THE EGG PRODUCTS INDUSTRY OF THE UNITED STATES

PART I HISTORICAL HIGHLIGHTS, 1900-59

AGRICULTURAL EXPERIMENT STATION
KANSAS STATE UNIVERSITY OF AGRICULTURE
AND APPLIED SCIENCE, MANHATTAN

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Cover photo: The "pour-off test" for yolks is a regular part of daily inspection of broken-out eggs. Contents of several cans are poured into other cans before the product is placed into a freezer. This test assures that no breaks have developed that permit pieces of shell and chalazae to pass through the straining equipment.

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FOREWORD

The research on which this report is based was undertaken as a part of the North-Central Regional Poultry Marketing Project, NCM-14. The project was supported by funds made available under the Research and Marketing Act of 1946, and by state funds.

This is the second report in a series studying various aspects of the egg products industry. The first was by Raymond, D., A. Axelrod and E. Feder, "Federal and State Laws and Regulations Applicable to Egg Products Plants in the North Central Region (as of September, 1957)," Dept. Agr. Econ., Progress Report 13, Nebraska Agricultural Experiment Station, January 1958.

Future reports will cover economic trends, operations of commercial egg breaking and/or drying plants in the North Central Region, legal-economic aspects, and integration of egg production and processing.

To H. J. Keith and Mary E. Pennington

Many individuals contributed to the early development of the egg products industry. However, two names stand out--H. J. Keith (1857-1923) and Dr. Mary Engle Pennington (1872-1952). Keith founded the industry. Miss Pennington, a scientist with the Department of Agriculture, conducted basic research on the principles of sanitation and refrigeration. Application of this research revolutionized the industry.

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The Egg Products Industry of the United States
Part I. Historical Highlights, 1900-59[1]

BY

JOE W. KOUDELE AND EDWIN C. HEINSOHN[2]

PURPOSE OF THE STUDY

Since its humble beginning in 1900 the egg products industry has undergone many significant changes which probably will be accelerated in the future. The purpose of this study is to provide a brief but authentic recording of the major economic forces, events, and technological developments that have shaped the industry's history and to serve as background for the new generation which is gradually assuming the direction of this industry.

SOURCES OF INFORMATION

Part of this history is based on observations, personal experiences, and knowledge of one of the authors[3] whose major life work has been spent in the egg products industry. Other valuable information was obtained through consultation and correspondence with various persons directly associated with the industry in various capacities. In addition, valuable reference material was drawn from various industry and governmental sources, in particular certain periodicals and research publications of the Department of Agriculture.

EARLY GROWTH PERIOD: 1900-20

Founding of the Industry

In the late 1890's, H. J. Keith, a young ex-schoolteacher from Maine, was engaged in the shell-egg business in St. Paul, Minn. Distressed by inability to market eggs with checked and soiled shells, he conceived the idea of removing the egg meats and freezing them. In his first attempt to pack frozen whole eggs the product was frozen before mixing the yolks and whites. Upon thawing, the prod-

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2. Associate agricultural economist and instructor, respectively.

3. E. C. Heinsohn holds a B. S. degree from Cornell University (1915) with a major in poultry marketing. From 1915-19, he worked under Dr. Mary E. Pennington in the Food Research Laboratory, Bureau of Chemistry, USDA. He helped conduct research to improve the performance of railroad refrigerator cars for shipments of perishables, particularly poultry and eggs. During 1919-22, he was in charge of branch egg buying stations for a plant of the Amos Bird Company (Boston) in Shanghai, China. While associated with Seymour Foods, Inc. his responsibilities included sales representative (shell eggs, frozen eggs, and poultry) at Albany, New York (1923-42); supervision of egg drying operations (1942-46) and sales work in egg products (1947-57) at Topeka, Kansas. Since 1957, he has been employed as a Cooperative Field Agent by the North-Central States Poultry Marketing Research Committee.

uct consisted of whites containing gummy lumps of yolks, and a co-operating baker experienced considerable difficulty in using the product. Next, Keith thoroughly mixed the yolks and whites before freezing and the results were much more satisfactory. Later experiments indicated that adding small quantities of sugar and salt resulted in a smooth product when thawed.

Convinced that the idea of freezing eggs had real possibilities, Keith moved his operations from St. Paul to Boston. There he raised the necessary capital and established the first egg-breaking room shortly before 1900. The new business, the H. J. Keith Company, prospered and grew rapidly. Previously each bake shop, large or small, had broken its own shell eggs. When bakers began using frozen eggs and learned that their cakes were fully equal in quality to those made from freshly-broken eggs, acceptance of the new product was rapid. Soon egg-breaking operations began not only in large cities like New York, Philadelphia and Chicago, but also throughout the egg-producing areas of the Midwest.

Significance of the Egg Separator and Other Techniques

From the beginning some whites and yolks were packed separately, but the process was slow and inefficient. In early breaking operations, girls manually flipped the yolks back-and-forth between halves of the shells until the whites drained off—the method commonly used by housewives. In 1912, the hand separator was invented by Harry A. Perry. Its use greatly improved the efficiency and speed of breaking and contributed to the development of large-scale breaking operations.

While this invention significantly affected the production side, another technique was of major importance in stimulating consumption. A characteristic of plain frozen yolks when thawed is heavy viscosity which makes it somewhat difficult to mix with other ingredients in food manufacturing. In the early 1900's it was discovered that adding 10 percent sugar, by weight, to the yolks before freezing would prevent gelation. Consequently, it was easier for food manufacturers to use frozen yolks and consumption increased. Later it was learned that the addition of salt or glycerin to yolks accomplished the same purpose as did the sugar.

Larger supplies of separated products, made possible by the egg separator, led to an expanding demand for frozen eggs, particularly yolks. While noodle makers continued to use plain yolks, bakers and ice cream manufacturers demanded sugared yolks and mayonnaise manufacturers switched to salted yolks. Frozen whites already were in good demand for white and angel food cakes, meringue, and candy.

Early Drying Operations

In the United States, egg drying preceded the freezing of eggs on a commercial basis. Records indicate that in 1878, a St. Louis, Mo., firm was "transferring egg yolk and albumen, by a drying process, into a light

brown, meal-like substance."[4] From 1895 to 1905 a number of plants began operations and dried eggs were shipped to Alaska and even to China to be used by the United States Army stationed there.[5]

Early driers were the rotary drum type. In 1907, the belt-type dryer was perfected and produced "flake" whole eggs and yolks. Flake-dried whole eggs were especially liked by pie bakers for custard, cocoanut, pumpkin, and cream pies.

Imports and Frozen Eggs

The idea of breaking and freezing eggs for bakers and other food manufacturers spread rapidly not only in the United States but also to other parts of the world--notably China--before World War I. Square cans holding 44 pounds of frozen eggs packed in China began to appear on the American scene and undersold the domestic pack. At the same time Chinese dried eggs began to be imported.

When the United States entered World War I, prices rose on all foods including eggs and trade interest in the cheaper Chinese frozen and dried eggs increased. As a consequence, activities of the egg-drying industry of the United States decreased markedly. Some belt-type drying equipment, already operating in the United States, was dismantled and shipped to Shanghai, China, for installation.

Legal Battles Over Liquid and Frozen Eggs

Meanwhile, the infant egg products industry was having real troubles of its own. The Food and Drug Act passed in 1906 had established federal responsibility to insure that wholesome food supplies reached the public. Notices of Judgment by the United States Department of Agriculture for cases involving egg products under the Food and Drug Act began to appear in 1909 and by 1910 there were no fewer than 14 such judgments.[6]

Two cases in particular had an important influence on the early development of the egg products industry. Details of one case [7] follow:

> The government seized 50 cans of whole eggs preserved with 2 percent boric acid on grounds of "adulteration." The company did not contend that the eggs were not adulterated, but it did contend that the Food and Drug Act was inapplicable to egg products, the principal argument arising from the fact that egg products were raw materials for other food products. Several nice legal points were made by the company from this factual foundation, but the Supreme Court opinion made it perfectly clear that the egg products industry was subject to the full coverage of the Food and Drug Act.[8]

In another case,[9] 443 cans of frozen eggs packed with 10 percent sugar were seized in November, 1910, and condemnation was sought under the Pure Food Law on grounds of "decomposition." The H. J. Keith Company, for whom the eggs were packed by a reputable firm in Kansas, decided to fight the case. Because the case

4. Termohlen, W. D., E. L. Warren, and C. C. Warren, "The Egg-Drying Industry in the United States," AAA, U. S. Department of Agriculture, PSM-1, 1938, p. 2.

5. *Loc. cit.*

6. *Loc. cit.*

7. Hipolite Egg Co. v. U. S., 220 U. S. 45 (1911).

8. Letter, November 2, 1959, to the authors from Allen Axelrod, professor of law, University of Nebraska.

9. U. S. v. 443 Cans of Frozen Egg Products.

was tried in the District Court at Trenton, N. J., it became known thereafter as "The Battle of Trenton."

This case aroused a great deal of interest both within the industry and among the public. "Expert testimony" on both sides and "lay testimony" as to odor, taste, appearance, and baking qualities of the frozen eggs were presented.

At that time very little was known about the proper method of thawing frozen eggs--a fundamental point in the case. Labels placed on these cans by the packer stated, "Slow thawing gives best results." By this instruction, the packer meant thawing in cold water or in a refrigerator.[10] Under this method, the eggs remained cold and bacterial growth was retarded as the product thawed progressively from the outside to the center of the can. To others who testified, "slow thawing" meant thawing at room temperatures.[11]

Testimony on both sides indicated that when the eggs were removed from the freezer no off-odor was detected. But evidence was also presented showing that some of the eggs had a very high bacterial count and, when thawed at room temperatures, off-odors indicative of decomposition were noticeable. The defendants contended that eggs thawed in this manner were not handled properly and were allowed to deteriorate before being tested. Judge Cross' decision was in favor of the packer.

In October, 1911, the government appealed the case and it was argued before the Circuit Court of Appeals at Philadelphia. Judge Buffington's opinion reversed the decision of the District Court. He directed that a decree of condemnation be entered in favor of the government.[12] In December, 1912, the Keith Company appealed the case to the United States Supreme Court which decided on technical grounds that the Circuit Court had no jurisdiction in the matter[13] and reversed the judgment of the lower court.[14]

By action of the Supreme Court the eggs were now released from federal authorities. However, the eggs could not be removed from cold storage and sold for food without a certificate from the New Jersey State Board of Health. In July, 1913, after reviewing all court testimony and conducting further investigations concerning the quality of the frozen eggs, the Board released the eggs after specified labeling requirements were met.[15] The eggs were then sold in interstate commerce and used for baking.

During the period of litigation, much was learned from actual experi-

10. H. J. Keith, "The Battle of Trenton," Boston: H. J. Keith Company, 1914, p. 34.

11. *Loc. cit.*

12. U. S. v. 443 Cans of Frozen Egg Products, 193 Fed. 589, (C. A. 3rd. 1912).

13. 443 Cans of Frozen Egg Products v. U. S., 226 U. S. 172 (1912).

14. In writing the Food and Drug Act, Congress had a choice--to spell out in detail the judicial procedure to be used in condemning food or to borrow a procedure from other types of condemnations. They decided on the latter and Section 10 of the Food and Drug Act specified that Food and Drug condemnations were to be as like admiralty condemnations as practical. The Act did not say, however, whether admiralty procedure or standard procedure was to govern in appeals from condemnations. The government guessed wrong in using an admiralty type appeal in the Trenton case. (Letter, November 2, 1959, to the authors from Allen Axelrod, professor of law, University of Nebraska.)

15. Keith, *op. cit.,* pp. 69-70.

ments concerning the alleged decomposition and fitness of frozen eggs for food. Because the eggs were packed by a Kansas firm, the State Board of Health of Kansas requested that tests be conducted in the bacteriological laboratory of the University of Kansas. Frozen eggs, *equivalent to 3½ eggs per day* per student, were used in various cooked foods eaten by six men students for 17 days. Tests indicated that none of the men had any disorder of the digestive tract, a type of ailment that generally accompanies the ingestion of decomposed or putrid food.[16]

The Supreme Court decision possibly saved the infant frozen egg industry from an abrupt closing. Moreover, the case was significant in another respect--evidence introduced at the trial showed that bacterial counts of some frozen eggs were very high[17] and leaders of the industry, as well as government officials, recognized the need to correct this situation.

Sanitary Requirements Established for Egg Breaking Plants

The Food Research Laboratory, Bureau of Chemistry, was created in 1907 by the Department of Agriculture to conduct technological studies primarily in egg and poultry processing. Initially most of its activities centered on poultry meat and shell eggs. But the legal cases over frozen eggs clearly indicated how little was known about the sanitary and refrigeration requirements of egg products. Therefore, after the trial at Trenton, the Laboratory was specifically assigned the task in 1911 to conduct investigations on liquid, frozen, and dried eggs.

A group of scientists under the direction of Dr. Mary E. Pennington began conducting basic research regarding the preservation of egg products. As information became available, Dr. Pennington, in line with her Laboratory's motto of "Clean, Cool, Cooperate," helped the industry improve its physical facilities and technology. Sparkling white egg-breaking rooms, models of sanitation, began to appear. Improved techniques in breaking eggs and handling liquid eggs were adopted to minimize bacterial counts. According to Dr. Pennington:

> The laboratory findings practically revolutionized the apparatus used and the routine followed in the breaking room. Instead of the haphazard collection of odd pieces of china, glass, and tin there were evolved machines accurately adapted to the work to be done; and the careless, inconsequent methods of cracking and emptying the shells were replaced by a standardized, definite routine, making for both quality and efficiency.[18]

The improved quality which resulted from adopting the new technology was largely responsible for the ready acceptance by food manufacturers of frozen eggs and subsequent increased demand for them. In 1910, the press and public had little knowledge of the egg products industry except vague knowledge of the seizures of condemned products. But as a re-

16. *Ibid.,* pp. 50-51.

17. As a matter of interest, two of the 443 cans of frozen eggs were held in a freezer in Topeka, Kan., for 41 years. Occasional examinations showed a constant reduction in the number of bacteria, and the eggs retained their ability to make cakes. The cans were destroyed in the flood of 1951.

18. M. E. Pennington, *et al.,* "A Study of the Preparation of Frozen and Dried Eggs in the Producing Section," Bureau of Chemistry, U. S. Department of Agriculture, Bulletin 224, 1916, p. 6.

sult of the scientific investigations by the Food Research Laboratory, public sentiment and knowledge of the industry changed rapidly. In 1914, the founder of the industry wrote, "We believe it is now pretty generally understood that this line of business is not only a legitimate one but also both useful and important." [19]

Government Inspection Requested by the Industry

Industry leaders early realized the advantages of government inspection and endeavored to have the Meat Inspection Law of 1906 extended to cover frozen and dried eggs. A bill to this effect was introduced into the United States Senate by Senator Henry Cabot Lodge as a rider to the Agricultural Appropriation Bill of 1911.[20]

The bill and rider passed the Senate but the rider was defeated in conference.[21] While this legislation was under consideration, the Iowa Wholesale Butter and Egg Dealers Associa-

19. Keith, *op. cit.,* p. 73.

20. *Ibid.,* p.72.

