A BACTERIOLOGICAL STUDY OF

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by

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A Thesis Submitted to the

Faculty of Graduate Studies and Research of McGill University

in Partial Fulfillment of the Requirements for the Degree of

MASTER OF SCIENCE

April, 195[illegible]

Department of Bacteriology,

McGill University,

Montreal, Quebec (Canada).

A BACTERIOLOGICAL SURVEY OF INSTITUTIONAL DISHWASHING

by

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ACKNOWLEDGMENTS

The author wishes to express his gratitude to Dr. C. D. Kelly for his invaluable advice, criticism and guidance during the course of this investigation.

Gratitude is also expressed to Professor E. G. D. Murray for his constant encouragement and counsel.

For the co-operation received from the dietitians and staffs of the dining halls investigated and from the Department of Buildings and Grounds, the author is most grateful. Special thanks are extended to Dr. Lars Gram, Oslo, Norway, for his correspondence and helpful suggestions related to the subject.

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INTRODUCTION

Although the first dishwashing machine was patented in 1879 (45), it was quite some time before any interest was shown in the possibility of improperly cleansed eating utensils acting as vectors for the transmission of diseases.

At the turn of the present century, the possibility of tuberculosis being spread through this medium was investigated, but perhaps the most valuable attempt to study this means of transmission resulted from a small outbreak of typhoid fever in Wisconsin. The apparent significance of the study failed to maintain interest in this work, and it was not until after the influenza epidemic of 1917-1918 that interest was revived.

Once again, however, the stimulation was short-lived; and only sporadic attempts at investigating dishwashing as a possible source of epidemics were made until the end of the second decade and the beginning of the nineteen-thirties.

At this time, the United States Navy and the British Army conducted rather extensive surveys into both mechanical and manual dish washing methods as applicable to closed groups such as those aboard ships and those in the fields. However, these two groups could well afford to undertake such investigations, for they were not subject to outside indifference and interference. This apathy and suspicion, prevalent with respect to community investigations, had been brought to light and scored several times, but to no avail. With the close of the third decade and the outbreak of hostilities, many investigations into dishwashing procedures in public eating and drinking establishments began. It had become a matter of necessity, not choice, that every means of prevention should be brought to the fore and rigidly controlled and practised in order to obtain the highest level of efficiency from a nation at war.

With the cessation of hostilities, the releasing of many heretofore restricted materials made possible investigations to improve the dishwashing equipment. This stimulated new interest, and, since it had been proved that unclean eating utensils were a possible source of infection, the health authorities were able to devote their time to bringing dishwashing equipment to a state of near perfection, and to the revision of out-dated codes of health with respect to restaurant sanitation.

The interest in the present investigation is two-fold:

1. to establish a definite relationship between the operator and his equipment;
2. to modify present equipment to determine if its efficiency can be improved.

HISTORICAL REVIEW

The historical review of institutional dishwashing may be divided into five parts:

1. the diseases transmitted through improperly cleaned eating utensils;
2. organisms found on improperly cleansed eating utensils;
3. surveys on dishwashing in public eating and drinking establishments;
4. techniques involved;
5. methods for sanitizing eating utensils.

1. Diseases Transmitted Through Improperly Cleansed Eating Utensils:

A. Tuberculosis:

Early in 1909, Price (91) began an investigation into the possibility of spreading tuberculosis through improperly cleansed eating utensils. This work was conducted at the Reception Hospital at Saranac Lake, New York, where preliminary investigations revealed that the utensils were mopped in hot soapy water and rinsed under a tap with water at near the boiling point. Without previous forewarning, he made visits several months apart to take swabbings of thirty forks and twenty-five each of cups, spoons, and glasses. Guinea pigs were inoculated intraperitoneally with 0.75 ml. of the sodium bicarbonate fluid in which the swabs were suspended, and fourteen of the animals died. All the animals were autopsied on the forty-first day of the experiment, and none showed evidence of tuberculosis. However, using groups of five utensils that were unwashed, eight guinea pigs were inoculated in the same manner and autopsied on the forty-first day. All of this group of animals showed evidence of tuberculosis. Brown, Petroff, and Pesquera (10) doing similar work, stated that the common carriers of the tuberculosis bacillus seemed to be the spoons, forks, cups, and glasses, with the plates and knives remaining free of contamination.

Cumming (21), in his attempt to establish the main route of tuberculosis infection, stated that man must not try to control air-borne infections except through the inanimate objects that served as vectors. With regard to tuberculosis, he felt that the main route of the infecting organism was by direct entry into the mouth. From thence the bacillus made its way to the tonsil or mesenteric lymph node and thus gained entry into the lymph system and finally the blood stream. When the blood reached the lungs to be filtered, the bacillus met its first impassible barrier in the capillaries of the lung, and therefore became lodged, causing the production of the tuberculous lesion. Consequently, since eating utensils would introduce the bacillus directly into the mouth, he felt that this was the most important avenue of attack in the prevention of the spread of tuberculosis. He also revealed that death was due to tuberculosis in thirty-five percent of the guinea pigs inoculated with wash water specimens from the utensils, in twenty-five per cent of those inoculated with rinse water specimens, and in forty-three percent of those inoculated with scrapings from the hands of patients, while none of the eleven guinea pigs inoculated with an air filtrate died of the disease. This fact led him to conclude that all eating utensils used by tuberculous patients must be boiled. Taylor (106) also reported positive results from unwashed utensils, while Floyd and Frothingham (32) stated that the incidence of tuberculosis from the swabbings of clean utensils was one out of twenty-five, and the incidence from swabbings of unclean utensils rose to four out of twenty-five. This evidence pointed to the fact that eating utensils that had been improperly cleansed could act as a vector in the spread of tuberculosis.

