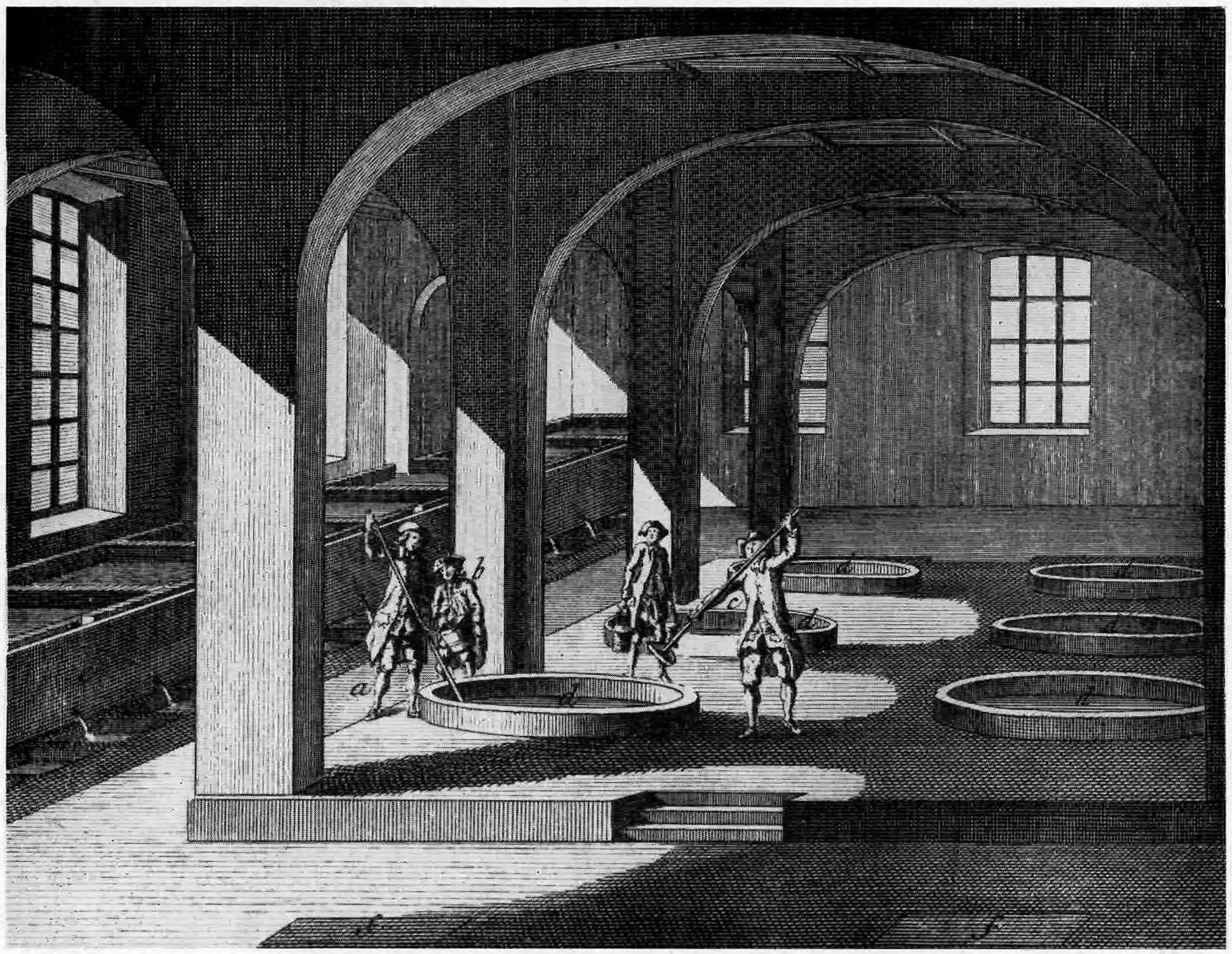


FIG. 1. "Kettle house" of a French soap factory in about 1750. The kettle soap was boiled by open fires underneath these kettles, and the adding of fats and base materials was a "bucket-brigade" operation.

Soap in Peace and War

BY J. G. PLEASANTS

NOWADAYS soap is perhaps the commonest of all household supplies. It is among the cheapest and yet the most necessary. Few things in our daily lives are more familiar than that handy bar of soap on the washstand or the package of granulated soap on the kitchen sink. Most of us accept this everyday article in much the same matter-of-fact way that we accept the very water we use with it. But there are some interesting facts behind that bar of soap and the millions of others like it.

The story of soap's beginnings takes us very far back. It begins with the days of ancient Rome, on Sapo, a sacrificial hill outside the city. Sapo was the poor man's altar ground, where he could make his burnt offerings to the gods. Unlike the well-swept altars in the great Roman Forum, Sapo's crude altars accumulated fat and wood ashes, which, over the years, collected and mixed with the soil and were washed by the rains down to the banks of the river Tiber. Thereupon the river-bank clay was found to have amazing properties—it would loosen the dirt from the clothes scrubbed at the river-bank laundry. So, according to the storytellers, this Sapo clay was the first soap. And by the same token the word, *Sapo*, has become the root of the word for soap in most modern languages—*sapone*, *savon*, *jabon*—and likewise forms the base of our word for soapmaking, saponification.

