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REPORTS
ON
**PUBLIC HEALTH AND
MEDICAL SUBJECTS**

No. 37.

A REPORT ON THE
**Occurrence of Glass Fragments
in Foods Packed in Glass Containers**

By
GEORGE C. HANCOCK, C.B.E., M.R.C.S.



MINISTRY OF HEALTH.

LONDON:
PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE.
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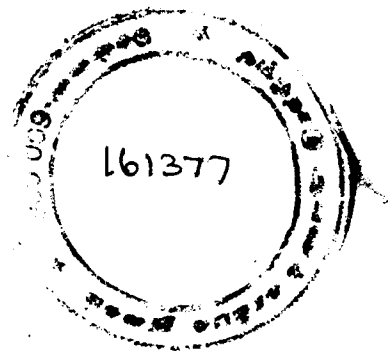
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PREFATORY NOTE BY THE CHIEF MEDICAL OFFICER.

The Right Hon. NEVILLE CHAMBERLAIN, M.P.,
Minister of Health.

SIR,

The investigation to which this report relates was undertaken by Dr. Hancock in consequence of reports by Public Analysts.

Dr. Hancock shows that the presence of particles of glass in foods put up in glass containers is by no means an uncommon occurrence. In the great majority of instances in which they have been found, however, the glass has usually been in the form of fine powder, the particles being of similar microscopic dimensions to particles of silica, slag, etc., which constitute a high proportion of ordinary atmospheric dust. Dr. Monier-Williams has prepared a series of micro-photographs which indicate how glass particles may be differentiated from other siliceous material by means of polarized light. That the source of such glass particles is usually the dust of towns and is unconnected with the use of glass containers is confirmed by the fact that other prepared foods in which glass containers are not employed have been similarly contaminated. There is no direct medical evidence that glass particles in this form, and in the relatively small amounts detected, have produced injury when swallowed with food.

The case is different, however, where the particles of glass are of appreciable size. The report deals with the various sources from which these may gain access to food, including imperfect manufacture of bottles and other containers, the bursting and breaking of glass vessels where sufficient care is not taken to prevent the scattering of fragments over food material being packed, and the practice of repacking food materials such as jams when the container has been accidentally broken during handling in the factory. The particles in such cases may be of a size and sharpness capable of producing injury in spite of the natural protection afforded by the mucous secretions and contents of the alimentary tract. Fortunately, the presence of such particles in food appears to be of rare occurrence, and is, therefore, extremely unlikely to be a cause of irritation that would have any relation to the incidence of acute or chronic diseases met with in the alimentary tract or elsewhere. The relatively uncommon occurrence of such particles in foods may be attributed to the care already taken by most manufacturers to use good glass-ware and to prevent fragments

of glass gaining access to vessels during the various processes to which they are subjected. In the concluding paragraph attention is drawn to the importance of such precautionary measures and to the need for their vigilant observance by all manufacturers engaged in the packing of foods and beverages in glass containers.

I have the honour to be, Sir,

Your Obedient Servant,

GEORGE NEWMAN.

Whitehall,

January, 1927.

THE OCCURRENCE OF GLASS FRAGMENTS IN FOODS PACKED IN GLASS CONTAINERS

By

GEORGE C. HANCOCK, C.B.E., M.R.C.S.

From time to time in recent years, statements have appeared in various medical and trade journals relating to the presence of particles of glass in certain foods and beverages which are put up in glass containers, and particular prominence has been given to the dangers which it is alleged attend the use of such containers for foods. Cut mouths and tongues, gastric and intestinal ulcers, and appendicitis and cancer are mentioned in this connection, and various theories have been advanced in regard to the two last-mentioned diseases to explain how the contamination of foods with glass may be accountable for their increasing prevalence. In some cases the authors of these statements deny the suggestion that broken or powdered glass is a common cause of appendicitis or a likely cause of cancer; but admit the potential dangers, and competent opinion has been expressed that finely powdered glass such as could be easily administered without detection in certain foods might be capable of producing serious symptoms and even death, by extensive scarification of the stomach and intestine, followed by bacterial infection and the production of acute gastro-enteritis. In view of the extent of the trade in glass-packed foods, it seemed desirable to ascertain how far, if at all, these statements could be substantiated and I was instructed to make some enquiries into the subject.

It is not denied, even by food manufacturers themselves, that glass particles may occasionally be found in foods and beverages put up in glass containers; but it is averred that these occurrences are extremely rare and that injuries arising therefrom are rarer still. There is little available evidence in this country of injury arising from the ingestion of foods containing glass. Some years ago a case was reported from Scotland, in which a consumer recovered a substantial sum in damages for illness said to have been caused through eating marmalade which contained particles of glass; and in December, 1924, a jury in a High Court case awarded £130 damages against the proprietors of a Leicester Restaurant, one of whose customers was alleged to have suffered illness through eating mince-pie which also contained minute pieces of glass. ("The Grocer," Vol. LXXVI, No. 3284, p. 80.)

Likewise there would appear to be but few cases of injury from swallowing glass in the records of the London Hospitals. This, as will be seen, is borne out by the following extracts from letters which I have received on the subject from the Registrars and other responsible officials of four of the largest hospitals in

the metropolis, namely, St. Thomas's Hospital, St. Bartholomew's Hospital, St. George's Hospital and the Middlesex Hospital.

St. Thomas's Hospital :—"There is no case in our records for the last five years where a fragment of glass has been proved to be swallowed, i.e., has been actually recovered from the alimentary tract or has been identified when passed per rectum. This seems strange, as I have personally treated two cases of cuts of the mouth due to glass fragments in food; in one case the glass fragment was produced. The explanation would appear to be that a fragment of such size as to be swallowed readily, subsequently causes little or no trouble in the intestinal tract. The history of swallowing glass fragments is usually a doubtful one, and, in the absence of symptoms, these cases are usually kept under observation as out-patients; the fact that in the last five years no such case has needed admission would appear to justify this."

St. Bartholomew's Hospital :—"I have consulted several members of the staff on the subject None of them had ever heard of a patient admitted to this hospital in whose case the ingestion of powdered glass had been even suspected."

St. George's Hospital :—"I have been so far unable to obtain any evidence of any disorders arising therefrom, in the records of this hospital."

Middlesex Hospital :—"This matter has been investigated and we have no evidence in our records."

Most of the recorded cases are reported from abroad, the glass in pounded form being used with homicidal or suicidal intent. Thus, Dr. W. Turner, of Spanishtown, Jamaica, relates that an attempt was made by a negro woman to poison a family of seven persons with pounded glass. On the discovery of the glass toward the end of the meal, purgatives were administered, in consequence of which all passed large quantities of coarsely powdered glass. No member of the family appears to have suffered any ill effects (*Edin. Medical and Surgical Journal*, 1824, XXII, p. 225).

Portal mentions a case in which a young man broke his drinking glass and swallowed the pieces. Severe gastric pains supervened, but the man ultimately recovered after appropriate treatment. (*Arch. de Pharm; Second Series*, Vol. XCI, p. 9).

Dr. W. Hebb mentions the case of an infant who was destroyed by some person or persons administering to it a quantity of roughly pounded glass. A considerable quantity of gritty powder, proved to be powdered glass, was found in the stomach, which was lined with a thick layer of tenacious mucus streaked with blood. No other morbid appearances were detected in the body. (*Midland Medical and Surgical Reporter*, 1828, Vol. i, p. 47.)

Professors Baudelocque and Chaussier, in 1808, reported a case at Paris in which a man was supposed to have poisoned his wife with pounded glass. This substance was found in the stomach of the deceased, and this organ, as well as the intestines,

showed signs of great irritation. After a careful consideration of all that had been written on the subject, they gave their opinion that pounded glass is not a poison and suggested that any glass found in the stomach might have come from some vessel of that material being broken by the deceased's teeth during the convulsions which preceded death. (Beck—*Medical Jurisprudence*, Vol. II, 10780, Eleventh Ed.)

Dr. Haines (Peterson, Haines and Webster's *Legal Medicine and Toxicology*, Part II, 1923, p. 888, 2nd Edition), says there can be no question that the ingestion of particles of glass of a certain size may lead to such injury of the mucous membrane of the stomach and intestines as to cause death Still there can be no doubt that the dangers of broken glass and of similar objects have been greatly over-estimated; the results of experiments and the experience of professional glass eaters indicate that they are far less dangerous than is commonly supposed. In support of this contention he quotes the case of a professional glass eater who came under his own observation—a young negro who apparently was in excellent health. He consumed in Dr. Haines' presence half a dozen test tubes, two good-sized lamp chimneys, an ordinary 4 oz. medicine bottle, two pieces of window glass, each 4 ins. square, and three strips of coloured glass, each 1 in. wide and 3 in. long. He was kept under observation for several hours after eating the articles mentioned, but he at no time showed the least unfavourable symptom.

Gracy reports another case of glass eating very similar to the above; (*Medical and Surgical Reporter*, 1888, LVIII, p. 61); and the experiments of Le Sauvage published at Paris in 1810, are of similar import. (E. Le Sauvage, *Recherches sur les effets du verre and des substances vitriformes portés à l'intérieur des organes digestifs*.)