B. Typhoid Fever:

A small outbreak of typhoid fever was investigated by Ravenel and Smith at the University of Wisconsin in 1909 (96). Bacteriological examinations ruled out the possibility of the epidemic being caused by milk, ice, or water. It was concluded that the outbreak had been caused by an infected student who acted as a dish-wiper at one of the approved boarding houses. However, no conclusive evidence of this was shown because the student succumbed to the disease before this phase of the investigation could be studied.

C. Influenza:

Before the close of the work on tuberculosis, another investigation was begun into the possibility of influenza being transmitted through improperly cleansed eating utensils. Lynch and Cumming (56) found that the incidence of the disease among a group of soldiers eating from boiled utensils was five times less than that in a group eating from unboiled utensils. In their report, they mention samples of mess kit wash water containing as many as 40,000 organisms per ml., while dish water in hotels investigated at the same time had counts as high as four million per millileter. These authors felt that 'crowd diseases' have their origin in constant accumulative contamination of intermediate objects, which in turn serve as distributing centers for causal organisms. Cumming (20) believed that the epidemic could have possibly been prevented, if not controlled, by the use of boiling water in washing the eating utensils, which in his opinion constituted the major avenue of infection in this type of disease. Later he claimed (22) that in an institution with over 250,000 inmates only 3.2 percent of the influenza cases were caused by means other than improperly washed eating utensils.

2. Organisms Found on Improperly Cleansed Eating Utensils

A. Haemolytic Streptococcus:

In considering the spread of haemolytic streptococcus by eating utensils and wash water, Nichols (82) found no evidence to show that the organism would live in soapy dish water, since soap was toxic to the streptococcus. However, he did find that soap had no effect on colon bacilli which he isolated from specimens of wash water in amounts as small as 0.01 milliliter.

Further, Cumming, Spruitt, and Reuter (23) argued that eighty-five percent of the utensils used by healthy carriers of haemolytic streptococci remained contaminated after handwashing. Saelhof and Heinekamp (99) also report finding haemolytic streptococci on supposedly clean utensils taken from small restaurants and cafes.

The particular strains that they were able to isolate proved virulent for rabbits suggesting that they corresponded to the human pathogenic strains. For this reason, they advocated subjecting all utensils to live steam for a period five minutes and making a routine periodic health check on the personnel to detect the possibility of a carrier state being in existence.

B. Intestinal and Other Organisms:

With reference to particular groups of people, especially military groups in the field, the main problem seems to be that of intestinal disturbances. Faecal organisms are commonly isolated from eating utensils in this type of group (8). Personnel in these groups can be considered to be selective in that persons with tuberculosis are eliminated and those with respiratory diseases are promptly isolated and subjected to the proper therapy. Evidence now appears to indicate that the gastro-intestinal upsets encountered in these selected groups are due to improper cleansing of the messing equipment. In 1943 at Fort Leavenworth, Kansas (46), cultures of wash and rinse waters that contained intestinal organisms preceded, from one to three days, outbreaks of diarrhoea of sufficient seriousness to warrant hospitalization.

Another instance in which the improper cleansing of eating utensils was blamed for an outbreak of intestinal trouble was that of an outbreak of gastro-enteritis among the members of a group of adult graduate students at Yale University in 1947 (90). Bacteriological examinations of the water and milk supplies ruled these out as the cause of the epidemic. There was no concurrent outbreak within the university or the surrounding community. In trying to trace the source, it was found that an infected student was working as a dish-wiper in the kitchen. Although no conclusive evidence was presented to prove the case, it was surmised that he was responsible for the spread of the disease, since none of the employees in the kitchen became ill and due to the fact that the utensils used by the employees were washed and stored separately from those used by the students who had contracted the disease.

Escherichia coli has been reported to be as prevalent as 37.5 percent on utensils in taverns, 28.5 percent in drug stores, and 7.6 percent in restaurants by Marden et al. (65), while Christavao (16) quotes figures of 4.7 percent on glasses and 6.3 percent on demitasse cups in bars and cafes, and in restaurants he found 9.1 percent of the glasses and 4.5 percent of the dishes and forks were contaminated with this organism. As well as isolating E. coli, Horwood and Pesare (44) recovered Aerobacter aerogenes from 41.8 percent of the utensils that they examined. They also isolated acid fast organisms, haemolytic streptococci, and haemolytic staphylococci. In a survey of glasses, from bars and taverns, Lyons (57) found Spirochaetaceae on nineteen percent, Borellia vincenti on twelve percent, Treponema microdentium on two percent, and Treponema macrodentium on five percent. Dick and Hucker (29) once more showed that glasses were a major harboring point for bacteria when they pointed out that Streptococcus salivarius would survive on the rims for at least forty-eight hours when stored at room temperature. Their investigation further revealed that in two cities, almost eighty percent of the glasses investigated were contaminated with this organism, due to the fact that improper washing and rinsing procedures were in use. However, Rose and Georgi (98) report Streptococcus salivarius as a contaminant on glasses in their investigation to the extent of only 5.5 percent.

With this evidence, it can easily be seen that improperly cleansed utensils in public eating and drinking establishments may serve as vectors for the spread of diseases.

3. Surveys on Dishwashing in Public Eating and Drinking Establishments

The types of organisms that have been isolated from supposedly clean eating utensils have already been discussed. A review of past investigations shows how unsanitary conditions have been, and still are in some places.

As early as 1920, Dearstyne (26) conducted investigations into the dishwashing procedures in use in Alexandria, Virginia. He found counts as high as 1,200,000 organisms on glasses that were washed by hand, and even with the machine washers then in use, his lowest count from glasses was 1,200. Krog and Dougherty (55) in 1936 offer further evidence of glasses being one of the most improperly cleansed utensils in use when they revealed counts of 115,000 organisms on tumblers from bars and taverns. Fellers, et al. (30), report that some beer halls did not even wash the glasses. As late as 1940, out of 347 drinking establishments investigated by Bushong and Fletcher (13), only thirty-one percent had glasses with counts under two hundred, and in restaurants investigated at the same time, the percentage with counts under two hundred rose up to thirty-six percent. According to Marden et al, (65) in 1938, less than ten percent of the drinking establishments in Hartford, Connecticutt, had facilities that would comply with the board of health regulations then in force. Only three years later, Hall in 1941 (41) claimed that accidents in industry were accounting for only five percent of the absenteeism, with the remaining ninety-five percent being due to the common illnesses such as colds and influenza. She felt that the incidence of these common illnesses could be greatly reduced by the use of proper sanitary measures with regard to dishwashing in industrial cafeterias.

