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OF THE
MANUFACTURE OF EDIBLE PASTES
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ENGINEERING ASPECTS OF THE MANUFACTURE OF EDIBLE PASTES

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Engineering Aspects of the Manufacture of Edible Pastes.

In consequence of the increasing importance of the paste trade in different countries, and the rapid development which has transformed a small home industry into an extensive manufacturing business, it has been found necessary to substitute for the simple kitchen utensils, machines of great size and power.

The impetus of a too rapid growth has sent this industry ahead so fast that we find an important food producing organization somewhat unprepared to cope with its own problems, and sadly lacking a "master mind" to step in and systematize its engineering features.

Macaroni, used as a generic term, includes the many miscellaneous pastes, all made of wheat flour and water, sometimes with additions of other food, flavoring or coloring materials. A somewhat complete
collection of the different forms is illustrated on the following pages.

Macaroni is universally made by mixing various raw materials together with water into a more or less stiff paste and forcing this material through proper form plates by means of mechanical or hydraulic pressure. The first operation will consist, for the manufacture of pure stick macaroni, of mixing together the raw Semolina with an amount of water which usually runs about 25 pounds per 100 pounds of Semolina. The object at this point is not to use as little water as possible or any certain amount of water but to obtain a certain consistency of paste and the amount of water to be incorporated will depend on the type of mixer, length of time of mixing, absorption characteristics of the raw flour or Semolina, the chemical analysis of the water and the temperature of mixing.

In some of the more up-to-date plants
in the United States, a little testing machine, similar to the asphalt tester, is mounted right next to the mixer and the mixing foreman will so adjust matters that his finished mix, when ready to go in the kneaders, will pass a certain specification in this machine. In other words, the flange will drop a certain distance in a unit time. Those factories, and they are by far the larger of the number, which really have no scientific control whatever, are at the mercy of their mixing foreman in the matter and these men will be found to be about as highly paid as any in the whole plant. Sometimes he draws as much money as the plant superintendent. The general characteristics of the finished product depend almost entirely on the accuracy of the mixing and with some raw materials the quality and physical appearance of the finished product can be varied within wide limits by slight variations at this point.
European Type of Macaroni Mixer
These mixers are special machines, similar in all respects to a standard bread dough mixer, except for the arms. On account of the extreme stiffness of macaroni doughs it is necessary to use special design at this point.

Foreign practice tends towards the use of short spade-like projections from a central shaft. There is no mechanical assist for sidewise motion.

American practice uses two circles, hung across the central shaft at 45° angle, and cut away so as to leave opposite halves projecting somewhat resembling horns. These horns act as spades and their angularity gives the entire mass a decided lateral motion. Usually there are two shafts and four cutaway circles, the pitch of the circles being in opposite directions.

The mass from the mixers is more or less granular but is in such a condition that a very slight pressure will cause it to agglomerate. Some plants, notably those
American Type of Macaroni MIXER
in Eastern Canada, feed this material directly to the press cylinders, but their product is inclined to be streaky and the cause for this is simply insufficient kneading. There will be dry and wet particles which the mixer arms have not succeeded in bringing into close contact. In order to overcome this difficulty a special type of kneader is used. It consists of a cast metal pan about 10 inches or 1 foot deep, circular in shape, mounted on a central shaft which is driven through gears. Suspended in this pan are conical grooved rollers which are placed in such a way that the bottom face of the conical roller is parallel to the bottom of the pan and about 3 inches above it, for an ordinary type machine.

The wet paste is shoveled into these kneaders until a sufficient amount is present to form a continuous ring around the periphery of the pan. Just ahead of
Standard Kneader

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one of these conical rollers is set a plough which is for the purpose of turning over the ring of dough in such a way that it is upended before it enters beneath the rollers. These machines are built exceptionally heavy and the drive is positive and they are very efficient machines from the standpoint of production of a homogeneous mass. When a sufficient period has elapsed, in the judgment of the operator, the machine is stopped and the dough is cut out into pieces of such a size as to permit of convenient handling.

These pieces are treated very differently in different plants. In all cases, they are loaded more or less directly into the press cylinders and pressed through dies into the different forms of goods. Some plants insert these chunks of dough directly from the kneaders into the presses and bring down the ram onto the goods until it just starts to emerge from the die. Then the ram is reversed and as many more pieces as is possible are placed
Dough Break

Used in preparing press cylinder cartridges or for rolling out dough from noodle machines.
in the cylinders in order to fill them up. This process causes a considerable waste of time and seriously effects the daily output per press. In order to overcome this difficulty a considerable number of manufacturers take the kneaded mass from the kneaders and roll it out in machines called dough-breaks into long ribbon like forms which are rolled up just as paper would be rolled. This process enables the maximum amount of dough to be gotten into the minimum amount of space and at the same time permits the production of a loading cartridge for the press which is practically identical in shape with the inside of the press cylinders. There are several very serious objections to the method in spite of its obvious advantages.

Unless this operation is carried out in a room which is practically saturated with moisture the great amount of surface exposed during the rolling process causes
the dough to dry out and alter in consistency. Furthermore, it is almost impossible to prevent the formation of a skin and this skin seriously interferes with the proper flow of the mass when under pressure. It would seem as though to-day the more advanced of the American manufacturers use the first of the two methods described and even claim that the added expense of machinery and increased cost of labor of the second method is not warrented by the increased production per press which can be obtained.

The presses used for these processes are of one of two types, the hydraulic press and the mechanical screw press. Either of these types may be horizontal or vertical, the general method of use is that for long goods the vertical press will be used and for short goods the horizontal press will be used, although this is by no means essential.

In construction these presses vary widely.
Vertical Swinging Double Cylinder Hydraulic Press

Direct Connected Hydraulic Pump
One of the largest factories in the country, who have, in fact, the most powerful presses in the United States which are being used for this purpose, have their machinery built to order in such a way that it contains no part which can possibly be dispensed with. It is found in this factory that the up-keep of these presses is remarkably low and, furthermore, that the performance is remarkably good. These presses, in fact, consist of a cylinder for the dough, a cylinder for the liquid under pressure, pillars to take up the strain, a die, a ram and two hydraulic packings. Of course there is the necessary piping and hydraulic valves to control the flow of the power. These presses are capable of developing a working pressure of 1,500,000 pounds and give no trouble whatever. As against this, the writer has seen in a rival concern presses with every possible appendage for supposedly safe and convenient operation.
These presses are obtainable in the United States only through one engineering firm but are of the type generally used throughout Europe. They are extremely large, running as high as 27 feet in total height for a 5 ton press (capacity per day) and requiring operation by two crews of men, one on the loading level and one at the discharge level. They are equipped with every possible device for supposedly automatic operation and really do operate satisfactorily under careful hands but do not seem to stand the strain. The writer understands from reliable authority from this plant that the breakdowns per unit period of such a press and the difficulty of obtaining repair parts and their actual inability to come up to the producing power of the more simple types has put them into disfavor.