Simmons and Von Glahn, in an attempt to determine what lesions, if any, are produced by glass in the gastro-intestinal tract, carried out feeding experiments on dogs. As a result of their experiments they came to the conclusion that the ingestion of ground or powdered glass had no toxic effect and produces no lesion, either gross or microscopic, on the gastro-intestinal tract of dogs. (*Jour. Amer. Med. Assoc.*, 1918, 71, p. 2127.)

Dr. Haines points out that consideration of such facts as the foregoing has led some medico-legal authorities to question altogether the dangerous properties of pounded glass, forgetting the well-authenticated cases of serious sickness and death from this agent and overlooking the circumstance that in the experiments of Le Sauvage and of others in the same line the largest pieces of glass administered were still quite small.

J. D. Gimlette says that Malay poisoners are believed seldom to employ crushed glass alone, but to use it always in combination with well-known vegetable irritants such as Bamboo hairs. He suggests that glass is not likely to cause symptoms, if given alone, unless perhaps, in the form of fine splinters, because in all

probability it is quickly enveloped in an excess of mucus caused by mechanical irritation of the stomach and intestine. He also draws attention to the immunity from injury enjoyed by professional glass eaters. (Malay Poisons and Charm Cures—1923.)

Waddell comments in much the same way in speaking of the use of pounded glass, as a poison, in many parts of India. He remarks that the more finely the glass is pounded the more likely are the particles to become completely enveloped in mucus, etc., and to be thus prevented from injuring the mucous membranes. Hence as the consequences arising from swallowing pounded glass are solely due to the mechanical injury it inflicts, the more finely it is pounded, the less likely is swallowing it to cause harm. (Lyons Medical Jurisprudence for India. 2nd Ed., pp. 541-542.)

Herein doubtless lies the truth of the matter. The effects produced by swallowing glass probably depend upon the size and form of the particles swallowed, sharp edged and angular fragments of appreciable size being much more likely to produce injury than powdered glass, which in this form is readily enveloped by the food taken with it and by the secretions of the stomach and intestine. That this is the case finds confirmation in the relatively few recorded cases of injury from swallowing glass, for, as will be seen, its presence is by no means infrequent in foods. When present, however, it is usually in powdered form, the particles few in number and identifiable only by the most careful microscopic examination. In this form it is probably rendered innocuous in the ways mentioned, and would account for the large measure of immunity from injury enjoyed by those (and they can be numbered by the million) who consume daily one or other of the immense variety of foods and beverages which are put up in glass containers—marmalades, jams, potted meats, beer, mineral waters, etc.

In order to determine the frequency with which glass particles are to be found in these containers, I sought the assistance of a number of Sale of Food and Drugs Acts authorities, who were good enough to obtain a large number of articles of food and beverages for the purposes of my Inquiry. The examination of these samples for glass was made by the Public Analysts of the local authorities concerned, and while some reported the total absence of glass in any of the samples submitted to them, others reported the presence of glass particles in quite a large percentage of the samples examined. Thus, the Public Analyst of one of the northern counties of England, who also acts in the same capacity for a number of urban districts, examined 156 samples and found glass particles in 72.4 per cent. of them. A summary of the articles examined, with the results of the examination, are given below :—

Article.	No. exam-ined.	No. free from glass.	No. contain- ing glass fragments.	Character of glass particles.
Aerated waters and beverages	31	10	21	Mainly minute frag- ments.
Bottled fruit ..	1	0	1	Mainly fragments.
Calves' foot jelly ..	1	1	0	—
Jam, fruit jelly and marmalade	66	20	46	Some particles of appreciable size.
Lemon 'cheese and curd	8	5	3	Minute particles.
Mince meat	3	0	3	Ditto.
Orange cream ..	1	1	0	—
Fish and meat pastes	31	2	29	Some particles of appreciable size.
Pickles, relish and sauce	11	2	9	Minute particles.
Meat in jars (tongue)	3	2	1	Ditto.
Totals	156	43	113	= 72.4 per cent.

The largest particles were found in the jams— $\frac{3}{8}$ in. $\times$ $\frac{5}{8}$ in., pickles, $\frac{1}{4}$ in. $\times$ $\frac{1}{8}$ in., $\frac{1}{4}$ in. $\times$ $\frac{1}{4}$ in. and $\frac{1}{5}$ in. $\times$ $\frac{1}{4}$ in., etc.; one particle $\frac{1}{4}$ in. long was found in an aerated water, but in the main these beverages contained minute glass fragments only $\frac{1}{1000}$ to $\frac{1}{10000}$ or $\frac{1}{20000}$ ths of an inch in size.

Similarly the Public Analyst of one of the chief cities in the north-east of England examined 79 samples and found glass particles in 31.6 per cent. In these samples the largest particles were found in the lemonade crystals and powders— $\frac{1}{4}$ in. and $\frac{1}{8}$ in. in length; other samples contained particles $\frac{1}{8}$ in. long and many contained particles of much smaller size $\frac{1}{10000}$ sq. in.

The Public Analyst of another large industrial town mentions that in the whole of the samples submitted to him for the examination of glass he had only found four samples containing fragments of $\frac{1}{16}$ in. in length and over. Each of these samples—in addition to more minute fragments—contained one particle of glass of the respective lengths of $\frac{1}{20}$ in., $\frac{1}{32}$ in., $\frac{1}{32}$ in. and $\frac{1}{16}$ in. The remainder of the glass particles in these and in the other samples which were reported as containing particles of glass were classified as between $\frac{1}{32}$ in. and $\frac{1}{16}$ in., and between $\frac{1}{16}$ in. and $\frac{1}{2000}$ in. in length. In the majority of the samples examined he had also found particles of mineral matter, chiefly sand, corresponding to and in some cases exceeding in length the above-mentioned particles of glass.

The Public Analyst for one of the London Metropolitan Boroughs examined 12 samples of foods and drinks comprising two lemonades, two ginger beers, three jams (mixed fruit), one plum jam, two meat pastes and two fish pastes. He reported that the beverages contained minute particles of siliceous matter

indistinguishable microscopically from ground glass In all the jams small quantities of siliceous matter were found similar to ground glass The pastes also showed the presence of similar glass particles In no case was any glass found larger than microscopic particles.

The Public Analyst of another of the London Metropolitan Boroughs reported that the examination of six samples of preserves revealed the presence of glass in two, both being jams. In one of these samples it was present as finely powdered glass and in small quantity only; the other contained a small number of spicules of glass together with fragments resembling quartz.

The above data afford sufficient evidence to show that glass particles are not infrequently found in glass-packed foods and beverages; and the fact that such commodities are taken with impunity for the most part, can only be explained by the hypothesis that the glass when present, is usually microscopic in size, or so small as to be virtually harmless. Now and again are found pieces of glass of larger size, and complaints, and even judicial proceedings, are sometimes the outcome of such finding. Fortunately, these occurrences are comparatively rare and, as has been shown, there is little available evidence in this country, at any rate, of injury arising from them.

Apart, however, from considerations of this sort, glass, in whatever form, is an undesirable ingredient in food materials, and it remains to consider how it originates or gains admission to them. In seeking a solution of this problem it is necessary to consider (a) the container, (b) the methods of the food manufacturer and (c) extraneous sources of the glass.

THE CONTAINER.

In using glass containers as receptacles for food it is of the first importance that they should be well made, strong, showing but few air bubbles or blisters and capable of resisting considerable variations of temperature. The extent to which a glass vessel fulfils these conditions is determined by several considerations, the chief of which is a correct appreciation on the part of the manufacturer of the chemical and physical properties of glass. Thus, its durability, its strength, its hardness, its elasticity and its power to withstand, without breaking, sudden changes of temperature are only some of the properties a knowledge of which is essential to the manufacturer of good glassware. These and other fundamental principles underlying the processes of glass production embrace the whole subject of glass technology, a subject which is beyond the scope of this report.

Most food manufacturers using glass containers are well aware of the value of good glass; and this appears to be borne out by the observations of certain of the public analysts already referred to. They say in this connexion:—

“With a few exceptions I have been unable to trace a direct connection between the presence of glass particles and the glass jar containing the food.”

“The general quality of the glass jars and bottles was good, although a few of them contained rather numerous air bubbles.”

“The possible sources of contamination from the container itself, by the disruption of air bubbles I must admit I do not find supported by the examination I have made of the container after the contents have been removed, for I have failed to find more than two jars which had probably contributed to the glass found in the samples they contained.”

On the other hand there are some food manufacturers who, failing to appreciate the significance of good glassware, use containers of inferior quality, with the result that particles of glass are liable to become detached from one cause and another, and to find their way into the contained food. How this may happen from defects inherent in the container itself can best be explained by a brief description of the different methods of manufacturing glass bottles and jars.

The methods employed in the manufacture of glass containers such as bottles and jars fall into three main divisions:—

- (1) Hand processes.
- (2) Semi-automatic processes.
- (3) Completely automatic processes.

