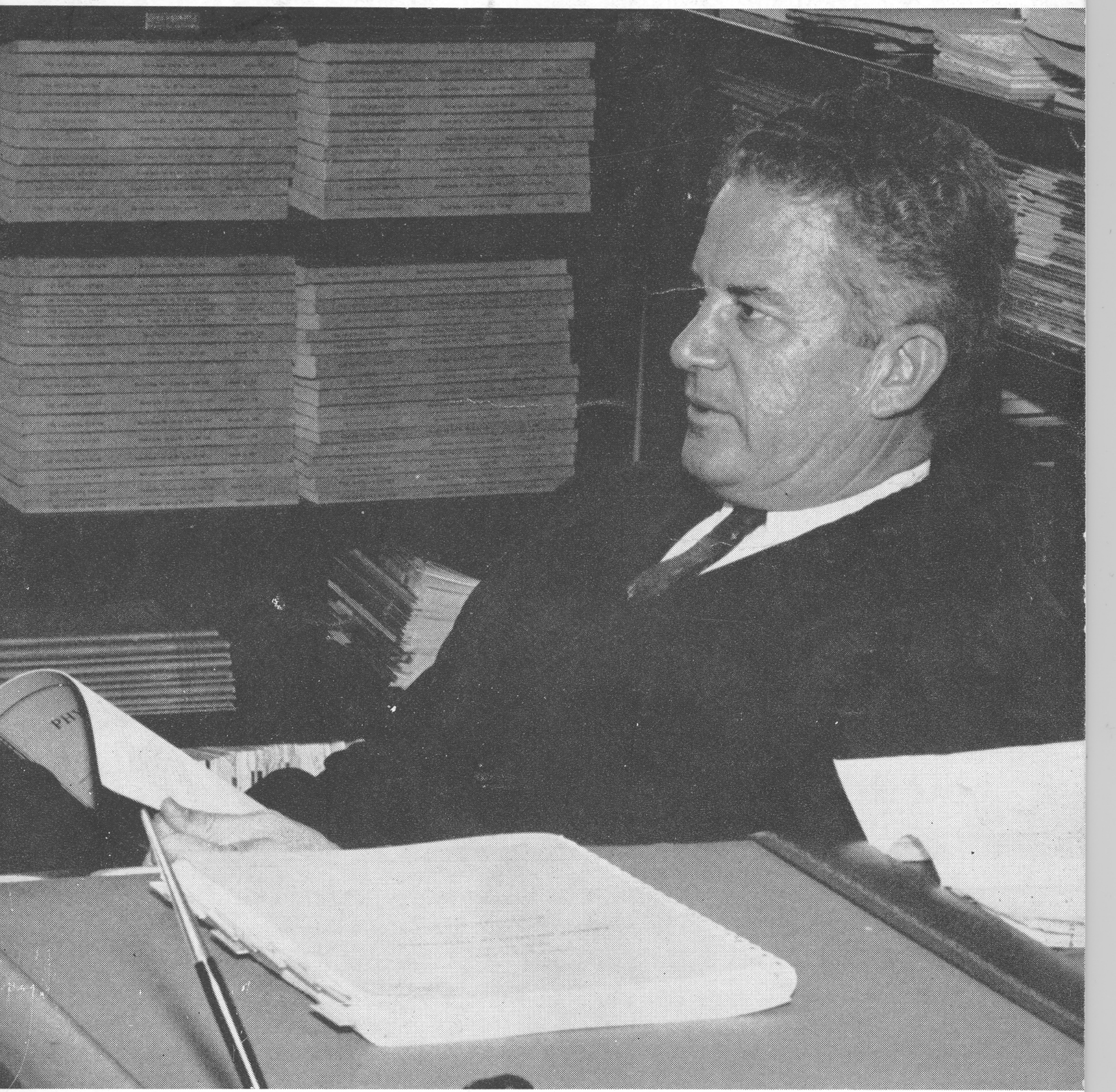
JUNE 1961

The Research Engineer

Published by the Georgia Tech Engineering Experiment Station



DR. JAMES E. BOYD – see pages 3 and 16

Industrial Products Series

RESEARCH ENGINEER

VOLUME 16, NO. 3 JUNE, 1961

Published five times a year by the Engineering Experiment Station
Georgia Institute of Technology, Atlanta, Georgia

the station

James E. Boyd, Director
Harry L. Baker, Jr., Assistant Director
Arthur L. Bennett, Chief, Physical Sciences Division
Maurice W. Long, Chief, Electronics Division
Wyatt C. Whitley, Chief, Chemical Sciences Division
Frederick Bellinger, Chief, Materials Sciences Division
Thomas W. Jackson, Chief, Mechanical Sciences Division
William F. Atchison, Head, Rich Electronic Computer Center

the staff

Robert B. Wallace, Jr., Editor
Bryan W. Miller, Jr., Associate Editor
Mary J. Reynolds, Jean Boney, Editorial Assistants

contents

THE PRESIDENT'S PAGE 3
LOOKING IN ON THE LAMPWORKER 4
THAT TATTLETALE GRAY 7
ADHESIVES 12
SHAKE WELL BEFORE USING 14
EDITED IN RETROSPECT 16

the cover

The cover is an informal photograph of Dr. James E. Boyd, Director of Georgia Tech's Engineering Experiment Station.

COVER AND ALL PHOTOGRAPHS BY VAN TOOLE

THE RESEARCH ENGINEER is published five times a year in February, April, June, October and December by the Engineering Experiment Station, Georgia Institute of Technology. Second-class postage paid at Atlanta, Georgia.

The President's Page

THE MAN who more than any other has been responsible for the amazing success of the Georgia Tech Engineering Experiment Station is leaving the campus to return to the scene of his first academic position. Dr. James E. Boyd—teacher, researcher, and administrator—will become president of West Georgia College this fall. He first worked at West Georgia College from 1933-1935 as head of the Mathematics and Science Dept.