In 1942, Horwood and Pesare (44) found a gross lack of knowledge on the part of some restaurant owners as to proper procedures to be applied to dishwashing. As a result, they obtained counts as high as 76,000,000 organisms per utensil in some of the places they investigated. The following year, the apparent laxity with regard to restaurant sanitation was scored severely when the U.S. Public Health Service blamed a large part of the sixty percent increase in dysentary cases on improper methods in use in food establishments (93). Hutchinson (47) in 1947 reports finding wash water specimens with counts of well over 1,000,000 organisms per ml. and that sixty-seven percent of these specimens contained coliform organisms in excess of 1,800 per ml. when the hydrogen ion concentration range was from pH 7.0 to pH 10.6.

In Rio, in 1949, only 14.1 percent of the cups in establishments investigated by Christavao (16) were considered satisfactory from the bacteriological standpoint. Even with mechanical dishwashing, Higgins and Hobbs (43) found counts from plates as high as 100,000 in 1950.

This information can mean only one thing: that is, as long as the lack of good equipment and the lack of knowledge as to its proper use exists, the need for investigations into dishwashing procedures in public eating and drinking establishments remains essential. Until conditions are such that counts are reduced to within an acceptable range, the possibility of the appearance of the previously discussed organisms will remain high.

4. Techniques Involved.

A. Bacteriological Plate Count:

Although the bacteriological plate count is not used universally, it is perhaps the most reliable means available at present for measuring the effectiveness of institutional dishwashing methods. Using sterile materials, a cotton wool swab on steel wire is dipped into a suspending liquid, pressed nearly dry, and then rubbed over a specified surface. The swab is then replaced in the suspending fluid and agitated to remove adherent particles. A portion of the suspension fluid is then placed in a Petri dish and nutrient agar is added. Colony counts are then made after incubation.

Many methods have been recommended for obtaining reliable bacterial counts, and for this reason Cumming and Yongue (24) stated the need for standardization of methods in order to obtain comparative results. Cotton wool swabs on glass rods in a sodium bicarbonate suspension fluid have been used (91). Steel wire with non-absorbent cotton has been recommended as being superior to wooden applicator sticks (114), but Buchbinder et al. (12) believe that wooden applicator sticks are better. This controversy centered around the point of which type of swab holder would remove the most bacteria from the tested surface. In sterilizing swabs, the U. S. Public Health Service recommends sterilization in the suspension fluid (114) while France et al. (33) have found dry sterilization to be better. This latter method enabled them to recover fourteen percent more bacteria than were recovered with swabs that had been dipped in the suspension fluid and sterilized damp.

Although physiological saline has been used frequently as the suspension fluid, it has been found to be one of the least satisfactory, with distilled water being the poorest (33). The fluid most often used is a phosphate buffered solution. This has been recommended by Butterfield (14) and is modified by the U. S. Public Health Service for use in its legislation governing restaurant dishwashing.

B. Interpretation of the Bacteriological Plate Count:

MacDonald and Freeborn (58) have suggested standards of acceptability as low as fifty colonies per utensil, and this is essentially the count that is used in the grading system in Concord, New Hampshire (78), although others (59) have recommended accepting any count that was under five hundred colonies per utensil. But in most instances where the plate count is used in grading, the maximum count allowable is one hundred colonies per utensil. This is the count that has been incorporated into the U. S. Public Health Service regulations concerning institutional dishwashing (114). As Gram has expressed it (38), with counts under one hundred colonies per utensil, the possibility of isolating coliform and oral cavity organisms is greatly reduced.

As far as the plating media are concerned, it should be mentioned that even though many types have been recommended from time to time, the nature of the organism to be isolated will determine if any specific media are to be used.

C. Other Methods of Obtaining Bacterial Counts:

Direct staining of glass rims has been recommended (30), but was found to be impractical, and the direct coating of the glass rims with double strength agar has been advocated (84). The use of contact plates (118) that permit the colonies to grow on the actual test medium is impractical from the standpoint of it being limited almost exclusively to flat surfaces.

5. Methods for Sanitizing Eating Utensils.

Throughout the literature, the means of reducing bacterial contamination in institutional dishwashing have been essentially by direct methods. These methods may be divided into three parts: (a) chemicals, (b) ultra-violet light, and (c) heat.

A. Chemicals:

Many chemical agents have been proposed for use and tested for their bactericidal effect. For field sanitation, Griffin (39) has advocated the use of a steeping solution of 1:1000 potassium permanganate. This is not only a good bactericidal agent, but it is most practical in this instance in that the appearance of the brown color indicates that the solution is no longer of any value, and the time of replenishing can be determined without recourse to intricate laboratory methods of testing. However, Searle (101) feels that this method is of no value because the time involved (five minutes) is too long. Devereaux and Mallmann (28) tested several detergents to determine their bactericidal effect. However, those tested were eliminated for such reasons as leaving a residual stain or being too slow to act. Even the organic chlorine containing compounds were found unsatisfactory due to the time consumed to effect sterilization. Kreuger (54) stated that even though some detergents possess bactericidal properties, they must not be relied upon to do the task because of the time involved. Later, Guiteras and Shapiro (40) discovered that when a cation active agent was used as the killing factor, its effectiveness was lost when the hydrogen ion concentration of the solution was sufficiently high to permit the saponification of fats.