(1) *Hand processes*.—In Great Britain the proportion of bottles and jars made by hand operations probably does not exceed 10 per cent. of the whole and is a continually decreasing proportion.

The process consists essentially in the workman gathering a suitable quantity of molten glass from the furnace on to a blow-pipe, shaping the plastic glass by processes which involve rolling it on a smooth iron or stone slab, known as a marver, blowing down the pipe so as to produce a hollow cylinder and, in some cases, swinging the glass to elongate it.

The blower, after marvering the gather of glass, allows it to hang vertically from his blowpipe inside a mould, which is usually made in halves and can be closed either by hand or foot manipulation. When the glass is in position and the mould closed, the blower introduces air through the pipe until the outer surface of the glass is in close contact with and assumes accurately the shape of the mould. The blow pipe is still connected to the partly finished bottle when removed from the mould by the excess quantity of glass above the neck, and the pipe has to be separated before the bottle is handed to the bottle maker, whose work is confined to the making of the neck or “finish” of the bottle. The separation of the bottle from the blowing iron is usually done in one of two ways. In the first method called “wetting-off” the neck of the bottle at the point where separation is desired is touched by a wet tool called the “mullet” and then a sharp knock causes a more or less clean break to take place. In the alternative method, the blowing iron is drawn up slowly while the bottle is still in the mould and the blower continues blowing down the pipe until a very thin-walled bulbous tube of glass is formed, which

can be broken at the slightest touch. In some of the very cheapest kinds of bottles this latter process is adopted and no finishing operation carried out, the thin paper-like excess of glass being rubbed away by rough grinding of the mouth of the bottle upon a stone or wheel. These bottles are known as "burst off" bottles. Bottles of the better class have a "finish," put on by the bottle-maker who, holding the bottle at its base by a special tool, reheats the neck by holding it in the furnace or in an auxiliary heating chamber. Then, with a suitable tool he shapes the mouth of the bottle to the desired pattern. In some cases a ring of glass is cast on to the neck. In all hand methods of glass manufacture a certain quantity of glass is unavoidably left adhering to the blowing iron and this has to be knocked off from time to time. This excess quantity of glass is known as the "moil." In the act of separation there is danger of splinters finding their way inside the bottle, and in the cheaper varieties of hand-made glass-ware this is liable to happen unless due precautions are taken.

(2) *Semi-automatic processes.*—In these processes a suitable quantity of molten glass is gathered by hand upon a gathering iron and dropped into a mould mounted on a forming machine. Considerable skill and judgment are required in order to ensure that the right quantity of glass drops into the receiving mould.

The forming machines are of two main classes:—

- (a) Those whose operations are controlled by hand, and
- (b) Those whose operations are automatic.

Class (a) comprises machines in which moulds are swung into position by hand for receiving the gather of glass above referred to, and for delivering the finished bottle. The output of such machines is not very considerably in excess of that obtained by entirely manual work.

In class (b) the machines usually consist of one or two rotating tables, upon which six or eight pairs of moulds are usually mounted. Each pair consists of a blank or "parison" mould, and a blow mould. The blank or parison mould is designed to give the mass of molten glass a form suitable for its reception by the blow mould. It is equivalent in its action to the preliminary marvering and blowing of the glass by the hand-method. The neck of the bottle is formed in this process, and by it the parison is transferred automatically to the blow or finishing mould for the final blowing operation, whereby the completed bottle is formed.

The chances of introducing splinters of glass are very much minimised by the use of semi-automatic processes. Care has, however, to be exercised, as has been said, in judging of the right quantity of molten glass for, in the moulding of the parison, if too much is dropped into the receiving mould "fins" or "flanges" are liable to be formed and break off in fragments. The percentage of bottles containing splinters from this cause is, however, said to be much smaller than that in the hand-manufacturing methods.

(3) *Completely automatic processes.*—Completely automatic processes for making bottles have developed along two main lines, namely (1) suction methods, and (2) flowing or feeding methods.

(1) *Suction methods.*—The glass forming machine mounts a number of moulds, six, ten or even fifteen pairs on radial arms, rotating about a central pillar. Each blank or parison mould is brought in turn into contact with the molten glass, and by an exhaustion apparatus, sucks up an accurately controlled measure from a revolving pot or hearth working in conjunction with a large continuously operating furnace. The parison is formed by this operation and after automatic transference from the parison mould to the blow mould, the bottle is completely finished and automatically ejected from the machine.

(2) *Flowing or feeding methods.*—In these methods, the glass is either allowed to flow as a stream or is forcibly propelled in compact charges from the furnace to the forming machine, but only the second method is now of importance.

Various devices exist for feeding charges of glass automatically to glass-forming machines. In those chiefly in use in this country, the glass flows from the furnace into a channel or forehearth through a circular bushing at the end of which it is ultimately projected in compact charges to a glass forming machine such as described above.

It will have been seen from the foregoing brief description of the several methods of operation that the quality of a bottle depends to some extent upon its method of manufacture. Bottles made by completely automatic processes are said to be superior as regards freedom from "blisters" and from splinters of glass, to bottles made by other methods. Such bottles are believed also to have other advantages, one of the chief being the accuracy and regularity of the capacity: variations in size are very small indeed, since the capacity of the bottle depends upon the weight of the glass gather, and this can be accurately controlled in both the suction and feeding methods to a fraction of an ounce. Bottles gathered by hand more often contain blisters, because in the process of hand gathering minute quantities of air are liable to become entangled in the molten glass, due to the rotating motion which has to be given to the nose of the blow pipe when the gatherer is taking a quantity of glass from the surface of the metal inside the furnace.

It must not be inferred from what has been said that hand-made containers are generally unsuitable as receptacles for food. Some very good hand made glass containers are obtainable, and it is chiefly the cheaper varieties which are liable to the defects mentioned. On the other hand, automatic processes are said to produce an article which is usually freer from defects than those made by hand or by semi-automatic machine methods.

THE METHODS OF THE FOOD MANUFACTURER.

It has already been pointed out that food manufacturers generally are aware of the need for using glassware which is

capable of resisting the various strains to which it may be subjected in the factory, during transit and in the home ; for practical experience has shown that it is false economy to use cheap and inferior bottles and jars, since any slight saving which might be effected in this way would be more than counterbalanced by loss of custom and damaged reputation should injury or claims for injury result from such use. For similar reasons precautions are taken in most well-regulated factories to avoid the risk of chipped or broken pieces of glass gaining admission to containers during the various operations of washing, filling, stoppering and retorting (as the case may be).

Apart from any inherent defects in the container itself, there are several ways in which, in the absence of proper precautions, the accidental contamination with glass of the contents of a glass vessel may occur. Among the commonest of these is the use of "returned" or "used" bottles and jars, these often showing chipped and jagged rims from which spicules of glass are liable to be broken off ; the neglect of making proper examination of all vessels at the times of washing, filling, stoppering and retorting (when this operation is performed) ; the failure to observe precautions when subjecting glass vessels to sudden changes of temperature such as happens when boiling jam is filled into a glass jar ; and failure to avoid subjecting glass vessels to similar sudden changes of temperature at the time of retorting.

All these and similar accidents can be and in most cases are avoided by the adoption of simple measures. Thus bottles and jars showing chipped or jagged rims should never be used ; indeed some firms, with a view to preventing any danger arising from this cause, always use new glass containers as receptacles for food.

In the several operations of washing, filling, stoppering and retorting the container should be carefully examined at each stage for evidence of fracture, jagged edges, loose particles of glass, etc.

When a glass container is subjected to the influence of heat, as in the potting of hot jams and marmalade, endeavour should be made to acclimatise the vessel to the new conditions of temperature. To effect this two methods are in vogue : in one the glass jar is pre-heated in some form of oven, and in the other the boiling jam before being filled into the jar is allowed to cool down to a temperature which would enable the filling operation to be performed without risk of fracturing the jar.

Again in all retorting operations the temperature within the autoclave should be raised gradually, so as to avoid subjecting the glass vessel to undue strain produced by the sudden and uneven expansion of the glass.

It is probably true that more accidents occur through ignorance or carelessness in the treatment of glass vessels when being subjected to the influence of heat than from any other cause. But when proper attention is given to detail it is surprising how few

accidents occur. In the case of a firm who keep a record of all breakages during retorting the figures are as follows :—

In the year 1922	the average breakage was	..	0.11	per cent.
" " 1923	" " "	..	0.11	"
" " 1924	" " "	..	0.069	"
" " 1925 (1st quarter)	" " "	..	0.059	"

The procedure adopted by this firm in the operation of retorting is briefly this :—

After steam is admitted to the autoclave the temperature is raised gradually to 180° F., which takes about 25 minutes. The temperature is again raised gradually to 230° F., taking a further 40 minutes. It is maintained at or about this temperature for a still further 40 minutes, after which the steam is turned off and the exhausts very gradually opened up. The door of the autoclave is thrown open about 30 minutes later.

It is the practice with the firm in question, as with some other firms, to destroy the contents of any container which has been fractured or broken at the time of retorting, or indeed from any other cause. Some firms, in the case of jams and marmalade, extract the sugar and destroy the fruit. Still other firms report the contents of a broken bottle or jar after making a careful examination for particles of glass, a practice to be deprecated.