Jim Boyd came to Georgia Tech in 1937 as an assistant professor of physics. He has served Tech as associate professor and professor of physics; and as a research associate, chief of the physical sciences division, the assistant director, the associate director, and since 1957, the director of the Engineering Experiment Station. Excluding three years of service in World War II as a naval officer, Jim Boyd has served Georgia Tech for 26 years.

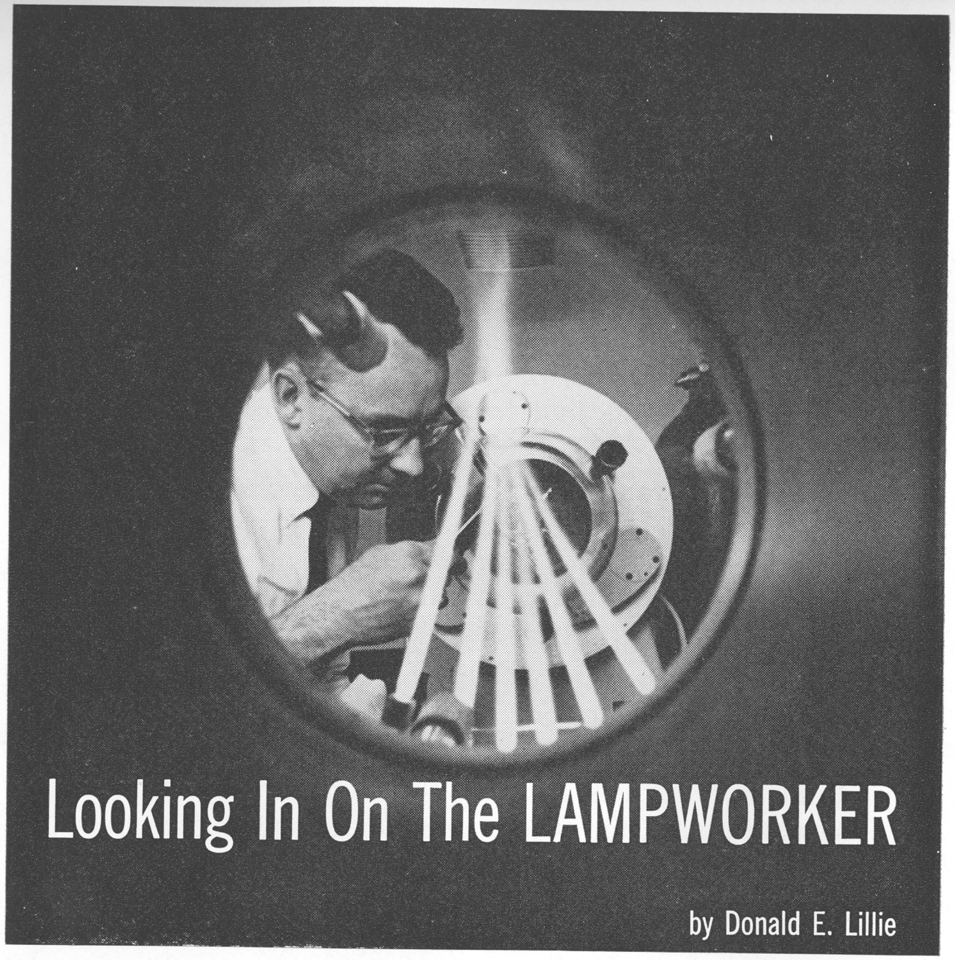
Too often, people tend to measure a man's worth to a research program by following the dollar volume chart. If this were our only measure, then Jim Boyd was a most successful man, for in four years under his direction the dollar volume of the station's research went from less than $2,000,000 to over $4,000,000. But Jim Boyd meant much more than this to Georgia Tech. He worked tirelessly to see that the station was making the highest possible contribution to the academic program at Georgia Tech. He was one of the main reasons that the station was able to attract more than its share of outstanding scientists. A great number of exceptional people came to Georgia Tech from all over the country simply because they wanted to work under Jim Boyd.

I know that he will make a great president for West Georgia College, because he has all of the traits that go to make a top college administrator, but we at Georgia Tech feel a great sense of loss at his leaving us.

E. D. Harrison *President*

Looking In On The LAMPWORKER

by Donald E. Lillie



High temperature glass, multiple burners, and complex machines enable the lampworker to fabricate large and small apparatus to close tolerances. Don Lillie measures apparatus.

Glass surrounds us in our civilization. We drink from it. We ride behind it. We depend on it so much that it is now taken for granted. In today's field of new materials—the high temperature alloys, the durable fabrics, the miracle plastics—the average person forgets that glass is one of the oldest, most useful materials man has yet discovered.

Glass has been used by man for over 5000 years. But, it was not until 300 B.C. that man discovered that a molten gob of glass on the end of a hollow tube could be blown and manipulated into many hollow, useful shapes. After the invention of the blowpipe, the history of glass blowing proceeds through the Roman and Syrian Eras; the golden, artistic age of Venice; and up to the gigantic, automated bottle factories and fiber glass plants of today.

There are essentially four types of glass blowers: the neon sign benders, the novelty glass blowers, the "gaffer" who gathers glass from a furnace on a blowpipe to fashion vases and large containers, and, finally, the lampworker who fabricates intricate apparatus from tubes and rods.

About 300 years ago, a technique was discovered by which a jet of air from a foot-operated bellows was directed across the burning wick of an oil lamp. The resulting flame was useful in melting and forming small articles from tubes and rods of colored glass. The glass blowers who utilized this technique were called lampworkers. Their torch was the oil lamp. Their factories were known as lampshops.

Today, the glass blowers who form scientific apparatus from glass tubing of all sizes and use a gas torch to melt the glass are still rather archaically referred to as lampworkers.