21. Reasons for defeating the rider are not known, but it was the opinion of "old timers" that those who would have been responsible for setting up the program felt that trained personnel to supervise the breaking operations were not available. This type of service was inaugurated 31 years later, in 1942.

FIG. 1. An egg-breaking room in 1904. Very little was known about sanitary require. ments for handling fresh-broken eggs at that time.

FIG. 2. The egg-breaking room of Figure 1 as it appeared in 1912 after recommendations of the Food Research Laboratory, U. S. Department of Agriculture, to improve sanitation and technology had been adopted.

tion sent the following telegram to Secretary of Agriculture Wilson:

> At our annual convention which was held today, motion to endorse Lodge amendment to House amendment 31596 providing for factory inspection of canned and dried eggs was unanimously carried. We request your hearty cooperation in support of this motion which is of vital importance to Iowa producers and egg dealers.[22]

Use of Dried Eggs in World War I

Some efforts were made during World War I to interest the Armed Services in using dried whole eggs. A demonstration breakfast, in which flake-dried whole eggs were used to make scrambled eggs, was held at the White House. It is said that President Woodrow Wilson, along with other high officials, participated. While this event paved the way for some use of small sample packages in a few army camps, the product was not used extensively. The best information available indicates that the use of whole egg solids by the Army at this time was first suggested by Henry Hahn, a distributor of frozen and dried eggs in New York City, who arranged with the Army for the demonstration breakfast.[23] While the Army was not prepared to use dried eggs during World War I, the soundness of the idea was later confirmed by developments during World War II.

22. Termohlen, *et al.,* loc. cit.

23. Letter, September 13, 1958, to the authors from Anne Finlay Brink. Mrs. Brink was associated with H. J. Keith Company, Borden and Company, and Seymour Packing Company in frozen and dried egg sales during 1907-50.

Industry Trends in the United States

During 1921-31, significant changes were taking place in the poultry industry. Domestic production of eggs was gradually increasing. Farm production rose from 30.8 billion eggs in 1921 to 38.5 billion eggs in 1931.[24]

The commercial hatching industry was growing rapidly, thus gradually reducing the necessity for farmers to hatch their own chicks. This advance, in turn, removed the need to produce fertile eggs on every farm, and reduced the quantities of heated fertile eggs reaching market. Before this development, marketings of eggs from farms during the hot summer months contained an average of 10 to 20 percent inedible eggs.[25] Increasing emphasis on quality egg programs by extension specialists helped to improve the general quality of eggs marketed and to decrease the percentages of undergrade and inedible eggs.

Meanwhile, demand for frozen eggs was growing and the annual volume packed rose from 46,000,000 pounds in 1921 to 185,000,000 pounds in 1930.[26] This increase absorbed all available undergrades and breakers began using "current receipt" [27] eggs for additional supplies. About 1927, a change occurred in the seasonality of breaking and storing eggs. It was reported:

> Prior to 1927, eggs were broken from the shell in all the months of the year and a large percentage of frozen-egg holdings was accumulated during June, July, and August, when a considerable portion of shell eggs suffers from deterioration due to hot weather. An important part of frozen egg holdings since 1927 has been produced during March, April, and May, when the best eggs are available. Prior to 1927, storage holdings of frozen eggs on June 1 were not significantly higher than on February 1, indicating that the movement into storage did not become heavy until June 1 and was unimportant during March, April, and May.[28]

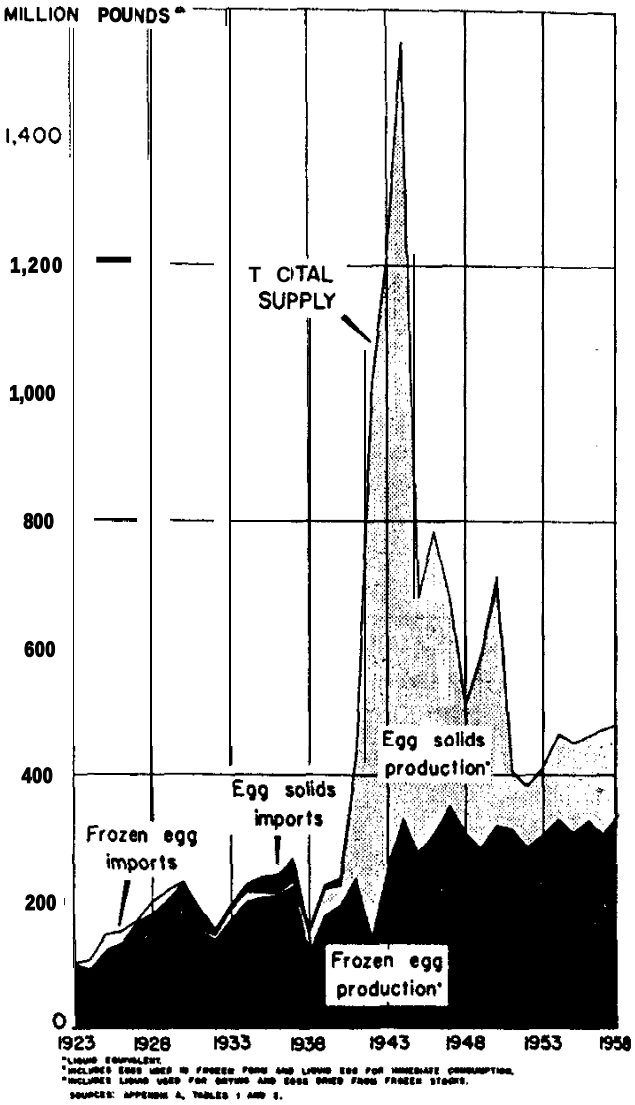

FIG. 3. Egg Products: Total annual supply from domestic production and imports, United States, 1923-58.

24. *The Poultry and Egg Situation,* AMS, USDA, November, 1958, p. 24.

25. A. G. Phillips, *The Marketing of Eggs,* Kansas State Agricultural College, Fanner Bulletin 162, 1909, p. 245.

26. Department of Agriculture Poultry Committee, *Eggs and Egg Products,* USDA, Circular 583, 1941, p. 62.

27. Nest-run eggs sold by fanners to buyers without regard to size or grade.

28. James H. Radabaugh, "Economic Aspects of the Frozen Egg Industry in the United States." *Proceedings, Seventh World's Poultry Congress and Exposition,* 1939, p. 364.

Annual dried egg production in the United States during 1927-31 was small. In terms of liquid equivalent, production ranged from only 500,000 to 1,500,000 pounds (Fig. 3).

Imports of Frozen and Dried Eggs

When domestic egg breakers began using current receipt eggs, their costs advanced. This put domestic frozen eggs at a greater competitive disadvantage with the lower cost frozen and dried eggs being imported from China. The opening of the Panama Canal in 1914 also made possible direct shipments from China to New York City at relatively low rates. During the 1920's, imports of Chinese frozen and dried eggs were heavy (Fig. 3).

The Chinese Egg Industry

Large poultry flocks were almost unknown in China. Chinese farmers did not live on individual farms but congregated in small villages surrounded by outlying fields. This custom undoubtedly developed because it afforded some measure of protection against bandits who roamed the country.

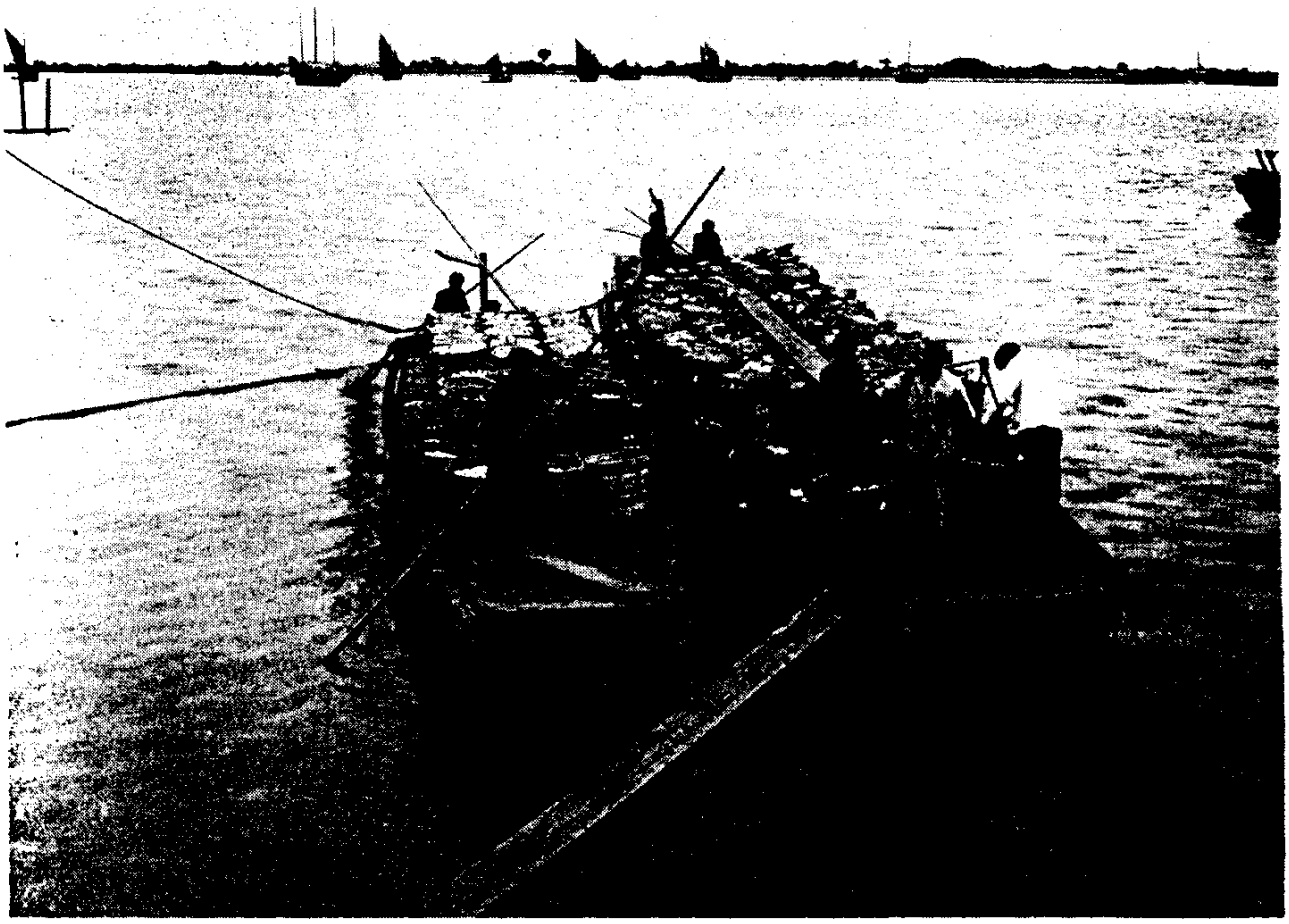

FIG. 4. Eggs for breaking being unloaded from a native junk at the American-owned plant of the Amos Bird Company on the Whangpoo River in Shanghai, China, 1920. Eggs were packed loosely in bamboo baskets, each containing 700 to 900 eggs. Surprisingly, egg breakage was small with leakers ranging from only 3 to 6 ercent. Despite occasional large river waves, caused by passing steamers, a coolie seldom lost his balance when walking down the narrow gang plank carrying eggs.

FIG. 5. Egg-breaking room of the Amos Bird Company, Shanghai, China, 1920. After candling, eggs were carried in square pails to the breakers who separated the whites from yolks with hand separators. The floor was constructed like a ship s deck to minimize slipping. Many of the Chinese women had "bound feet." When these women were first required to wear white aprons and caps, they resisted because white indicates mourning to the Chinese.

Most families kept a few hens which ranged for food and layed eggs in or around their owners' homes. Periodically an egg collector, with bamboo pole and attached egg baskets, would walk from village to village and purchase eggs from each house. Egg sales provided farmers one way to obtain a little money. When the collector's baskets were full, he walked to a larger village or small city and sold the eggs to dealers inside the city walls. A sizeable volume of eggs was collected in this manner. Egg dealers shipped their accumulations in baskets, each holding 700 to 900 eggs, by canal boats to large cities like Nanking and Shanghai. There the eggs went either to an egg breaking plant for freezing or drying or to exporters who packed them in rice hulls for further shipment to Japan and Europe. Surprisingly, the breakage of eggs in transit was quite small.

All frozen eggs shipped from China to the United States were packed by

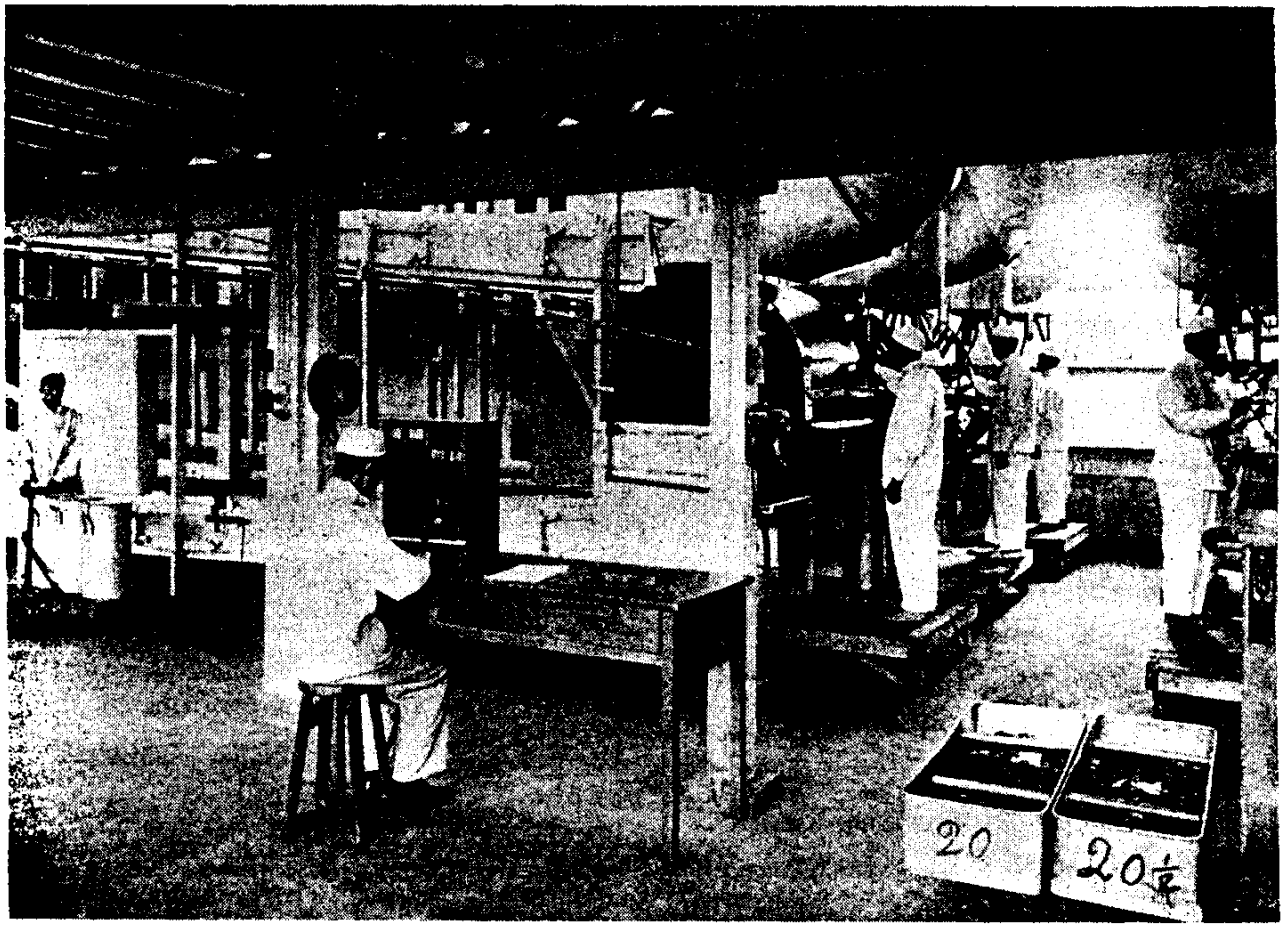

FIG. 6. Belt-type egg dryers in the Amos Bird Company, Shanghai, China 1920. Three of these units originally had been used in Topeka, Kans. A continuous tin belt, 1 yard wide, revolved on two drums set about 25 feet apart. Liquid whole eggs or yolk was spread in thin layers on the belt which passed through a heated duct. After sufficient moisture was removed, the flakes of dried eggs were scraped off, spread on wire-mesh frames to be cooled at 35° F. and then packed in tin-lined boxes for shipment to the United States and Europe. In the foreground the foreman is weighing samples to determine moisture content.

either American or British companies and their plants were operated under strict Western sanitation standards. The quality of Chinese frozen eggs, in general, was considered equal to that of the American product packed largely from undergrades at the time. In contrast, the Chinese product was packed from the usual run of eggs produced during the spring months when quality was generally good.