SOAP BECOMES AN INDUSTRY

True or not, the story of Sapo hill gives us a pretty good idea of how thoroughly crude the first soap was. And it was many centuries before anything approaching the substance we call soap was available for general use. The art of soapmaking revived in Italy, Germany, and France during the 13th century; and in 14th-century England there was developed almost a flourishing soap industry. Sometime around 1800 the French discovery that sodium hydroxide could be made from common salt gave the home manufacture of soap a real spurt. It was an improved product, but was nonetheless a harsh, jelly-like stuff that contributed little pleasure to the process of cleansing.

There have been some vast improvements in the ancient business of soapmaking. Today's industrial plants employ complex machines, chemical process equipment, and skilled operators to produce the seemingly simple, commonplace cake of soap. The basic materials, however, except for their quality, have not changed fundamentally since Sapo hill. Soap still comes from the reaction of a fat or an oil with a base. In the modern soap factory this reaction is carried out on a tremendous scale.

THE SOAP INDUSTRY MODERNIZES

Measured against the standards set by industries producing "20th century" developments, such as the automobile, the airplane, radio, etc., the soap industry does not appear to have modernized itself very rapidly. Much of the soap made today is still produced in about the same way that it has been for at least 100 years. Steam may have replaced open fires for heating, and power drives may have replaced manpower, but batch methods are still used to a large extent, much as they were in the last century.

Almost everyone is familiar with the term "soap kettle," and the kettle house was and is the heart of the soap factory. It is the point at which the saponification of fats with sodium hydroxide creates soap and glycerine simultaneously. The kettle house of a sizeable soap factory may contain from 20 to 100 kettles, three stories high, each holding four or five tank cars of material.

The boiling of soap in a kettle is a batch operation. On the average, a week will elapse from the time the kettle is "stocked" until the finished soap is ready to deliver. During this time the kettle goes through a fairly complicated boiling cycle, which usually involves the saponification, several "washes" to remove the glycerine from the soap, another sort of "wash" to remove the excess "strength" (sodium hydroxide) from the soap, and two or three "pitches" to bring the soap into the proper condition for delivery. Each of the boiling operations mentioned is followed by a settling period, and the final "pitch," which is generally called the "finish," is followed by an extended settling period of from one to three, four, or five days, depending on the type of soap. Thus boiling kettle soap is an operation which inherently ties up large quantities of material and a considerable amount of equipment for relatively long periods of time.

When the finished kettle soap is delivered from the kettle house, a great deal of it is further processed by batch methods. Before framing, spray drying, or rolling, for bar soap, granules, or flakes, respectively, the kettle soap is mixed with the proper amounts of builder and perfumes, and this is still done to a large extent in mixers with power-driven agitators. These mixers are called "crutchers" and this term is a hold-over from the days when a man did the mixing or stirring by hand with a stirring pole which looked something like a crutch.

In recent years, however, the old batch methods have been giving way to continuous processing. For example, there are a number of soap factories in this country in which the "kettle soap" is not made in kettles at all, but comes from a continuous soap-making unit, which con-

