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SCIENTIFIC RESEARCH IN THE CANNING INDUSTRY.*

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In September, 1913, Dr. A. D. Little delivered the annual address as President of the American Chemical Society. His subject was "Industrial Research in America," and his address began with the following words:

"Germany has long been recognized as preëminently the country of organized research. The spirit of research is there imminent throughout the entire social structure. This is not the time or place, however, nor is it necessary before this audience, to refer in any detail to the long record of splendid achievement made by German research during the last fifty years. It is inscribed in luminous letters around the rock upon which Germany now stands secure among the nations of the world.

"The virility and range of German research were never greater than they are to-day. Never before have the superb energy and calculated audacity of German technical directors and German financiers transformed so quickly and so surely the triumphs of the laboratory into industrial conquests. Never has the future held richer promise or orderly and sustained progress, and yet the preëminence of Germany in industrial research is by

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no means indefinitely assured. A new competitor is even now girding up his loins and training for the race, and that competitor is, strangely enough, the United States—that prodigal among nations, still justly stigmatized as the most wasteful, careless, and improvident of them all."

He then discussed briefly some of the more striking illustrations of industrial research in this country. As we listened to this comprehensive survey we little realized the transformation that was so soon to begin in the field of industrial research throughout the world.

In the late summer of 1914 Europe was suddenly convulsed with the present war. Instead of mere armies being pitted against each other, whole nations, with all their resources, were involved. It soon became evident that the long development of the German nation in industrial research gave that country an important advantage which could only be offset by a systematic organization of the scientific resources of the countries opposing her. Unfortunately, in the early days of the war, the scientific men of England and France were sent to the trenches, where many of them were sacrificed. Steps were finally taken to restore to the laboratories those who were left, and industrial research was organized on a scale which had not been contemplated before.

Within the first few months of the war Great Britain decided that the system of industrial research of the nature found necessary in war time should be extended and placed on a permanent basis, and an organization was effected looking to that end. On July 28, 1915, approximately eleven months after the beginning of the war, a committee of the Privy Council was appointed to direct the application of any sums of money provided by Parliament for the organization and development of scientific and industrial research. An Advisory Council was also appointed, and to it were referred recommendations:

(I) For instituting specific researches;

(II) For establishing or developing special institutions or departments of existing institutions for the scientific study of problems affecting particular industries and trades, and

(III) For the establishment and award of research studentships and fellowships.

It is especially noteworthy that the Advisory Council did not

limit the scope of its plan to industries necessary for the prosecution of the war. Not only was it concerned with research as supported by the government or conducted by educational institutions, but also with encouraging coöperative industrial research conducted partly or entirely by manufacturing and trade organizations.

The Advisory Council has issued two reports which show that the work has been surveyed on a scale and in a manner that must necessarily exert a sweeping influence on manufacturing industries. The overseas dominions, including Canada, Australia, South Africa, and New Zealand, have appointed appropriate councils and taken action in line with the movement of the Advisory Council of Great Britain.

It is obvious that systematic coöperation of this kind must necessarily advance the manufacturing industries and the public welfare. The movement marks a new epoch in the world's history. On this subject the Advisory Council says:

"It will inevitably tend to bring industries into intimate relation, which are at present independent of each other; to transform what have hitherto been crafts into scientific industries, and to require coöperation not only between different firms in the same industry, but between groups of industries in a continuously widening series of interrelated trades."

Active coöperative research in connection with the manufacturing departments of corporations that have known each other only as rivals represents a wide departure from our customary habits of thought. Under ordinary conditions so important a step would be taken only after great deliberation. The progress made, therefore, may be attributed to the patriotism of British manufacturers.

Even in the first report of the Advisory Council it is stated that

"There are indications of a change of view among certain firms which give us hope that a more far-reaching coöperation may be possible, and we understand that the necessities of this war have led to an exchange of information once tenaciously reserved, which may survive the present critical days and, if it does, will augur well for the future."

The same report also says:

"The necessity for the central control of our machinery of

war had been obvious for centuries, but the essential unity of the knowledge which supports both the military and industrial efforts of the country was not generally understood until the present war revealed it in so many directions as to bring it home to all. War has remained as much an art as ever, but its instruments, originally the work of the craftsman and the artist, are now not only forged by the man of science; they need a scientific training for their effective use. This is equally true of the weapons of industry. The brains, even the very processes, that to-day are necessary to the output of munitions were yesterday needed, and will be needed again to-morrow, for the arts of peace."