In addition to the ways mentioned, the contents of a glass vessel may be contaminated through the use of faulty machinery for filling, bottling or stoppering ; or through want of attention on the part of the person operating the machine. In the bottling of sweet carbonated mineral waters for instance, considerable care needs to be practised in order to avoid the risk of glass particles gaining admission to these beverages. The danger arises from the bursting of bottles in the process of filling with carbonated water. The filling operation is done under varying degrees of pressure according to the type of filler used ; the higher the pressure the greater the risk of burst bottles. Many of the larger manufacturers use rotary power fillers capable of dealing with 50 to 60 dozen bottles per hour. It is said that the number of burst bottles varies from 1 to 1.5 or even 2 per cent. When a bottle bursts during the process of filling, some of the glass particles, owing to the sticky nature of the fluid, adhere to the rubber pad around the mouth of the filler orifice, and unless these particles are carefully removed before a new bottle is placed in position, they are apt to be detached by and fall into it. Some firms, with a view to obviating the risk of glass particles being present in these beverages, make a practice of "sighting" every bottle before it leaves the factory. This is usually done by a factory hand employed for the purpose, who inverts each bottle after it has been filled. In this way any loose particle of glass observable by the naked eye can be detected.

EXTRANEEOUS SOURCES OF GLASS.

It has been shown that glass particles when present in the food content of a glass container are usually microscopic in size, and that larger pieces are seldom present. The explanation may be that the precautions taken by manufacturers in the ways mentioned, whilst affording protection against contamination by the larger pieces of glass, do not afford the same protection against contamination by the smaller or microscopic particles. It is suggested that these microscopic particles are, in part, derived from the flaking off of glass from the internal surface of the vessel during processing, and results from the expansion and contraction of the vessel when under the influence of heat. It is very unlikely that the flaking off of glass particles in this way is of common occurrence. A well-made and properly annealed vessel would withstand the temperatures ordinarily employed for sterilising; and in the case of a badly made bottle the effect of heat would result in fracture rather than in a disintegrating process on the surface of the vessel; indeed examination of glass receptacles which have been retorted seldom shows any indication of "flaking" such as etching or roughness of their inner surfaces. Furthermore, the presence of these glass particles is not confined to vessels which have been subjected to the shock of sudden changes of temperature; and what is still more significant, they are not infrequently present in vessels made of other materials. They have also been found in fresh foods such as the meat of savouries and in fresh butchers' meat and fresh fish.

Of 36 samples of jam of different kinds put up in earthenware or stoneware jars, no less than 20, or 55.5 per cent., were found to contain particles of glaze or glass. Included in these 36 samples was a batch of 4, all of which contained one or other of these mineral matters or both.

Sample 1.—1 particle of glaze, $\frac{1}{100} \times \frac{1}{100}$ of an inch, and 1 particle of glass $\frac{1}{7} \times \frac{1}{6}$ of an inch.

Sample 2.—3 particles of glaze, $\frac{1}{5} \times \frac{1}{11}$, $\frac{1}{18} \times \frac{1}{20}$, and $\frac{1}{12} \times \frac{1}{13}$ of an inch.

Sample 3.—1 particle of glaze, $\frac{1}{8} \times \frac{1}{100}$ of an inch, and 3 particles of glass, $\frac{1}{5} \times \frac{1}{6}$ of an inch, $\frac{1}{5} \times \frac{1}{6}$ and $\frac{1}{7} \times \frac{1}{11}$ of an inch.

Sample 4.—1 particle of glaze, $\frac{1}{10} \times \frac{1}{100}$ of an inch, and 3 particles of glass, $\frac{1}{10} \times \frac{1}{6}$ of an inch, $\frac{1}{10} \times \frac{1}{20}$, and $\frac{1}{10} \times \frac{1}{100}$ of an inch.

Glazed stoneware and earthenware vessels, since they are not suitable for retorting, are not subjected to the same variations of temperature as glass vessels, yet, as has been shown, they are just as liable to contain particles of a glass-like nature. Further, in the series last mentioned both glass and glazed particles were discovered. It may be inferred, therefore, that these mineral matters are by no means necessarily associated with the container, and

that they have their origin in some extraneous source. The most likely source is the dust of the factory, for such dust must be inevitably largely impregnated with mineral matter derived from the frequent breakages of the glassware and stoneware receptacles used in the factory.

Then again, factory dust commonly contains much other mineral matter of a glass-like nature. Mr. Munro, Analytical Chemist to Messrs. Angus Watson and Son, has recently carried out some experiments in this connection. He made an examination of samples of dust collected in various parts of the factory.

After being subjected to appropriate treatment the residual dust was examined microscopically. It was found to consist mainly of transparent, glassy fragments with varying degrees of optical activity. He points out that these fragments are of the nature of true glass, and if found in a glass jar might be taken for particles of glass from the container. He also points out that the dust to be found in a factory consists largely of ash and often contains particles in the nature of slag, which has all the properties of true glass. Mr. Munro also carried out some experiments for the examination of:—

- (1) The meat of savouries (a) before being filled into glass jars; and (b) after being processed in glass jars.
- (2) Examination of meat products packed in tin containers, e.g., soups.
- (3) Examination of fresh butchers' meat and fresh fish as purchased from shops in the district.
- (4) Examination of powdered glass made by grinding up a fragment of glass from a glass container.
- (5) Tests on glass jars filled with distilled water, capped and processed in the usual way.

The method employed by Mr. Munro in the analysis of the meat and meat products was as follows:—

The contents of the jar were scraped out, any fragments left in it being washed out with distilled water. The material was then gently warmed in a nickel dish until all lumps were broken up. A stick of caustic soda was then added and the dish heated until the meat was hydrolysed. After cooling, the layer of fat was removed and the solution filtered through "ashless" filter paper. The residue after being thoroughly washed with hot water was partly washed off and partly scraped off the filter paper into a beaker of Pyrex glass. It was then heated with dilute hydrochloric acid and potassium chlorate to destroy the organic matter. The solution was again filtered and the residue carefully washed off the filter paper into a platinum crucible, using as little water as possible. The excess water was then evaporated off and the residue, if any, carefully heated to remove any residual organic matter. In certain cases the residue was examined without this final heating.

The residues were examined dry under the ordinary microscope and also under a polarising microscope.*

A further and more critical test consisted in examining the particles for their refractive indices.

The method employed consisted in adding a drop of liquid of the same refractive index as that of the glass particles of the savoury jars, and observing through the microscope whether the particles obtained from the various foods were visible or not. The total disappearance of the particles would indicate that the glassy particles were of the same refractive index and hence, probably from the same source. Conversely the non-disappearance of the particles obtained as the result of analysis of the food stuff would indicate that the particles were of a different refractive index from that of the glass jar and so were derived from a different source.

In the case of the savoury jars it was found that pure benzene had a refractive index almost identical with that of the particles of glass obtained by grinding up a portion of the savoury jar. Benzene was therefore used to test the particles found in the various food stuffs.

Mr. Munro summarises the results of his experiments as follows:—

"Test 1.—(a) and (b). A very slight inorganic residue was found in the contents of a glass jar of turkey and tongue savoury after processing. This residue resembled in all respects the residue found in the meat before being processed in the glass jar. In both several small transparent and irregularly shaped particles were found; none exceeded $\frac{1}{100}$ in. and the majority were microscopic in size and of the order of $\frac{1}{1000}$ in. Under the polarising

* Mr. Munro has recently devised a new and improved method for the detection of glass particles in certain foods such as meat savouries.

About 20 gms. of the contents of a glass jar of savoury are placed in a nickel basin, about 15 gms. of stick caustic potash are added and then 50 ccs. of methylated spirit. The contents of the basin are stirred up with a nickel spatula and kept gently boiling for about 15 minutes on a wire gauze over a bunsen burner.

By this means the fat present is saponified to form a soluble alcoholic potash soap and subsequent filtration is rendered easy.

The contents of the nickel basin are now filtered, the residue being well washed with hot alcohol and finally with hot water.

A granular mass is left in the filter paper. This is washed out into a Pyrex beaker with hot water. Slight excess of hydrochloric acid is added and also about 2 gms. of potassium chlorate and the solution boiled for a few minutes.

By this means any residual organic matter is oxidised and a clear solution is obtained.

The solution is now filtered again, and the residue, if any, is washed into a platinum crucible with alcohol. The alcohol is evaporated off and the residue is then gently ignited. Care must be taken to avoid too high a temperature to avoid fusion of any glass particles present.

The inorganic residue in the crucible is then moistened with a few drops of water or alcohol and then run on to a glass slide, and after gently warming the slide to drive off the liquid, the solid particles if any, are examined under the microscope.

microscope most of the particles showed optical activity but a certain number were quite inactive optically and were indistinguishable from glass fragments. The particles obtained in Test 1(a) and (b) were now tested for refractive index with benzene, this substance, as has been stated, having the same refractive index as the glass of the savoury jars. Whereas the slide with the savoury jar glass particles (Test 4) gave a perfectly clear field, that of the slide bearing the residue of analysis of the food from the savoury jar (Test 1(a) and (b)) gave a quite different result. The transparent and glassy particles were clearly visible and clearly defined, thus showing that they were not particles of glass from the savoury jar.