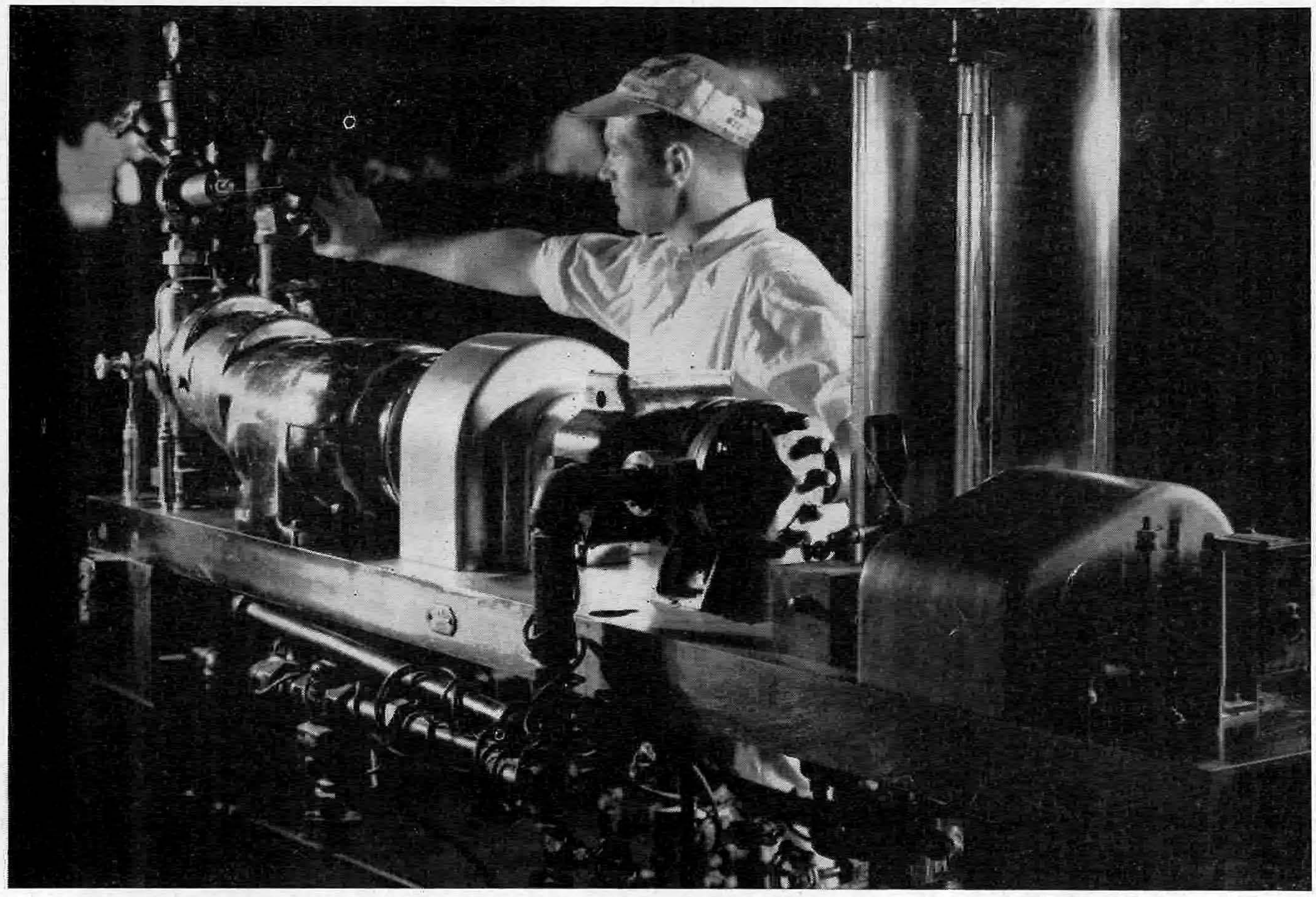
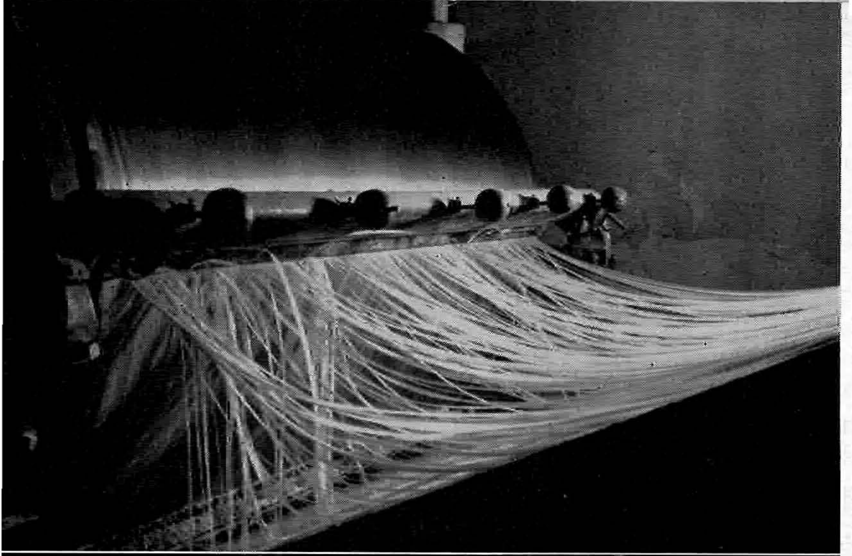


FIG. 2. Automatic machinery and continuous processing equipment are steadily replacing the batch methods of production which have been characteristic of the soap industry for centuries.



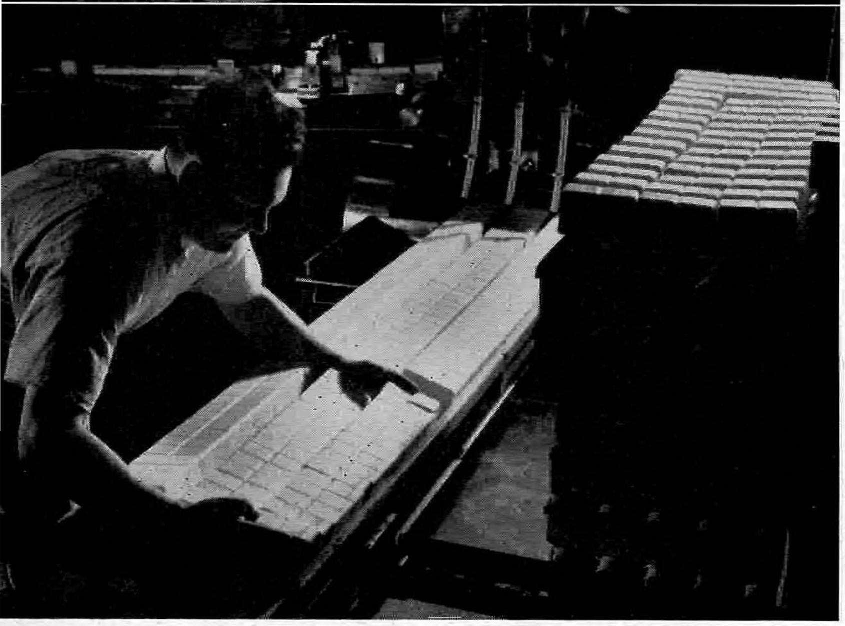


FIG. 3. Soap products are tailored for many specialized uses. Here paper-thin ribbons of soap are feeding off a huge roll into a drying oven on their way to becoming flakes. FIG. 4. Here three conveyor belts are feeding bars to a high-speed stamping machine. A watchful eye for quality is part of the stamp-feeder's job.