There are many questions one might ask about these men; for example, how many are there in the U.S. today? How are they trained for their occupation? What does a modern day lampshop look like? What type of glass do they work with and just how is a complicated piece of apparatus fabricated?

As the field of research becomes larger and more complex, the services of a professional glass blower are almost indispensable. Approximately 1000 lampworkers in the United States and Canada are primarily located in industrial research institutions, colleges, and universities. In the Southeast, 30 lampworkers are located in such research institutions as Oak Ridge, Savannah River Plant, Redstone Arsenal and in such universities as Duke, North Carolina, Florida, Georgia and Georgia Tech.

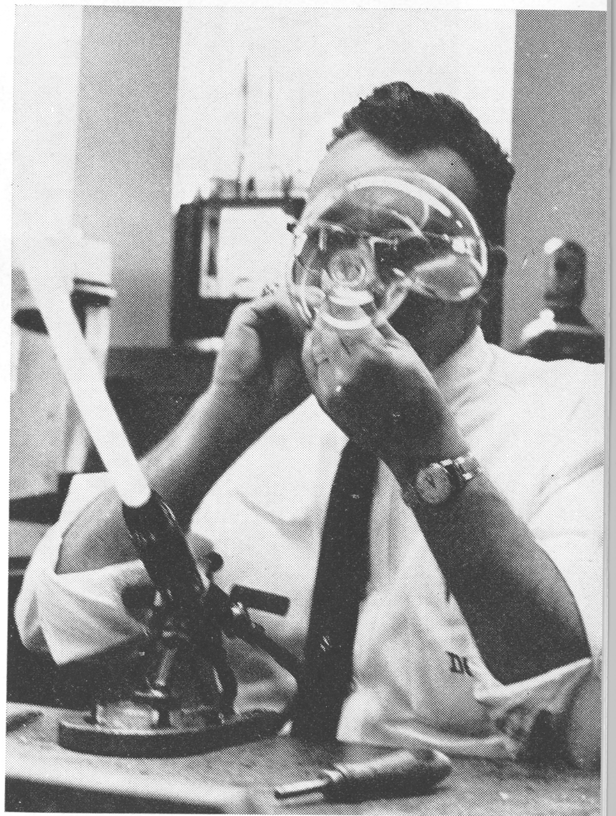
Although a few lampworkers learn the skill by simply teaching themselves by trial and error, a majority of them are taught as apprentices and spend a period —three to five years—studying under a professional glass blower. The demand for lampworkers has become so great that a trade school in New Jersey has created a 15 month course for basic instruction. The apprentice starts his glass blowing by making simple bends and seals and progresses to such complex maneuvers as multiple ring seals and glass-to-metal joints.

The average lampshop consists of a desk with a gas-oxygen torch, a glass saw, a glass blowing lathe for large diameter tubes and flasks, and an annealing oven to remove strains induced in the glass by bending and sealing.

The lampworker's tools are simple and crude. His reamers and shapers are made of carbon or wax-coated brass with insulated handles. And, he has his stock of glass tubes and rods of all sizes, demountable ground glass joints and valves. All the intricate, complicated glass forms seen in a laboratory are created from these basic components.

The glass most used today in research industry is a borosilicate glass trademarked either Pyrex or Kimax. This glass has good heat and chemical resistant properties. It is transparent but

WITH ONLY A SLIGHT PUFF, A BUBBLE AS THIN AS PAPER CAN BE BLOWN.



The gas-oxygen torch heats the glass to over 2500° F. and enables the lampworker to form the tubing into almost any shape. Here Mr. Lillie is sealing one tube inside the other.

does not have the brilliance or clarity of lead crystal. It contains approximately 82% silica, 13% boron and small percentages of soda and alumina. The softening point is 2228° F. The annealing point is 1065° F.

Before a lampworker starts a piece of apparatus, he must carefully study the drawing or sketch and mentally proceed step by step with each phase of fabrication, because once the piece is started and the glass is hot, he cannot stop to get a tube that was forgotten or a tool that is not readily available. The glass is heated by uniform rotation in a flame of natural gas and oxygen. By varying the proportion of oxygen, a whole range of flame sizes and temperatures can be obtained. Once the glass is molten, it can be pulled, pushed, blown or pressed. By careful manipulation and application of years of experience, the skilled lampworker can transform the scientist's dream into a useful reality.

THAT TATTLETALE GRAY

by W. H. Burrows, Head Industrial Products Branch

In the realm of industrial employment, each individual has his strong and weak points. His effectiveness on the job will depend largely upon the degree to which his strong points are utilized and his weak ones submerged. A certain amount of compromise is always required. The most effective course in most cases is the development of a "team" in which the strong points of several individuals may be merged to the mutual advantage of all, or such that the strong points of one may compensate for the weak points of another. In a similar fashion, "industrial chemistry" puts molecules to work.

Some molecules are very versatile, the number of their industrial applications being almost innumerable. Among these are certain solvents, such as "Cellosolve," "Dioxane," "Carbitol," etc., which are employed as solvents for many resins, waxes, gums, carbon deposits and in innumerable other applications. Many of the synthetic and natural polymers exhibit a wide diversity of properties and applications. By contrast, there are some molecules of very limited applicability. However, increased uses may be found as our technology expands.

Among the most versatile and most numerous molecules on the chemical market today are the "surface active agents" or "surfactants." These are encountered most frequently in the form of synthetic detergents, or "syndets"; shampoos and other toiletries; household, automotive, and industrial cleaners; insecticides; motor oils; paints; and many other commercial products. A great deal of teamwork is involved in getting the maximum efficiency out of detergents, and there is hardly a better field in which to illustrate the teamwork of molecules.