During 1921-31, a prime reason for the relatively heavy imports of Chinese dried eggs into the United States was their low cost compared with the American product. Another reason, particularly in regard to albumen, was the superiority of the Chinese product.

Drying of eggs in China had begun when German engineers built drying equipment there just prior to 1900.[29] During World War I, practically all German nationals left China and the Chinese took over the drying operations.

29. Termohlen, *et al., op. cit.,* p. 3.

The Chinese dried albumen was superior to the American product in "shelf life" and "whipping qualities" because of one important step in processing. Liquid white was allowed to ferment spontaneously before drying with the effective agents being primarily bacteria derived fortuitously from shells during egg breaking.[30]

At the time, it was unknown why the Chinese were able to produce a better product than the Americans could. But years later, American scientists discovered (1941) the important role played by bacterial fermentation. The process improved shelf life by removing the glucose naturally present in egg whites and, in addition, improved the product's whipping qualities by removing yolk contamination and the protein mucin.[31]

One early attempt was made to dry unfermented whites in China under American supervision and the flake product [32] was shipped to the United States. However, by the time it arrived in this country, the product had turned pink and was insoluble. Chinese albumen driers were aware of the superior performance of their albumen and tried to keep their methods secret.[33] Persons visiting their drying plants were not permitted to see certain phases of processing.

Tariffs on Egg Products

Egg producers in the United States viewed the heavy imports of Chinese frozen and dried eggs with increasing concern. As it became evident that the domestic industry had sufficient productive capacity to supply this nation's normal requirements of shell, frozen, and dried eggs, cries grew louder for higher tariffs.

Since the early 1920's import duties on egg products have varied considerably.[34] The Tariff Act of 1922 established import duties of 18 cents a pound on dried eggs and 6 cents a pound on frozen eggs. These duties were raised to 27 cents and 11 cents a pound, respectively, on dried and frozen eggs, under the Tariff Act of

30. J. Brooks and D. J. Taylor. *Eggs and Egg Products,* Department of Scientific and Industrial Research, Food Investigation Report No. 60, London, 1955, p. 59.

31. Letter, December 28, 1959, to the authors from G. F. Stewart.

32. The method of drying flake albumen has remained virtually unchanged over the years. Liquid egg is poured into pens in drying cabinets. On drying, fragile thin sheets form and, when scraped from the pan, break into small flakes.

33. An incident in the early 1920's illustrates how valuable the Chinese regarded their secret. One day, J. G. Halpin of the poultry department at the University of Wisconsin, was visited by a Chinese businessman representing the "North China Farming Federation," a group of promoters. He had pictures of large tracts of gently-rolling land in North China which, at that time, could not be farmed because of bandit activity. The promoters had visions of building roads and, aided by the Chinese Army, restricting bandit activity thus making possible the settlement of this area. It was proposed that farmers would produce eggs to be dried and shipped to the United States and Europe.

The Chinese offered young Halpin a professorship at the University of Peking. His job was to train men who, in turn, would demonstrate to Chinese farmers the modern methods of incubation, brooding, and egg production. He was offered a five-year contract, a year's leave in the United States at full pay, a pretentious house and a house staff of four men and one serving woman. Halpin knew that Americans had been trying, but without success, to learn the Chinese secrets in drying eggs, particularly albumen. So he asked his Chinese visitor, "If I should take this job, I would learn all about your egg-drying operation. What would there be to prevent me from coming back to the Unitesd States and using this secret information?" "You could ," his Chinese visitor replied blandly and frankly, "but not live." (Letter, February 13, 1959, to the authors from Professor Halpin.)

34. C. F. Wells, *United States Tariff Rates on Agricultural Products* (Revised), U. S. Department of Agriculture, May, 1951, p. 35.

1930. In 1948, the General Agreement on Tariffs and Trade led to appreciable reductions in tariff barriers. The United States gave and received significant concessions. As a result of the agreement, U. S. import duties were lowered to 17 cents a pound on dried eggs and 7 cents a pound on frozen eggs. However, after China withdrew from the program, the United States terminated its concessions to China in late 1950 and duties effective under the Tariff Act of 1922 were restored.

Inflationary pressures resulting in higher prices in the late 1920's made it possible to import both frozen and dried eggs despite the high tariffs. However, during the depression of the 1930's low domestic egg prices greatly diminished the quantities imported. After 1929, frozen egg imports practically stopped although small quantities of dried eggs continued to come in (Fig. 3, page 12).

Early Methods of Packing Frozen Eggs

Up to the late 1920's, cans of frozen eggs were packed with varying weights. The weight per can was 31 pounds for whites, 32 pounds for whole eggs, and 34 pounds for sugared yolks. Although egg cans were all the same size, different weights were used to fill the cans completely.

The cans were filled in three stages, to freeze the liquid egg as rapidly as possible. The weight of each fill, by products, was :

	1st fill	2d fill	3d fill
Whites	10 lbs.	11 lbs.	10 lbs.
Whole eggs	10 lbs.	12 lbs.	10 lbs.
Sugared yolks	10 lbs.	14 lbs.	10 lbs.

When "sharp freezers" became available, this practice was discontinued. By 1930, all frozen eggs were being packed 30 pounds to the can because food manufacturers had found the different weights confusing.

THE REVIVAL OF EGG DRYING IN THE UNITED STATES: 1932-40

Factors Favorable to Re-establishment of Egg Drying

Several factors were responsible for stimulating the resumption of egg drying on a commercial scale in the United States. First, the outbreak in 1927 of the Chinese Civil War tended to curtail exports of dried eggs. Second, during the early 1930's prevailing low shell egg prices in the United States resulted in a more favorable competitive relationship with Chinese prices. Third, higher import duties were established in 1930 on frozen and dried eggs.

A fourth factor was research. Up to this time Chinese albumen generally had been preferred to the domestic product because of its greater "whipping qualities." But American scientists directed their research efforts toward improving the Chinese method of bacterial fermentation. Probably the first advance was to take starter cultures from a vat that had good fermentation and inoculate subsequent

FIG. 7. An egg-breaking room in 1930. Eggs were brought to the breaking tables in 30-pound cans, instead of egg cases, and girls stood while breaking eggs. Funnels were placed on top of the cans of liquid egg at the breaking table in an attempt to keep out pieces of shell. Each cup was smelled individually before it was emptied into the liquid egg can. To double check, each full can was smelled before it was emptied into the churn. These precautions were taken to keep eggs with off-odors, particularly musty eggs, from getting into the product.

vats.[35] It was also discovered that one of the predominant organisms in a satisfactory fermentation was "Aerobacter aerogenes," which is found in soil and quite readily available. The next improvement was to use this organism in a pure culture. The process was called "controlled bacterial fermentation."[36] These developments made possible the production of domestic albumen solids fully equal in performance to the Chinese product.

In 1936, there were 15 egg-drying plants in the United States. A few were on the Pacific Coast but most were located in the Midwest, with six in Texas.[37] This small group of drying plants laid the ground work and fur-

35. R. H. Forsythe, "Sugar Removal from Egg White Solids," *Poultry Processing and Marketing,* March, 1953, pp. 23-24.

36. *Ibid.,* p. 24.

37. Termohlen, *et al., op. cit.,* p. 8.

nished the nucleus for the tremendous expansion in egg-drying operations during World War II.

The Demand for Yolks and Whites

Prior to the invention of the egg separator in 1912, there had been good demand for whites by bakers and confectioners, but relatively small supplies of yolks had restricted their use. As a consequence, the price of whites at times was higher than that of yolks. However, use of the egg separator greatly improved the efficiency of egg breaking and resulted in much larger supplies of separated products. Bakers, and mayonnaise, noodle and ice-cream manufacturers began using frozen yolks in increasing quantities and doughnut-mix manufacturers found dried yolks very convenient. Thus demand for yolks increased but the demand for whites did not expand proportionately, and the industry was faced with the difficult problem of keeping the consumption of whites and yolks in relative balance. This problem continues to trouble the industry intermittently. In 1938, the following statement was made:

> Expansion of market outlets for egg albumen appears to be particularly desirable. The demand for frozen albumen is considerably more inelastic than the demand for frozen yolk, and in many years prices of frozen albumen have had to be materially reduced in order for the large supplies of this product, occasioned by an expanding demand for yolk, to be consumed. Frozen albumen is therefore in the nature of a "by product" of the production of frozen yolk. Further research resulting in the development of new uses for albumen in any form should result in a reduction in the selling price of both frozen and dried yolk, without lowering prices paid for shell eggs. This would benefit the poultry industry by encouraging an increased use on the part of food manufacturers.[38]

The Spray Dryer and Other Technological Developments

During the mid 1930's the spray dryer, which had been used for drying milk, was adapted to dry whole eggs and yolks. In this dryer, liquid egg is forced under pressure of approximately 3,500 pounds per square inch through fine nozzles into the drying chamber. In the chamber heated filtered air, forced through the dryer by a powerful blower, comes in contact with the fine spray of liquid egg causing it to dry instantly and fall as a fine golden powder. Widespread use of this relatively efficient dryer was a significant technological factor in the rapid expansion of dried egg production during World War II. This type of dryer, with improvements in design, is still used extensively. Around 1939, it was adapted to dry whites as well as whole eggs and yolks.

During the late 1930's, equipment was developed to remove all pieces of egg shell and chalazae from the liquid egg. This innovation further enhanced the product's acceptability by bakers and other users. About this time processors also began to provide laboratory facilities for quality control work related to egg breaking and drying operations.

38. *Ibid.,* p. 63.

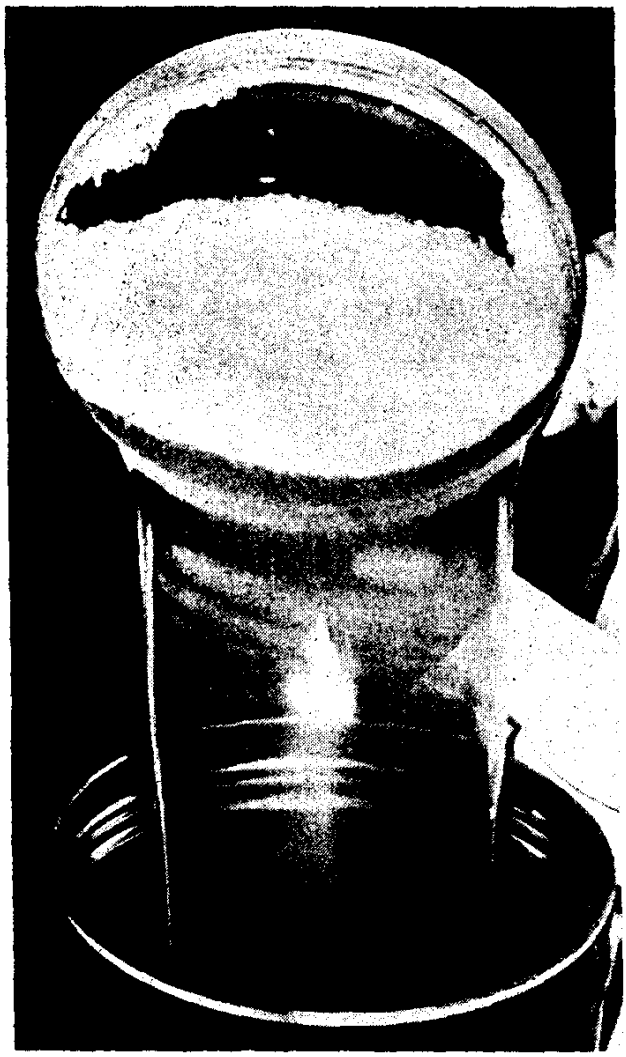

FIG. 8. The "pour-off test" for whites is made to be certain that no holes are present in the strainers. All liquid eggs pass through a fine screen with holes .024 inch in diameter that remove pieces of shell and chalazae. Holes of the screen are smaller than openings of nozzles used in spray drying, thus clogging of nozzles is minimized.

By 1938, pasteurization of liquid whole eggs was practiced on a commercial basis for the purpose of improving the keeping quality of egg products.[39] The process was used extensively during World War II, when the Armed Services required that all whole eggs prepared for them be pasteurized before being dried.

In 1941, scientists showed conclusively that removal, by the bacterial fermentation technique, of glucose from liquid albumen before drying resulted in albumen solids with remarkable stability.[40] This discovery was one of the major contributions of research efforts near the outbreak of World War II.

A new frozen egg product--whole egg, enriched by additional yolks, found increased acceptance. It became known as "fortified whole egg." Also, about this time, the "Irish sucker" so named for its inventor, J. C. Irish, made its appearance in egg-breaking operations. This suction device recovered any remaining edible albumen, previously wasted, from the egg shells.

About 1935, the industry began making "technical albumen." Spent shells were taken directly from the breaking room, crushed and run through a centrifugal extractor which salvaged the remaining nonedible liquid albumen. This liquid was then dried for sale as technical albumen, a product used to fasten cork inserts in beverage bottle caps.

Types and Quantities of Dried Eggs Packed, 1938-40

At the outbreak of World War II, a relatively high proportion of the eggs dried in this country consisted of separated products, albumen and yolks, while only a small amount of dried whole egg was packed. (Table 1.)

The 15 drying plants then in operation actually had had little experi-

39. Committee on Foods, National Academy of Sciences--National Research Council, "Stability of Dehydrated Eggs—A Symposium," September, 1954, p. 62.

40. Brooks and Taylor, *loc. cit.*

TABLE 1.-Dried eggs: [1] Annual production, United States, 1938-40.