Chlorine from inorganic sources seems to be the most practical of the chemical bactericides (63). It has been recommended for use in concentrations of from one hundred parts per million (60) to two hundred parts per million (28). Most of the modern public health codes allow for this type of substance to be used as an alternate method in place of steam or hot water for bactericidal purposes.

B. Ultra-violet Light:

Ultra-violet light has been tested for its bactericidal effectiveness, and although it has definite germicidal properties, it is thought to be impractical for use in sterilizing eating utensils because it is too slow and complete sterility cannot be obtained (5). Further, grease films, food particles, finger prints, etc., prevent the ultra-violet light from reaching the surface of the object to be sterilized (17).

C. Heat:

Heat is undoubtedly the most effective method of sanitizing eating utensils when considered from the standpoint of time involved. This discussion, however, will be limited to moist heat only.

Griffin (39) and Klicka (53) feel that steam from an open boiler is useless, yet Sandiford and Walker (100) have reported obtaining 96.5 percent sterility when using steam for five minutes at atmospheric pressure in a closed compartment. McDaniel (68) has obtained complete sterility by combining steam with boiling water. This was an easy matter, however, since it was done on a ship whose motive power was steam, part of which could be diverted for the purpose of sterilizing eating utensils.

The use of hot water and plenty of soap is the most effective method of controlling bacterial counts from the viewpoint of practicality (86). Many different methods have been recommended for both the washing and rinsing in automatic machines. Cox (18) has advocated the use of wash temperatures of 160°F. for a period of no less than sixty seconds, followed by a ten second rinse at 180°F., for single tank machines. For multiple tank machines, he has suggested using wash temperatures of no less than 165°F. for forty seconds, followed by a rinse at 180°F. for a period of twenty seconds. He claims that this results in a 99.99 percent reduction of the non-spore bearing organisms that contaminate eating utensils. The former temperature and time is essentially that recommended for use by Klicka (53). However, Andrews (4) states that wash temperatures should not exceed 140°F., for above this, food particles have a tendency to be cooked onto the surface of the utensils. He sets the rinse temperatures at a minimum of 170°F. for a period of fifteen to thirty seconds. Using M. caseolyticus, Mallman (62) found a one hundred percent reduction in counts at this temperature for only twenty seconds. Gilcreas and O'Brien (36) have shown that E. coli and haemolytic streptococci have a survival rate of less than one colony per plate when the utensils (glasses in this case) are processed at 110°F. for washing and with a temperature of 170°F. for rinsing.

However, the time factor in the wash and rinse periods varies greatly throughout the literature and in use in the modern health codes. It is, on the other hand, generally accepted that the rinse temperature must be no lower than 170°F., but the range of time of exposure runs from fifteen seconds as used in Richmond, Virginia (117), up to two minutes as used in Toronto (88). Seldom does one encounter rinse temperatures lower than this figure, but higher ones with a reduced time of exposure may be used and still remain satisfactory, the extreme being found in use in New Brunswick which requires a rinse temperature of 190°F. for a period of three minutes (76).

REVIEW OF PUBLIC HEALTH REGULATIONS

In order to review regulations governing restaurant sanitation and methods employed in dishwashing in present-day eating and drinking establishments, letters with a simple questionnaire were sent to seventy health authorities throughout the world. The returns from these questionnaires have totalled eighty per cent for Canada, seventy-five per cent for the United States, and seventy-five per cent for the group marked 'Others'. This latter group includes the following: Hawaii, Puerto Rico, Alaska, England, Sweden, Peru, Brazil, Cuba, Norway, Switzerland, the District of Columbia, and the World Health Organization of the United Nations.

In each group, only one health authority was questioned. An attempt was made to select a city which was prominently known in that particular district, but the capital of the district was not always selected. Size was the main consideration in writing to some cities; whereas in the foreign countries, the capitals were polled in order to obtain a more thorough reply directly from the ministers of health of the countries involved.

The following questions comprised the questionnaire:

1. Are the regulations governing dishwashing as used in public eating establishments of local or of federal origin?
2. Is any specific detergent recommended or required?
3. Is the health of the personnel involved in the dishwashing taken into consideration? If so, in what manner is it considered?

4. What are the minimum equipmental requirements?
5. What is the maximum plate count allowable to determine the satisfactoriness of the method under investigation?
6. What are the times and temperatures of the wash and rinse cycles?

Each question is considered separately and an analysis is made on a percentage basis. This percentage is based on the number replying to the questionnaire, and not on the number of questionnaires sent. Where necessary, comments on the questions will be made and examples of regulations will be cited to demonstrate the manner in which the particular question is approached. This questionnaire is summarized in Table XVI in the Appendix.

1. <u>Are the regulations governing dishwashing as used in public eating establishments of local or federal origin?</u>

Canada:	12.5% local, 50% federal, 37.5%unspecified.
United States:	22.2% local, 69.5% federal, 8.3% unspecified.
Others:	44.4% local, 44.4% federal, 11.2% unspecified.

(When percentages in these groupings do not add up to 100%, it may be taken as an indication that some cities do not have either federal or local regulations pertaining to the particular question.)

On the federal level, some states have general blanket laws like that of California (15) which adequately covers the sanitizing of dishes used in public eating establishments. This type of law is flexible in the sense that local authorities can, if they deem it advisable or necessary, impose laws more stringent than those of the state; in no case can the laws imposed by local authorities be less inclusive than those of the state.

The ultimate in control, or at least a start for more nearly perfect control, will in all probability come through individual federal governments, such as the standard code adopted as a guide in the United States (114). This guide is being used in many places in Canada and in several states in the United States not only as a basis for their laws, but as the law itself. However, though it is perhaps far too early to expect such far-reaching controls, the subject has not been taken up in the World Health Organization of the United Nations as yet, nor is there any work planned on sanitation of dishes in the present agenda of this group (113).