The mechanical screw presses used in this industry are extremely simple and consist merely of a revolving square threaded
Vertical Swinging Cylinder

Screw Press

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screw with a running nut the front of which forms the ram. The machines are belt driven and a system of reducing gears is employed. The reaction pressure on this type cannot, of course, be taken up by any pressure liquid as in the case with the hydraulic ram and must be taken up by a thrust collar. The standard type of thrust bearing is absolutely useless under these conditions on account of the enormous reaction pressure dealt with.

The largest screw press the writer has ever seen had a 14 inch ram and the pressure developed was 3700 pounds per square inch. This figures out over 500,000 pounds total pressure on the thrust bearing and no thrust bearing has ever stood the strain. The common construction at this point is to use a fibre ring which is run dry and, strange to say, these rings will last for months under these conditions, whereas if a lubricant other than graphite is used the ring will sooner or later split, throwing the entire machine out of
commission, as when this happens the sudden release of the pressure usually strains the frame of the machine. The only argument in favor of these machines is their low cost. A screw press, for instance, of two ton capacity will cost about one-fifth to one-eighth what a hydraulic press of the same capacity will cost and I have been in plants of national prominence which do not contain a single hydraulic piece of apparatus.

The disadvantages from a sanitary and mechanical standpoint are considerable. On account of the necessary exposed condition of the screw and gears, there is considerable liability of contamination of goods with grease and the operators hands are usually greasy. Mechanically the machines on the American market have weak frames and give considerable trouble in the drive between the gear on the main pressure shaft and the pinion on the intermediate shaft. No matter how large a factor of safety is allowed at
Ferati (top) and Macaroni (bottom) shapes

Dies above

12-a
this point, these gears are sure to wear excessively.

The pressed goods are given their special shapes by their passage through specially formed holes in the bed plates of the press cylinders. The variety of these shapes is enormous and a few of the more particular ones are illustrated here-with.

For the purposes of discussion there exist but three elementary shapes, the hollow cylinder as examplified in macaroni, the solid cylinder as in spaghetti and the band as in noodles. These goods are handled after the pressing operation according to methods which are more or less distinct according to the shape of the product. The process is to dry the goods to such a stage as to make them capable of handling without breakage and of indefinite preservation. This is accomplished in a variety of ways and it is impossible to use a method which
Vermicelli, Spaghetti, and Press Noodle Shapes

Dies above
will successfully dry macaroni on spaghetti, neither will the usual method of drying either of these successfully dry noodles.

Macaroni is commonly cut wet into the proper lengths and then dried in special machines. This process facilitates the handling of the dry material as we are dealing with a more or less uniform article which will permit the use of automatic machinery. Furthermore, for some reason or other macaroni will permit of more ready drying than will the spaghetti. This latter, if an attempt is made to cut it into saleable lengths before drying, will curl during the drying process into a badly tangled mass. Noodles permit of the roughest treatment of any and can be dried by special machinery in as short a time as one-half hour without causing damage. It might be stated at this point that by the damage spoken of is meant cracking of the goods tending to cause it to crumble in the package, on one hand; and the carmelization
Dies for Soup Specialties
and Elbow Macaroni

14-a
of the goods due to excessive heating on the other hand. The object of the drier is to put the macaroni into saleable form as quickly as possible with the least harmful results. There is another danger to be guarded against in the drying of these goods. It will be noted that the principle raw material used, Durum Semolina, is a product which contains a considerable proportion of the germ of the berry. These carry with them a considerable number of enzymes and it would be impossible to let dough made from such material stand very long without inducing enzymatic changes to say nothing whatever of spontaneous fermentation. To get an idea of how rapid these changes can take place under proper conditions, the writer has in mind a breakdown in one plant which occurred at a moment when several of the spaghetti presses had only driven half of their charge out through the dies. The breakdown was complete and there was no means at hand for reversing the presses and emptying the dough cylinders.
Italian Macaroni Shapes

Usually cut short for
Soup Specialties
Approximately one hour and forty minutes later the pressure in the cylinders due to fermentative gases had become so strong that the hydraulic power was itself reversed and the rams pushed out of the top of the presses. This, of course, renders the dough sour and incapable of being dried into finished marketable product. Furthermore, it does not seem possible, under ordinary factory conditions or even special factory conditions, to eliminate the possibility of contamination by wild yeasts. It would really be necessary to sterilize the raw materials as it is from these sources that most of them enter the dough and sterilization at this point is commercially impracticable.

A macaroni factory under normal operations is not bothered by fermentation changes such as stated above but does depend almost entirely for the flavor of its goods upon the fermentation which takes place during the drying operation. Strange to say, in
spite of the important effect on the flavor and quality of the finished product, the writer knows of no macaroni factory in the world which has given special attention, even from the standpoint of an investigation, to these particular fermentative changes. The only clue at hand to the possible nature is based on a remark made by Professor Bolley, Agronomist of North Dakota, that the fermentation seemed to be one of malic acid. It would seem that it would be a paying proposition for the large manufacturers to develop pure cultures of the particular organism found most beneficial and deliberately inoculate their doughs with this organism.

The changes which are controlled in a large plant are the enzymatic changes. There are two types of enzymes which are particularly detrimental to the quality of the finished product. These are the proteolytic and diastatic enzymes, both of which are present in considerable amounts and have opportunities
for action presented them during the drying process which are almost ideal. The raw flours used in this industry are, or rather should be, those with the very highest percent of gluten obtainable and the lowest percentage of water soluble carbohydrates. One of the fundamental requisits of a perfect edible paste is that it shall stand long boiling in water without either losing its shape or disintegrating. The proteolytic enzymes have the property of softening down the gluten and the diastatic enzymes have the property of rendering more soluble the less soluble of the carbohydrates. The optimum temperature of action of these enzymes is from 104°F. to 145°F. and the temperature of edible paste in the drying rooms is within this range of temperature over periods of several hours.