sists of an autoclave, in which fat is hydrolyzed into fatty acid and glycerine continuously, and of a continuous saponifying unit, which mixes sodium hydroxide or potassium hydroxide with the fatty acid from the autoclave in just the right proportion to give finished kettle soap. These units operate at high temperatures and pressures and must be made of non-corrosive metal, but one of them will take the place of several of the old soap kettles. One of these continuous units will be delivering finished kettle soap within an hour from the time the fat is started into it, in contrast with the week required for a soap kettle. The advantages of the continuous equipment are better control of product quality, less physical space required, and less material tied up in process.

In addition to the continuous soap-making equipment, the industry is introducing continuous crutching equipment, by means of which the proper amounts of perfume and builder are proportioned into the kettle soap continuously, rather than batchwise.

As in the field of equipment, so also in the type of product offered, the soap industry has only recently shown any very revolutionary progress. It is true that we have bar soaps, both laundry and toilet; flakes, and granules; cold process soaps, pumice soaps, and liquid soaps, castile soaps and medicated soaps; but they have all been nothing but vegetable or animal fats saponified with sodium or potassium hydroxide and mixed with greater or lesser amounts of water softeners, perfumes, glycerine, abrasives, etc. The active wetting and cleansing agent has been the sodium or potassium (in a few cases ammonium) salt of a fatty acid.

Relatively recently, however, some other organic compounds have been found which exhibit wetting and detergent properties. These products are obtained variously by the sulfation of high molecular weight fatty alcohols; the sulfation of monoglycerides; the sulfonation of alkylated benzenes, naphthalenes, and paraffines, and in other ways. Those mentioned are the most common, though there are many more.

These products are known generally as synthetic detergents and have in many cases qualities which make them better than conventional soap products. For instance, some of them make suds equally well in hot or cold or hard or soft water. Most of them do not react with calcium and magnesium salts in hard water, and therefore possess the happy property of not "leaving a ring around the bath tub."

Because of their free-sudsing and complete-rinsing characteristics, synthetic detergents have found a popular outlet in shampoos, and in granules for fine fabrics and for other "quality" washing jobs. It is reported, incidentally, that one of these products has been used very successfully at the Mt. Wilson Observatory for washing the telescope mirrors.

A SOAP FOR EVERY PURPOSE

Almost every industry speaks with pride of the "design" of its products. It may sound surprising to say that each soap product is especially designed for the job it is to do, but that is actually the case. Soaps are tailor-made to handle everything from the delicate jobs of washing infants and fine fabrics to the heavy duty tasks of textile mills and commercial laundries.

Many things are considered in soap "design." The type of washing to be done, the hardness of water in the region, the temperature of the water likely to be used, along with other factors, are all considered in settling on a fat formula, builder content, and the physical form of the soap product.

With respect to physical form, almost everyone can recall the time when bar soap was all there was. People would slice this bar soap into their wash in order to get quicker solution. The soap companies took a hint from this practice and started to do the job for the customer. The original crude rotary knives used to manufacture soap chips have been replaced by modern equipment capable of making endless ribbons of soap less than 0.0005 inches thick. An even greater step in the direction of quick dissolving was made with the development of spray-dried soap granules.

During the past couple of decades, much attention has been given to developing and producing these specialized soap products for many specialized applications. The paper-thin soap flakes and efficient granules tackle their respective household tasks. Industrial soaps are used for cleansing, emulsifying, and lubricating. Pumice soap is the answer for millions of greasy and grimy hands turning out today's tools of war. The scented toilet soaps are made for the luxury bath.

Soap's widest use, of course, is to clean anything that's cleanable. This use alone has taken it far afield from the household washbowls and dishpans. More and more, soap becomes a universal handyman, serving civilization in more ways than civilized mankind generally realizes.

At the outset of World War II many of these varied uses for soap came into sharper focus as their essential value in the war effort became apparent.

THE BIGGEST LAUNDRY PROBLEM IN HISTORY

Wartime or peacetime, the commercial laundry does an important job in maintaining American cleanliness at the world's highest level. But with wartime the job has become more acute because millions of women who stepped from the kitchen into war plants are now saying "send it to the laundry." Added to this demand is a tremendous volume of laundry for the Armed Forces stationed all over the country.

New and knotty washing problems have been occasioned by these conditions. Special soaps and washing formulas have been required of the soap industry. Detergents that cut the grease and grime from millions of work clothes, soaps that protect the synthetic fabrics of wartime—these and many more needs draw on soap's ability to be versatile enough for every need.

But all the laundry isn't on the homefront. From the big Navy laundries on board battleships to the G.I.'s helmet washtub at the front line foxhole, America's fighters are trying hard to maintain their cleanliness standards. But washing conditions are tricky and just any soap won't do—especially in salt water.