(Number of pounds)

YEAR	Whole eggs	Albumen	Yolks
1938	700,000	11,300,000	9,500,000
1939	700,000	17,300,000	16,600,000
1940	1,400,000	14,400,000	11,400,000

1. Liquid weight equivalent.

Source: "Poultry and Eggs: Liquid, Frozen and Dried Egg Production, 1938-49." Revised estimates, USDA, September, 1953. p. 24.

ence in drying whole eggs. The product packed usually had a moisture content of 8 percent or more. Little was known about its shelf-life except that quality was preserved better under refrigeration than without it. Since the "leavening ability" had been reduced by the drying process, bakers were not interested in using dried whole eggs.

EXPANSION DURING WORLD WAR II: 1941-46

Egg Production Stimulated by Price Supports

In the spring of 1941, plans were inaugurated for agricultural products to be included under the lend-lease program. At the same time a program was set up by the U. S. Department of Agriculture to encourage increased production of eggs for the next two years. Expansion was to be stimulated by government purchases of eggs in the open market at supported prices. The purpose was to provide for export requirements under provisions of the lend-lease program while maintaining about normal levels of per-capita consumption in the United States.[41] Other details of the government program were:

> In addition to the uses in the lend-lease program, supplies of eggs acquired through Department purchases will be available for direct distribution in this country through State relief agencies to needy families and for free school lunches; for release on the market in case of unwarranted speculative price increases; and to meet requests from the Red Cross for shipment to war refugee areas.[42]

Fortunately, unlike World War I days when feed for poultry production was scarce, ample supplies of feed were available. Total production of eggs in the United States increased from 41.9 billion eggs in 1941 to 56.0 billion eggs in 1946.[43]

Prior to 1941, the Department of Agriculture had purchased only shell eggs in its price-support activities. But in May, 1941, it began purchasing dried and frozen egg products in addition to shell eggs.

The Increase in Egg Drying Facilities

As the war progressed, the demands for ocean-shipping space multiplied. This situation was further complicated by the damage inflicted by

41. *The Poultry and Egg Situation,* BAE, USDA, April, 1941, p. 3.
42. *Loc. cit.*
43. *The Poultry and Egg Situation,* AMS, USDA, November, 1958, p. 24.

enemy submarines starting in late 1941. Because of the tight shipping situation, dried eggs were extremely important to the lend-lease program. Drying of eggs for lend-lease started in May, 1941, and drying facilities in the United States increased rapidly. Prior to 1941, peak annual production of dried eggs by 15 drying plants was about 10 million pounds. "On the basis of a 20-22 hour day and 300 days' operation, plants in existence in early 1941 probably had the capacity to produce 50 million pounds of dried (whole egg) product." [44] With government encouragement and some granting of priorities, additional plants were erected in 1941. It was expected that, by January, 1942, the industry's total capacity, on an annual basis, would be "between 130 and 140 million pounds." [45] However, production greatly exceeded expectations and, in the first six months of 1942 alone, totaled about 130 million pounds.[46]

In August, 1942, the drying capacity of plants then in operation was about 315 million pounds, based on 300 days' operation of 20-22 hours per day, and the Food Requirements Committee recommended a further expansion of egg-drying facilities by 110 million pounds.[47] In September, 1943, domestic egg-drying capacity was estimated at 420 million pounds, on an annual basis.[48] The peak number of drying plants during World War II was "in the neighborhood of 135." [49]

Government Purchases of Egg Solids

During the period 1941-45, purchases of eggs and egg products by the Department of Agriculture totaled about 88 million cases, which represented 12.5 percent of the total number of eggs produced on farms during those years. About 90 percent of the purchases were in the form of spray-dried whole eggs. During the same period military purchases were "equivalent to about 57 million cases, or 8 percent of total farm egg output." [50] Purchases by the Department of Agriculture during this period were largely for lend-lease requirements.

Most of the egg solids purchased by the government were packed in 150- and 200-pound barrels. "For some purposes, the Department of Agriculture contracted with firms to package considerable quantities of the dried product previously purchased in consumer-size packages of 5 ounces net." [51] Egg solids purchased by the Armed Services were packed in 3-pound sealed cans.

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44. *The Poultry and Egg Situation,* BAE, USDA, September, 1941, p. 12.
45. *Loc. cit.*
43. *The Poultry and Egg Situation,* BAE, USDA, August, 1942, p. 4.
47. *Ibid.,* pp. 4-5.
48. *The Poultry and Egg Situation,* BAE, USDA, September, 1943, p. 16.
49. Letter, August 29, 1958, to the authors from B. W. Kempers, Grading Branch, Poultry Division, AMS, USDA.
50. *The Poultry and Egg Situation,* BAE, USDA, April-June, 1946, p. 5.
51. *The Poultry and Egg Situation,* BAE, USDA, May, 1942, p. 6.

Continuous Inspection Program for Egg Products

In 1942 the Department of Agriculture began inspecting on a continuous basis, in breaking and drying plants. When the service was inaugurated, an inspector was available at all times to make the official check weighing and sampling of products for laboratory analysis. Later the inspector's duties were broadened to include other specific requirements, particularly with respect to candling eggs and the removal of loss (inedible eggs) .[52]

Also, during 1942 the first minimum sanitary requirements applicable to plants operating under federal inspection were prepared. Resident inspectors first began working under a program of minimum sanitary, operating, and facility requirements in August that year.[53]

Shelf Life Problems with Whole Egg Solids

At the outbreak of World War II in 1939, very little was known about the keeping quality of dried whole eggs. Nevertheless, stimulated by strong de-

52. Letter, August 29, 1958, to the authors from B. W. Kempers, Grading Branch, Poultry Division, AMS, USDA.

53. *Ibid.*

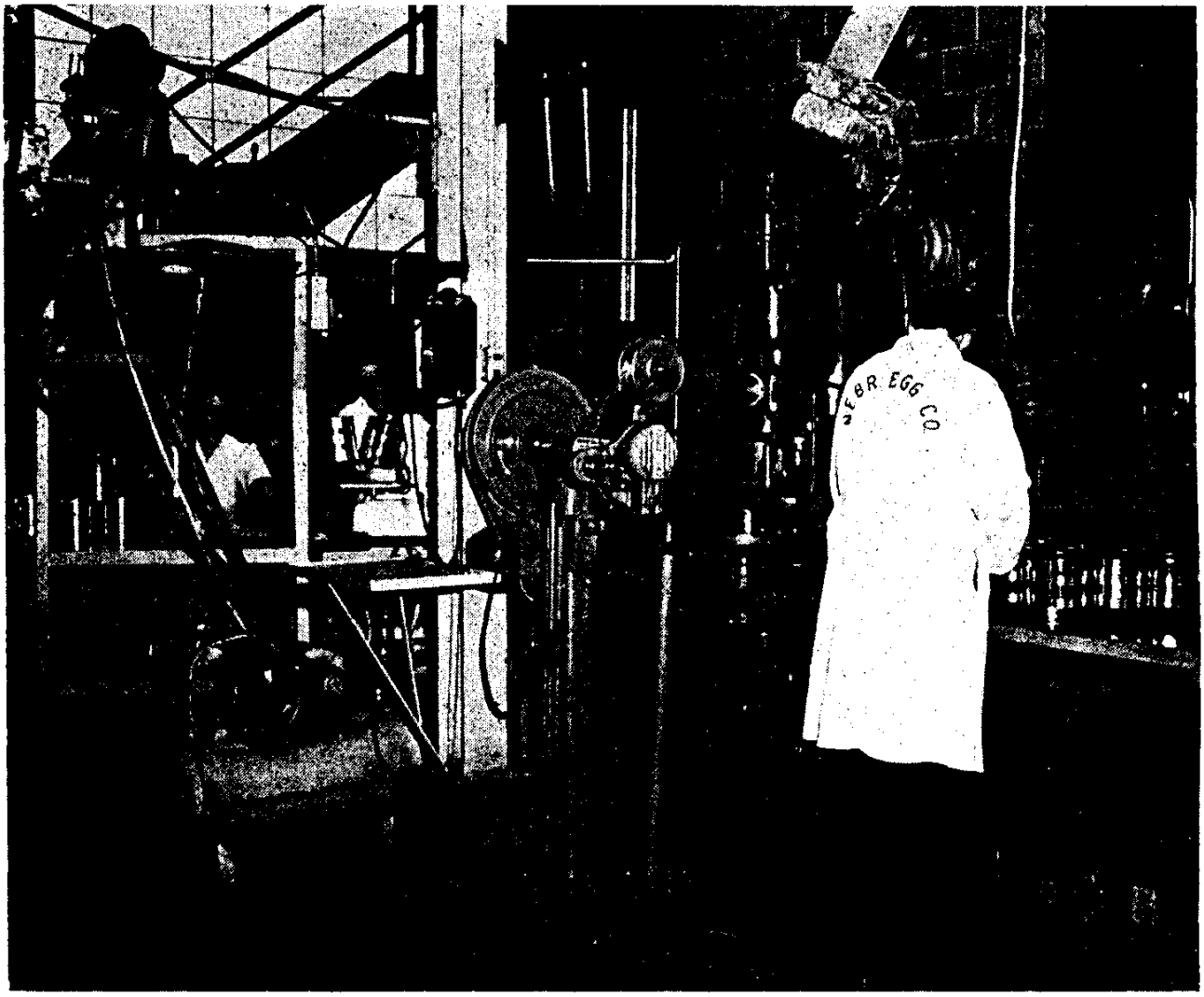

FIG. 9. Packing egg solids in 3-pound, hermetically sealed cans.

mand, production of whole egg solids expanded almost a thousand fold from 1940 to 1944. (Table 2 and Fig. 3, page 12). This expansion occurred despite a wartime shortage of strategic metals to manufacture new drying equipment and the lack of trained personnel by industry and the government for its inspection program.

TABLE 2.—Whole egg solids: Annual production, United States, 1940-44
(1,000 pounds)

Year	Production
1940	392
1941	31,241
1942	226,127
1943	252,903
1944	311,369

Source: "Poultry and Eggs: Liquid Frozen and Dried Egg Production, 1938-49." Revised estimates, USDA, September, 1953, p. 24.

During packing, the powder had to pass rigid government inspection tests for palatability and other quality criteria before it was accepted for shipment. However, it was seldom possible to store the product under continuous refrigeration until it was consumed and objectional off-flavors developed which seriously affected its usefulness. An objective appraisal of the quality and shelf life of most of the dried whole eggs produced during World War II follows:

> The initial quality . . . was good. The bad reputation given to dried eggs during the War was justified because the product deteriorated seriously between the time it was prepared and the time it was offered for consumption.[54]

During World War II, scrambled eggs made from dried whole-egg powder was a rather common item in the daily menu of our armed services. Therefore, product deterioration presented a knotty problem.[55]

To determine causes of quality deterioration, a broad research program was undertaken in which the efforts of industry and government were coordinated.[56] Joint efforts of collaborative laboratories resulted in the production of whole egg powder with improved "stability." Modifications in processing and packaging methods included: More sanitary handling of liquid melange; pre-heating or pasteurization before drying; rapid cooling of the product after drying or redrying; production of low-moisture (2%) powders; and packaging the powder under inert gases in hermetically-sealed containers.[57]

Laboratory findings were quickly adopted in commercial practice. "Some plants were producing prod-

54. H. Lineweaver, and R. E. Feeney, "Improving Frozen and Dried Eggs," *1950-51 Yearbook of Agriculture,* p. 654.

55. An incident related by an Army officer indicates the ingenuity of one mess sergeant.
"One of my duties as batallion mess officer in Germany was to check the daily menu against the cook's work sheet.
"One day when scrambled eggs were on the breakfast menu, the cook's work sheet listed powdered eggs followed by the note, 'Add one broken eggshell.' Perplexed, I asked the mess sergeant why he was feeding the troops eggshells with their scrambled eggs.
" 'Just using a little psychology, sir.' he replied. "The boys don't go for these powdered eggs at all, and when they bite into a piece of eggshell they think they're eating the real McCoy. There's hardly any waste nowadays.' " (By permission of Reader's Digest, September, 1959, pp. 17-18, story by K. D. Bigelow.)

56. The program became known as the "Coordinated Dried Egg Research Program." Funds were supplied by Federal agencies, state research institutions, individual companies and the National Egg Products Association.

57. Western Regional Research Laboratory, USDA, "A Report on the Status and Significance of Glucose-free Whole Egg Powder." 1950, p. 2.

ucts of superior initial quality and shelf-life only a few months after the necessary basic information was made available by the collaborators."[58]

The improvement in initial product quality and in the shelf life of commercially-dried whole egg was very marked. The coordinator of the "Coordinated Dried Egg Research Program," stated:

> Whereas the product of a year ago was, in numerous cases, poor in sanitary quality and initial palatability, with a shelf-life of only a very few weeks at 100° F. and a few months at 70° F., it can now be prepared with low bacteria count, excellent flavor, and with a shelf-life of several months at 100° F. and about a year at 70° F.[59]

Contributions of USDA's Mobile Laboratory[60]

During the early years of World War II, many new egg-breaking and drying plants were established over the country. In the interest of promoting more efficient production of quality egg products vitally needed for the war effort, the government set up a mobile laboratory unit headed by Dr. H. E. Goresline and Dr. V. H. McFarlane. This unit used commercial egg and poultry plants as field laboratories to collect information and to develop improved methods of processing, sanitation, and quality control. Studies were made of incoming raw materials, handling and processing methods, and the quality of final products.

The laboratory unit was of service to industry members by providing demonstrations of "approved" plant techniques and by training plant personnel. It also helped to point out and correct specific weaknesses in existing plant operations or techniques, particularly in relation to efficiency of production and product quality. When a plant failed to meet government product specifications, a technologist was sent to investigate the matter and make necessary recommendations to correct the trouble.

When the war ended, the Mobile Laboratory was continued as a part of the research and development program of the U. S. D. A. Many plants cooperated by making their facilities available for full-scale experiments. For example, pasteurization of liquid whole egg for drying, on a commercial basis, was studied and techniques developed are in use today.

Lessons from Feeding Dried Eggs to Undernourished People

During World War II, use of a special diet resulted in almost miraculous speedups in recovery of many war-wounded and starving victims of concentration camps. The diet consisted of water plus a mixture of powdered egg and powdered milk which tasted like eggnog or ice cream. It was reported that:

> Of 92,000 soldiers liberated from German prison camps and treated with this bland diet, only eight died, although 40 percent of them suffered from severe malnutrition and at least 80 percent were undernourished.

At Recovered Allied Military Prisoners'

58. G. F. Stewart, coordinator, "Coordinated Dried Egg Research Program," Report No. 2, December 10, 1944, p. 63.
59. *Loc. cit.*
60. Based on letter, January 13, 1960, to authors from H. E. Goresline.

camps, daily sick call rate averaged more than 20 percent when the men were fed an ordinary Army ration. About four-fifths of the complaints were due to stomach and intestinal disturbances. One week after the bland diet was introduced, the sick call rate dropped to 4 percent. There were no cases of nausea and vomiting, and only 15 percent of the complaints were due to intestinal disturbance.