It is now generally recognized that at the beginning of the war scientific research in the United States was better organized than in any other country, with the exception of Germany. During the last three years scientific research in the United States has increased by leaps and bounds. Great Britain, however, has far outstripped us. Her early participation in the war necessitated the utmost activity in scientific research. Her systematic encouragement of coöperation in this field of labor has resulted in unprecedented advancement. It must be a great satisfaction to us all that the action of Great Britain in encouraging coöperative research is being carefully studied in this country, and the advisability of organizing a similar system of coöperation here is actively discussed.

In view of this great world-wide movement in the broad question of industrial research, I have some hesitation in addressing you this evening in regard to the scientific research that has been conducted and is now under way in a relatively small field of industry. Yet it is of interest to note that at the time Mr. Little delivered the address to which I have referred the research laboratories of the National Canners' Association were being equipped and organized and, at the time the ideas of Great Britain on the subject of coöperative industrial research were formulating, these laboratories had been established and afforded the first instance in this country of a permanent organization for coöperative research maintained by an organized industry.

The canning industry has presented a field with which science has played small part. The first experimental work from which was evolved the process of sterilizing in hermetically sealed containers was conducted before the day of Pasteur and before the

idea of sterilization was conceived. The present canning technology was developed by means of an immense amount of experimental work, sometimes conducted in a systematic manner, but often more or less haphazard. The records of this experimental work are not available. Thus countless repetitions have occurred and a world of effort and experience has been lost. With trained observers, experienced in scientific research, much greater progress might have been expected.

From time to time various problems and difficulties were referred to scientific men not familiar with the industry, but, for the most part, the problems given them were incompletely or incorrectly stated or the workers had not the opportunity to grasp the full scope of the questions submitted to them.

Still there were several incursions of scientific men into the problems of the canning industry which resulted in great good. Among these may be especially mentioned the work of Russel in 1895, of Prescott and Underwood in 1896 and on three subsequent occasions, and of Harding and Nicholson in 1903. These articles—all on bacteriological subjects—while describing work which was not carried out to the extent that might have been desirable, were fundamental in their character and gave to the industry new data and new ideas whose value cannot be overestimated.

The idea of systematic research in connection with the canning industry is a very recent development. Only a relatively short time ago the industry was governed largely by trade secrets, and the methods of the canner were shrouded in mystery. Within the memory of men still operating the process, man was supposed to be possessed of secrets which were guarded from even the proprietor of the establishment in which he was employed, and the process-room was a place of mystery to which no one but the man who controlled its operations was admitted. At the present time this condition of affairs has been reversed, and technical processes are now openly discussed. The operatives of competing manufacturers commonly consult each other with the utmost freedom regarding the technology of the industry, and such consultations result in material progress. This transition from the era of trade secrets to the era of helpful collaboration was not a simple step, but rather a gradual development. The important thing is that it has been accomplished.

In connection with this transition, there has grown up the recognition of the need of systematic scientific study, which has been somewhat gradually developed and has been placed upon a coöperative basis. Unfortunately, this work has had to be extended over a greater field than would have been necessary if coöperative research had been general in the industries of the country. It has been necessary to take up as fundamental some of the questions which should have been studied earlier by other industries. For this reason the work has not been as intensive as it would otherwise have been.

The interests and responsibilities of the canner cover a much broader field than is usually supposed. They begin with the planting of the seed and continue until the finished product is finally consumed. The canner must give active personal attention to the growing of his crops, because some of his most important problems are purely agricultural. The acreage must be ample and the seeding so arranged that the harvest will be distributed with as much uniformity as practicable over a relatively long season, in order that the plant may be kept in operation regularly and for the maximum time. The greatest care must be exercised to harvest each field at the proper stage of maturity. The raw product must be of high grade, or the finished product will be inferior. Finally, the crop must be profitable to the grower, or he will turn his attention to other crops.

The canner, therefore, in addition to securing contracts for the acreage he desires, must give his personal attention to the character of seed planted, the methods of cultivation, the use of fertilizers, and the fighting of insect and fungous pests that may be encountered. Fortunately, all of these problems come within the general field of agriculture, and an army of well-trained men have given them attention in the Department of Agriculture and in the various State Experiment Stations. These agencies, moreover, are always ready to give assistance and to investigate new problems that may arise in their fields. Still, such new problems are constantly arising, and especially problems which are new to an individual locality, and the canning industry could not succeed without keeping in close touch with the various agencies engaged in agricultural research.

After the raw product is received at the canning plant, each of the operations necessary for the completion of the canned

article presents problems which often require investigation. An experienced employee must make frequent inspections of the product at every stage of its preparation and, whenever any abnormal condition appears, the cause must be discovered and removed.