The writer has known of a flour which would give almost 50% of wet gluten before being made into macaroni which refused to give any trace of gluten whatever after the
finished macaroni was ground back into flour. In any case the diminution of gluten is seldom less than 30%. Similarly the raw materials run into the mixers total seldom more than 1.5% of reducing sugars and the finished macaroni about 3.75%.

Another serious effect of the drying process is the carmelization due to excessive heating which is rather a dextrinization of the starch and the particular dextrines formed possess considerable of a burn sugar taste. This, of course, can be avoided and is due to carelessness.

Drying of Macaroni

Macaroni, whether cut into standard lengths at the press or dried in long lengths and then cut, is, in all except the smaller factories, machine dried. These machines vary considerably in operation but are identical in principle. They consist in the forcing of air through and around the macaroni, so tempering the air as to humidity and
Modern Quick Drying Apparatus
for Uncut Long Pastes (right)
and Cut Long Pastes (left)
German Type of Kneader in Background
temperature that the goods are dried in from 16 to 30 hours. Extreme care and skill are needed at this point and what appears sometimes to be a correctly dried batch as long as it remains in the drier when taken out into the open rooms will be spoiled entirely on account of what is called checking. The macaroni will split longitudinally into halves. This phenomenon is usually caused by too low humidity during the last few hours of drying or, what amounts to the same thing, too high temperature. A strain is produced which causes the stick to split when it attempts to readjust itself to ordinary atmospheric conditions. Some factories succeed in drying their macaroni perfectly in as short a time as 14 or 15 hours. This is based on the American principle of mixes running from 30 to 34% water and drying to finished product running from 9 to 12.5%. Other factories using the same machines take a longer period running from 18 to 24 hours and claim to put
Modern Quick Drying Apparatus
for Short Pastes

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out a higher grade product on account of the gentler treatment. This is not at all the case as we have in mind two plants, both nationally known, one drying in about 14 hours and the other in about 22 hours and the former goods being undoubtedly the better. By far the largest number of the American plants dry their macaroni by simply hanging the wet goods over sticks and allowing these frames to hang in a suitable space until dry, but it must be remembered that this large number of the American manufacturers consist almost entirely of the smaller plants operated by Italians who do not seem to be willing to adapt themselves, either in their native country or in America, to machine methods. The writer even has in mind one of the largest of the American plants who widely advertise the cleanness of their product who have a French superintendent and an Italian crew and dry their goods by this old fashioned more or less unsanitary
Spaghetti has not been dried successfully in machines by anyone on account of the fact that it consists of a solid cylinder. The removal of the moisture from the center portion of the stick is a matter difficult to accomplish rapidly without checking the goods. The reason for this is that a rapid process of drying will tend to put a skin on the outside of the goods and produce a cylinder of dry crust enclosing a core of wet dough. If the rate of drying is kept up the dry crust will shrink so fast that it will crack into pieces. In order to eliminate this difficulty spaghetti is dried in a slowly moving current of air which is even more accurately controlled as to humidity and temperature than the air used in drying of macaroni. The regulation is such that the outside of the cylinder is quite thoroughly dried and then the humidity is raised almost to the saturation point. This causes the spaghetti to "sweat" which means that the
the distribution of the moisture within the stick is given a chance to equalize. At the same time, naturally, the average moisture percent is decreased. The humidity of the drying air will now be lowered again and another skin formed on the outside of the spaghetti and the cycle will be repeated a sufficient number of times to produce dry goods with the desired percentage of water. It will readily be noticed that this is a slow process and that the fermentation and enzymatic changes in spaghetti will be much greater than in macaroni.

It is the writer’s belief that the more or less universally acknowledged preference of some people for spaghetti over macaroni and vice-versa is due to these little understood changes rather than to any mechanical condition. It would be difficult to imagine the variation in palatability as being due to difference in shape.

On account of the impossibility of
drying spaghetti in machines of the macaroni type it is a universal custom to cut the spaghetti into saleable lengths after drying. This is done by sawing on an ordinary cross-cut saw and a convenient bunch of dry spaghetti in long lengths will be handled either by hand or by machinery in exactly the same way as lumber is handled in the lumber mills.

There is, however, an interesting note to be made at this point. A vast amount of crooks will be formed from the short pieces which are sawed off of the spaghetti at the end at which it hung over the sticks during the drying process. It is necessary to eliminate these crooks for the high class trade as they are usually somewhat misshapen and on account of being the point most handled, sometimes do not appear perfectly clean. Formerly it used to be customary to grind these crooks into meal and run this meal back into the mixers in amounts small enough to prevent any danger of disagreeable effects. This is an expensive and dangerous
process and someone someday conceived the idea of putting these crooks into packages and selling them as a soup specialty. To-day the demand for these crooks has become so great, at least in the United States, that no manufacturer small or great is without special machines for deliberately making these very crooks. As a matter of fact, the development of this elbow macaroni manufacture has reached a greater perfection than any other one product of these factories. The machines are of the highest class, the sanitary conditions are of the best and the devices for handling, drying and packing this particular product are the most highly developed of any. This is largely due, of course, to the convenient shape and the adaptability of handling of the product. Elbow macaroni cannot be dried as fast as ordinary straight macaroni. This most probably is due to the fact that these special machines for the manufacture of this product depend for their successful operation on the production
Horizontal Swinging Double Cylinder Hydraulic Press
Separate Pressure Pump

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of a stick the wall of one half of which is thinner than the other half. This causes the stick to curl as it leaves the die and a circulating knife is employed to cut it into suitable lengths. This very uneveness, however, of thickness of wall does not permit of rapid drying on account of the obvious difference of time required to dry the thick wall and the thin wall under the same drying conditions.

Noodles, whether made from water dough or egg dough, on account of the fact that they consist of a very thin band, are best adapted for rapid drying. An ordinary belt driver will decrease the moisture by twenty actual percent in less than one half hour under proper humidity conditions without any bad effect whatever on the product. On account of this remarkable ease in drying noodles, very little attention is paid to them. The product of the noodle machines is usually simply placed on trays, these trays placed
Horizontal Simple Elbow Press

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on racks and the racks shoved in a corner until the load is dry. No trouble is experienced in drying goods in this way over night or at the longest in 18 hours providing the air in the room is kept in gentle motion. The standard method of accomplishing this is by the use of ceiling fans. There does not appear to be the slightest occurrence of trouble even in the worst of the muggy days of late summer and early fall.