The earliest commercial surfactants were soaps. The manufacture of soap literally grew out of the backyard. In earlier days soap was made by boiling waste kitchen fats with caustic obtained by leaching wood ashes with rain water. The resultant liquid, largely potassium stearate, was converted into a solid soap (sodium stearate) by the addition of salt (sodium chloride). The solid soap was easily pressed into bar form although no more efficient than the liquid soap. "Soap" is a generic term, as there are many different soaps with diverse characteristics. Any vegetable or animal fat or oil, reacted with caustic, produces a soap. Figure 1 shows the typical reaction which takes place in the production of a soap from a fat. The most common soaps used for household cleansing are made from waste kitchen, market, and slaughterhouse fats and consist largely of sodium stearate, the most effective dirt mover among soaps. "Castile" soap is traditionally prepared from olive oil and consists largely of sodium oleate and linoleate. Much of the "Castile" soap is now prepared from cottonseed oil, which is high in oleate and linoleate content. The soap most desired for shampoo preparations is coconut oil soap, largely sodium laurate. The laurate is unique in restoring lustre and "manageability" to the hair.

The backyard method of preparing soap provides little flexibility in the matter of producing molecules "tailored" to a particular job. The selection of a particular oil and a caustic, potassium hydroxide for liquid soaps and sodium hydroxide for solid soaps, about sums up the posssibilities. During the past two decades there has been an extensive shift in soap making which adds enormously to the number of soaps which can be produced. The Twitchell process, patented in 1890, provides a means of separating the fatty acids from the fat molecule. These fatty acids can then be separated from one another in relatively pure form by fractional crystallization or, more recently, by fractional steam

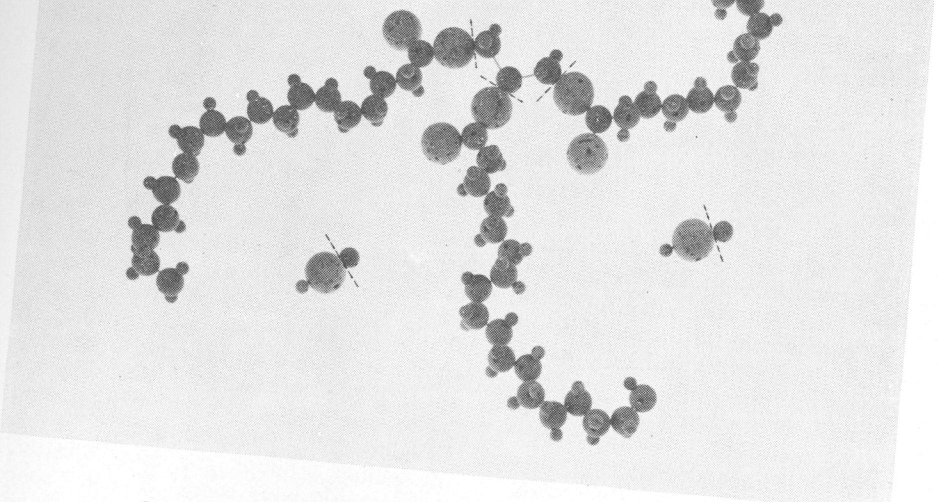
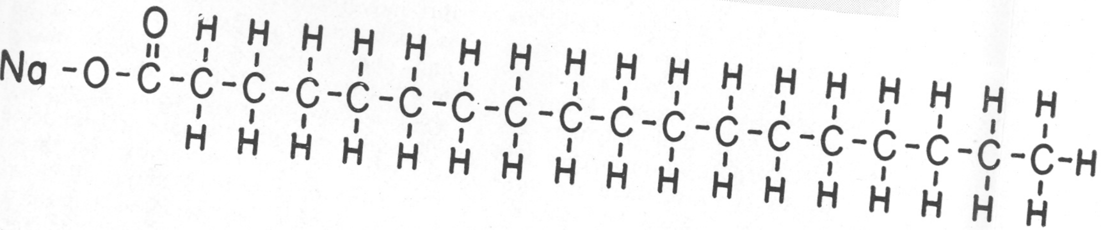


Figure 1A

Three soap molecules formed from one fat molecule. The sodium from the sodium hydroxide has joined with the fatty acid radical to form each molecule of soap. A bi-product of this reaction is the one molecule of glycerine, $C_3H_5(OH)_3$ in center.

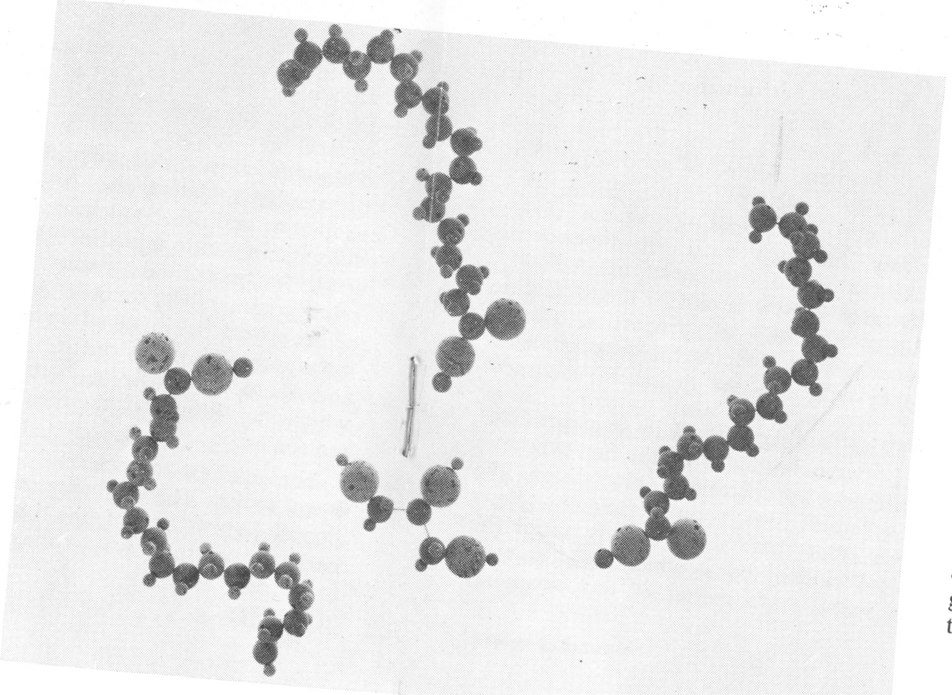


$$\mathrm{Na{-}O{-}\overset{\displaystyle O}{\overset{\|}{C}}{-}(CH_2)_{16}{-}CH_3}$$

One of the soap molecules of Fig. 1B in "structural" form demonstrates bonding between atoms in the molecule.