The problems that present themselves are of the most diverse nature. Difficulties frequently arise while the product is being canned and must be solved quickly and remedied if a normal product is to be secured. More frequently, however, difficulties are encountered after the product is canned. They may be apparent when samples are opened for inspection as soon as the canning operations are completed, or they may develop on storage. Such difficulties can be adequately studied only by men who are thoroughly conversant with the technology of the industry.

Among the experienced men of the canning industry there is already a world of information regarding questions of this kind. Unfortunately, this information is not always accurate, and opinions of experienced packers are frequently conflicting. Many skilled operatives have considered only a part of the conditions under which they were working and, as a result, have drawn wrong conclusions. The attention to such questions of trained observers, therefore, must necessarily be of value.

As an illustration of the difficulties referred to may be mentioned a general dark-gray discoloration in canned corn. This has been encountered rarely, but where it has been found it occurred in considerable amount. Its study showed that it was due to a mere trace of copper coming from the cooker in which the corn was heated before being filled into the can. While the plant was in operation this color was not produced. It sometimes happens, however, that as a season nears the end a plant shuts down for a few days and then starts again to take care of some belated fields. In this interval a slight tarnish forms on the copper surface of the cooker valves and is not removed by careful scrubbing. When the canning of the corn is resumed this film of copper oxide is dissolved and passes into the corn. Then, when the corn is sterilized after the can is sealed, the infinitesimal trace of hydrogen sulphide which is always formed when any food is cooked converts the dissolved copper into sulphide, which, in the colloidal form, exerts a marked coloring action on the product. In this way one ten-thousandth of one per cent. imparts

to the corn a dark-gray color which is unattractive to the eye. The cause being known, the remedy was obvious, and this particular difficulty caused no further trouble. This one instance is cited merely as an illustration of a broad class of problems that arise from difficulties in the daily work of the industry.

SPOILAGE.

Spoilage in canned foods betrays itself either by the swelling of the can or by the abnormal taste or appearance of the food. Usually it occurs rapidly and is evident a day or two after the food is packed. It is always due to faulty technic, and it is of the utmost importance to the manufacturer to locate the cause of the spoilage and provide a remedy at the earliest possible moment.

When we remember that the rate of penetration of heat through the contents of a can depends largely on the physical nature of the food, it is evident that slight changes in the character of the food will greatly influence the time of heating necessary for sterilization.

The temperature and time required for the sterilization of a particular food sometimes vary in different seasons and in different parts of the country. It may happen, therefore, that a canner will find his product undergoing spoilage, though it was put up by a method which had always been satisfactory before.

Again, spoilage is often due to the can not being properly closed. The brief duration of the canning season makes it difficult to have the factory manned with a sufficient number of highly skilled operatives. It sometimes happens, therefore, especially when working with a new type of can, that the closing machine will not be properly adjusted, and cans closed with it will contain a leak so slight as to be very difficult of detection and yet sufficient to cause the contamination of the contents.

Then the process man may be misinformed regarding the capacity of some machine he is using. Sometimes the temperature is not uniform in all parts of the sterilizing equipment, so that in processing the cans do not receive the temperature indicated for the required time.

When we consider that a given case of spoilage may be due to one or several of these causes or to a variety of similar reasons, it is apparent that the cause of spoilage is frequently

difficult to determine, and both skill and experience are necessary to make this determination accurately and quickly.

But spoilage does not necessarily occur while the goods are being packed. It is sometimes due to organisms which multiply slowly, especially at the temperature at which the goods are stored. In such cases it appears only after the goods have been stored for a considerable time, either in the canning plant or after distribution. When spoilage of this nature is discovered it is, of course, important to locate its cause as promptly as possible and to determine its probable extent.

In connection with a question of spoilage, however, whether it occurs while the food is being packed or while it is in storage, the important thing is to understand and learn to safeguard against it.

BY-PRODUCTS.

Much has been said of the possibility of utilizing by-products of the canning industry. On the whole, great progress has been made in the matter. Many products, such as cobs and husks of corn and the vines of peas, are used directly for feeding stock or are preserved in silos for use in winter.

A relatively small number of by-products are used in the manufacture of fertilizers or are applied directly to the fertilization of the soil. There are still, however, countless tons of material whose removal is only an expense to the industry and for which no use has yet been found. It is frequently pointed out that much of this material has a certain food value and, if placed in such form that it could be preserved and transported, would add to the food supply available for our domestic animals. In these matters, however, it must always be kept in mind that to dry a product containing 90 per cent. or more of water is a relatively expensive operation. When we consider the large volume of this material in a single canning plant it will be understood that the drying of the offal would require an elaborate and expensive equipment. Most canning plants are operated only for a few weeks in the year and on this account cannot consider an expenditure for "overhead" which could be carried readily by a plant running continuously.

