of many of the existing AOCS committees. This is true from the Governing Board, clear through to the last technical committee formed. It would be highly desirable to have for every officer of the Society, and for the Executive Secretary, a job description and for every committee of the Society, a scope. J. C. Harris was appointed to select a committee whose purpose it would be to obtain from the individual committee a scope of their activities, or where these scopes could not be obtained from the committee, to write them. This report should be available for the Board meeting in Houston in the Spring.

The Board recessed temporarily at 3:07 to have registration of the Board members and to reconvene with invited personnel not concerned with the above matters already discussed. The meeting was reconvened at 3:18 p.m.

A. V. Graci, on behalf of the Chicago Convention Committee, welcomed the Governing Board to Chicago. He then introduced a number of his co-chairmen, including Ladies' Chairman, Cecilia Gilmore, and his own co-chairman,, S. C. Miksta. A. V. Graci then related some of the problems concerned with the Fall Meeting preparations and some of the predictions concerning its success from the standpoint of registration. He also commented on some of the current program activities and the outstanding technical program.

R. T. O'Connor submitted a final report of the 1964 New Orleans Meeting. A formal written report was submitted in which each subchairman reviewed his experience with the meeting and offered significant recommendations for the benefit of his successors in future years. It was announced that Dr. O'Connor had agreed to accept the chairmanship of the 1967 meeting in New Orleans.

Kimball Smart, representing the Houston Convention Committee, read a report by G. M. Kreutzer on current preparations for the 1965 Spring Meeting. Several problems concerning the policies of the Convention Committee were discussed and suitably answered. Several outstanding symposia have been planned for this meeting, with one symposium to be dedicated to an outstanding chemist in the field.

C. E. Morris, Chairman of the AOCS Housing Committee, reported that his findings were essentially those reported at the last Board Meeting in which the purchase of a local Chicago property was recommended. After considerable discussion, it was decided to defer action on the purchase of the recommended property as no immediate pressure to move now exists. The committee was discharged by the Board with thanks, and a decision will be made at some future time concerning the necessary action to be taken.

N. H. Kuhrt, Chairman of the Education Committee, delivered a report on the activities of the Short Course for 1964 and on the activities of the MacGee Award Committee. Mr. Kuhrt reported that plans for 1965 involve two proposed subjects, "Oil, Fat and Lipid Processing and Related Analytical Procedures" and "Advanced Lipid Methods." Details of these symposia will be available in the Journal at a later date.

The Governing Board, after considerable discussion, voted to make available to the MacGee Award Committee, $1,000 per year for the next two years to continue the student program now completed. Since the money allocated to students for attendance at AOCS conventions is not strictly an award of merit, the Governing Board voted to change the name of this program to the MacGee Honor Student Program. This program will continue to operate under its new name.