Figure 1B

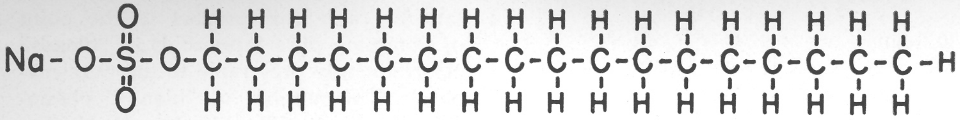
Molecule of a common fat, consisting of three long chain fatty acid radicals joined to a central glycerine radical. Fatty acid chains consist of seventeen carbon atoms, each with two hydrogen atoms. Waiting to react with the fat molecule are three molecules of sodium hydroxide, NaOH (one atom each of sodium, oxygen and hydrogen). Dotted lines show the place in each molecule where separation of atoms takes place when a reaction occurs producing soap.



unnecessary to carry this process to the point of obtaining pure fatty acids as "blends" are frequently preferable to the pure materials. The number of "blends" obtainable is infinite. The number of alkalies (or caustics) with which these acids may be reacted is also greatly increased as the reaction now becomes a simple one of neutralization between acid and base, rather than saponification which requires a much stronger alkali. Thus, soaps may be produced with ammonia, the alkanolamines such as triethanolamine, morpholine, and other organic bases.

The number of possible soaps available to industry has been further increased by the production of fatty acids which do not occur in natural animal or vegetable fats. The Fischer Gatsch process involves the oxidation of petroleum paraffins to fatty acids and provides the soap maker with molecules having from 18 to 28 carbon atoms, whereas the common oils and fats contain acids limited to some 12 to 18 carbon atoms. Some highly specialized applications are found for the higher molecular weight soaps.

Even before these developments in the soap-making process, soap was the best all-purpose detergent on the market. These developments have increased its usefulness in many respects. However, soap also has its weak points: for example, its somewhat higher than average cost, and its incompatibility with hard water. Ions present in hard water react with the soap, forming a curdy precipitate which manifests itself as "tattletale gray" in the laundry, ring-around-the-tub in the bath, etc. To overcome these weaknesses, soap manufacturers early learned to add other materials to the soap, thus building a team with greater capabilities than any single ingredient. Among the first materials added were sodium metasilicate, sodium carbonate (soda ash), borax, and trisodium phosphate. These are all mild alkalies and possess a certain amount of detergent action within themselves. In addition, sodium carbonate and trisodium



$$\mathrm{Na-O-\underset{\underset{O}{\|}}{\overset{\overset{O}{\|}}{S}}-O-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-H}$$

Replacement of CO_2 by the group SO_4 produces a molecule having the detergent power of soap, but not showing the same adverse reaction to hard water, that soap would have.

THAT TATTLETALE GRAY—cont.

phosphate remove the offending ions from hard water, preventing the wasteful formation of hard water scum. These additives increase the effectiveness of soap at the same time producing a cheaper product, as soap is more costly than any of these "builders" as they came to be called. With these builders present the soap's performance was so good that the soap manufacturers found it advisable to add a cheap, inert "filler," such as sodium sulfate just to dilute the product. The filler reduces the cost, of course, and no manufacturer will argue against that. In addition, it facilitates measurement of the proper amount for charging the washing machine, especially in a society of housewives who are traditionally averse to measuring and strongly prefer too much to too little.

Subsequently, various modifications of these first builders were employed, such as sodium sesquicarbonate, sodium hexametaphosphate, sodium tripolyphosphate, and tetrasodium pyrophosphate. Each of these has some advantage to offer in contributing to the overall efficiency of the detergent team of which it is a member. Their signficance has become much more pronounced during the last two decades, due to synthetic surfactants moving into the detergent field to the point that they now exceed the soaps in volume production. Builders, which are good for soaps, are essential for synthetic detergents.

Soil, since it may consist of almost anything, is universal. One would think, then that the chemist would be in search of a universal detergent which would solve all cleaning problems. This is not so. A universal detergent would remove grease from paint to be sure, but at the same time it would remove the paint from the wall, and who knows whether it would stop there? It takes balance in detergent power to remove the soil without affecting the substrate. This is quite a problem in modern laundering and dry cleaning as there are many new fabrics on the market, some of which are quite sensitive to strong agents. The field of detergency, rather than being open to universal agents, is a field of highly specialized agents. This concept applies to both the surfactant and to the builders which work with it in the detergent team.

Just within the confines of the alkyl aryl sulfonates, there is wide diversity in detergent performance towards various types of soils and substrates. Some are high foamers. Some are only moderate foamers. Some are good emulsifiers for certain oils, poor for others. Performance as "wetting agents" vary widely, although most are superior to soaps at equal concentration. Actually, detergent action is not a single feature but a manifold of properties. Consequently, it is difficult to measure detergency with any real degree of accuracy.