The egg and milk mixture sped Army wounded and post-operative patients in Europe back to duty in about one-third the average time. The high protein content of the mixture, together with its high calorie value from the fat and carbohydrate, and its lack of irritation to the stomach and intestines constitute its advantages. Prolonged convalescence will be a rarity when this war lesson is applied.[61]

POSTWAR TRANSITION: 1947-50

The poultry industry now faced the task of readjusting egg production and the manufacture of egg products from the high war-time levels to normal peace-time requirements. However, the transition was made easier by the fact that the nation's armed forces had to be supplied until brought home and demobilized, and shipments for foreign relief had to be continued until war-torn nations could rebuild their own sources of food supplies.

As late as the spring of 1951, large

61. Science News Letter, October 19, 1946 (based on a report by Dr. Herbert Pollack, Mount Sinai Hospital, New York. During World War II, Dr. Pollack was chief medical consultant for the United States Army in the European Theater.)

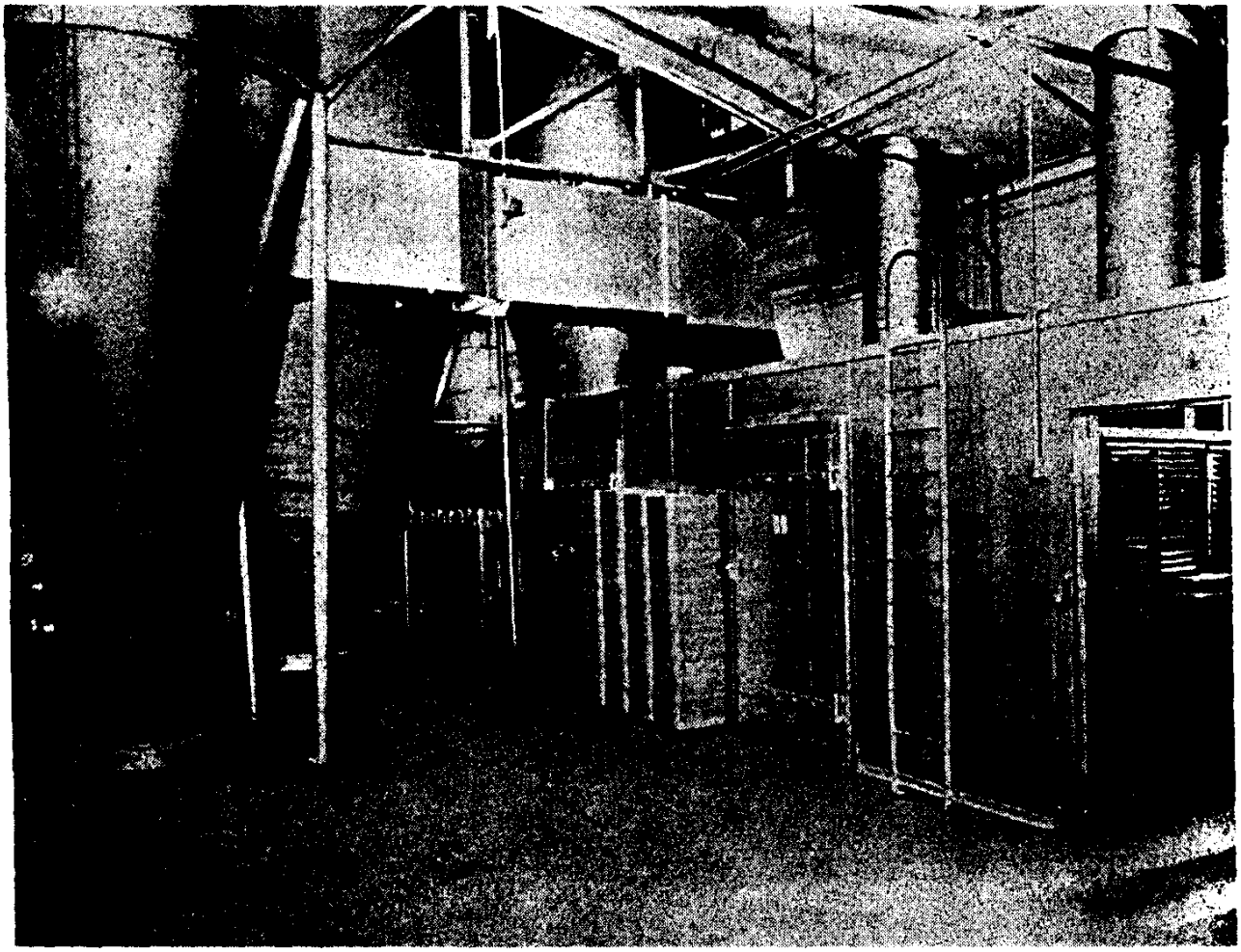

FIG. 10. These egg-drying facilities consist of two cone-type spray dryers (on the left) for drying whole eggs, yolks, or special products. On the right is a pan dryer for flake-type whites.

quantities of whole egg solids were still being exported, including 25 million pounds sold to the United Kingdom from stocks that had been purchased by the Department of Agriculture for price support purposes in 1950.[62] So high level egg production of the war period continued. Under the price support program, the Department of Agriculture made the following purchase of whole egg solids during 1948-50.[63]

Year	*Million pounds*
1948	28
1949	69
1950	82

Reduction of Egg Drying Capacity

After the war many drying plants closed but a number of firms that had established breaking rooms to supply their own dryers continued to break and freeze eggs. In 1950, the Department of Agriculture supported the price of eggs and bought the surplus production in the form of dried whole eggs. This government program probably helped to ease the industry's transition to a peacetime economy. At that time about 60 egg-drying plants,[64] considerably fewer than the wartime peak of 135, were in active operation in the United States.

Influence of Price Supports and the Egg Drying Program on Egg Quality

During the postwar transition, another problem facing the egg industry was the re-establishment of quality egg programs. During the war, heavy demands for eggs to be frozen and dried had played havoc with graded-egg buying programs. Witness this statement:

> Influence of the vast lend-lease procurement program was felt in all quarters, and patterns of the industry were greatly altered. Government buying at country points short-circuited the movement to central markets and the emphasis on frozen and dried eggs virtually wiped out quality distinctions.
>
> With the government paying liberal prices to encourage egg drying, values of current receipts and undergrade breaking stock were almost on a par with graded shell eggs.[65]

It was this situation at the end of the war that prompted many states of the North-Central Region to pass new egg laws with the primary objective to improve egg quality.

Research on Egg Products

During 1947-50, a broad program of research on egg products was carried on by both government and industry laboratories. The detection of Salmonellas in dried whole egg imported into the United Kingdom from the U.S.A. during World War II stimulated considerable research on the problem. The attention of scientists centered on the proper method of thermal pasteurization, that is, the exact holding time and temperature for the control of Salmonella, without appreciably affecting the functional qualities of the product. Research conducted over several years was successful and the government finally issued specifications concerning the preparation of whole egg solids that it would purchase. As of 1958, the Department of Agriculture specified, "the strained or filtered liquid egg

62. *The Poultry and Egg Situation,* BAE, USDA, March, 1951, p. 13.
63. *The Poultry and Egg Situation,* BAE, USDA, November-December, 1950, p. 9.
64. *Ibid.,* p. 8.
65. Dairy-Produce Year Book, 1941, pp. 99-100.

FIG. 11. A modern "hand-operated" breakroom with three complete lines of breaking conveyors. There are 104 breaking positions in this installation.

shall be flash-heated to not less than 140° F. and held at this temperature for not less than 3 minutes and not more than 4 minutes." [66]

An important discovery showed that a principal cause of the loss in palatability of whole egg solids during storage was due to reaction between the sugar, glucose (1.2% of egg solids), and the lipid constituent, cephalin. Removing glucose before drying became the most direct way to eliminate palatibility loss.[67]

A simple method of removing glucose by yeast fermentation before drying was perfected and resulted in

66. Poultry Division, AMS, USDA, *Regulations Governing the Grading and Inspection of Egg Products,* effective December 1, 1958, p. 14.

67. Western Regional Research Laboratory, USDA, *op. cit.,* p. 18.

whole egg solids with greatly improved shelf life.[68] It was also demonstrated that pre-acidification of liquid eggs before drying retarded the glucose-egg protein reactions that are largely responsible for solubility and texture changes in the egg.[69]

Research continued on methods of processing albumen solids that would make angel food cakes comparable in texture and fluffiness to those using fresh or frozen whites. The efforts were successful and led to the now popular angel food cake mix.

Ways to improve the lifting ability of whole egg and yolk solids in cake making also were developed and encouraged bakers to substitute egg solids for frozen eggs.

Industry Laboratory for Egg Products

The National Egg Products Association in 1947 established a laboratory to assist plants in maintaining quality controls for egg products. When the NEPA became part of the Institute of American Poultry Industries in 1953 the Institute agreed to continue the laboratory services. Its testing services include: "Control services and analysis for percent solids content, percent sugar, salt and fat tests, NEPA color, bacteria count, coliform counts, yeast and mold counts and solubility tests."[70]

The Institute's Egg Products Laboratory has been particularly useful to firms that do not have laboratory facilities. The laboratory also provides a "referee" service for other firms, to check or confirm tests on egg products, and it conducts an annual training school for plant personnel. In addition, many requests are handled from plants for information relating to equipment, operating procedures, and quality and sanitation problems encountered in the breaking, freezing, and drying of eggs.

A noteworthy contribution of the Laboratory was its development of a standard procedure, the NEPA color test, to determine color of yolks. Before the industry officially adopted this method considerable confusion existed arising from the use of different color tests. In 1959, a new color test, the B-carotene method, was approved by the Laboratory and probably will gradually replace the original NEPA color test.

Implications of Reduced Imports of Dried Egg Yolk

Trade between Red China and the United States was stimulated by tariff reductions under the General Agreement on Tariffs and Trade in 1948. But the outbreak of the Korean War in 1950 cut off U. S. imports of Chinese dried eggs into this country. This development caused industry leaders to foresee possible difficulties arising from changes in relative supplies of albumen and yolk. The possible significance of these events was analyzed in 1951 as follows:

> In December, 1950, the United States "froze" the American dollar balances owned by Red China or by her nationals, and the Red Chinese Government declared an embargo on exports to the United States. . . . Of the 7.4 million pounds of dried

68. *Ibid.,* p. 19.
69. *Loc. cit.*
70. Institute of American Poultry Industries, Annual Report, May 1, 1955--April 30, 1956, p. 10.

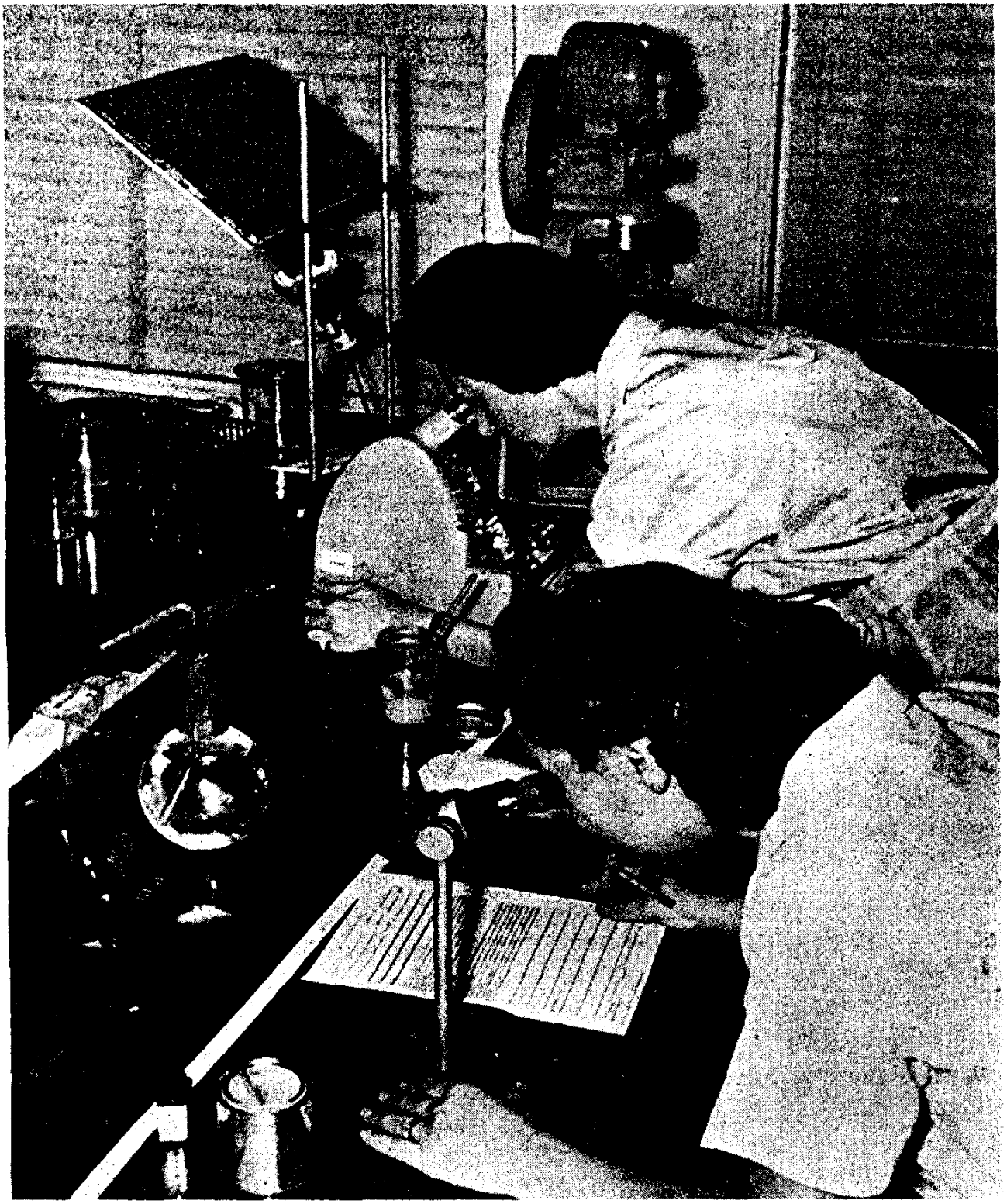

FIG. 12. The Institute of American Poultry Industries' laboratory showing equipment used for quality control and product analysis. In the foreground are two types of refractometers used to determine percentage of solids content. In the background are a Hobart mixer and equipment for the surface film test to measure the percentage of yolk in whites.

yolk imported into the United States in 1950, 7.2 million pounds or 97 percent was from China. The quantity of dried yolk imported from China in the year was equal to the yolk from 982,000 cases of eggs. Imports of dried albumen from all sources during the same period were 192,000 pounds, equivalent to the albumen from only 68,000 cases of eggs. . . . If the potential decrease in Chinese imports is to be offset by an increased domestic production of egg products separated to yolk and albumen components, there will be an increased supply of albumen available from domestic production. . . . Yolk and albumen separately from whole egg or mixed egg products comprise an important proportion of the trade in frozen and dried egg products. Accordingly, changes in the proportions of albumen and yolk available in the U. S. market might be expected to alter the price relationships between the two components of the egg.[71]

EXPANDING DOMESTIC USE OF EGG PRODUCTS AND AUTOMATION IN EGG BREAKING: 1951-59

Dried Eggs Officially Renamed Egg Solids

Unfortunately, reasons for the off-flavors (loss in palatability) of dried whole eggs were not discovered until near the end of World War II. During the war a certain stigma became attached to the term "dried eggs" by the nation's armed forces. This was a challenging problem that the industry knew it must overcome if dried eggs were to be acceptable to the general public.