Tests 2 and 3 were now carried out. In both, a residue was obtained which closely resembled the residues obtained in Test 1. However, in the case of the butchers' meat and fresh fish, the residue was very much greater than that obtained from the potted meat or tinned soup. The nature of the residue was similar in each case, numerous transparent irregularly shaped fragments of a glassy appearance being visible. Under the polarising microscope a similar behaviour was exhibited as in Case 1; whilst the majority of the transparent particles were optically active a certain number were quite inactive and so indistinguishable from glass fragments.

Test 4 consisted in grinding up a fragment of glass from a glass jar and comparing this powdered glass with the residue already obtained. Under the polarising microscope all the particles were inactive save a few at the edges. This slight inactivity was probably due to unequal stresses set up in the glass during grinding.

The next test, and, in my opinion, the crucial test, consisted in filling six glass jars with distilled water, capping them and then processing them in the usual way. After processing and holding the jars up to a strong light no glass particles could be seen. Any particles present would have been readily detected when the bottle was inverted, as was shown by placing some powdered glass in a glass jar filled with water. The particles were of the order of $\frac{1}{30}$ in. and less, but these were readily visible from the light reflected from their surfaces when the jar of water was inverted."

Dr. Monier-Williams, of the Ministry of Health Laboratory, has also carried out some experiments with a view to devising a reliable method of detecting glass splinters in foodstuffs and of differentiating between them and particles of sand or similar mineral matter originating from dust of various kinds, or present originally in the material. The foods examined and the results of the analysis of them are given below:—

Foodstuff.	How packed.	Weight taken for examination.	Weight of residue in grams.	Nature of Residue.
1. Whole fruit black currant jam	1 lb. glass jar	100 grams	0.0022	Appeared to consist largely of sand grains. No glass.
2. Potted anchovy paste ..	Small glass jar	Whole contents (88 grams.)	0.0107	Mostly sand. Many diamond shaped crystals present. One piece of glass 0.8 x 0.9 mm. (Plate 9).
3. Potted salmon and shrimp paste	Small glass jar	Whole contents of jar (84 grams)	0.002	Contained four or five glass particles, the largest being shown on Plate 7. Also much sand (Plate 8).
4. Apricot jam (English) ..	1 lb. glass jar	120 grams	0.0035	1 piece of flint $1\frac{1}{4} \times \frac{3}{4}$ mm. Remainder all sand. One small glass fragment less than 0.2 mm. in diameter.
5. Golden plums (English) ..	1 lb. glass jar	Whole of liquid portion (270 grams)	0.0006	Two glass splinters 0.4 and 0.3 mm. in length. Several others about 0.2 mm. long and sand grains (Plate 10).
6. Lemonade crystals ..	Small glass bottle	Whole contents of bottle (52 grams)	0.0002	One piece of glass 0.23 mm. in diameter. Several much smaller fragments. Very little residue.
7. Coffee and chicory extract	Glass bottle	Whole contents of bottle (167 grams)	0.0002	Two pieces of glass 0.6 x 0.2 mm. and 0.34 x 0.1 mm. (Several smaller fragments and sand grains (Plate 12).
8. Meat extract ..	2 oz. brown glass bottle	Whole contents of bottle (57 grams)	0.0002	One piece of glass 0.5 x 0.23 mm. (Plate 11). Several other small fragments of glass about 0.1 mm. long, and sand grains.
9. Loganberries (U.S.A.) ..	1 lb. tin	100 grams	0.0055	Residue mostly crystalline. Several small glass fragments.

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Foodstuff.	How packed.	Weight taken for examination.	Weight of residue in grams.	Nature of Residue.
10. Prunes (U.S.A.) ..	$\frac{1}{2}$ lb. tin	Whole contents of tin (243 grams)	0.0027	Contained two glass fragments 0.2 mm. in length. Rest of residue mostly crystalline. Practically no residue of any kind.
11. Cherries (Italian) ..	1 lb. tin	225 grams liquid and solid together	0.0001	Residue was very high and appeared to consist wholly of sand. One glistening transparent fragment with sharp edges like glass was shown to be crystalline under the polarising microscope (Plate 13).
12. Anchovy paste ..	Small tin	Whole contents of tin (100 grams)	0.0257	One particle of glass or glazé less than 0.2 mm. in length. Very little other residue (Plate 14).
13. Marmalade (English) ..	1 lb. white glazed earthenware jar	100 grams	0.0002	Several glass splinters 0.1 to 0.2 mm. in diameter, and some sand grains.
14. Meat extract ..	White glazed earthenware jar	Whole contents of jar (69 grams)	0.0002	Two large and several small fragments of red earthenware. Many glass particles from 0.1 to 0.2 mm. in diameter. Remainder chiefly crystalline particles (Plate 15).
15. Honey (English) ..	Red glazed earthenware pot	Whole of contents (214 grams)	0.0019	

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Dr. Monier-Williams has also prepared a number of micro-photographs which demonstrate the presence of glass particles in many of the samples examined (See Appendix). Plates 1 to 6 are test photographs for purposes of comparison. Plates 7 to 15 show the presence of glass and of other extraneous mineral matter in the residues of foods examined. These photographs show that glass splinters when examined under the microscope are transparent and usually present characteristic sharp edges and the concentric markings associated with conchoidal fracture, while sand grains are more or less rounded and less transparent. This is not always the case, however, as will be seen on reference to Plate 13, which illustrates a crystalline particle isolated from a sample of anchovy paste. The transparency, sharp edges and conchoidal fracture shown by this fragment would render it difficult to distinguish it from glass were it not for the assistance afforded by the use of polarised light. Under the polarising microscope with crossed nicols, glass fragments are invisible, the field being uniformly dark (Plate 1), while crystalline particles appear bright on the dark field and show, in most cases, vivid interference colours (Plate 3). Quartz particles of an amorphous nature, such as flint and agate, also appear bright on a dark field, the transmitting light having a mottled appearance (Plate 2). A few of the particles in the residues from foodstuffs are quite opaque, and transmit no light at any position of the analysing prism. (Plates 7-12; 14 and 15). In view of the drastic treatment with strong acids to which the foodstuffs were subjected, these particles must consist of mineral matter or extremely resistant carbon.

The method adopted by Dr. Monier-Williams for the isolation of the mineral residue from foodstuffs was as follows: The whole or part of the contents of the container, depending on the amount and nature of the foodstuff, was boiled with a large quantity of 10 per cent. sulphuric acid in a Jena or Duro glass flask for about half an hour. The contents of the flask were then filtered hot on a Buchner funnel with suction through one thickness of ash-free filter paper and the solid residue washed with water on the filter. The residue and filter paper were put back into the flask and "wet-ashed" by boiling with a small quantity of concentrated sulphuric acid with repeated addition of small quantities of nitric acid. When the organic matter had been completely destroyed, the residual sulphuric acid, which should be colourless or only slightly yellow, was cooled, diluted with water, and transferred to centrifuge tubes, the solid residue being washed out into the tubes with water. After being centrifuged, the acid liquor was poured off and the residue treated in the centrifuge tubes alternately with hot 10 per cent. sodium hydroxide solution and with concentrated hydrochloric acid, and finally washed with distilled water, dried, and weighed. It was then mounted in glycerine jelly on a microscope slide and examined in polarised light for the presence of glass particles.

To meet the possible objection that glass fragments might be

derived from the glass vessels used in the analysis, Dr. Monier-Williams carried out numerous blank experiments on filtered solutions of pure cane sugar. Although a slight residue was usually obtained, this residue was never found to contain particles of a size which would enable them definitely to be identified as glass. Since, however, the method which he employed involved a good deal of boiling in glass vessels, he has not used a greater magnification than 35 diameters in examining the residues, and has, in general, not considered the presence of glass as definitely proved unless the particles are at least 0.2 mm ($\frac{1}{50}$ in.) in diameter.

Mr. Stock, Public Analyst for the County of Durham, has pointed out that road dust may be a further source of contamination. He has observed that preserves made with soft fruits, such as blackcurrant, raspberry and strawberry, more often contain siliceous matter than those made with the harder varieties of fruit.

Road dust which contains quantities of siliceous particles is carried for considerable distances by high winds, and much of the fruit in market gardens and fruit farms which are situated in the vicinity of towns or near to highways is often covered with dust.

In the process of jam making, the soft fruits mentioned, after being "picked over" to remove any fruit that is badly moulded or otherwise unfit for use, are usually admitted to the boiling pans without any previous washing, and any minute particles of mineral matter adhering to the fruit would almost certainly be present in the jam.

Many fresh food materials too, such as meat, fish, poultry, game and vegetables, are at times exposed to contamination by road dust, and articles of food prepared with these materials are liable to contain dust particles unless proper precautions as to cleanliness are observed.