The "builders" used in soap products were omitted from the first synthetic detergent preparations placed on the market. It was soon discovered, however, that these detergents required the same kind of boost which builders gave to soaps. As a matter of fact, soap has certain properties which are lacking in some synthetic detergents, so additional builders must be added to compensate for these deficiencies. Moreover, new additives have recently found their way into the detergent market and are now standard ingredients of the detergent stock in trade. A good detergent for use in the home washing machine will generally contain the following materials—an alkyl aryl sulfonate of medium low foaming properties (40% active ingredient, 60% sodium sulfate left over from the neutralization reaction), 30%; sodium metasilicate, 10%; sodium tripolyphosphate and/or tetrasodium pyrophosphate, 35%; sodium sulfate as "filler," 20%; other ingredients at 1% or less, such as sodium carboxymethylcellulose, sodium ethylenediamine tetracetate, optical brighteners, etc. The sodium carboxymethylcellulose helps prevent the soil from redepositing on the fabric. The sodium ethylenediamine tetracetate prevents deposition of compounds of iron, manganese, etc., which darken cloth. The optical brighteners are compounds with dyelike structure, which absorb ultraviolet light and emit white light, making the cloth look cleaner than it actually is. The surfactant is only about 40% of 30%, or about 12% of the total powder. When 2/3's of a cupful is added to the washing machine full of water, it is well under 1%. Furthermore, there is about four times as much builder than surfactant. But these are the constituents for a good team. The combination works far better than either taken alone would do.

When the non-ionic surfactants are used in detergents of this kind, the builders and fillers take on a new duty in addition to the one they already have. The non-ionics are liquids, rather than solids. Since so little is required in the "built" product, however, this amount of liquid is readily absorbed by the other ingredients, which are all dry powders. The dry powders then serve as "carriers" for the liquid surfactant. Non-ionic surfactants have more easily controlled foam levels, and are therefore more readily adaptable to special cleaning tasks, such as wall cleaners, etc.

A rather obvious question arises since the non-ionics are naturally liquids. Why not compound them with builders as liquids, rather than powders? Some non-ionics are on the market as liquids without builders, but they are mild, not heavy-duty cleaners. When the common builders are added, it is found that they as sodium salts are not sufficiently soluble to remain in solution in a detergent of strength comparable with the dry powders. Sodium compounds are generally not as soluble as potassium or ammonium compounds. Very recently the market has been literally flooded with heavy-duty liquid detergents, which do contain builders. However, these are potassium compounds. They are somewhat more expensive, but consumers are willing to pay a slightly higher price for a product which they consider more convenient to use.

The potassium compounds are almost completely soluble, although a little residue might form on the bottom of the container or otherwise cloud the solution a bit. So what does the manufacturer do about this? He adds a bit of fatty acid (such as stearic acid) and a bit of zinc chloride (calcium chloride or magnesium chloride would do as well) to form a precipitate just like that formed when soap is used with hard water. Here, however, the precipitate, instead of settling out, forms in very fine dispersion and gives the solution a "pearlescent" effect, which not only masks the cloudiness of the builders, but adds beauty to the product.

So here we are, back with the potassium which we abandoned for sodium in our backyard soap-making. Back with the fatty acids and their soaps we gave up for synthetic detergents. Even back to the "ring-around-the-tub" in a slightly different form. To complete a full cycle, it might be added that soap may be used as a very effective builder for liquid detergents in place of the phosphates and silicates. Or is it, perhaps, the other way around?

Starches, asphalt, polyvinyl alcohols— they are all

ADHESIVES

by Lewis W. Elston, Industrial Products Branch

Adhesives may be roughly divided into four classes based on their method of application. A solid material may be melted, applied, and cooled. The second method is to dissolve a solid material in a volatile solvent. A solid material may be liquefied by pressure and solidified when the pressure is removed. The fourth method is to apply a liquid, low molecular-weight material and form the adhesive by chemical reaction in the film.

In order to bring the molecules of the adhesive and its substrate within the limited range of attractive molecular forces, the adhesive is usually in a liquid state during some part of the bonding operation. Since hardening of the adhesive, be it by solvent evaporation, hydration, cooling, polymerization, or any other chemical or physical process, usually results in shrinking of the glue, residual strains are left in the bonded joints. To minimize these strains, it is desirable that most of these processes take place before the adhesive hardens.

Where the material to be bonded is thin or elastic, deformation of the substrate may reduce the strains. This flexibility of the adherend permits the use of rigid adhesives in the assembly of cardboard cartons. Where wrinkling of the glued surface is objectionable, e.g., in mounting photographs on paper, a more elastic adhesive is preferable.

The terms thermoplastic and thermosetting are related to whether an adhesive will soften on heating. Thermoplastic adhesives, even though they may be hard at ordinary temperature, are held together by Van der Waals dispersion forces which may be overcome by thermal energy as heat is applied. A thermosetting resin hardens through the formation of new primary chemical bonds whether initiated by chemical catalysts, heat, or pressure. Since enough heat to break these bonds is sufficient to destroy other bonds in the molecule, a thermosetting glue will usually char rather than soften when heated. An interesting application of these properties is found in moulding plywood. The laminate stock is prepared at a moderate temperature just high enough to cause the glue to flow. For final fabrication the stock is pressed into the desired form at higher temperatures activating reactive sites in the glue molecules. The new primary bonds form a crosslinked thermoset adhesive which folds the object in the desired shape.

Blomquist has suggested that classification of adhesives according to composition might lead to two major groups, naturally occurring materials and synthetic materials. The first group might be divided into starches, dextrins and a sub-group of proteins. The proteins would include animal bones and hide, albumin or whole blood protein casein, and soybean protein. A third subgroup of naturally occurring materials includes asphalt, shellac, natural rubber, and sodium silicate. The second major group, synthetic adhesives includes a subgroup of thermoplastic materials such as cellulose esters, alkyd and acrylic esters, polyamides, polystyrene, synthetic rubber, and polyvinyl alcohols. The second synthetic or thermosetting subgroup includes the familiar epoxies, urea, melamine phenol, furane and resorcinol resins. The choice of adhesives for each application is based on working properties of the adhesive, bond strength required, and cost.