Before Pearl Harbor a satisfactory soap for Army-Navy use was being produced from coconut oil. When the South Sea supply of this material was cut off, it meant finding a new formula which would give the Armed Forces a soap that would lather and wash in hard water, cold water, and even salt water. A synthetic detergent stepped into this problem and provided the answer. It is completely indifferent to hard water conditions, and lathers promptly in seawater. It does not react to form insoluble calcium or magnesium soaps; so it rinses thoroughly in hot, cold, or salt water. Thus a combination of soap and synthetic detergent produced an all-purpose salt-water bar soap that meets all washing conditions, from the Aleutians to the tropical jungle.

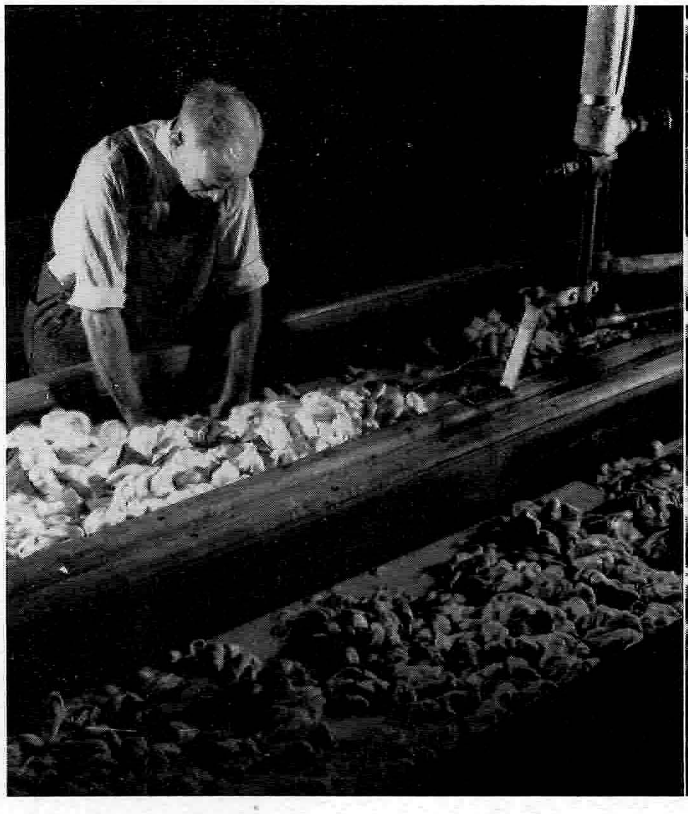
HOMEFRONT HEALTH

National health is always one of soap's busiest jobs, whether during war or peace. Millions of bars of soap go into American homes, factories, hospitals, and institutions each week. Cleanliness is a "must" for health, and America's soap consumption of almost 25 pounds per capita far outstrips the washing habits of any other nation, even by pre-war standards.

There are soap uses for health, however, which have nothing to do with the washing of millions of human beings. One, for example, is the use of special soaps and synthetic detergents for washing fruits and vegetables before they go to market. The delivery of food to America's dinner tables and mess kits means getting it there in a pure, wholesome condition. For certain types of fruits and vegetables, a good soap and water bath is an absolute necessity to insure their reaching the final destination in good condition. Washing helps to reduce spoilage and it removes any dirt, insect spray, or other foreign matter. In the meat-packing industry, too, soap-and-water gets liberal use during the process.

SOAP IN THE TEXTILE INDUSTRY

The textile industry undertook the big job of clothing the fighting forces and supplying blankets, cots, tents, truck coverings, surgical dressings, camouflage fabrics, and rayon and nylon for uses ranging from tire cordage



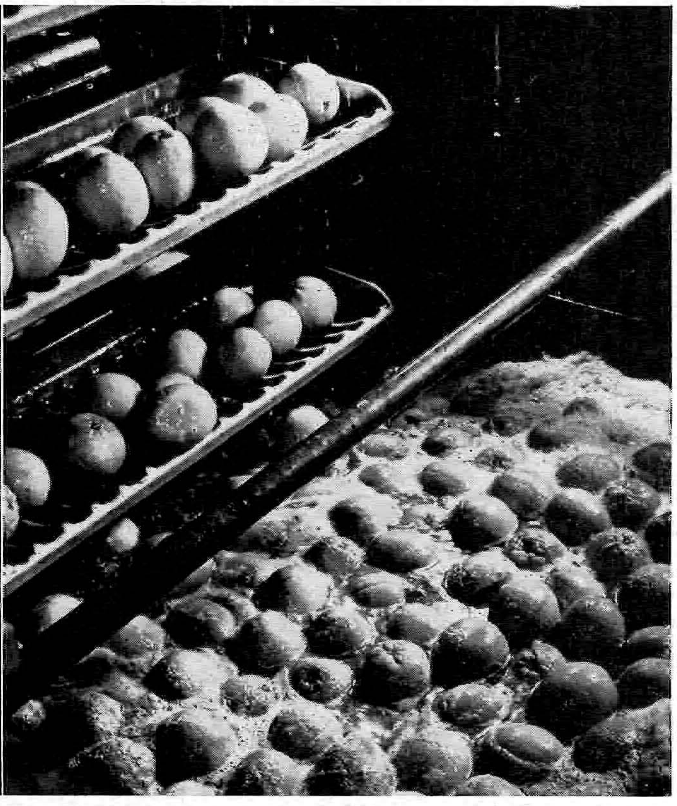


FIG. 5. AT LEFT: Soap has a role in many industrial processes. Here raw silk for parachutes and shroud lines gets a "soaking" bath as an important step in its processing. FIG. 6. AT RIGHT: First step at the packing house in preparing oranges for market is the soap-and-water bath. On the left, a carrier removes oranges from the suds and takes them up to be rinsed with warm and cold showers, then dried by brushes and warm air currents.