In 1952, domestic dryers organized the Egg Solids Council to improve and promote the use of egg solids. Since research had now corrected the problem of off-flavors and had greatly improved the product's stability, it was decided to drop the term "dried eggs" and to adopt the term "egg solids."

Increased Demand for Egg Products

Research after World War II period now began to bear fruit. The use of frozen yolks in baby food expanded rapidly. The cake mix industry became a large user of eggs, both shell and egg solids, particularly albumen solids for angel food and white cake mixes. The doughnut-mix industry continued to require large quantities of yolk solids, and egg solids gradually began to replace frozen eggs in bake shops.

Use of Egg Solids by Schools

In 1943, the Department of Agriculture began buying whole egg solids for distribution in the National School Lunch Program. By May, 1959, 37 million pounds had been purchased for this purpose.[72] In the beginning some schools were slow to use the product. Therefore, considerable effort was made to acquaint school lunch personnel with approved methods of storing and using egg solids in an attempt to overcome their prejudices and to obtain satisfactory results. Instructions for reconstituting whole egg solids and for determining quantities to use in recipes calling for shell eggs were sent to state school lunch agencies. In addition, many recipes using whole egg solids were sent to these agencies to use in their workshops.

In general, the state school lunch

71. *The Poultry and Egg Situation,* BAE, USDA, January-February, 1951, p, 16.

72. Letter, May 11, 1959, to Henry G. F. Hamann from H. D. Rorex, Chief, School Lunch Branch, AMS, USDA. A copy of this letter was given to the authors.

officials have been favorably impressed with the stabilized whole egg solids used in the school lunch program. The Department of Agriculture has had many requests for names of packers of this product. Excellent reports on the acceptability of whole egg solids in schools have been received.[73]

In 1959, 12 million children were eating lunches in schools that took full advantage of the National School Lunch Program.[74]

The Demand-Supply Situation for Yolks and Whites

During 1951-59, the uses of yolks in both old and new products continued to expand. When the cake-mix industry began to absorb sizeable quantities of whites, it was hoped that this demand would correct the excess supply of whites relative to yolks.

By 1953, interest in the new angel food cake mix and white cake mix had developed a good demand for whites. However, this created a problem for egg breakers who separated a substantial part of their eggs. Market outlets had to be found to use the yolks. But this particular problem was only temporary since the food industry soon developed new uses for yolks. Then consumption of whites by the cake mix industry and other users was insufficient to absorb all the whites produced while packing the required yolks. As a result, in 1958 and 1959, burdensome supplies of whites depressed the price of albumen solids while the price of yolks was relatively high. Thus history repeated itself, and the market situation became similar to that of 20 years earlier.

The unbalanced demand-supply situation for yolks and whites arose largely from the expanded use of yolks, necessitating increased production of whites for which demand is not so great. To sell the whites, it was necessary to price them at a low level.

Automation in Egg Breaking

Almost since its beginning in 1900 the egg-breaking industry had dreamed of mechanizing the breaking of eggs. One of the first breaking machines was invented in 1928 but could break only whole eggs. However, it was used relatively little until World War II when a strong demand developed for whole egg solids. During 1944, the machine was put into active operation. Because it was complicated and required constant attention, it was soon discarded. After the war, efforts to develop a breaking machine that not only "broke out" whole eggs but also separated whites and yolks were successful.

In hand breaking and separating eggs, a girl usually breaks 2 to 2½ cases an hour. But a girl operating an egg-breaking machine can break and separate 15 or more cases an hour. The breaking machine became the first major technological change in egg-breaking operations since the invention of the yolk-white separator in 1912. Now more plants are installing egg-breaking machines each year.

73. *Ibid.*
74. *The Poultry and Egg Situation,* AMS, USDA, March, 1959, p. 5.

Modern breaking machines make it possible to wash and sanitize all shell eggs before breaking and significantly reduce bacterial counts of the liquid raw material. Some breaking machines are equipped with a manually-operated device to enable the operator to select yolks according to color. By 1959, several firms had completely mechanized their egg processing operations. Also, use of insulated tank trucks to transport liquid eggs from the breaking room to a dryer at some distant point was increasing.

Contract Egg Production and the Egg Products Industry

Contract production in broilers, turkeys, and eggs for shell use caught the imagination of some breakers. While several reasons explain their interest in contracts, the need for a dependable supply of eggs for breaking was the principal motivation.

In certain important egg-breaking states of the North Central Region, notably Kansas and Missouri, egg production has declined since World War II. This decline, coupled with the expanding use of egg products, forced some breakers to go longer distances for supplies and increased their raw cost. The "drying up" of traditional procurement areas has caused increasing concern to many large breakers, and considerable thought has been directed to this problem.

One possible solution is "contract egg production" whereby large breakers contract with sizeable producers to take their entire year's production of eggs. The producers provide hous-

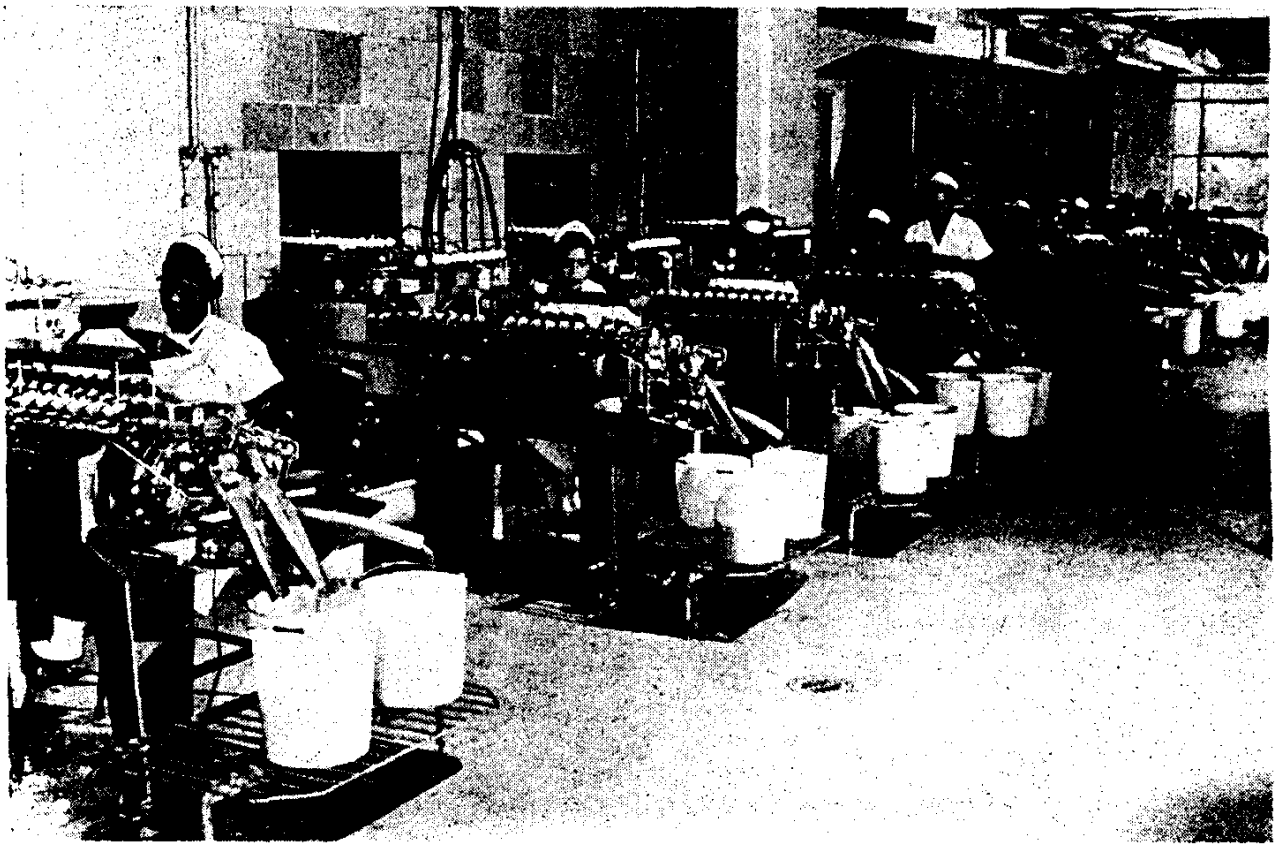

FIG. 13. Automatic egg-separating machines. At this plant, 12 machines break up to 1,500 cases of eggs per 8-hour shift. The machine operator inspects each egg in an individual cup.

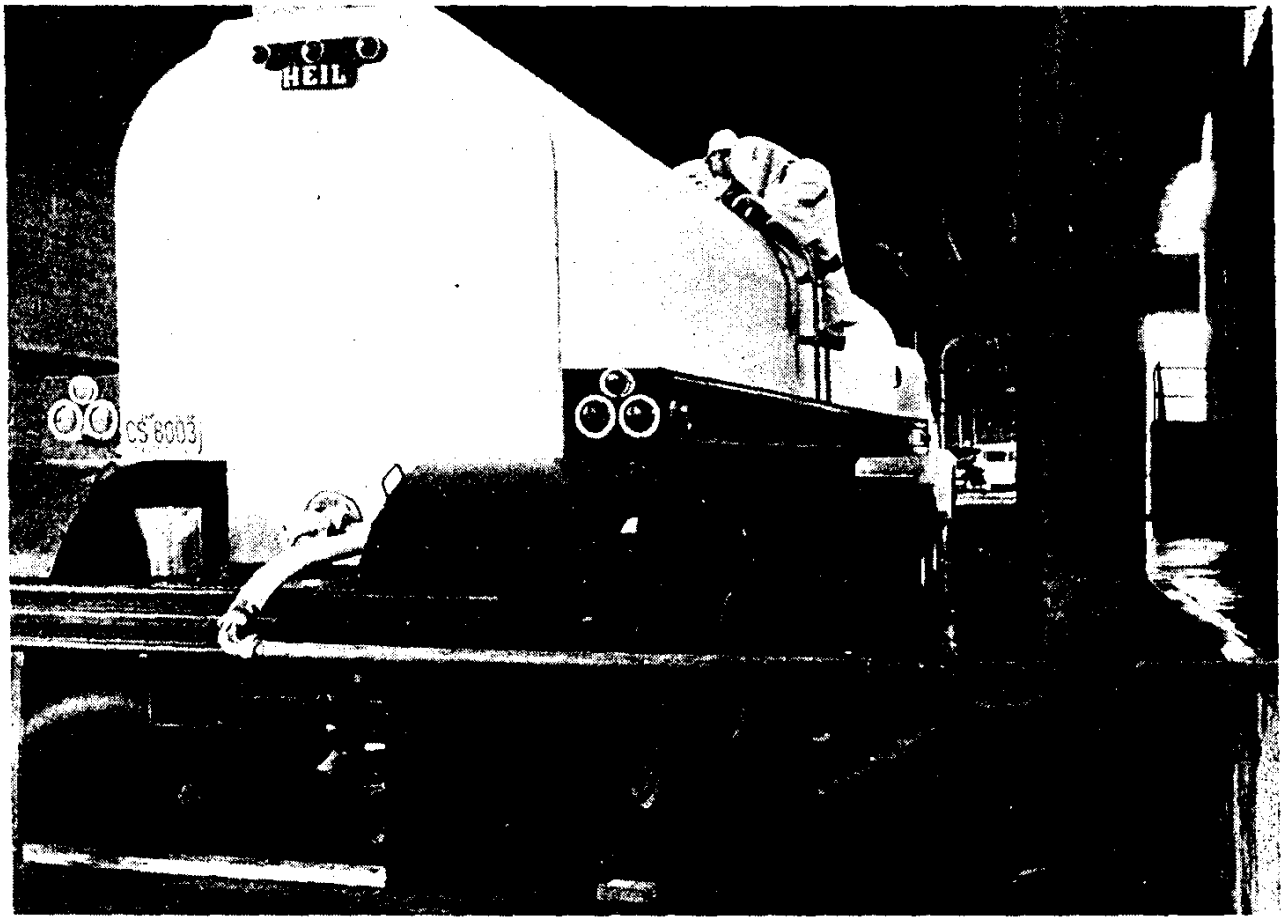

FIG. 14. A tank truck used to transport liquid eggs from an egg-breaking plant to a drying plant, sometimes located a considerable distance away. A 35,000-pound load of liquid whites is being pumped into tanks at the receiving plant.

ing, equipment, and labor while the egg breakers furnish feed, medications, ready-to-lay pullets, and necessary supervision. The producer and breaker sign an agreement covering a given period of years. A specified amount per dozen eggs produced is paid to the producer for his labor and the use of his buildings and equipment. All eggs produced are the property of the breaking plant.

Under contract production, it is believed that a concentration of large egg-producing units in a relatively small area would result in a steady supply of eggs, at lower costs of procurement, and of better quality. A growing demand for higher quality eggs by egg-breaking plants reflects, in turn, the constant efforts of food manufacturers to improve the quality of their products.

Although seasonal egg production has leveled out in recent years, egg breaking activity is still largely concentrated from January through June. However, demand for egg products is fairly steady each month and a relatively stable source of eggs for breaking the year 'round would be advantageous to the industry. Better seasonal distribution of supplies would reduce the size of inventories which firms pack and store during the spring to meet customers' requirements during the fall and winter. Thus the

speculative risk, which breakers prefer not to bear, of possible lower egg prices during the fall is lessened. Also, year 'round breaking probably would result in greater utilization of breaking facilities, improved plant efficiency, and perhaps solve some labor problems. Many breakers feel that, with sources of supply on a year 'round contract basis, the cost of raw material would depend more on the actual cost of labor and feed to produce eggs than is true today.

Some state egg laws now require that all eggs be bought on a graded basis. Egg breakers contend that the additional expense of candling and grading eggs that are destined for the breaking room simply adds to the cost of raw material without any compensating advantages. They also contend that, in states with compulsory grading laws, exemptions might be granted to breakers who have contracts with producers because, technically, the breakers and producers are partners in the egg enterprise.

This new development in procurement may have other impacts on the egg products industry. It could provide an opportunity for controlled feeding that would produce yolks of desired color. Also, breeders might develop a strain of layers to produce eggs with other characteristics most suitable for breaking purposes, in particular, eggs with a higher percentage of yolk.

In early 1959, contract production of eggs for breaking was being considered seriously in some areas. But when egg prices fell to unusually low levels, interest by egg breakers in such plans waned. However, the basic problem of procuring ample supplies for breaking in these areas still remains and will have to be solved.

Trading in Frozen Egg Futures

Rules and procedures for trading in futures contracts in frozen eggs [75] were established on the Chicago Mercantile Exchange [76] in 1945. While the product possessed all inherent characteristics necessary for futures trading, very little occurred prior to 1957.[77] There were several reasons. First, technical differences exist in manufacturing processes of individual firms. Therefore, the products of competing firms had slightly different specifications. Brand names for frozen egg products were emphasized and the largest firms resorted to aggressive selling of brand-name products. Second, in the pricing of frozen eggs between buyers and sellers, contracts were frequently used. A 1949 study estimated that "quality packers" of frozen eggs sold 75 percent of their pack by contracts.[78] Under such an arrangement, the processor contracted to supply food manufacturers with the quantity of egg products needed during the ensuing year. Frozen eggs were sold based on prices paid during

75. Standard grade frozen whole eggs, whites, plain yolks, sugared yolks and salted yolks.

78. Trading in frozen egg contracts is governed by rules of the exchange and is not regulated by the Commodity Exchange Authority.