In the paper industry, adhesives are selected principally for low cost and convenience of processing in high speed machinery. Only sufficient bond strength to give some evidence of torn fiber in ruptured bonds is required. Other requirements are that the adhesive set rapidly under very little heat and pressure and that the adhesive not liberate sufficient water to cause warping of the bonded stock. A typical corrugated board operation using high speed roller adhesive applicators may produce several hundred lineal feet of board per minute. Another technique might consist of laminating flat sheets together at high speed under roller pressure. Tubular cartons may rapidly be wound on a mandrel. For bookbinding, the old animal glues which required drying have largely been replaced by thermoplastics. For closing cartons there are gummed tapes which may be activated by water or pressure sensitive tapes which adhere to almost anything except the paper or cloth roll which bears the adhesive.

For plywood manufacturing, glues should be inexpensive, fast curing, and free from tendencies to form pockets during heat curing. Phenolics are generally used in exterior and marine plywoods. Less costly glues are permissible for interior use. Laminated woods may be used for tennis racket frames, bridge girders, turning blocks and furniture lets, and architectural shapes such as arches and beams. The advantages of building large members from thin strips and discarding defective wood is readily apparent. In commercial production of laminated shapes, an electrically conductive thermosetting resin permits inductive heat curing for a few seconds in the glue line only rather than heating and distorting the wood. Adhesives for wood assembly, e.g., for gluing furniture and millwork joints are available for nearly any technique the user may desire.

Since the coefficients of thermal expansion of dissimilar metals create strains on heating and cooling, adhesives for metal bonding are usually formulated to provide elastic bonds. This elasticity is obtained at the expense of some sacrifice in ultimate bond strength. Sandwich construction of metal faces over a honeycomb core for aircraft panels is a recent spectacular development. For most applications, however, the rigorous cleaning procedure required and consequent high process cost have prevented extensive use of high strength adhesive metal bonding.

Several clever techniques are found in the adhesive bonding of glass laminates. For the bonding of glass or iron it was necessary to develop a glass with a thermal coefficient of expansion resembling that of iron. Such a glass could be bonded to iron with only conventional metal solders. The tendency of lead from leaded glass to migrate into iron on heating and to weaken the joint was overcome by coating the iron with lead-free glass before soldering. Zirconium or titanium will cold weld to glass. Early glass laminates (safety glass) were made with mitrocellulose films bonded to glass with gelatin. Later research led to polyacrylic esters as layers, and then to polyvinyl acetal films which bond to glass without additional adhesive. Glass fibers, whose bond to laminating resins is poor have been made usable by treatment with allyl or vinyl silanes. The silane portions of the molecules "react with the glass surface to form a sized glass fiber, and the vinyl or allyl tails of the molecules are later included in the polymerization of a thermoset adhesive.

BIBLIOGRAPHY

1. Adhesion and Adhesives, Fundamentals and Practice. (Papers read at a Symposium held at Case Institute of Technology in Cleveland, Ohio, and at a Conference held in London, England). Society of Chemical Industry, London and John Wiley and Sons, Inc., New York 1954.
2. Reinhart, Frank W., "Survey of Adhesion and Types of Bonds Involved" (same) p. 9.
3. R. G. Blomquist, "Types and Uses of Adhesives" (same) p. 74.
4. L. L. Yaeger, "Adhesives for Glass," p. 81.

"Shake Well Before Using"

by A. C. Topp, Associate Professor, Chemistry and Research Associate

The common denominator of the medicine bottles has long been "Shake well before using." It often refers to the type of preparation that separates into two liquid layers on standing. The admonition is becoming less necessary as the use of a third component, the emulsifying agent, is added to prevent the separation of the two liquids by forming a stable emulsion. Not only pharmacy but many diversified industries make use of the properties of emulsions and are, in some cases, concerned with the destruction of emulsions fortuitously formed in some stage of processing treatment.

An emulsion consists of two immiscible liquids, one of which is generally water, in the form of droplets of one (the internal phase) dispersed in a continuous phase of the other (the external phase). Such a system would be unstable were it not for the presence of an emulsifying agent in the boundary or interface between the two liquids. The choice of the emulsifying agent determines the characteristics of the emulsion.

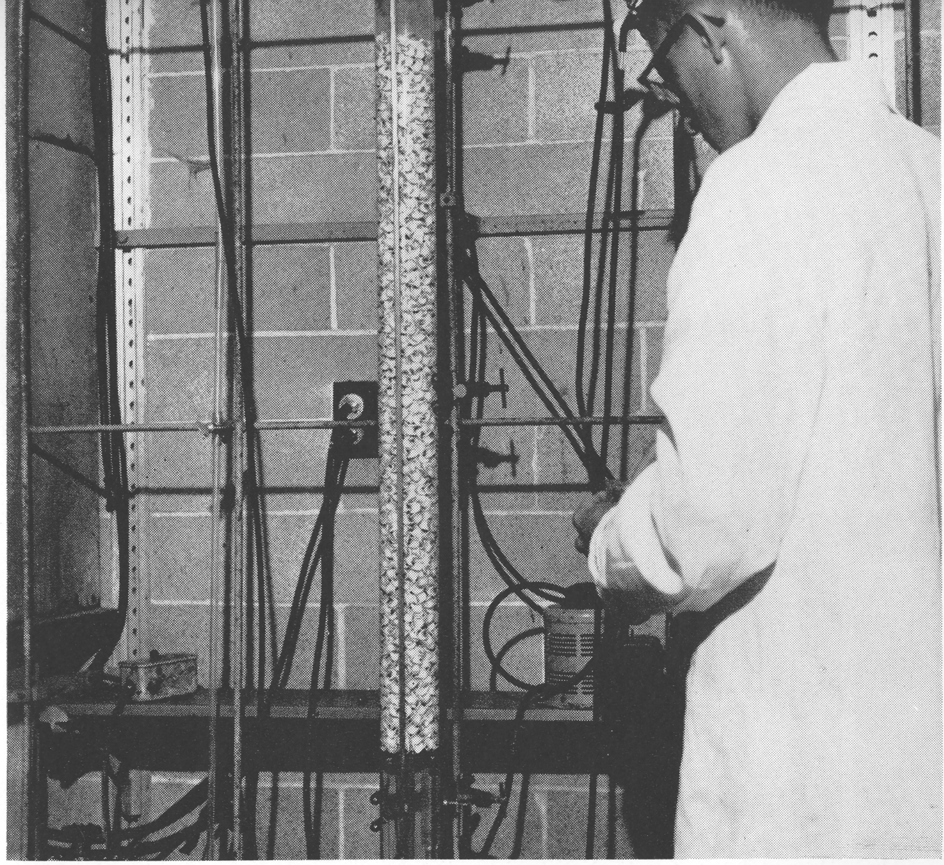
With any pair of immiscible liquids two emulsion types are possible: oil in water, in which droplets of oil are dispersed in a continuous water medium, and water in oil, in which water forms the dispersed droplets. There are several methods for determining the type of emulsion the most common of which are electrical conductivity, dilution and dye absorption.