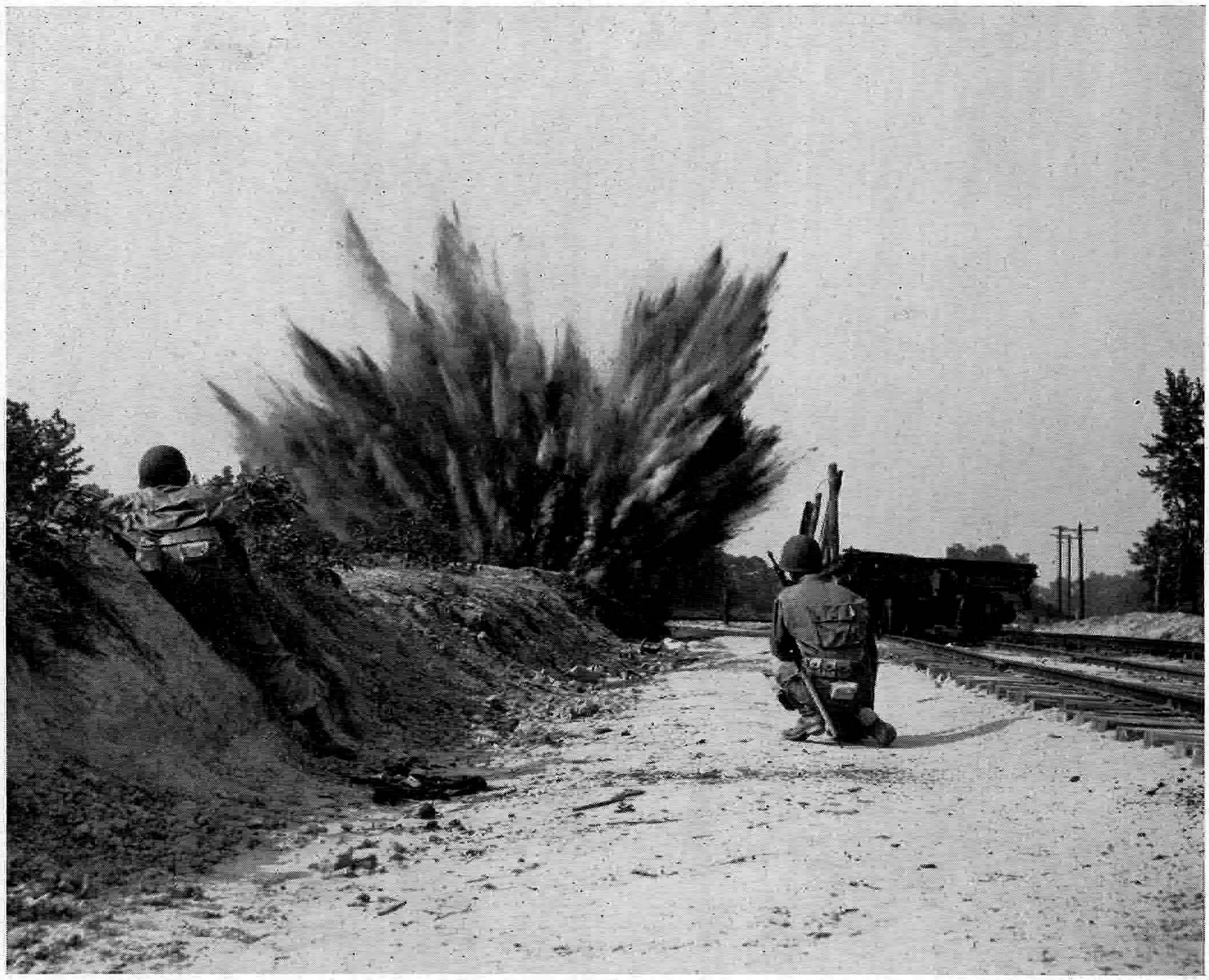


FIG. 7. Glycerine's many uses range from medicines to explosives. Demolition dynamite depends on glycerine; so does the smokeless powder which propels big shells.

to parachutes. In producing all of these things, soap is needed in quantity. Soap scours the raw wool, and a series of baths follows all the way from the carding operations to the finished fabric "fulling" which sizes the cloth with the help of special soap solutions. Cotton, silk, and nylon likewise undergo numerous washing operations on the way to becoming cloth for either war or peacetime needs.

Of course in actual service, all these textiles again meet soap. Cleanliness of clothing is a "must" for civilian and military health. And many fabrics stand longer wear because of periodic washings.