2. Is any specific detergent required or recommended?

Canada:	0% yes, 100% no
United States:	0% yes, 100% no
Others:	0% yes, 100% no

No health authority has mentioned any specific detergent that is even recommended. Most officials, in the wording of the laws that govern dishwashing, do state, however, that a satisfactory detergent be used to cleanse the dishes and utensils. The interpretation of the word "satisfactory" is left up to the discretion of the restaurant owner, but it is used to imply a detergent that will meet with the specifications of a good detergent as set forth by Tiedeman (109). These specifications, which are specific to action and not to type, are as follows:

1. Must emulsify food fats.
2. Must flocculate other food solids.
3. Must wet glass, china, and metal surfaces readily.
4. Must function equally well in hard or soft water.
5. Must rinse freely.

With such specifications as to action only, the manager of a restaurant or eating place has a wide variety of detergents from which he may choose. This competitive factor is one of the reasons that present-day laws do not define the specific detergent that is to be used. Perhaps another reason is that the methods of evaluating detergents are still relatively new and are constantly being changed and improved.

However, in considering detergents as such, Strong (104) has suggested that if it is fed to the dishwashing machine automatically, the hydrogen ion concentration of the wash water should be maintained at approximately pH 10.5 by adjusting the rate of feed. The value of this hydrogen ion concentration for the wash water has been borne out somewhat by Hutchinson (47), who showed, with wash waters whose hydrogen ion concentration ranged from pH 7.0 to approximately pH 10.6, that up to 1,000,000 organisms were obtained per ml. of the water. In this pH range, sixty-seven per cent of the wash waters contained coliform organisms to the extent of 1,800 organisms per milliliter. On the other hand, if the hydrogen ion concentration range was over pH 10.0, only thirty-five per cent of the wash waters had organisms in excess of 1,000,000 per ml., and only forty-seven per cent had coliform organisms present in excess of 1800 organisms per milliliter.

3. <u>Is the health of personnel involved taken into consideration, and, if so, in what manner?</u>

Canada:	37.5% yes, 0.0% no, 67.5% not specified.
United States:	36.1% yes, 5.6% no, 58.3% not specified.
Others:	22.2% yes, 11.2% no, 66.6% not specified.

Most of the regulations governing the operation of public eating establishments have clauses that deal with personnel sanitation in a general way. For example, the municipal code of Wilmington, Delaware, (27) states:

> All employees shall wear clean outer garments and shall keep their hands clean at all times while engaged in handling food, drink, utensils, or equipment. Employees shall not expectorate or use tobacco in any form, including smoking, in rooms in which food is manufactured or prepared. Hair nets shall be worn by female employees. Suitable head-dress shall be worn by chefs, male and female.

Fuchs (34) has stated that the examinations of employees by private physicians cannot be relied upon and that the cost of such examinations is prohibitive to the public health services. However, in some cities like Indianapolis, Indiana, (50) the health clause of the municipal code requires a physical examination once every six months to insure freedom from any infectious or transmittable disease, plus a blood test for syphillis once a year. It is this latter type of regulation that comprises the percentages in the 'yes' column of this question.

As for the prohibition of the use of tobacco by personnel on duty in restaurants, the code of Kentucky (52) gives the following as the reason:

"The use of tobacco tends to promote careless food handling methods and may promote spitting and the contamination of fingers and hands by saliva."

Alaska, under its laws (2) provides for the exclusion of an infected person from any restaurant, the examination of the employee and his associates, and, if necessary, the closure of the restaurant until all danger of a disease outbreak has been eliminated. Still others, like Houston, Texas, (107) go so far as to impose a fine of $200 for failure to comply with their regulations, including the health clause. This fine is cumulative on a per diem basis until compliance has taken place.

Baltimore, Maryland, has instituted a swab rinse technique of the employees' hands to determine how thoroughly hands are washed after toilet use. Results to date have been reported as being (66) very good.

4. <u>Are there minimum equipmental requirements?</u>

Canada:	50.0% having requirements, 50.0% without.
United States:	88.8% having requirements, 11.2% without.
Others:	22.2% having requirements, 77.8% without.

Most of the cities polled have general regulations for equipment comparable to those expressed in the state code of Arkansas (7) which states that equipment must be made of seamless or non-absorbable material, easily cleaned, and that the equipment shall be used for no other purpose than that for which it was originally intended. It further states that the use of cracked dishes or chipped utensils and tarnished silverware is forbidden.

Still others, like Atlanta, Georgia, (35) go so far as to regulate the spacing of equipment, particularly dishwashing machines, with regard to the distance from walls and the height off the floor. Perhaps the ultimate in an attempt to produce nearly perfect results from mechanical dishwashing was reached by the Committee on Sanitary Engineering and Environment of the National Research Council at Washington, D.C., when it set forth a series of specifications for equipment, installation, and the operation of mechanical dishwashing machines (74). This information is included in the appendix of this report for the academic interest therein.

5. <u>What is the maximum plate count that is used to grade the method under investigation?</u>

Canada:	62.5%using a count of 100, 37.5% not using counts.
United States:	61.1% using count of 100, 38.9% not using counts.
Others:	11.1% using count of 100, 88.9% not using counts.

A plate count under 100 seems to be the generally accepted basis of satisfactory results. Concord, New Hampshire, uses a graded count (78) that is in general agreement with the count established by MacDonald and Freeborn (58) which is shown for comparison in parenthesis.

1 to 25, excellent	(below 10............excellent)
25 to 50, very good	(below 50................good)
50 to 100, passable	(between 50 and 100.......poor)
above 100, unsatisfactory	(over 100.......unsatisfactory)

Some cities, like Montreal, Quebec (95) and Boston, Massachusetts

(67) test routinely for the presence of E. coli in all specimens submitted to the laboratory, but the significance of the presence of E. coli on the washed dishes and in the wash waters is not quite clear.