All of the goods, when once dry with the exception of elbows, are taken to the packing room either on belt conveyors or by truck. When the goods have been dried in a machine the entire interior of the machine is usually a large truck and this will be simply removed, taken to the packing room and a fresh truck of green goods inserted into the machine. Elbows are usually manufactured on one floor and blown to an upper floor by means of a cyclone fan. A continuous drying machine is installed on this
upper floor and the discharge end feeds a hopper in the packing room through a chute. Noodles are handled with shovels and spaghetti by means of conveyors. The packing machines, where such are used, are simply sealing machines. The writer knows of no successful automatic packing machine for edible paste in existence with the exception of elbows and soup specialties.

The actual packing consists in placing in the machine the amount of goods which has been weighed by hand by the operator. The machine simply forms the package, seals the bottom, lines it with waxed paper, delivers the package to the operator, takes the package from the weighing tables, seals the tops and delivers them to the boys who put them in cases. These machines, in as far as their sealing ability is concerned, are extremely efficient but even with the elbows there is no successful automatic packer on the market. This, in spite of the insistent demand for
such a machine by all the large manufacturers. A crew of six operators can readily turn out thirty finished packages per minute.

The most interesting of the machines about a macaroni factory are the hydraulic presses. Foreign tendency is towards the use of presses of majestic size, equipped with elaborate safety devices, and usually directly connected to pumps located immediately behind the press. The impressive build of these machines is well illustrated in the photograph of the two large presses, taken in a Swiss factory. Incidentally, the trade name of these particular presses is "Mammut" which is suggestive.

American practice in general tends towards simpler construction. Furthermore, the pumps are usually located in another room and kept running constantly. Anytime the press is idle, the liquid simply circulates.
Modern Hydraulic Press

Installation

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One of the most discussed engineering features around a plant using hydraulic machinery is the question of whether water or oil is the best power medium. There are large plants in the country operating on water and equally large plants operating on oil. Each have attempted to change to the other medium and each has returned to the original liquid, the reason given by both being that when the change was made it was found that the other liquid severely cut the faces of the hydraulic valves. From the writer's experience it has been found that starting with a perfectly clean system either liquid was used as satisfactorily as the other but that when a system has been running on oil, for instance, an attempt is made at the time of change to clean out the system by using sal soda dissolved in the water in order to clean out the traces of grease. This sal soda seems to be the real cause of the cutting of the valves and if
the engineer would only get his system once cleaned out thoroughly and then swing over to clean water the valves would be all right. In case the change is made from water to oil an emulsion is formed and this emulsion cuts very seriously into the valve faces. The result of this is that when a system attempts to change trouble is experienced but when starting up a system there is little or no preference either way. Water, of course, is the most desirable on account of the cheapness and supply.

There is one feature about the use of water in hydraulic machinery which does not come into consideration when oil is used. Water carries with it a considerable amount of dissolved air and this air, when the water is put under pressure, is forced out. If this partition of dissolved air happens to occur at a point where the air can get into the low pressure return and eventually escape no harm will result. But if one of the high pressure cylinder heads happens to be a high point in
the system an element of extreme danger is encountered. The resiliency of the entrapped air under high pressure is far greater than that of the oil and any weakness in the cylinder bolts promptly causes disaster. The writer has seen a cylinder head 26 inches in diameter, probably weighing about 350 pounds, go through two solid factory floors and land on the third floor above. The accident was caused by air entrapped in this manner. Had oil been the medium used this probably would never have happened, inasmuch as failure of cylinder head bolts under such conditions would have relieved the pressure in the fluid before the head would have had time to move any considerable distance. Otherwise than due to these reasons hydraulic machinery is by far the safer than mechanical apparatus for producing pressure. Usually it is built much more sturdily and is capable of such immediate control that serious accidents can almost always be prevented.
Mechanical machinery usually has a train of reducing gears which are working at such a high pressure that frequent lubrication is essential. Obviously there is considerable danger under such conditions as in spite of factory and other regulations the operator will insist on attempting lubrication while the gears are moving. With hydraulic machines there are really no moving parts other than the ram and this can hardly be considered a moving part in view of the slowness of its travel. On account of the fact that a hydraulic press is pre-eminently a slow moving machine the custom has been to feed a high pressure fluid and a low pressure fluid from separate pumps to the same cylinder and to use the high pressure fluid when the ram is doing useful work and to use the low pressure fluid to move the ram into and out of working position.

The pressures mainly employed in the
macaroni industry for this purpose are about 500 pounds per square inch on the low pressure side and all the way from 3500 to 8000 pounds per square inch on the high pressure side, depending on the press, the type of goods and the nature of the die. The control valves on these two systems feed into the main pressure pipe running into the cylinder but otherwise the two are totally separate. It is possible, however, to have two incoming pressure valves open at the same time as they are manually operated. This causes the wrecking of the low pressure pump unless it is especially built to stand a high pressure. Frequently when such a thing happens the sudden inrush of high pressure fluid into the low pressure lines causes every right angle joint to yield.

Another way of getting around the time lost by the slow return of the ram is to have two dough cylinders on the press and to load the second cylinder while the first cylinder is being run out. These cylinders are hung
on pivoted bearings. Then as soon as the ram has been withdrawn the cylinder is swung around into position and the ram immediately started down again. This saving of time of loading does not, of course, save that which would be saved by having a quick return system but it overcomes the danger of having two lines running to the same cylinder carrying widely different pressures. It introduces a danger which is almost worse than the danger in the other system. A locking device is provided which is supposed to retain the dough cylinders in the proper position to prevent any interference with the ram. Frequently a careless operator on swinging his dough cylinders into place will do this so quickly and violently that the cylinder will rebound sufficiently to throw the outer edge of the counter-bore out of line with the outer edge of the ram. If the pressure is applied under these conditions the result will be an enormous bending moment on one of the pillars.
The press will promptly attempt to double over and, of course, will be put out of commission. There is no immediate danger to the operator from such an occurrence inasmuch as the bending of the press will promptly be noticed and it takes but a twist of the hand to shut off the power. The bursting of the pressure lines, of course, will flood the operator with warm oil but this is, beyond being disagreeable, not at all dangerous. For a period of several years during which the writer witnessed at least one injury per type of machine used in a large factory the only exception to this statement were the many hydraulic presses, which speaks well for their superiority over the mechanical type.