It must also be remembered that, during the canning season, all the facilities of the canner are taxed and it is a difficult matter for him to secure the labor necessary for his ordinary operations—

let alone the drying of the by-products and placing them in suitable form for shipment. It has been suggested that such by-products be prepared for commerce at central plants to which they would have to be delivered from the separate canneries. Even if this were done, however, preliminary drying would be necessary at the canning plant. In summer and early fall, when most of the canning is done, spoilage occurs rapidly, and all by-products, if they are to be handled at all, must be dried immediately.

This question is now being studied by competent engineers. I have no doubt much progress will still be made in the matter of disposing of the by-products of the canning industry. It must be borne in mind, however, that the question has limitations which are not apparent to the cursory observor, who is inclined to criticise the canner when he sees tomato peelings or pomace hauled away from the plant at a direct expense.

SANITATION.

In addition to the peelings, trimming stock, and other solid material just referred to, there is frequently a considerable amount of liquid waste and wash-water whose disposal is difficult in some localities. Under some circumstances such products become a nuisance in the community, and their cure offers new problems in sanitary engineering. This is a matter to which sufficient attention has not been given, but it is being studied by the Public Health Service and other agencies.

Methods of treatment have been devised for handling the liquid waste from some types of canning plants, and progress has been made in others.

TIN PLATE.

Industrial research in the canning industry must cover a much broader field than would be necessary if coöperative industrial research had been adopted by your manufacturing industries a generation ago. Defective tin plate has been believed by some canners to be responsible for many difficulties of the industry.

Under bad storage conditions cans frequently rust on the outside. This gives them an unattractive appearance and, if the rusting continues, sometimes causes perforation of the can and spoilage of the contents. With some light-colored products, such as corn, patches of a dark pulverulent substance occur on the

inside of the can. Sometimes acid fruits perforate the cans and thus permit the contents to spoil.

These phenomena and many others have long suggested the thought that imperfections in the tin plate or faults in its manufacture might be responsible for some of the canner's troubles. Many studies of tin plate were undertaken, but the expense involved was so great and the amount of detail so enormous that the investigations were not made sufficiently comprehensive to be of material value.

Finally, in 1915, a collaborative study was begun of the relative value of different weights of tin coating on canned food containers. This investigation was conducted by a joint committee representing the laboratories of the American Can Company, The American Sheet and Tin Plate Company, and the National Canners' Association. Two representatives of the Bureau of Chemistry were also associated with the committee, participating in all the work and taking part in the discussions. The committee reported early in 1917.

As might be expected in an investigation of this scope, the study suggested more question than it settled. Yet it did afford conclusive answers to some important questions. Among these are the following:

1. None of the difficulties with canned foods that have been attributed to tin plate are caused entirely or even largely by light or defective coating.

2. No weight of coating will overcome faulty technic or faulty storage in the finished product.

3. When cans are stored under conditions that promote rusting, heavy coating will retard rusting, but will not prevent it.

4. The various discolorations on the inner surface of the can and in the contents have no relation to weight of coating.

But it is evident that there may be other considerations in tin plate than weight of coating. The importance of the composition of steel and of the conditions of its treatment in other industries emphasize the probable importance of the same considerations in connection with tin plate. As stated above, the canner is interested, among other things, in the rusting of the exterior of the can, the corrosion and formation of undesirable colors on the inner surface, and in localized corrosion resulting in perforations and leading eventually to spoilage. We cannot

tell, without a comprehensive experimental study, whether these conditions will be influenced by the composition of the steel, the character of its surface, the temperature of annealing, or other conditions of manufacture.

A comprehensive collaborative investigation of this subject was instituted a few months ago by the laboratories of the American Can Company, the Titanium Alloy Manufacturing Company, and the National Canners' Association. This investigation may require several years for its completion, but it is being conducted on so elaborate a scale that it is believed the results will be conclusive and fundamental.

FOOD POISONING.

The responsibility of the food manufacturer does not cease even when the food has passed into the hands of the consumer. There is a general popular impression that food poisoning is likely to be produced by this food or that, and many people are prone to attribute an attack of indigestion to poisoning caused by a particular food.

Then it is well known that cases of food poisoning do occur, due to the infection of the food at some period in its history. This infection may occur at the time of the original harvesting of the food or at the time of its preparation in the form in which it is placed on the market or it may occur in the preparation of the food for the table after it reaches the hands of the consumer.