On the subject of plate counts, any number assigned to designate satisfactory dishwashing is purely arbitrary. This brings up the point of whether or not sterility is to be desired in such operations as public dishwashing by mechanical methods. It would surely be the safest criterion; but, on the other hand, it would be most difficult to obtain this point of perfection. Absolute sterility would involve too many changes in existing equipment, and in some cases, no doubt, be too expensive to make the changes commercially feasible. Also, until health authorities and persons in charge of public eating establishments can be thoroughly convinced of the value of the proper cleansing and sanitizing of dishes and utensils, it would be practically useless to approach them with the thought of trying to obtain surgical sterility in the dishwashing operations. Surgical sterility has been attained (68) but under rather extraordinary circumstances as previously pointed out in this report. It has also been considered (110) from the standpoint of the public eating place. But pathogen survival under the most modern regulations of sanitizing has been reduced to a minimum, and from all practical purposes, the ultimate of surgical sterility can be dismissed for the present time.

6. What are the times and temperatures of the wash and rinse cycles?

The results of this question were so varied that it is impractical to subject them to a percentage analysis. Of the cities that were polled, none permitted a temperature for the wash water of under 110°F., with the upper limit being 120°F. for dishes washed by hand: for the mechanical counterpart, the lower limit was again 110°F. with the generally-accepted upper limit of 140°F. The temperature of 140°F. seems to be the maximum that should ever be used, for at temperatures in excess of this, materials cook to the surface of utensils (4) thereby giving an appearance of uncleanliness even though they may be acceptable from the plate count standpoint. However, a wash of forty seconds at a temperature of 165°F. has been suggested by Cox (18) and McDaniel has suggested a pre-rinse at 212°F. (68).

Lengths of time for the wash period were even more varied than the temperatures of this cycle. They ranged from "an appearance of cleanliness" (65) for hand washed dishes to a range of eight to forty seconds (72) (74) for machine washed dishes.

The time and temperature of the rinse cycle varied from 15 seconds at 170°F. at Richmond, Virginia (117) to 15 seconds at 180°F. in Providence, Rhode Island (97). However, a majority of the cities used a rinse of 170°F. for two minutes. This was even applied to dishes washed by hand and machine in some cities, such as Toronto, Ontario (88).

The hot water method of disinfecting is not the only one that is acceptable by health authorities. California (15) lists approved quartenary ammonium compounds that may be used in lieu of the hot water method. In fact, most cities give at least one alternate method which usually involves a chlorine or a quartenary ammonium compound.

To summarize these six questions, the following points may be used as a guide for sanitizing dishes, whether they are washed by hand or by machine:

1. Time of the wash cycle.....until visibly clean if washed by hand, and a minimum of 20 seconds (74) if washed by machine.
2. Temperature of the wash water.....no less than 110°F. if washed by hand, and preferably no less than 120°F. if washed by machine (with higher temperatures up to 140°F. without a thorough pre-rinse, and up to 160°F. with a pre-rinse).
3. Time of the rinse cycle.....for both manual and machine washed dishes, an absolute minimum of 15 seconds but preferably 2 minutes (depending on the equipment and method of operation).
4. Temperature of the rinse cycle.....for the minimum time stated, the temperature should be in excess of 170°F. in order to assure complete removal of pathogens, but if the temperature is maintained at 170°F. the longer period of rinse should be used. No rinse should ever be below 170°F.
5. Detergent.....any detergent that is satisfactory for the water that is being used, i.e. one that will give satisfactory cleaning without undue residue. It should by all means be fed to the dishwashing machine automati-

cally to insure a constant amount at all times.

6. Plate count.....a maximum of 100 colonies per utensil can be considered a "safe" figure, provided the time and temperature of the rinse cycle is such that only the occasional non-pathogen will survive the wash and rinse operations. If the conditions of washing and rinsing are not up to satisfactory levels, the resulting plate count should be analyzed before allowing the continuance of the method in use.

In conclusion to this modern approach, one more factor must be mentioned, that is, the general cleanliness of the eating place. It would be fallacious to expect a machine to remove bacteria from dishes and then expect the dishes to remain clean if they were subjected to contamination from other sources in the dining hall.

Of the health codes obtained from this survey, all made mention of general cleanliness of the place of business that involved the public sale and serving of food. St. Louis, Missouri (73) has a grading system, the results of which must be publicly advertised by the restaurant. This system embraces the general cleanliness of the eating establishment as well as the bactericidal treatment of the dishes and utensils. Such systems as this include statements pertaining to: cleanliness of walls and floors, adequate water supply, adequate garbage disposal, freedom from infestation by rodents and insects, adequate and clean toilet facilities for personnel, and proper ventilation. To this generally accepted list of conditions, Iowa (51) has added a clause that prohibits the use of any room remotely connected with food to be used as a place for sleeping. The government of Switzerland goes so far as to provide for the temporary or permanent closure of a place that manufactures or sells food if it does not comply with the general rules of sanitation (105).

To illustrate the extent to which these general rules are handled, the following sections of health codes are quoted. These sections, although applying to rules in most sanitary codes pertaining to public eating establishments, were chosen because of their exacting coverage of the rule in question.

1. Floors....."The floors of all rooms in which food or drink is stored, prepared or served or in which utensils are washed shall be of such construction as to be easily cleaned, shall be smooth, and shall be kept clean and in good repair." (64)
2. Walls and ceilings....."All walls and ceilings of rooms in which food or drink is stored or prepared shall be finished in light color. The walls of all rooms in which food or drink is prepared or utensils are washed shall have a smooth, washable surface up to the level reached by splash or spray." (89)
3. Water supply....."Running water under pressure shall be easily accessible to all rooms in which food is prepared or utensils are washed, and the water supply shall be adequate and of safe sanitary quality." (31)

4. Adequate garbage disposal....."Every restaurant shall be equipped with covered metallic containers for receiving and keeping in a sanitary condition all garbage and waste. Every container shall be kept in such a place and manner as shall preclude odours and other nuisance in the restaurant, and all garbage and waste shall be removed from the restaurant and its premises at least once in every twenty-four hours." (76)
5. Freedom from rats and insects....."Buildings must be free from contaminated surroundings and vermin-proof." (69)
6. Toilet facilities....."Clean and adequate toilet facilities must be provided for both sexes. Toilet rooms and compartments shall be adequately lighted and properly ventilated. Doors shall be self-closing and shall not be open directly into a kitchen or storage room." (7)
7. Ventilation....."Every eating and drinking place shall be sufficiently well ventillated to prevent the accumulation of disagreeable odours and condensation. The Medical Health Officer, if he deems it necessary, may require:

   (a) The window area of all rooms shall be equivalent to at least 1/10 of the floor area. Windows fitted to open shall be equivalent to at least 5% of the floor area.