It is necessary, in order to avoid serious shocks in the hydraulic system, to use machines called accumulators. Such a device consists merely of a cylinder which contains a weighted ram. The weight of
the ram is such that the pressure necessary to support it in equilibrium will be that pressure at which it is desired to run the press. The pressure pumps instead of being at the speed at which it is desired to run the main press ram will be run at a higher speed and the excess liquid will go into the accumulators to be there as a reserve volume when the occasion occurs in which it is desired to move the ram more quickly than usual. It is very obvious that a considerable loss in efficiency occurs in this system on account of the fact that we are producing a high pressure and then releasing this pressure without doing any useful work. The system, however, does save time in that the accumulator will permit the ram to move quickly when this is desired. These accumulators have relief valves discharging back into the supply tanks of the main pressure pumps. These release valves are actuated by mechanical connections between the top of the ram and the valve in
such a way that when the ram has reached a certain height the release valve is opened and any excess liquid is pumped back into the storage tank. Any stopping of this valve or any interference with the action of the connecting link will close the return system and cause the ram to be pushed out of the top of the cylinder. When it is realized that this weight on the high pressure system amounts to as much as 100 tons in extreme cases, the damage which may result from such occurrence is obvious. On account of this possibility it is the custom to sink accumulators into pits and guard these with railings at a sufficient distance to prevent any injury to the observer. The writer has witnessed such an accident with a dozen men in the immediate neighborhood. None were injured although some received a very liberal bath of oil.
Building Construction.

In discussing the type of building to be used for the macaroni plant it is necessary to view the subject from two standpoints, the type as in use and the ideal type.

The type of building in use for the manufacture of macaroni in Europe is usually a multi-story affair. Reinforced concrete is the usual building material and corners are cast round in accordance with modern sanitary principles.

In Italy most of the macaroni factories are housed in more or less ancient brick structures. There is little or no provision for machine drying and a large number of frames will be erected either in the back yard or up on the roof. With the exception of the housing for the presses it can hardly be said that such a thing as special construction exists and the sanitary considerations are rather undesirable from the American standpoint. It is common practice to allow
Italian Methods of Spaghetti Manufacture
spaghetti, for instance, to run directly from the press onto the floor until a sufficient amount has collected when it will be taken up and placed on sticks to be hung out in the open air to be dried. It is a very peculiar psychological point that our highly educated American housewives will frequently prefer this imported Italian macaroni to the product made in a specially designed and highly sanitary American factory. Germany has developed this industry largely from the standpoint of egg noodles and soup specialties, and the factories conform to modern ideas of sanitation. In the United States by far the greater portion of the output of the macaroni factories is macaroni and spaghetti. These are what are known in the trade as long goods and are not adapted to being transferred from one floor to another by means of the cyclone blowing system. Soup specialties, alphabets and even heavier pastes of the class of elbows can be blown through a vertical pipe with a
sufficiently strong current of air and not suffer from the process.

This, of course, is impossible with long goods and it is on account of the predominence of the latter in American trade that the more recently built of the American factories will be found to be one story plants. The building will be of concrete construction throughout and consist of three wings joined together in the form of a T. The press room will be located in the short arm of the T and the ceiling will be of sufficient height to accommodate the highest press in use. Frequently this particular part of the building will be twice the height of the other part. The goods going from the press room will be divided according to nature into two divisions. One division consists of short goods and anything which will permit of machine drying; the other division consists of those goods which must be dried by the
air curing process. The goods to be machine dried will be dried in one end of the long section of the building; the goods to be air dried will be dried in the other end of the building and the two streams will then meet to be packed and shipped in the centre of the building, the shipping platform being the long way of the long part of the T. This type of construction permits of the minimum amount of handling of the goods, requires no elevator service whatever and with concrete construction using rounded corners, permits of the premises being kept in irreproachable sanitary condition.

There are in the United States, however, thoroughly modern plants of larger capacity built on the European system and these plants are usually reinforced concrete, multi-story structures, with the presses and machinery in the basement and the drying machinery, which is not very heavy, and air curing rooms on the upstairs floors. The system necessitates
truck and hardly seems to the writer to be an efficient layout, everything considered. Some owners regard a large city as a better place for the making of this class of goods than a country location and the city conditions will not allow of using as much ground space as a one floor factory will demand.

Great care must be exercised in the use of paints about these plants. An exceptionally high humidity prevails in the manufacturing rooms and will promptly start mold in any paints containing animal matter. Cold water paints containing casein must be particularly guarded against.

In the drying rooms the wet goods, during the sweating period, cover the walls and ceiling with moisture, which collects and drips back onto the pastes. Any lead or zinc paint is out of the question and a soluble paint impossible. Some plants do not paint these rooms, others use concrete throughout and the more progressive cover
all wood and metal with a white enamel. The most successful, in the writer's experience, was a phenol condensation product.

Power Plant Requisites.

The ever present question of power is answered by the macaroni manufacturer in one of two ways. He either makes his power or buys it. A power plant usually consists in a series of high pressure hydraulic pumps driven by the antiquated steam engine and these plants are rapidly yielding to the electric company who are very energetic in installing electric drives throughout the factories. There are really only two vital points in the macaroni manufacture which require power. The production of the liquid pressure for the hydraulic rams and the moving of the mixing and kneading machinery. The use of steam will necessitate the transmission of power by means of belts and in a factory consisting of more than one floor this means overhead shafting and overhead
shafting means grease and dirt. Therefore, at the start such a system is not desirable. In a plant laid out all on one level the shafting can all be located in the basement and a very clean layout obtained, but the large number of shafts and belts, the high speed of operation of some of the machinery and the frequent necessity of reversal all introduce conditions which tend to bring the cost per H. P. year to a rather high figure.

In fact, the writer has had the personal experience of transferring a plant from its own steam power to individual electric drive and to all appearances the transfer is going to be one of great profit to the company. Individual motor drive eliminates entirely the difficulty of countershafts and all incidental apparatus and at the same time gives full and instant control over all machines. The large number of motors used permits of the size being standardized to two or three sizes of motors and a very few
extra parts carried in stock will nicely anticipate any ordinary breakdown in the power.

In addition, the proper placing of switches which control the power circuits makes it possible to save a man by the quick stop permitted where with a prime mover running the plant a man might be seriously injured by the time the engine was shut down.