In any case, our information regarding the general question of food poisoning is altogether inadequate, and it is of the utmost importance to manufacturers and handlers of food that our information on this subject be made more complete. This is also of importance to the medical profession, and especially to the public.

The canning industry has long felt the need of an adequate survey of this subject by responsible parties, and something more than a year ago invited the National Research Council to organize a systematic investigation of this subject and designate people who were to conduct it, the investigation being supported by the industry. After careful consideration, the National Research Council accepted this invitation and organized the investigation, naming as director, Dr. M. J. Rosenau, head of the Department of Preventive Medicine and Hygiene of Harvard Medical School. The work was undertaken in June and is being actively continued.

THE PRESENT CONDITION OF THE INDUSTRY.

In view of the unprecedented conditions that now confront us, it seems best to digress for a few moments from the subject of the evening and discuss briefly the present situation in the canning industry.

During the last season there were packed, in round numbers:

Tomatoes	15,000,000 cases, of 24 cans each.
Corn	11,000,000 cases, of 24 cans each.
Peas	10,000,000 cases, of 24 cans each.
Other vegetables	13,000,000 cases, of 24 cans each.
Fruits	11,000,000 cases, of 24 cans each.
Evaporated and condensed milk	30,000,000 cases, of 48 cans each.

When we add to this total of 90,000,000 cases the pack of other varieties of canned foods, including the various kinds of fish and shellfish, and an unprecedented pack of meat products, we have a grand total of more than six billion cans.

In normal times a pack of this size would mean low prices, yet high prices prevail and must prevail, as they do in other industries. Everything the canner uses has increased in cost: cans, labels, boxes, nails, sugar, coal, machinery—every article used directly or indirectly in the operation of the factory and in preparing and shipping the food. Because of the shortness of the canning season an adequate supply of skilled labor is scarcely available even in normal times. Now the difficulty of securing labor presents an obstacle that is almost insurmountable.

Then we have an enormous increase in the cost of raw products. The grower gives preference to the crop that will give him the greatest return. It is no simple matter to pay enough for canners' crops to compete with $2.25 wheat and with corn at a proportionate price. Moreover, wheat and corn require little labor. Most canners' crops require much, and labor is not available. Perhaps the cost of producing canned food under present conditions is best understood when we remember that both canners and wholesalers are licensed by the Food Administration and are not permitted to make a higher charge for staple products than is necessary to yield them a fair profit.

No prediction can yet be made regarding the probable pack of the present year. The Army and Navy will require about 35 per cent. of a normal pack of tomatoes and 25 per cent. of a normal pack of corn, peas, salmon, and sardines. The Army and Navy and the civilian population of our Allies will require ten

million cases of milk if bottoms can be secured for its transportation. All these products must go from America, for no country in Europe can grow the food needed by its own people. It is known to all that canned foods are preserved by heat alone in hermetically sealed containers. They afford us the nearest approach we know to fresh cooked food. It is only in this form that the substantial equivalent of fresh foods can be supplied to our Army and Navy and to the military and civilian population of our Allies. Almost every variety of food that is cooked can be preserved by canning and is actually on the market in the can.

Desiccated foods have a promising outlook, but with many products are still in the experimental stage. Desiccated tomatoes, corn, and peas are unknown in a commercial way, except for the preparation of soups. We do not know whether they will be acceptable to the public. We know little of the technological difficulties still to be overcome in their commercial production. So far as experience has gone, there is no reason to believe that the manufacture of desiccated foods may not grow to large proportions—but it must be a growth. A large industry cannot spring into being. In any case, the present wants of the Army and Navy for tomatoes, corn, and peas must be supplied with the canned product.

No estimate can be made of the extent to which growers will be willing to contract for acreage in canners' crops.

Supplies of pig tin are always a source of anxiety. The amount on hand is never sufficient to make the future secure. Recently the condition in this respect has been less satisfactory than usual. Our chief anxiety regarding the supply of tin plate, however, is the lack of production of both plate and cans owing to transportation difficulties.

The plans of the early winter for the manufacture of plate and cans were impossible of execution. The many demands on the transportation system made it impossible to move plate from its place of production to the makers of cans, and, as a result, some can-making plants found it necessary to shut down for a time because of lack of plate, while, on the other hand, some plate manufacturers filled their storerooms and then were compelled to close their plants because of lack of additional storage space. Under these circumstances, accurate predictions cannot be made. We can only say that the requisite number of food containers for the coming season will not be available.