(b) The installation of mechanical apparatus to provide:

(1) Eight complete changes of air per hour in rooms in which food or drink is prepared or utensils washed.

(2) Four complete changes of air in all other rooms.

(c) Canopies of metal or other approved material to be installed over stoves and directly connected to the outside air." (9)

EXPERIMENTAL PROCEDURE

The experimental procedure used throughout the work is patterned after that described by the U. S. Public Health Service in its bulletin No. 280.

Speciments were obtained from test surfaces by the use of cotton wool swabs. These swabs were suspended in a phosphate buffered suspension fluid and agitated to remove adherent particles. Portions of this suspension fluid were then plated on various agars and incubated for colony counts and identification of organisms.

Swabs: With the exception of the initial work at Douglas Hall in which cotton-wool on wooden applicator sticks was used, swabs were made on stainless steel wire. These were fitted into No. 0 rubber stoppers and sterilized dry in a test tube.

Containers: The containers for the swab specimens were large size bacteriological test tubes, measuring 15 x 100 millimeters.

Suspension Fluid: A phosphate buffered distilled water was used throughout the experimental work. This was prepared in two solutions which were mixed prior to sterilization.

Solution A--Dissolve thirty-four grams of potassium di-hydrogen phosphate in 500 ml. of distilled water; add 175 ml. of a normal sodium hydroxide solution, dilute the mixture to one liter and adjust to pH 7.2.

Solution B--This is a 0.1 normal sodium thiosulphate solution.

Procedure--If no residual chlorine is likely to be present on the utensils being tested, dilute 1 ml. of solution A to 800 ml. with boiled and cooled distilled water and distribute into the swab containers. If chlorine is used in the washing operation, add 4 ml. of solution B to the 1 ml. of solution A and then dilute to 800 ml. with boiled and cooled distilled water. The solution is then autoclaved and distributed into the swab containers in amounts that will equal 1 ml. for each utensil tested in the group, i.e. four ml. for four utensils, five ml. for five utensils, et cetera.

Sampling: Just prior to sampling, and using a sterile technique, the suspending fluid was placed in the swab containers and the sterile swabs were then inserted.

Four of each utensil to be tested were selected from the racks as they came from the machine. As the swab was removed from the test tube, the excess moisture was squeezed from it by pressing against the inside wall of the container.

The area tested was swabbed three times firmly, the direction of the stroke being reversed each time. After each utensil was tested, the swab was replaced in the container and gently agitated to remove adherent material from the cotton. Then the same procedure for the next swabbing was followed. Only one swab was used for each group of four utensils tested.

Surfaces: The surfaces that were considered significant for testing are as follows:

Cups and glasses: the inner and outer rims to a depth of one-half inch.

Spoons: the entire upper and lower bowls.

Forks: the entire area of the tines.

Plates: four square inches. (A metal template for delineating this area was not used, due to its bulkiness.)

Knives: both sides of the blade.

Laboratory Procedure: After sampling, the specimens were returned to the laboratory and plated within ninety minutes. Usually the time was within forty-five minutes after sampling had begun.

Prior to plating, the swab containers with the swabs in situ were agitated rather violently by beating against the palm of the hand until there was visible disintegration of the cotton swab. This, in all cases, exceeded the two minutes agitation recommended by the U. S. Public Health Service.

After agitation, the excess moisture was removed by pressing the swab against the inside of the container. Using a sterile 1 ml. pipette, 1 ml. of the suspension fluid was transferred to a sterile Petri dish. To this was added approximately ten ml. of a sterile glucose-tryptone extract agar (without milk) as recommended by the U. S. Public Health Service. After the agar had set, the plates were inverted and placed in the 37°C. incubator and counts were made after forty-eight hours incubation. Also, one-half ml. of the suspension fluid was plated onto MacConkey's medium and blood agar for the isolation of possible pathogens.

For the identification of organisms, the following procedure was used: Colonies were picked from the surface of the blood agar and MacConkey plates and subcultured into peptone broth. After forty-eight hours of incubation at 37°C. smears were made from the broth. At no time were Gram negative rods found on the MacConkey plates. The staphylococci that were found on both media were further subcultured into mannitol, gelatin, plasma and onto nutrient agar slopes. The nutrient agar slopes were incubated for forty-eight hours at 37°C. and then for seventy-two hours at room temperature to allow for the development of pigment. The gelatin slabs were incubated at room temperature throughout the five days period, while the mannitol subcultured were incubated at 37°C. for the five days in order to detect late fermenters. The plasma innocula were incubated in a 37°C. water bath for four hours, readings being taken every half hour until the end of the incubation period.

INVESTIGATIONAL RESULTS

Four of the dining halls within McGill University were investigated. The purpose of this investigation was to examine the physical plant, determine the bacterial cleanliness of the washed eating utensils, and to make changes in operator technique and recommendations for changes to improve the existing conditions.

In Wilson Hall, Douglas Hall, and Royal Victoria College Dining Hall, a single tank automatic dishwashing machine is used, while in the fourth dining hall investigated, Royal Victoria College Cafeteria, a two tank automatic dishwashing machine is used.