Conclusion.—Having regard to the considerations set out in this report, I do not think that any real objection can be taken to the use of glass containers as receptacles for food. Glass packed foods of one or other sort, as has been mentioned, are eaten by the million daily, while glass particles of appreciable size are but seldom found in them. When present, the glass is usually in powdered or microscopic form and there is little, if any, evidence to show that in this form it is capable of exerting any injurious effect when swallowed with the food. It would, however, be unwise to accept such negative evidence as wholly conclusive, for glass, in whatever form, is manifestly an undesirable ingredient in foods. It has been shown that food manufacturers are for the most part well aware of the need for using good glassware and for avoiding contamination with glass of the contents of a vessel during the various operations to which it is subjected in the factory; and it is doubtless largely due to these measures that the larger particles of glass, derived from the burstings and breakages which are inevitable in such factories, are so seldom met with in food.

The need of using good glassware and of exercising proper care in the food factory cannot, therefore, be too strongly insisted upon, and provided manufacturers recognise these essentials little danger need be apprehended from glass-packed foods.

7th October, 1926.

G. C. HANCOCK.

APPENDIX

MICRO-PHOTOGRAPHS OF
GLASS AND OTHER MINERAL PARTICLES IN
FOODSTUFFS USING POLARISED LIGHT
MAGNIFICATION . . . APPROX: 35 DIAMETERS.

The two microscope fields on each plate are the same, the Nicol prisms being parallel in the upper photograph, and crossed in the lower one.

PLATE 1

TEST PHOTOGRAPHS FOR COMPARISON.

Powdered glass in polarised light.

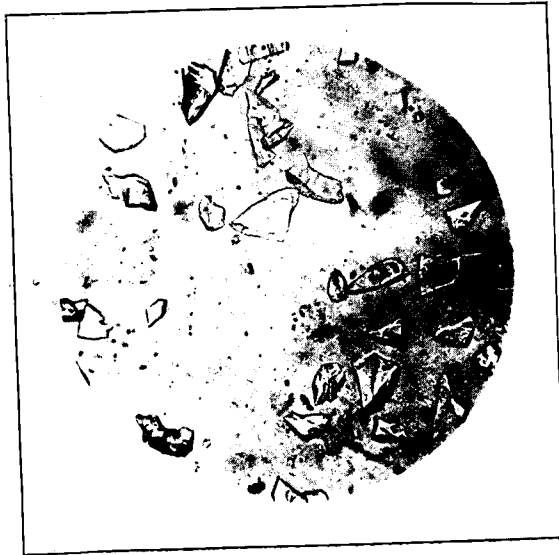
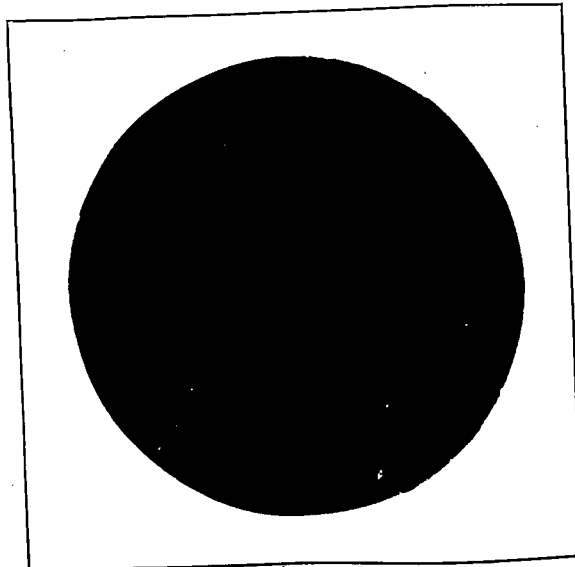
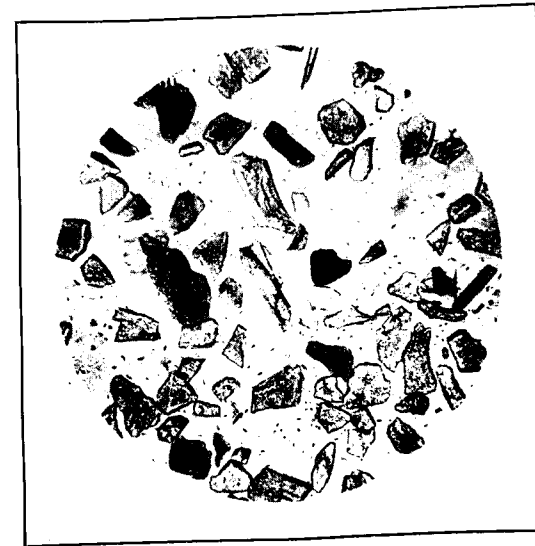
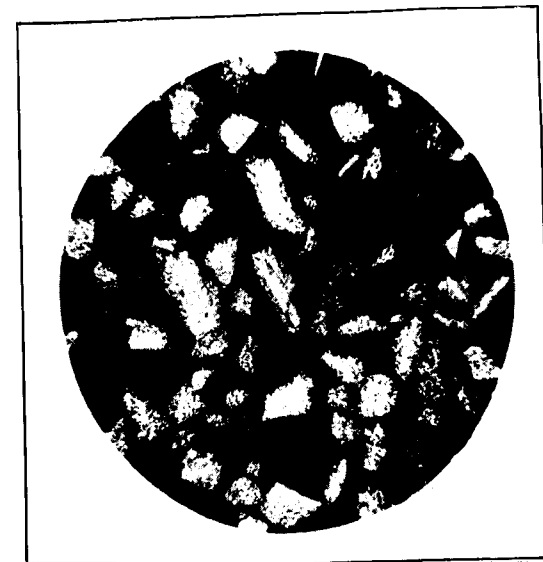
Nicol prisms parallel.*Prisms crossed, showing uniformly dark field.*

PLATE 2

TEST PHOTOGRAPHS FOR COMPARISON.

Powdered flint, in polarised light.

Nicol prisms parallel.*Prisms crossed.*

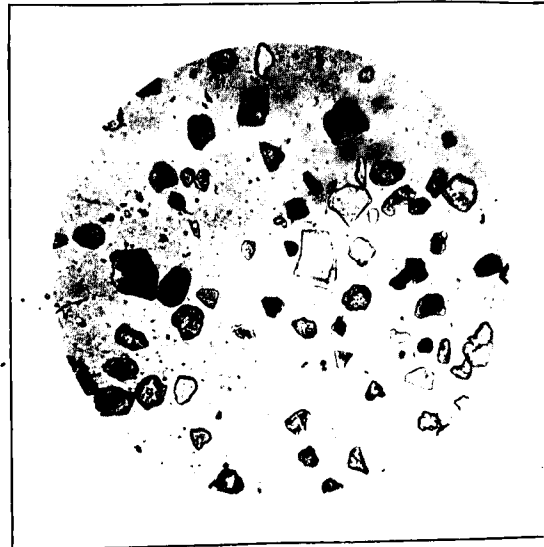
24

PLATE 3

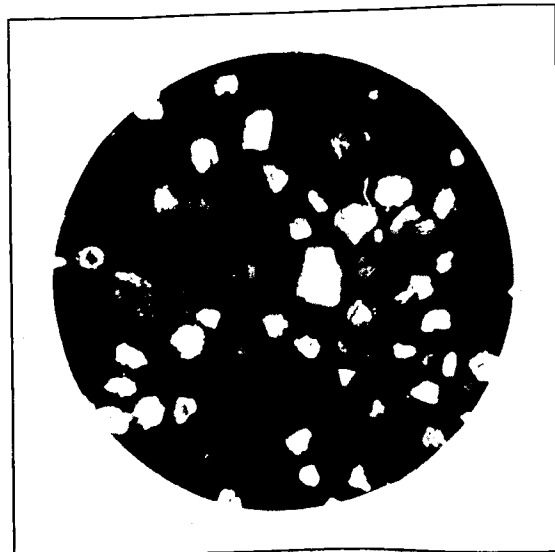
TEST PHOTOGRAPHS FOR COMPARISON.

Sand in polarised light.

Nicol prisms parallel.



Prisms crossed.



25

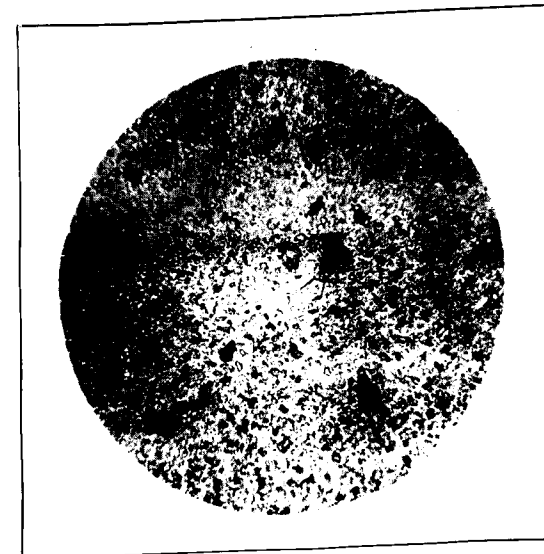
161377

PLATE 4

TEST PHOTOGRAPHS FOR COMPARISON.