Flour Storage Methods

On account of the nature of the Semolina, which is or rather should be used as a raw material for all macaroni products, it is not possible to store it for any considerable length of time. The large amount of fat present will rapidly deteriorate and cause the flour to become rancid. Furthermore, enzymatic changes take place with great rapidity and tend toward the deterioration of the gluten and the saccharification of the starch, both of which are very undesirable. Usually an attempt will be made to store about fifteen
days supply and this must be done in a room with a sufficient foundation to stand the load. It is customary to pile these sacks eight high which means an actual floor load in excess of 250 pounds per square foot and great care must be taken that not only the floor is capable of standing this great weight but that the foundation of the building is sufficiently strong. In several cases failures of foundations have been witnessed where the room of the building was amply strong to carry the load.

In any place where flour is stored the temperature should not rise very much above 60°F. If it does there will be undue developments of insect growth such as Mediterranean Moth and flour weevils. If the flour stock is changed rapidly enough there will be no appreciable trouble due to such pests but if they once get started vigorous fumigation is necessary or the factory will be overrun. In the long run fumigation with
hydrocyanic acid gas seems to be the only sure remedy. Carbon bisulphide is equally certain but is also equally certain to produce a fire which danger is absent with the former fumigant. It is possible to kill animal pests by freezing the entire factory but this is out of the question with a macaroni factory which operates year in and year out, in spite of the fact that the method is in successful use with small and medium sized flour mills in the northwest.

As a precautionary measure it has been my custom every time the flour stock ran low to liberally sprinkle the floor of the flour room with a 40% Formaldehyde solution. This solution would come into contact with any insects in the floor and kill their eggs and the fumes would be strong enough in the cracks of the room to get any insects existing in the walls or on the outside of the bags. It is more or less impossible to eliminate these pests when they once have penetrated into the interior of the sacks but when this happens the extent of the contamination
is usually such as to make the flour unfit for use as food and it becomes more a question of disposal than elimination.

Raw Material

The raw materials used in the macaroni industry are very few in number. In the actual manufacture of macaroni it is almost universal to use what is known as Durum Semolina and water for the manufacture of the plain pastes and Durum Semolina, water and eggs for the manufacture of the more elaborate pastes. Sometimes for special goods an edible oil, seasoning material and salt may be added. This oil may be olive or peanut oil which is otherwise known as Arachis. The seasoning materials may be garlic or a similar article and the salt used is ordinary common salt. Sugar enters the product sometimes in an indirect manner with the eggs. Contaminations during the manufacture are practically nil in the up-to-date plant as the product is handled in the most perfect
manner from a sanitary viewpoint.

Adulteration is almost entirely in two directions, the substitution of other flour for the Durum Semolina or the use of spoiled raw materials. Durum Semolina is a special product of special mills. The demand in this country has come to a point where large independent organizations have been established for the production of this one article. The nearest standard article on the market to-day to which it can be compared is middlings. Nevertheless, it is produced in a distinctly different manner. The fundamental idea of the production of middlings is that these middlings will be manufactured into flour and that any brany or germ particles adhering will be eliminated in the further passage through the mill. Durum Semolina requires to be produced in the first place with practically no bran and little germ as it is used in a granular condition and is supposed to consist only of granular particles of the endosperm of Durum wheat. Two strains
are used in this industry, a type known as Arnautka and one known as Kubanka. These are both Durum and some prefer one and some the other. They have distinctly different properties.

The Kubanka is a large, more or less translucent straw colored kernel with a very deep crease, with chemical and physical constants similar to spring wheat. The Arnautka is almost as large but is very dark in color, contains an enormous percentage of gluten, almost as much protein as meat and a very high milling value. The actual percentage of bran is about two thirds as much as with the other variety. The macaroni made from the Arnautka variety will be so translucent as to show the shape when looked through at dark objects and will have a beautiful amber color. The macaroni made from Kubanka has a tendency to be less translucent and more white in color. The type of macaroni which a plant wishes to
produce depends largely on the wishes of the consumer and this feature must be taken into account when buying raw materials.

In the United States in the central and south central portions a smooth translucent yellow macaroni is demanded. On the Atlantic and Pacific coasts, however, the public has been educated to a rather white, softer product. The ethics of this condition is poor inasmuch as the latter is the poorer product. In times of high prices of Durum Semolina and short crops, hard wheat flour is frequently blended in in considerable amounts. It is possible to blend in hard wheat flour to the extent of 50% and make a desirable macaroni and it is possible to make macaroni out of any flour. However, the danger in using those not suitable is the production of a macaroni which softens in cooking.

Frequently a substitution for Semolina which is not of so detrimental a nature is
the use of lower grades of Durum flours which are produced in the same mills as the Durum Semolina as by-products. Chiefly for purposes of selling, these flours are given such names as Macaroni Flour, Fancy Durum Flour, etc. whereas they are really low grade products which the mills find it impossible to dispose of to anyone except at a discount.

Water

The water for use in macaroni must be watched more carefully than would be supposed on the surface. The essential points are to make sure that the water is sanitary, that it is not too soft and that it does not contain a considerable amount of bacteria or yeasts which might cause undue fermentation. Inasmuch as the water is entering a mixture which is to be sold as a food it should be of a nature which would not prohibit its use as drinking water. Disease organisms should, of course, be totally absent. Contrary to the
usual idea of the layman, macaroni as sold is raw, not cooked, hence there is no sterilization during the process. With soft water there is a tendency to produce a very sticky dough with the Durum wheat flours inasmuch as the gluten is not fully developed. A very hard water is the most desirable.

The introduction of yeasts or organisms which might cause fermentation, from any source, is to be carefully guarded against and the biological examination of water in that direction should be very thorough. Needless to say, deep well water is the best all around water which fits into these conditions. It is always sanitary, usually distinctly hard and unless contaminated at the mouth of the well never contains any organisms which cause fermentation.

Oils

The oils which enter into the composition of macaroni are of two kinds, oils added intentionally for purposes of flavoring
and oils added incidental to the process of manufacture. The first should of course be edible and beyond this there is little to be said in the way of qualifications. The oils which get into macaroni incidentally are the lubricating oils used on hydraulic presses. Some companies use an edible vegetable oil for this purpose but find objections from two standpoints. The cost is high and there is a tendency of such oils to become rancid when purchased in large quantities and used in small amounts. The writer has seen cottonseed oil used for this purpose which had become so rancid that it possessed no lubricating value whatever. In fact, if left in contact with metal over night would cause serious corrosion and rust.