SOAP FOR LEATHER

Soap has a leading role in the leather industry, too. The first step in preparing hides for tanning is the cleansing and soaking. Wetting agents and soap compounds are especially designed for this job so that the hide can be put in a soft flexible condition for removal of hair and tanning.

After the tanning process, it is necessary to lubricate the leather by a "fat-liquor" process. Here special soaps play an important part in giving leather the mellow and pliant qualities so important in good shoes and other leather goods.

Saddle soaps and other lubricating soap solutions are on regular call to keep a wide variety of leather goods, from holsters to factory belting, on the war service list. Periodic washings keep the leather pliant and clean, ready for continued hard wear.

SOAPS FOR COOLANTS AND LUBRICANTS

Soaps and soap solutions have numerous applications as special lubricants and coolants in the metal trades. Modern wire-drawing machines turning out several thousand feet of wire per minute require efficient lubricants at the dies. Soap clings thoroughly and uniformly to the wire surface and can be cleaned off easily after the drawing operation; so it has top-rating for this work.

As hundreds of thousands of automatic machines cut and shape the tools of war, soap solutions are used plentifully in the coolant liquids which lubricate and prevent overheating of the metal being cut or drilled.

Numerous rolling mill operations, notably aluminum, require soap solutions to lubricate exacting jobs. Likewise metal stamping calls for lubricants which wet and cling to the metal surfaces. Soap qualified particularly well to ease the heavy friction of draw-press dies which stamped out, for instance, the millions of cartridge cases needed for victory.

(Continued on Page 14)

Month in Focus

(Continued from Page 3)

to teach techniques rather than fundamental concepts. Some engineering colleges have tried to do this by eliminating shop courses. Such an elimination has not in general proved to be wholly desirable, since it leaves the engineering student without any physical way of securing a feeling for processing operations which are so important in design. The report by Carmichael, however, indicates a unanimous opinion that the engineering college shop course given for the purpose of teaching routine machine operation and skill ". . . has no place in an engineering course." It has been argued that familiarity with processing operations should be derived by the student from industrial experience. This may well be true, but in order that certain academic work may be augmented and made to mean more to the student certain shop operations must be given with emphasis on manufacturing processes. These processes should be closely associated with design and materials. One possibility in shop courses is to shift the burden of this work to the high schools, thus bringing men to the college who have had training in the handling of shop equipment. The engineering college could then carry on from there into those processes which serve to coordinate with design. The difficulty of this procedure lies in the fact that the colleges have no direct control over the high schools. Further thought must be given to this problem.

A further point raised by the Carmichael report deserves mention. This concerns the faculty of engineering colleges. The report states, "Students are not taught by curricula but by men." These men must be forward-thinking, active individuals who maintain adequate contact with industry and research. They must keep abreast of developments and requirements in their field. Industry can assist in making this coordination possible.

This brief discussion is presented in the hope that it will stimulate reflection by engineers, all of whom should be vitally concerned with the preparation of engineers for the future. Now is an excellent time to make improvements, and may we hope that such improvements will be made in the training of young engineers as a result of careful analysis.

Soap in Peace and War

(Continued from Page 4)

SYNTHETIC RUBBER CALLS FOR SOAP

More surprising, perhaps, than many other industrial uses, is soap's important role in the production of synthetic rubber. About one hundred million pounds of soap is going annually into this process. During the polymerization process, soap is added to the butadiene and styrene as an emulsifying agent. For example, it takes about 31 pounds of soap to produce the tires for an Army truck, and 100 pounds of soap for the synthetic rubber in a medium tank.

Later on when the finished rubber is ready for molding into tires or other articles, soap still takes a part, this time as a mold lubricant. It is especially fitted for this job because it does not break down at the high temperatures of the process. So in every new or recapped tire, soap has had a role in one form or another.

GLYCERINE—1001 USES

The story of soap cannot be fully told without devoting a generous share of attention to glycerine. Always important for its manifold uses in industry, food, and medicine, glycerine became a vital product in wartime. As a primary ingredient of war's high explosives, glycerine was on urgent and constant call for dynamite, cordite, and smokeless powder. In addition, it ranges from "useful" to "indispensable" in numerous industrial operations.

It is reported that about 93 per cent of America's glycerine production comes directly from the soapmaking process. Kitchen fat collections from millions of American homes have been spurred by the plea for more and more glycerine from the soap kettles. So it is that soap and glycerine go hand-in-hand as products that are tools for both peace and war.

WHERE DOES GLYCERINE COME FROM?

The chemist classifies glycerine as a "trihydric alcohol," or he will designate it simply as $C_3H_5(OH)_3$. Glycerine is a syrupy, sweetish liquid, 26½ per cent heavier than water and hygroscopic to a high degree.

This product is not derived from soap, but is produced in addition to soap during the soap-making process. During saponification, the fat or oil is split into glycerine and fatty acids; the latter react with sodium hydroxide to make soap. The glycerine is recovered and further processed to remove impurities and prepare a pure and concentrated product.