Dust from top of shelf in room.

Nicol prisms parallel.



Prisms crossed.

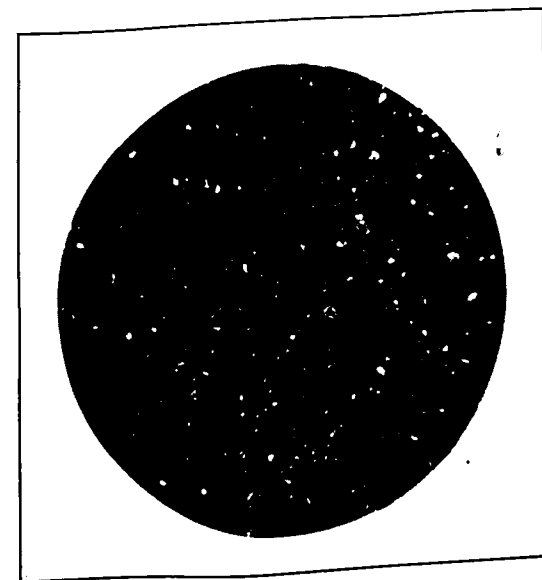


PLATE 5

TEST PHOTOGRAPHS FOR COMPARISON.

Blank experiment on pure filtered sugar solution.

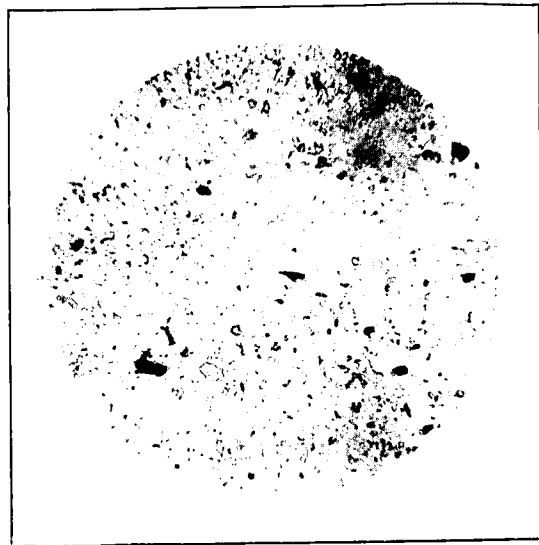
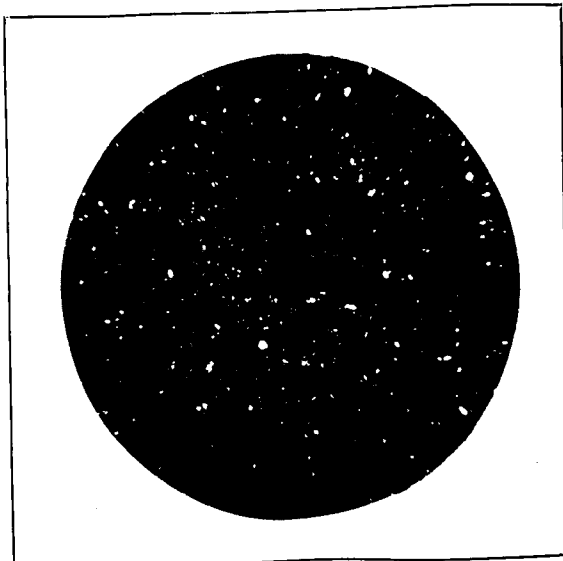
Nicol prisms parallel.*Prisms crossed.*

PLATE 6

TEST PHOTOGRAPHS FOR COMPARISON.

Residue obtained from black currant jam to which has been added powdered bottle glass.

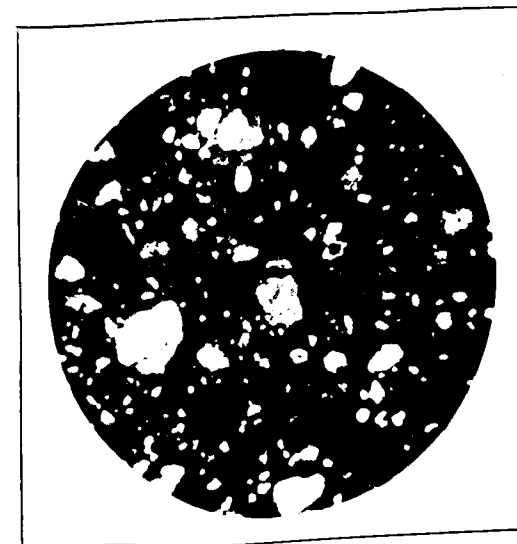
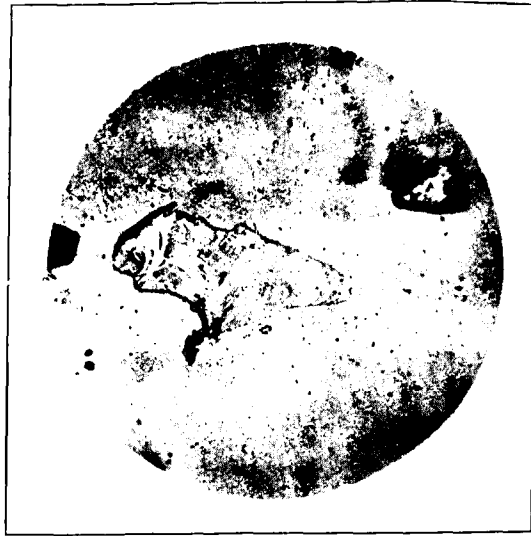
Nicol prisms parallel.*Prisms crossed.*

PLATE 7.

FOODS PACKED IN GLASS CONTAINERS.

Large glass particle in residue from salmon and shrimp paste.

Nicol prisms parallel.



Prisms crossed.

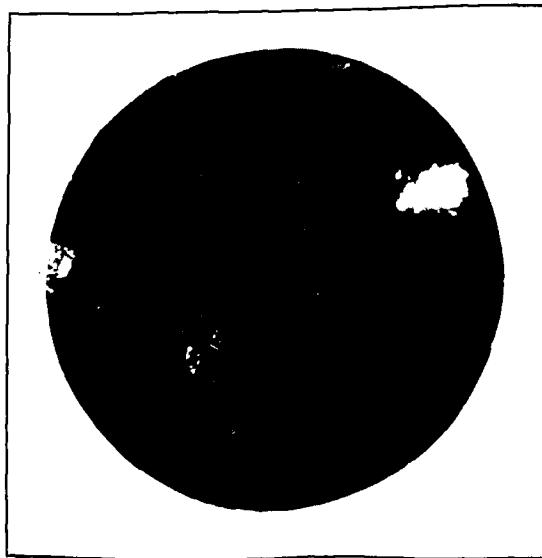


PLATE 8

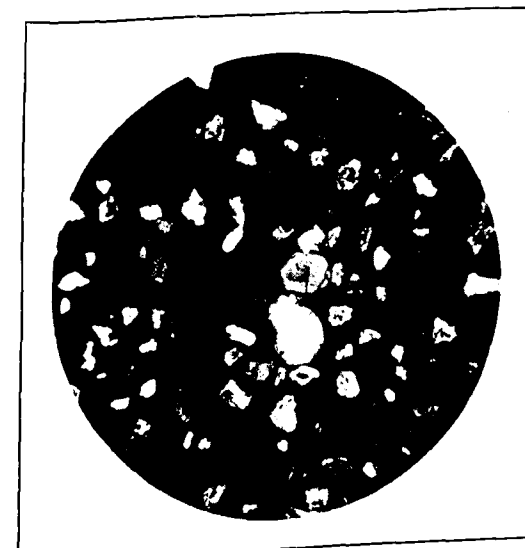
FOODS PACKED IN GLASS CONTAINERS.

General character of sandy residue from salmon and shrimp paste, with glass particle.

Nicol prisms parallel.



Prisms crossed.



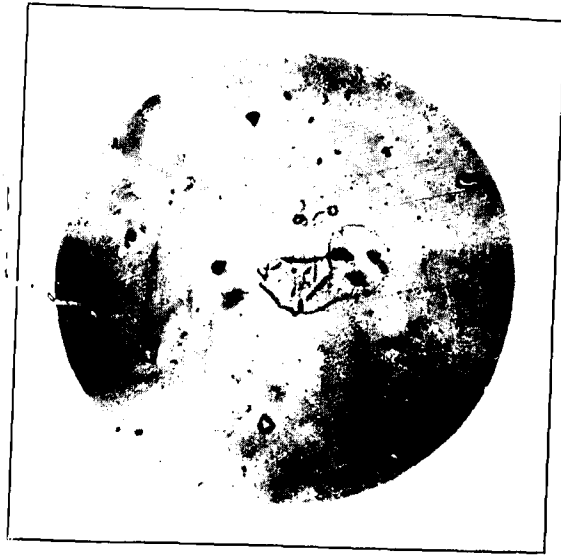
32

PLATE 11

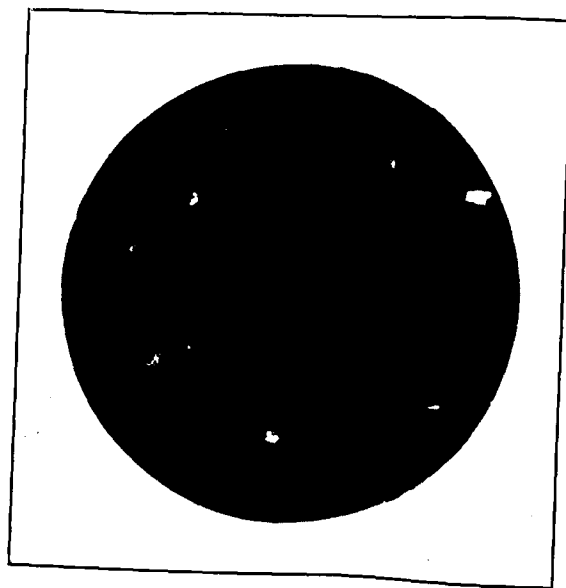
FOODS PACKED IN GLASS CONTAINERS.