The electrical conductivity of an oil in water emulsion is markedly higher than that of a water in oil emulsion. The type can be readily determined by any conductivity testing device. An emulsion can be diluted with the external phase but when some of the internal phase is added it will not mix homogeneously with the emulsion. A dye, soluble in the external phase but insoluble in the internal phase, will spread uniformly through the emulsion when dusted on the surface. A dye with the reverse solubility conditions will remain as discrete specks on the surface when dusted on an emulsion.

The action of emulsifying agents is illustrated with two common types—solid powders and soaps. The first requirement is that the agent will concentrate on the interface between the two components of the emulsion. The second requirement is agitation to disperse the two liquids into droplets one of which will coalesce to form the external phase.

A solid powder serves as an emulsifying agent if it is wetted by both liquids but more strongly by one than the other. The liquid which better wets the solid forms the external phase of the emulsion. Thus, carbon black will form an emulsion of water in benzene and other organic liquids while oil in water emulsions may be prepared by means of basic salts, clay, calcium carbonate, etc. If the contact angle between the interface and the solid powder particles is 0°, 90°, or 180° no emulsification will take place. The solid goes entirely into one liquid or the other or exhibits no preference. Intermediate angles of contact are required for emulsion formation.

Soaps are widely used as emulsifying agents. Their action is due to the relative change in the surface tension at the two film surfaces, water-emulsifier and oil-emulsifier. If the surface tension at the interface water-emulsifier is less than at the interface oil-emulsifier, the film will tend to bend so as to become convex on the water side, thereby tending to make an emulsion of oil in water. On the other hand, if the surface tension at the interface water-emulsifier is greater than at the interface oil-emulsifier, the film will tend to give a water in oil emulsion. Sodium and potassium soaps (which are peptized in water but not in oil) give oil in water emulsions, whereas calcium and magnesium soaps (which are peptized in oil but not in water) give water in oil emulsions.



THE EXTRACTION OF OIL IN A COUNTER-FLOW COLUMN IS SHOWN ABOVE.

If calcium chloride solution is slowly added, with agitation, to an oil in water emulsion prepared with a sodium soap, the emulsion will break when sufficient calcium chloride has been added to give equivalent quantities of sodium and calcium soaps. It becomes a water in oil emulsion upon addition of excess calcium chloride.

Common applications of the use of emulsions in industry include dilution of oil soluble insecticides and horticultural sprays, adhesives, latex paints, cod-liver oil and drugs. Cleaning metal surfaces by emulsifying oily soils, removal of oily feel in cosmetics, increased fluidity of liquefiable waxes and resins, food preparations such as butter, margarine, mayonnaise and sauces are some more applications.

Presently the Georgia Tech Engineering Experiment Station is continuing development work on a process for extracting oil from oil seeds. A patent was issued to Dr. Nathan Sugarman and assigned to the Station. The unique aspect of the process is in the separation of the oil from the remainder of the oil seed as a stable emulsion. Subsequently the stability of the emulsion is decreased through modifying the emulsifying agent by PH control. The oil is separated by centrifugally breaking the unstable emulsion.

Edited in Retrospect

For over six years, the man who appears on this issue's cover has been our friend. As a Tech alumnus, as an employee of the Institute, and as an editor, we would like to take up these few lines to say just how much this man's presence on the campus has meant to the growth of Georgia Tech and to our own relatively unimportant career growth. We are positive that if he saw this copy prior to its publication, he would immediately forbid it ever appearing in print. Therefore, we are just bypassing him for the first time in our term as editor of this magazine.

Among the truly great men we have been privileged to know in our lifetime (and they have been surprisingly few) Dr. James E. Boyd would have to appear at the top of our list. He is the most dedicated man we have ever known and only those who have worked closely with him know how strong this dedication really is. But dedication without talent, without vision, without gentility, and without a true respect for your fellow men is a hollow and often destructive thing.

Jim Boyd has talent, a great deal of it. He has even more vision. He has the quiet, worried ways of the gentle man. And, a great number of people on this campus and in the world of education and research know how he feels and acts towards his employees, his employers, and his fellow scientists and friends.

To this one man at least, he is the absolute model of what the scientist of today and of the future must be if this country and the world is to live with its own technology.

His interest in the careers of the people who work for him is something else you must be a part of to believe. His knack of quietly guiding you toward the correct decision, no matter how small the problem, is just another indication of his desire to better the people who work for him and in turn better Georgia Tech.

He has for a long time been the symbol of Georgia Tech research to a lot of people. He has seen it grow from a small $40,000 effort to a $4,000,000 giant that has outgrown its physical facilities to the point of absurdity. He has given all of us who have known him a great deal. And, we all wish him well.