In order to overcome this difficulty a mineral oil is frequently used and the writer knows of none better in this connection than the more highly refined of the petroleum oils. For a period of some years one plant has been
using with entire satisfaction the same oil sold them as a lubricant which the oil company was selling throughout the country for medicinal purposes. Ethically and practically this latter is the solution of the problem. 

Eggs

Eggs get into macaroni for flavoring purposes to produce a palatable and valuable food product and to place on the market a product of higher quality than plain macaroni. It is impossible for the macaroni manufacturer to buy eggs in the shell and break them for his own use. This would entail the maintaining of an egg breaking room, a refrigerator, a cooler, the necessary cold storage facilities and a considerable difficulty in disposing of such eggs as were found unfit for use. Furthermore, and the main difficulty, consists in the distance of at least some of the factories from egg centers. It is far cheaper to ship broken eggs than it is to ship shell eggs not only on account of the saving
in space but on account of the serious breakage which occurs in shipments of shell eggs. These conditions have produced industries which sell to food factories throughout the country eggs in either frozen or desiccated condition. These eggs products are obtained by sorting out from shell eggs by the candling process those eggs which are undamaged by mold or other unhealthy developments. These eggs are then broken into cans and subjected to one or two preserving processes. The cans are either frozen entire after having mixed the whites and yolks together and preserved in a frozen condition until used; or the liquid mixture is sprayed into a warm room and desiccated in this manner. These eggs are then sold to the large consumers who do not find themselves agreeably placed for the purchase of shell eggs.

It makes no difference which variety of commercial eggs are used as long as they are
sanitary, but considerable difficulty is experienced in getting sanitary eggs. If the eggs are purchased in the shell it will be found that a considerable portion of every case consists of defective eggs. If the eggs are purchased in a frozen condition a very uncertain feature of the purchase is the conscience of the man who sold the eggs. If the eggs are purchased in a desiccated form this latter again becomes almost a certain feature in that the eggs will most probably be unsanitary.

The writer has found it out of the question to consider the purchase of shell eggs direct by the macaroni manufacturer for several reasons. Firstly, no one manufacturer seems inclined to-day to make the necessary investment. Secondly, very few are located advantageously for the purchase of shell eggs. Thirdly, no one manufacturer uses a sufficient amount of eggs to maintain on an economical basis a breaking plant.
There is a great opportunity open to someone in this direction. Furthermore, the purchase of dessicated eggs which, from the practical manufacturing standpoint would be the simplest to handle, has been found impossible in that only one manufacturer was able to submit a sample which would pass even a lax sanitary inspection and this one was exhorbitant in price.

There is at present, therefore, no very large choice in the matter and frozen eggs will have to be used. Three or four years ago this would have been an impossibility as the reputation enjoyed by the frozen egg industry was so poor that any food product found to be made with them would be condemned by public opinion. Owing to an energetic system of education and investigation on the part of the United States Government the frozen egg industry has been placed on a totally different basis and provided it is possible to get a frozen egg dealer to sell on specification, the matter will be
settled satisfactorily in this direction.

The other raw materials entering macaroni, such as sugar or salt, are added as such in the pure state and no adulteration or sophistication is known to be exercised in this direction.

Standards and Deviations from Standards.

The standards in use in this industry are standards more of custom than of legislation. From time immemorial it seems that the true macaroni has been made from Durum Semolina and water and to-day the use of other raw materials is regarded as substitution. As a matter of actual fact, however, there are records that macaroni was made in China many thousand years ago from rice and water. But this historical record does not necessarily effect the situation seriously. The facts of the case are that to-day we would not regard the rice product as a true macaroni but would look upon it more
in the light of a special food. Webster defines macaroni as a paste, first made in Italy, consisting chiefly of wheat flour dried in the form of long slender tubes, used when cooked as an article of food.

This wheat flour is usually considered to be hard wheat flour and, in fact, a connoisseur will promptly tell you the difference between macaroni made of Durum wheat and spring wheat flour. The United States Government has attempted to take the stand that macaroni is not macaroni unless it is made from Durum Wheat Semolina but on account of existing conditions of the American wheat market the macaroni manufacturers association has prevailed upon the government to withhold publication of the definition at this time. This means that the only definition effecting the macaroni industry so far issued is the one on egg noodles which has been in force for somewhat over a year and which calls for the presence of $5\%$
solids due to whole fresh eggs in the total solids of the sample. This calls for practically 1 1/2 eggs per pound of flour to be used in the manufacture and is being vigorously adhered to. In view of the fact that the egg noodles on the American market two years ago varied in egg content from an amount so small as not to be detectable by chemical investigations up to almost six eggs per pound, the unfair competition introduced by this condition of affairs is obvious and has been corrected by the proper government regulations.

Coloring matter is used in macaroni for either of three reasons:-

1. Imitation of eggs.

2. Imitation of yellow color of Durum wheat.

3. Flavor.

On account of the expensive nature of eggs a great temptation exists to use a smaller amount than required in a product like egg noodles and to make up for the loss
in color value by the addition of either a coal tar dye or a vegetable coloring matter. This coal tar dye might be one of the permitted dyes but this does not excuse the imitation. It may be a yellow coal tar dye belonging to the class not permitted by food law and, strange to say, this latter is the usual case. The dyes most frequently met with are Naphthol Yellow S and Martius Yellow.

Very stringent regulations on this point as applied by the macaroni industry have been issued by the United States Government and within the last year practically all of these products containing artificial coloring matter have disappeared from the market. Another coloring matter used for this purpose, mostly in Italy but largely in the United States, is Saffron. This is a natural vegetable pigment possessing flavoring values and violent debate constantly takes place whenever a manufacturer is prosecuted for using this coloring matter as the manufacturer will always claim it has
been used for its flavoring property. As a matter of actual fact, however, it is used in quantities too small to have any effect on taste but is sufficient to induce the desired yellow color.

Coal tar dyes and saffron are both used in the other products not containing eggs but for the same purposes. Macaroni made from proper Durum Semolina possesses a rich golden yellow hue and this is not the case where even an ordinary hard spring wheat has been used and is much less the case where a winter wheat is used. The dyes are added in an attempt to imitate the yellow color of the more costly product and frequently the object is attained as far as the consumer is concerned in spite of the fact that an expert can immediately detect it. A peculiar exception to this case exists in the United States in one of the mining districts where a constant and large demand exists for macaroni on account of the nationality of
the labor employed. On account of the activities of one of the large concerns in this neighborhood the market has been educated to the artificially colored macaroni possessing a greenish yellow hue on account of the particular dye used. A leading competitor has for several years attempted to enter this field with an honest product made with the highest class of Durum Semolina. The rich golden hue of this product has prevented it from being sold in competition with the artificially colored and primarily on account of popular prejudice as to color. An experimental batch, artificially colored and made by the honest manufacturer, had immediate and profitable sale. Needless to say this presents a very difficult point and the facts of the matter are that the condition was responsible for the introduction of questionable methods into a plant otherwise beyond reproach from this standpoint. The business management take the stand that as long as the
the government saw fit to permit unfair competition of this nature, the government cannot prevent them from meeting competition on an equal basis.