Glass fragment found in meat extract.

Nicol prisms parallel.



Prisms crossed.



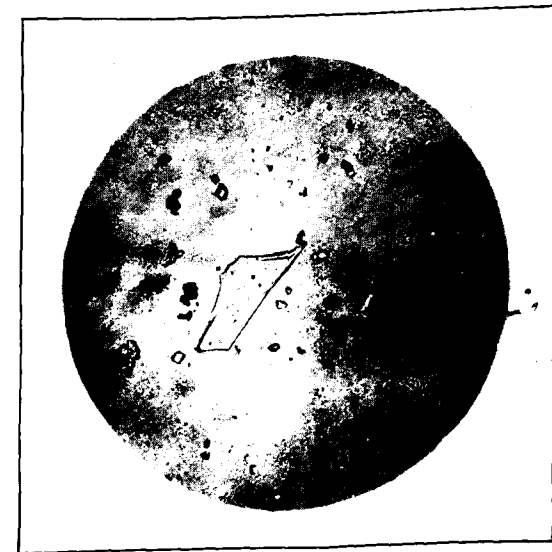
33

PLATE 12

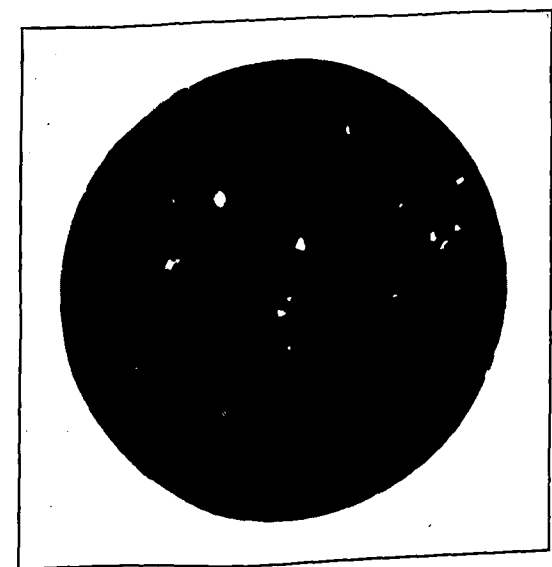
FOODS PACKED IN GLASS CONTAINERS.

Glass fragment from coffee and chicory essence.

Nicol prisms parallel.



Prisms crossed.



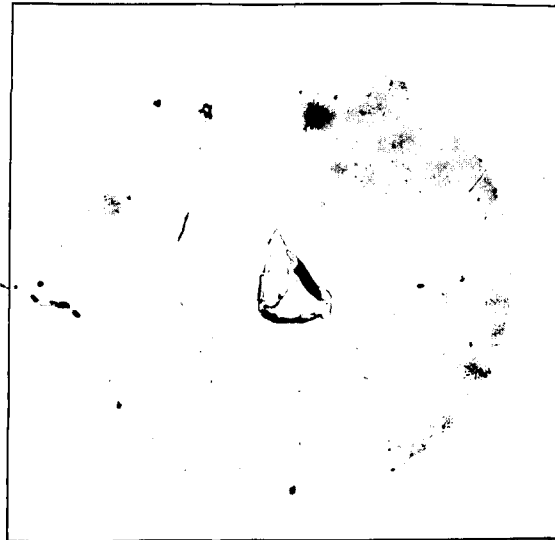
34

PLATE 13

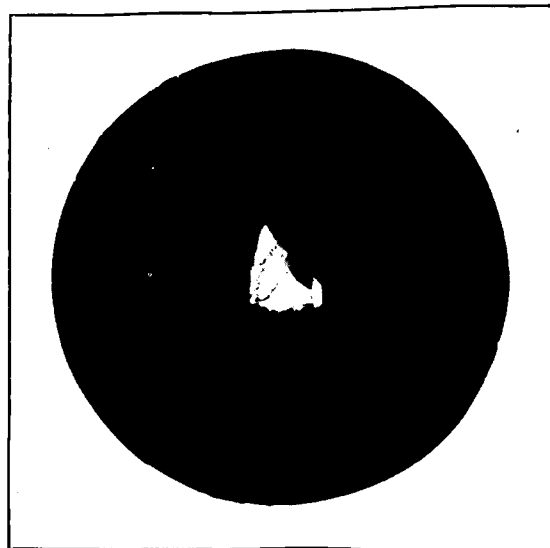
FOODS PACKED IN TIN CONTAINERS.

Transparent crystalline particle picked out by naked eye from sandy residue of anchovy paste (tinned).

Nicol prisms parallel



Prisms crossed



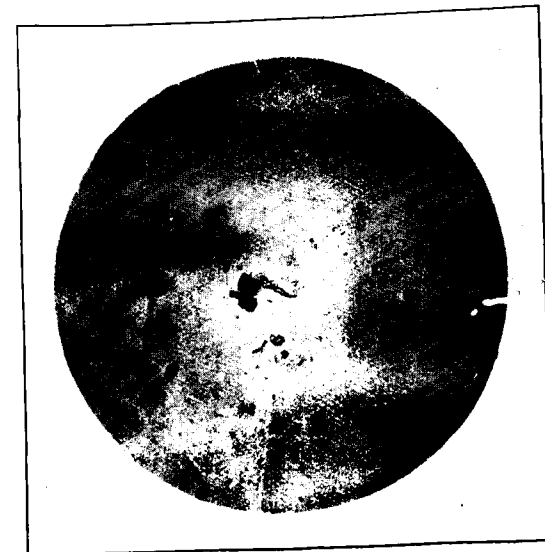
35

PLATE 14

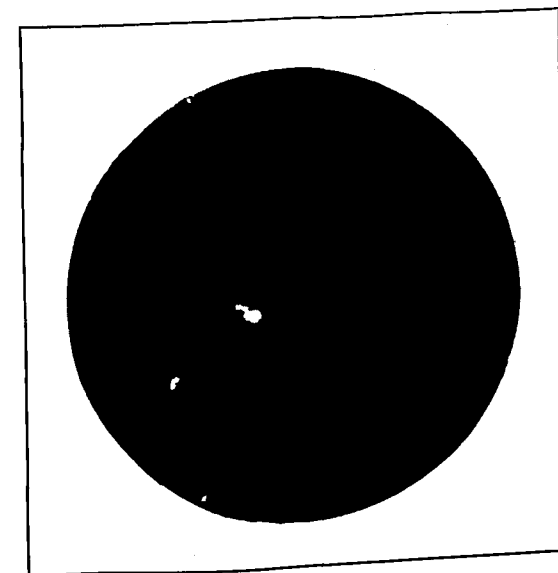
FOODS PACKED IN EARTHENWARE CONTAINERS.

Minute glass or glaze fragment from marmalade packed in earthenware jar.

Nicol prisms parallel.



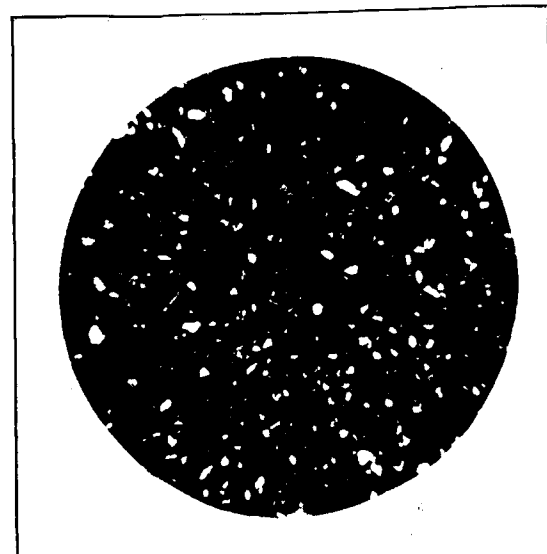
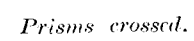
Prisms crossed.



FOODS PACKED IN EARTHENWARE CONTAINERS.

Residue from honey, packed in earthenware. Some of the opaque fragments were particles of red glaze or earthenware.

Nicol prisms parallel.

[illegible]