All fats yield glycerine in the soap process; some almost 15 per cent, but the usual average is about 10 per cent. The glycerine losses in kettle-soap boiling, and in evaporation and distillation processing, may run around 10 per cent. It is interesting to note that continuous soap-making equipment, employing high-temperature, high-pressure fat-splitting, enables recovery of as much as 95 per cent of the glycerine resulting from the reaction.

At the beginning of the war, annual United States glycerine production approximated one-quarter billion pounds.

WAR USES OF GLYCERINE

First and foremost war use of glycerine is in the production of explosives. Treatment of a "dynamite" grade of glycerine with nitric and sulphuric acids produces the potent nitroglycerine for dynamite. Glycerine also is used in the U. S. propellant charges of "smokeless" powder, while the British propellant, cordite, employs nitroglycerine directly in combination with pyrocotton.

But just as surely as glycerine packs the power to kill, it also applies its powers to heal. It is used in many antiseptics, drugs, and surgical dressings. It is a base for healing ointments and jellies, and is used in the miraculous sulfa drugs and numerous pharmaceuticals.

Nearly every one of our war machines carries into battle a double coat of armor. Most important is the thick metal plate that wards off enemy blows. And second is the tough glycerine-base paint that protects the surfaces of tanks, ships, jeeps, and planes from sand, rain, mud, ice, and snow. These alkyd-resin paints are really a liquid plastic, and their tough, flexible finish has made them the number one war paint for thousands of battle tools.

On shipboard, the marine compass moves in a glycerine solution. The recoil of big guns on land and sea, the ground impacts of landing bombers and of jolting trucks—these are cushioned by shock absorbers containing glycerine. The hydraulic liquid for plane-wing deicers likewise calls for a glycerine base.

No wonder America's glycerine-containing kitchen fats were called to war!

GLYCERINE IN INDUSTRY

In versatility, glycerine keeps pace with its companion product, soap. Industry of wide range and variety, for peace and for war, depends on glycerine's important qualities. *X*-ray, V-mail, and movie film, waterproof bonding cements, printing inks, and anti-freeze solutions —all require glycerine in their manufacture. Glycerine's hygroscopic quality makes it an ideal moisture-retaining agent in cigarettes and gives it importance in food processing and preservation.

During the past few years many new applications for glycerine have developed in plastics, cellophane, safety glass and rayon.

SOAP AND THE FUTURE

Americans like to wash. They like themselves, their possessions, and their surroundings to be clean. They like cleanliness in their stores and amusement places, and on their trains, ships, and planes. Therefore, it's easy to prophesy that soap will continue to be used to wash everything that's washable. Soap's unusual applications—from lubricating that sticky drawer in the bureau to performing an important role in synthetic rubber—also are likely to continue to increase.

The Mass Spectrometer

(Continued from Page 12)

were allowed to carry on photosynthesis in ordinary water and heavy oxygen potassium bicarbonate and carbonate.

In these experiments the determination of the excess O^{18} in the water was accomplished by first equillibrating the water with CO_2 and then running the CO_2 through the mass spectrometer. To determine the excess O^{18} in the carbonate ions a precipitate of calcium carbonate was formed and then calcined to liberate CO_2 which was run through the mass spectrometer. The O_2 was run directly through the mass spectrometer.

The results show that when the water contained excess heavy oxygen isotope, the liberated oxygen also contained excess heavy oxygen isotope; but when the carbonates contained the excess heavy oxygen isotope, the liberated oxygen did not contain excess heavy oxygen isotope. The liberated heavy oxygen must, therefore, have come from the water and not from the bicarbonate contained in the water.

CHEMICAL PROCESSES IN METABOLISM

There are many examples in the literature showing the application of the heavy isotope tracer techniques to metabolism studies. The field which seems to be the most fruitful, at this time, is that of intermediary metabolism; that is, the mechanism of the breakdown and synthesis of proteins, fats and carbohydrates and their introconversion, as well as the effects of vitamins and hormones thereon. The usual procedure in this isotope tracer work is to submit a labeled substance to a biological reaction either in an intact animal or in an isolated tissue or extract, and then to isolate the products and determine their heavy isotope content.

Some very interesting articles published by Schoenheimer[3] report the results of experiments in which normal adult rats were fed a labeled amino acid for a period of several days. The amino acid was labeled by synthesizing it with an excess of heavy isotope of nitrogen. At the end of this period the rats were killed and the various parts of the rats analyzed with the aid of a mass spectrometer for the labeled atoms.

There were only two important results. (1) Less than one-third of the nitrogen contained in the amino acids fed the rats was recovered in the excreta, although the total amount of excreted nitrogen was equal to that in the diet. This indicates that the other two-thirds of the labeled nitrogen had been assimilated into the tissues in exchange for normal nitrogen formerly present in the tissues. (2) It was observed that more than half of the nitrogen of the amino acids fed ended up in the body proteins. These two facts showed that the metabolism was much more efficient than previously supposed in incorporating the amino acids fed to the rat into the body protein. In other words, even though the excreted nitrogen was equal to that of the intake, only a small part of this excreted nitrogen passed in effect directly through the rat. Another important conclusion follows from the fact that the nitrogen incorporated in the proteins was

[3]Schoenheimer, R., Ratner, S. and Rittenberg, O., *J. of Bio. Chem.*, *130*, p. 703 (1939).