Coloring matters are added to macaroni to produce flavor only in the case of saffron which has been mentioned above. When sufficient saffron is present to produce a characteristic flavor we have, of course, a special article of food but this exists only in localities where small plants are catering to a limited local demand.

Chemical Control.

A food industry should never be without chemical control and that this principle is quite universally recognized is apparent from the inevitable chemical laboratory connected with every food corporation. The macaroni industry is considerably behind times in this respect as far as Italian, French and American manufacturers are concerned. Needless to say the German and Swiss manufacturers, as usual,
maintain quite efficient control.

The chemical laboratory of the macaroni factory should be equipped from three viewpoints, chemical analysis, biological analysis and research. The chemical analyses which will be made will be the usual analyses of any of the raw materials entering the macaroni. The difficulty and extent of such analyses varies from a moisture test on grains to a complete water analysis for boiler feeding purposes. The biological examinations are almost entirely confined to the examination of water, eggs and similar materials for sanitary purposes. The research department of the chemical laboratory is the most important, in fact, it is the means of determining the changes necessary in plant processes, defects in factory routine and investigations of new products. The research department should be a miniature macaroni plant, should have facilities for reproducing in miniature normal and abnormal conditions
and complete facilities for producing on a home scale any of the products according to any of the recipes which might possibly be used by the housewife.

The routine of chemical control is as follows:

All the raw materials will be bought on chemical specifications and a reasonable number of samples of shipments will have to be examined regularly in order to determine whether specifications are being met. The water supply will have to be periodically investigated both from the standpoint of its sanitary nature and for the purpose of watching any variation which might effect the boiler compound preparations.

It has been stated that the water best adapted for making macaroni is a hard water which, unhappily, is the worst water possible to feed a boiler. We have the miserable condition of factories located with excellent
boiler feed water and making poor macaroni and the other extreme of factories making excellent macaroni and constantly having boiler trouble.

In addition to this control of purchases the chemical laboratory and the biological laboratory will have to watch the dough and green goods in its passage through the factory. Great care must be taken that no development of undesirable fermentation or any inoculation with mold or bacteria occurs. Furthermore, the drop and moisture content must be repeatedly watched in order to avoid abnormal drying conditions and to prevent too wet goods being packed and to prevent loss in weight due to the production of over dry goods. That this loss is considerable may be illustrated with the following figures. An investigation in one factory which persistently reported a mysterious loss in weight between macaroni delivered to the drying machines and macaroni taken from the packing
machines after a correction had been made for moisture content showed that this loss was due to a certain proportion of the goods going through with a very low moisture content. About $85.00 was invested in apparatus, one of the packing room girls taught to make a moisture test and the process controlled in this simple manner is saving this factory over $7000 per year.

The extreme importance of constant watching as far as development of mold is concerned is not realized by the outsider. For very obvious reasons the manufacturer does not wish to have conveyed to the consumer that any such thing as mold exists at all but when it is realized that we have wet dough exposed to atmospheric conditions over a period of days the danger is apparent. In spite of the fact that the most sanitary conditions are maintained and that all air pumped to the curing rooms is filtered and washed and tempered, mold will and does grow. It is usually a perfectly
harmless penicillium. By this is meant that it could deliberately be eaten without producing any untoward results.

The absolute impossibility of selling moldy goods, of course, is a feature which makes the occurrence of mold in a factory so unwished for. Furthermore, on account of the almost ideal conditions for growth of these organisms, once started the rapidity of propagation is enormous. The writer has seen on a wall coated with a cold water paint in which casein was used as a binder, in one of the curing rooms, a little patch of penicellium glaucum about the size of a silver dollar spread into enormous patches covering considerable portions of the partition over night. The entire room, walls, ceiling and goods can develop mucor mucedo in a few hours in sufficient amount to make it difficult to find a square food without the growth. The usual treatment of fighting mold is to burn any goods afflicted with it
under the boiler and wash all utensils, fixtures, apparatus and the room itself with concentrated denatured alcohol. This treatment, even though vigorous, is necessary and is the most desirable method of fighting. Sterilization with heat is out of the question on account of the complete disorganization of the humidifying system; by gaseous fumes impossible on account of the effect on the highly sensitive wet goods and by such materials as bichloride of mercury undesirable on account of possible contamination. As a last resort the writer has used denatured alcohol applied by means of a white wash spray and has found it very quick and, in educated hands, absolutely satisfactory. The process is one of destruction of the mold by elimination of water and killing in this way.

A stubborn case, however, is in mind of a brown penicellium, exact name unknown, which occurred over an entire floor approx--
imately 8000 square feet in vigorous growth. This mold produced a very resistent spore and the alcohol treatment, although affording temporary relief, was found incapable of preventing periodically recurring epidemics. The trouble was finally overcome by washing the entire floor and all fixtures with copper sulphate wash and then spraying with boiling hot lime.

The research department of the chemical laboratory is apt to be called upon to solve almost any question. Frequently it is desired to determine as closely as possible the manner in which a competitor is making his product. This, of course, is not possible from an ordinary analysis and requires experimentation by an expert to get the proper information. This experimentation will probably take the form of the manufacture of small lots under conditions as closely as possible approximating a large scale.

The research laboratory is apt to be
called upon to find an outlet for the troublesome by-products. A specific case is the considerable amount of broken portions of macaroni formed during manufacture. These are not salable and can be disposed of in but few ways. They can be either reground and worked back into the mixes in amounts small enough to prevent undesirable results, they can be used for the production of a canned product and they can be used for the manufacture of a special product. This latter case is exemplified in the manufacture of several breakfast foods originating in the barrels of broken macaroni which collect.

An interesting side line of the chemical laboratory is the maintainence of a museum of competitors goods with complete analyses on the label exhibited in white bottles in a case and in a neighboring case freaks of manufacture.