77. Practically all trading has been confined to frozen whole eggs. A few cars of frozen egg whites were traded in 1959. There has been no trading in plain yolks, sugared yolks and salted yolks.

78. G. C. Kleiman, "The Role of the Frozen Egg Industry in the Marketing of Eggs," unpublished M. S. thesis, University of Illinois, 1949, p. 52.

TABLE 3.--Frozen whole egg futures: Volume of trading and contracts settled by delivery, Chicago Mercantile Exchange, 1956-60.

(Number of carlots)[2]

YEAR[3]	Volume of trading, by contracts					Contracts delivered
	October	November	December	January	All contracts	
1956-57	43	1	.....	4	48	20
1957-58	2,114	310	114	1,551	4,089	326
1958-59	861	49	.....	.....	910	75
1959-60 [4]	2,335	143	74	645	3,197	262

1. 1960 includes only the January contract.

2. The trading unit of 30,000 pounds of one uniform pack, from one regularly-established egg-breaking plant in the United States.

3. Because most trading in the January contract of a given year occurs during the year immediately preceding that of the delivery month, the January contract was grouped with the October, November, and December contracts of the previous year.

4. Preliminary.

Source: Chicago Mercantile Exchange Year Books, 1956-57, 1957-58 and 1958-59 and unpublished data for 1959-60 furnished by W. Kowalski, exchange statistician.

the breaking season for shell eggs plus allowances for processing costs and carrying charges. The contract provided definite market outlets, thus reducing uncertainty both on the selling and buying sides. Services of the future market were not essential, particularly for hedging protection. Third, prior to 1956, frozen eggs deliverable on futures contracts were not required to bear the USDA shield.

In 1956, the Board of Governors of the Mercantile Exchange announced a significant change in specifications for frozen egg contracts applicable to all contracts beginning with the "October 1956" contract. "To constitute good delivery, each can of frozen eggs must bear the USDA shield." [79] The quality of such eggs, packed under USDA supervision by different firms, was relatively uniform and dependable, thus instilling greater confidence in the product by the trade. This change in rules probably resulted in increased willingness to accept delivery of the product. In addition, another change related to a specific requirement for standard grade frozen whole eggs. "They shall contain a minimum of 25.5% egg solids." [80] This compares with 25% solids content in 1955.

During 1945-56, there was relatively little trading in frozen whole egg futures. During four years (1945, 1951, 1952, and 1955) no trading occurred. In the other years the volume of trading, on a calendar-year basis, ranged from only 3 cars in 1948 to 48 cars in 1947.[81] The small trading volume during 1945-56 compared with the relatively large volume since 1957 (see Table 3) shows the

79. Chicago Mercantile Exchange Year Book, 1956-57, p. 45.

80. *Loc. cit.*

81. Data were furnished by Michael H. Weinberg of Weinberg Bros. and Co., Chicago. (Letter, December 14, 1959, to the authors.)

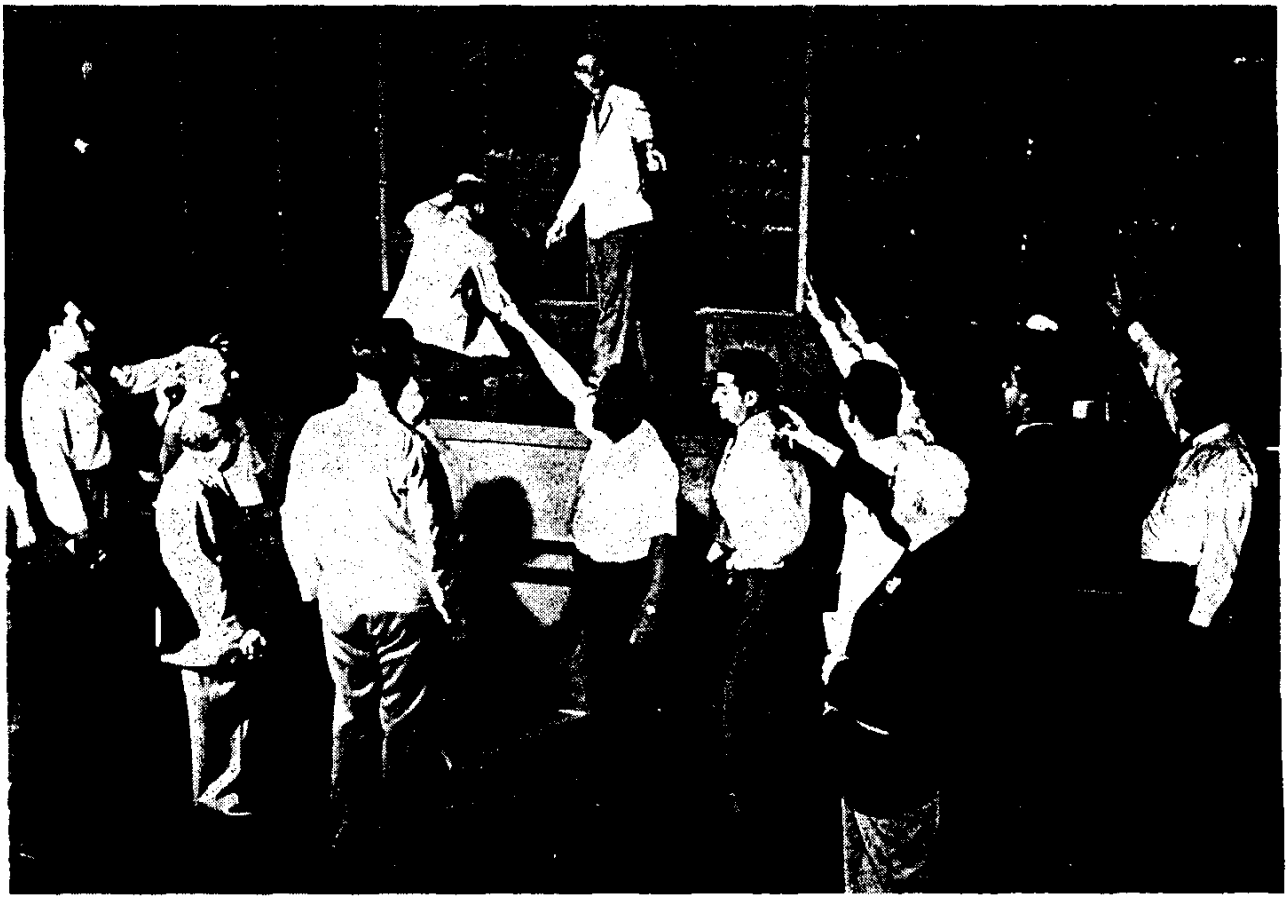

FIG. 15. Since 1957, the futures market for frozen whole eggs on the Chicago Mercantile Exchange has assumed greater significance.

increasing role played by the futures market in recent years.

Whereas the peak volume of trading in the earlier period was 48 cars in 1947, during 1957-58 it totaled 4,089 cars, representing 123 million pounds, with interest centered on the "October 1957" and "January 1958" contracts (Table 3). During 1958-59, there was less speculative activity and the volume of trading dropped to 910 cars, still a rather substantial quantity. In 1959-60, trading activity again increased and 3,197 cars were traded.

The first year of any appreciable activity in the frozen egg futures market was 1957. Trading was of such volume and importance that a brief review [82] of the market situation and other contributing factors, as well as the trading itself, is warranted.

Egg production during the spring of 1957 was heavy and, despite government purchases of both shell and dried eggs, springtime egg prices were sharply lower than in 1955 and 1956. A relatively small hatch for laying flock replacement and heavy cullings of layers indicated reduced egg supplies and prospective higher shell egg prices during the fall. Thus the opportunity for large-scale commercial production of liquid egg at that time would be limited. Rela-

82. Certain details regarding futures trading in 1957 were obtained by interviewing plant managers or central office personnel in a regional field survey of the operations of 64 commercial egg breaking and/or drying plants in the North Central Region in 1957-58 by the Kansas Agricultural Experiment Station.

tively high storage stocks of frozen eggs on February 1 (the normal start of the main breaking season) tended to discourage egg breaking, while low egg prices encouraged it. High prices of futures in relation to the cash market, particularly during March and April, encouraged many breakers to step up operations, store frozen eggs, and hedge their inventories in the futures market.

In early 1957, cold storage warehouses in Chicago had considerable unused storage space after government-owned stocks of butter were removed. Moreover, one broker, an investment counselor, recommended to his clients the purchase of frozen egg contracts because of "the possibility of long-term capital gains tax-wise." [83] One large warehouse in Chicago began purchasing frozen eggs in large volume during March and soon other warehouses did the same. To earn storage charges, warehouses bought frozen whole eggs for their own account or financed purchases by egg dealers and then hedged the commodity.[84]

During 1957, there was active trading in four contracts. Trading opened in the October contract in late February and in the other three contracts in March. As trading progressed, the prospect of high egg prices during the fall resulted in active buying, by speculators, egg dealers, and actual users of frozen eggs, to lend broad support to the market.

By September 1, storage reserves of frozen eggs, particularly yolks, were smaller than a year earlier. During the delivery month of the October contract many breakers, who had placed hedges during the spring, chose to deliver. Others, including warehouses, "bought in" their October contracts and rehedged by selling in the January contract since the spread was sufficient to pay for carrying charges from October to January and perhaps provide an opportunity for profitable merchandising.

During 1957, for the first time in the brief history of trading in frozen whole egg futures, the market provided a fair degree of liquidity. Many egg breakers reported that they took advantage of the seller's delivery privilege. A total of 326 cars [85] was delivered in 1957-58 (Table 3). The market provided an important, immediate outlet for the sale of frozen eggs during the spring. Several country egg breakers reported that they used the futures market during 1957 to hedge forward sales as well as storage stocks and were afforded some protection. Some plants reported that the futures market governed the price paid for eggs to break during the spring. A few plants let their sales in

83. H. I. Henner, *Weekly Commodity Letter,* Uhlmann Grain Company, Chicago, March 29, 1957.

84. They hedged by selling October contracts, hoping at least to break even or possibly to make a small profit after paying for carrying charges (warehousing, interest and insurance) plus brokerage fees. One source stated that most of the time a small profit was made because the "spring" pack commanded a slight premium from users over the "current" pack.

85. Seventy-eight cars and 219 cars, respectively, in the "October 1957" and "January 1958" contracts.

the futures market govern the quantity of frozen whole eggs they packed.

Technological Advances in Albumen Solids for Angel Food Cake Mixes

In 1944, it was discovered that glucose could be removed from egg whites by "yeast fermentation." In the process, yeast cells feed on glucose, producing alcohol and carbon dioxide which passes into the air. This method was a decided advance over earlier methods including "natural fermentation" and "seeding with aerobacter aerogenes." The yeast fermentation method was more easily controlled, faster, and produced glucose-free liquid whites having better bacterial quality and flavor than other known methods.

From a commercial standpoint, the yeast fermentation method represented a major "breakthrough" in the development of albumen solids suitable for use in an angel food cake mix. The first mixes to appear on the market were manufactured using this type of albumen solids.

During the early 1950's the "enzyme method" of removing glucose was perfected. Under this process, glucose is changed to gluconic acid, a stable product. The development is considered by several authorities as one of the most spectacular technological advances in the history of the egg products industry. Today, this method has been adopted quite widely by albumen driers.

Success also crowned the industry's efforts to dry egg whites with the spray-type drier. Prior to 1939, only the pan method of drying was used and produced "flake" albumen. When powdered albumen is desired, flakes are then ground. In 1935, the process of "fluff drying" was developed to produce powdered albumen. Liquid albumen "is whipped into a foam that is extruded onto a stainless steel belt traveling through a drying oven. The dried foam is then powdered to uniform mesh size." [86]

Around 1939, spray driers began using "bag collectors" to recover more of the fine albumen powder. This device made spray drying of albumen practical because it saved valuable powder which previously was lost. With the successful development of angel food cake albumen and the need for powdered albumen by cake-mix manufacturers, demand increased for the spray-dried product. Today, some packers mix ground flake albumen with spray-dried albumen for better control of quality and uniformity.

Stimulated by advertising and promotion, consumer demand expanded for angel food cake mixes. Cake mix manufacturers required a regular supply of albumen solids with a low yolk content in order to produce mixes with uniformly-high cake volume. It is well known that any appreciable quantity of yolk in albumen adversely affects "lifting ability" of whites. About 1955, the "monomolecular film test," a highly-sensitive method of testing egg whites for yolk contamination, was perfected. This

86. J. V. Ziemba, "Egg Solids to Forefront," *Food Engineering,* September, 1955, p. 70.

test not only is quick and accurate but also enables egg breakers to obtain whites with a very low fat content by running regular tests during the breaking and separating process.

During the mid 1950's another step to obtain uniform supplies of whites having adequate "lifting ability" culminated in the development of a chemical additive for whites which partially overcomes the problem of yolk contamination.

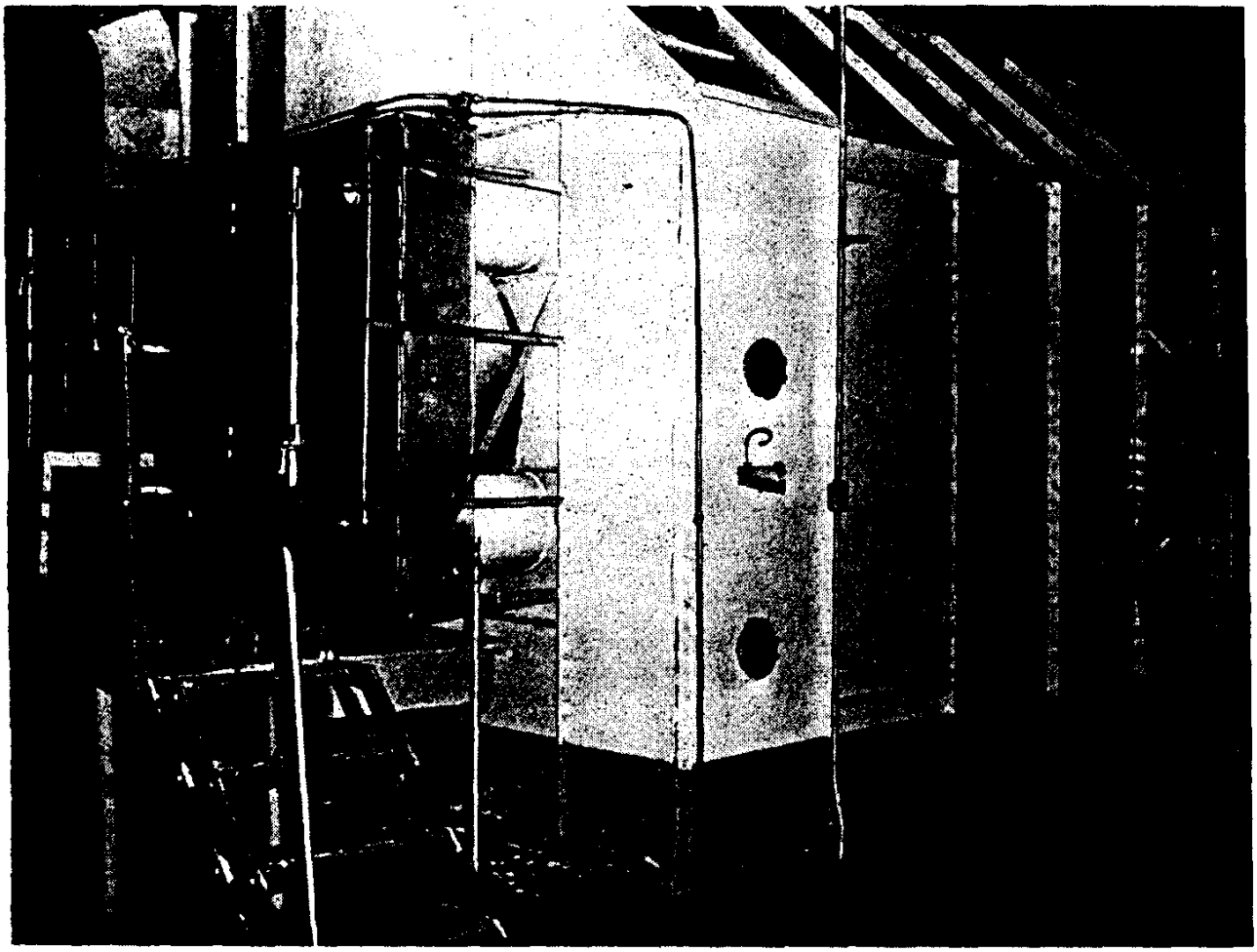

FIG. 16. A modern, cabinet-type spray dryer which can be used to dry whole eggs, yolks, or whites. Usually a machine that dries whites is used only for that product. Alternate drying of yolks and whites is not practical. When yolks are dried, some fat is deposited on the sides of the drier and, unless completely removed, will be picked up by whites during drying. That would adversely affect the lifting ability of albumen solids.

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APPENDIX A

TABLE I.--Egg products: [1] United States imports, 1914-58

YEAR	Dried or frozen eggs[2]	Frozen eggs				Eggs solids			
		Whole eggs	Yolk	Albumen	Total	Whole eggs	Yolk	Albumen	Total
	(1,000 pounds)	(l,000 pounds)				(1,000 pounds)			
1914	6,182[2]	.....	.....	.....	.....	.....	.....	.....	.....
1915	9,480[2]	.....	.....	.....	.....	.....	.....	.....	.....
1916	16,345[2]	.....	.....	.....	.....	.....	.....	.....	.....
1917	16,692[2]	.....	.....	.....	.....	.....	.....	.....	.....
1918	12,038[2]	.....	.....	.....	.....	.....	.....	.....	.....
1919	33,048[2]	.....	.....	.....	.....	.....	.....	.....	.....
1920	36,657[2]	.....	.....	.....	.....	.....	.....	.....	.....
1921	23,928[2]	.....	.....	.....	.....	.....	.....	.....	.....
1922	18,034[2]	.....	.....	.....	.....	.....	.....	.....	.....
1923	.....	1,106	1,210	636	2,952	5,964	3,416	19,899	29,009
1924	.....	8,751	4,151	1,106	14,008	5,675	8,835	21,512	36,021
1925	.....	12,647	5,662	5,662	23,428	9,000	12,301	22,993	44,293
1926	.....	8,114	4,601	3,967	16,682	5,624	12,015	25,242	42,881
1927	.....	611	1,229	553	2,393	3,141	7,060	24,586	34,786
1928	.....	12,616	4,581	610	17,807	3,043	9,616	20,090	32,749
1929	.....	9,824	3,475	955	14,254	5,264	12,022	29,006	46,292
1930	.....	113	1,052	2	1,167	4,740	13,620	25,199	43,559
1931	.....	2	443	0	445	7,385	12,516	18,108	38,009
1932	.....	[3]	403	0	403	79	1,598	9,313	10,990
1933	.....	81	308	0	389	37	3,594	6,381	10,013
1934	.....	5	1,006	0	1,011	4	5,103	2,938	8,046
1935	.....	0	666	[3]	666	2,149	8,696	13,695	24,540
1936	.....	25	1,499	0	1,524	1,903	10,783	17,214	29,901
1937	.....	1	887	[3]	888	2,144	11,938	20,762	34,844
1938	.....	[3]	168	0	168	410	580	5,081	6,071

TABLE I.--Egg products: [1] United States imports, 1914-58--CONCLUDED

YEAR	Dried or frozen eggs[2]	Frozen eggs				Eggs solids			
		Whole eggs	Yolk	Albumen	Total	Whole eggs	Yolk	Albumen	Total
	(1,000 pounds)	(1,000 pounds)				(1,000 pounds)			
1939[4]		[3]	0	0	0	209	3,310	2,628	6,147
1940[4]		[3]	12	0	12	47	5,751	2,124	7,922
1941[4]					0	162	3,980	2,102	6,244
1942[4]					42	32	630	350	1,012
1943[4]					0	4	0	7	11
1944[4]					47	0	63	635	698
1945[4]					2	7	236	788	1,031
1946[4]					2	4	0	15	19
1947[4]					6	0	0	854	854
1948[4]					4	104	520	394	1,018
1949					473	335	4,075	350	4,760
1950					40	529	16,576	1,401	18,506
1951					13	4	155	503	662
1952					32	0	121	1,898	2,019
1953					137	32	56	3,351	3,439
1954					68	0	105	467	572
1955					4	0	0	182	182
1956					6	0	0	66	66
1957					7	8	0	15[5]	15
1958					4	0	36[5]	0	36

1. Liquid equivalent. Data for egg solids for 1938-57 were converted from dry weights on the basis of 1 pound whole egg solids equaled 3.6 pounds liquid; 1 pound yolk solids equaled 2.25 pounds liquid; and 1 pound albumen solids equaled 7.3 pounds liquid.

2. Products were not shown separately before 1923.

3. Less than 500 pounds.

4. Fiscal year basis.

5. Data for egg solids imported in 1957-58 did not indicate types of products. Allocations were based on information obtained from the trade.

Sources: Termohlen, W. D., E. L. Warren and C. C. Warren, *The Egg Drying Industry in the United States,* AAA, USDA, PSM-1, 1938, p. 64 for egg solids, 1923-37; *Agricultural Statistics,* USDA, 1941, p. 492 for dried or frozen eggs, 1914-22 and for frozen eggs, 1923-39; for both egg solids and frozen eggs, 1947, p. 451 for 1938-45; and 1949, p. 551 for 1946-47: *Foreign Agricutural Circular,* USDA, for both egg solids and frozen eggs, Sept., 1953, pp. 14-15 for 1948-52; Sept., 1957, p. 14 for 1953-56; and Sept., 1959, p. 9 for 1957-58.

TABLE 2.--Liquid egg: Annual production and disposition, United States, 1921-58 [1]

YEAR	Total liquid egg production	Original disposition			Final disposition				Final percentage disposition	
		Frozen	Used for drying	For immediate consumption	Dried from frozen eggs	Total dried	Used as frozen	Total used as frozen and for immediate consumption	Used for drying	Used as frozen and for immediate consumption
	(1,000 pounds)								(Percent)	
1921.	46,000	46,000	.....	.....	.....	.....	46,000	.....	0.0	100.0
1922.	49,000	49,000	.....	.....	.....	.....	49,000	.....	0.0	100.0
1923.	71,000	71,000	.....	.....	.....	.....	71,000	.....	0.0	100.0
1924.	57,000	57,000	.....	.....	.....	.....	57,000	.....	0.0	100.0
1925.	79,000	79,000	.....	.....	.....	.....	79,000	.....	0.0	100.0
1926.	92,000	92,000	.....	.....	.....	.....	92,000	.....	0.0	100.0
1927.	131,000	129,000	1,500	.....	.....	1,500	129,000	.....	1.2	98.8
1928.	149,000	148,000	500	.....	.....	500	148,000	.....	0.4	99.6
1929.	156,000	155,000	500	.....	.....	500	155,000	.....	0.4	99.6
1930.	187,000	185,000	1,500	.....	.....	1,500	185,000	.....	0.8	99.2
1931.	153,000	152,000	1,000	.....	.....	1,000	152,000	.....	0.7	99.3
1932.	145,000	138,000	7,000	.....	.....	7,000	138,000	.....	4.9	95.1
1933.	187,000	171,000	16,000	.....	.....	16,000	171,000	.....	9.6	90.4
1934.	215,000	198,000	17,000	.....	.....	17,000	198,000	.....	7.9	92.1
1935.	214,000	206,000	7,500	.....	.....	7,500	206,000	.....	3.7	96.3
1936.	213,000	208,000	4,500	.....	.....	4,500	208,000	.....	2.2	97.8
1937.	233,000	225,000	8,000	.....	.....	8,000	225,000	.....	3.9	96.1
1938.	148,800	116,100	22,300	10,400	.....	22,300	116,000	126,500	15.0	85.0
1939.	220,233	177,144	31,000	12,089	.....	31,000	177,000	189,233	14.0	86.0
1940.	229,274	189,578	27,050	12,646	.....	27,050	189,578	202,224	11.8	88.2
1941.	421,919	237,182	165,972	18,765	.....	165,972	237,182	255,947	39.3	60.7
1942.	1,011,106	257,631	731,046	22,429	115,752	846,798	141,879	164,308	83.7	16.3
1943.	1,221,012	112,615	782,080	26,317	159,346	941,426	253,269	279,586	77.0	23.0
1944.	1,554,037	511,791	1,009,402	32,844	179,146	1,188,548	332,645	365,489	76.5	23.5
1945.	681,571	197,580	265,287	18,704	122,167	387,454	275,413	294,117	56.8	43.2

TABLE 2.--Liquid egg: Annual production and disposition, United States, 1921-58 1--CONCLUDED

YEAR	Total liquid egg production	Original disposition			Final disposition				Final percentage disposition	
		Frozen	Used for drying	For immediate consumption	Dried from frozen eggs	Total dried	Used as frozen	Total used as frozen and for immediate consumption	Used for drying	Used as frozen and for immediate consumption
	(1,000 pounds)								(Percent)	
1946.	788,194	392,218	375,945	20,031	84,219	460,164	307,999	328,030	58.4	41.6
1947.	682,480	371,096	295,567	15,817	20,538	316,105	350,558	366,375	46.3	53.7
1948.	502,141	345,192	140,048	16,901	25,311	165,359	319,881	336,782	32.9	67.1
1949.	587,656	318,227	250,601	18,828	32,395	282,996	285,832	304,660	48.2	51.8
1950.	696,663	354,148	322,400	20,115	32,134	354,534	322,014	342,129	50.9	49.1
1951.	408,654	339,537	50,777	18,340	23,220	73,997	316,317	334,657	18.7	81.9
1952.	382,394	320,352	43,638	18,404	32,400	76,038	287,952	306,336	19.9	80.1
1953.	411,274	343,064	47,116	21,094	34,684	81,800	308,380	329,474	19.9	80.1
1954.	465,931	361,184	73,716	31,031	28,681	102,397	332,503	363,534	22.0	78.0
1955.	453,435	314,514	78,768	33,153	31,478	110,246	310,036	343,189	24.3	75.7
1956.	464,855	349,085	82,659	38,111	18,901	101,560	330,184	363,295	21.8	78.2
1957.	474,730	333,823	103,413	37,494	24,369	127,782	309,454	346,948	26.9	73.1
1958.	480,798	350,886	98,578	31,334	16,131	114,709	334,755	366,089	23.9	76.1

1. Data were unavailable for years not shown.

Sources: Eggs and Egg Products, USDA, Circ. 583, Jan., 1941, p. 62 for 1921-37; *Poultry and Eggs—Liquid, Frozen and Dried Egg Production, 1938-49,* Revised estimates, BAE, USDA, Sept., 1953, p. 19 for 1938-42; *Egg Products—Liquid, Frozen, Solids Production* (monthly), USDA, 1953-58 for 1943-58.

1942—Methods and equipment developed to produce low loisture, whole egg powder. (G. F. Stewart, R. Conrad, J. W. Greene and others).

1943—Determination of the adverse effects of oxygen on the low-temperature deterioration of dried whole eggs and yolks (J. Brooks and E. C. Bate-Smith). This discovery caused the U. S. armed forces to specify that whole egg powder for them be packed in inert gases, nitrogen and carbon dioxide.

1943—Discovery that adding sugar to whole egg liquid before dying greatly helped retain the "lifting ability" of the dried product (J. Brooks and J. R. Hawthorne). Confirmation by R. Conrad, et al.

1944—Discovery that glucose in whole eggs could be removed by yeast fermentation (J. R. Hawthorne and J. Brooks). Confirmed by workers at Armour and Co.

1946—Observations that a diet of reconstituted dried milk and dried whole eggs remarkably accelerated the recovery of undernourished and wounded soldiers. (H. Pollack).

1946—Acidification of liquid whole eggs to pH 5.5 prior to drying and neutralization of powder by adding sodium bicarbonate (M. M. Boggs and H. L. Fevold). In 1947, the U. S. armed forces designated use of this process in their product specifications.

1948—Discovery that a principal cause of loss in palatability of dried whole eggs and yolks during storage is reaction between glucose and the lipid constituent, cephalin. Therefore, removal of glucose prior to drying is the most direct means of eliminating a principal source of palatability loss. (L. Kline, H. Hanson, R. E. Feeney, and H. Lineweaver).

About 1950—Discovery that glucose can be removed from yolks and whole eggs by use of an enzyme (B. Sarett, T. Rector, and H. Slosberg).

Albumen solids production

About 1900—Albumen was dried in China using methods probably developed by the Germans. Liquid whites first were fermented and a "flake" product produced by pan drying in a cabinet dryer.

Early 1930's—"Controlled bacterial fermentation" was developed in the United States. (A. K. Epstein and S. Tranin). Continued research on this problem by H. Goresline, L. S. Stuart and workers at Armour and Co. and Swift and Co.

1935—Development of powdered egg whites by "fluff drying" process (L. D. Mink).

1935—The conversion of nonedible liquid egg whites, extracted from egg shells, to "technical albumen." (G. F. Stewart and H. Drews).

Mid 1930's—Drying of whites for some uses, by means of a cyclonic-type spray dryer was demonstrated to be feasible commercially.

1941—Discovery that removal, by bacterial fermentation, of glucose from liquid whites prior to drying assures the stability of albumen solids (G. F. Stewart and R. W. Kline).

1944—A yeast fermentation method developed to remove glucose from whites prior to drying. (J. R. Hawthorne and J. Brooks). Confirmed by J. Ayres, et al., Armour and Co.

About 1949—Tilbest, Inc., of Milwaukee, Wisc., probably was the first concern in the United States to market a retail package of angel food cake mix. The Blair Milling Company, Atchison, Kan., introduced its mix in 1949. By 1953, many large cake-mix manufacturers were marketing such a mix which met with good consumer acceptance.

About 1950—Enzyme method developed to remove glucose from whites prior to drying (B. Sarett, T. Rector and H. Slosberg).

1953—Discovery of a chemical additive to partially overcome yolk contamination in whites, thus insuring the "lifting ability" of whites (H. J. Kothe).

1955—Monomolecular film method developed to detect trace quantities of yolk in whites (D. Berquist and F. E. Wells).

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