I. WILSON HALL

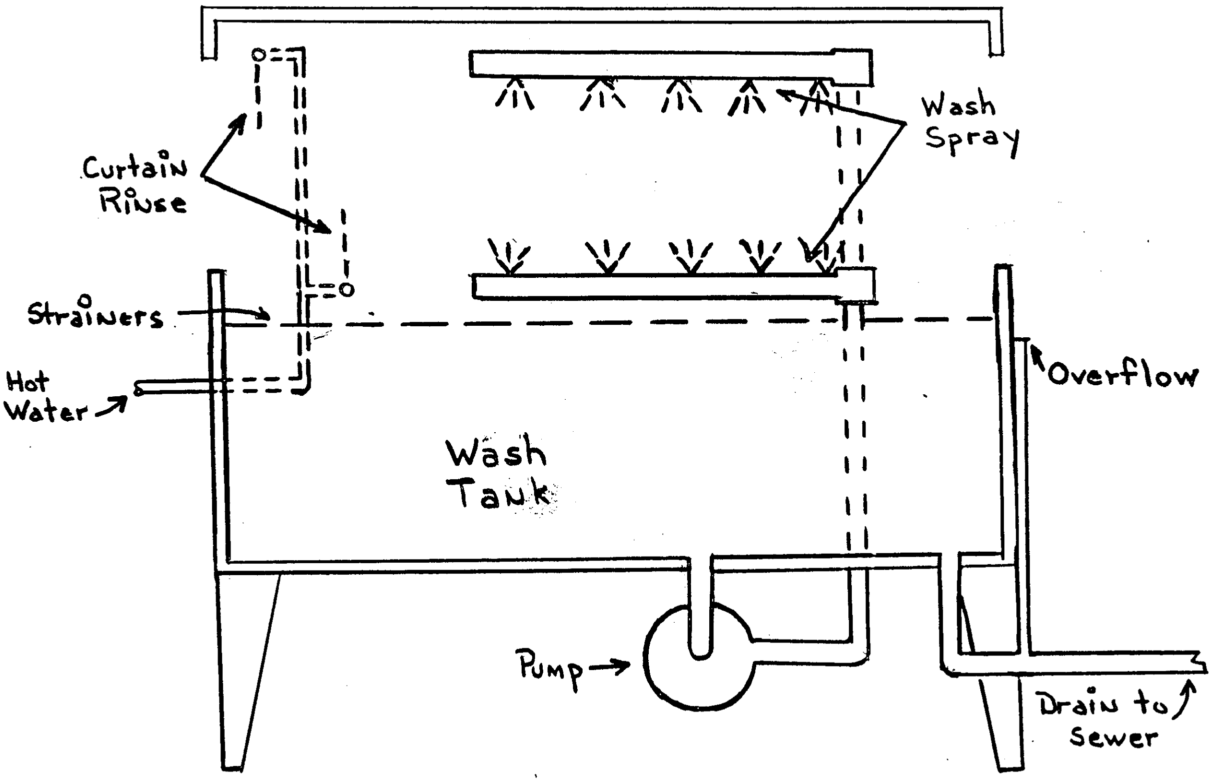
A. Resume:

The following is a resume of the conditions in existence at Wilson Hall residence for men, where the meals are served in a cafeteria style.

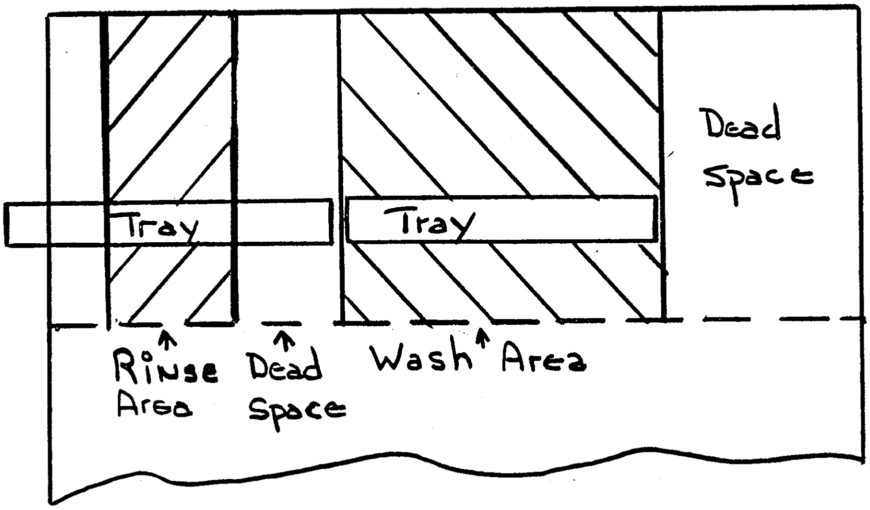
Personnel: The staff is well trained, but more supervision and revision of methods is needed. One of the men responsible for the operation of the dishwashing machine has had several years experience with the equipment at Wilson Hall. The relief operator was hired during the fall of 1950. A woman is responsible for washing the glasses, and on her weekly holiday the relief machine operator takes over.

Lavatory Facilities: Adequate lavatory facilities are maintained for both sexes in the basement of the building, thus making them quite remote from the dishwashing facilities. Both rooms are kept clean by

Internal Alignment of Single Tank Dishwasher



Elevation



Spray Pattern

Figure 1

the building janitor, and although their condition is generally satisfactory, they are dingy from age and are in need of a brightening coat of paint. The men's room has no natural lighting, and ventilation is by artificial means. Signs, distributed by the city board of health, pointing to the need of proper hand washing, are prominently displayed in both rooms.

Dishwashing Room: This consists of a small section of the kitchen, being separated from the kitchen proper by storage cupboards and the dishwashing machine itself. The section devoted to dishwashing is quite small, but the staff works as a well integrated team and there seems to be little if any confusion resulting in the area.

Lighting is both by artificial and natural means. Ventilation seems to be adequate, being by natural means and enhanced by cross drafts.

Storage Facilities: Dishes are stored in closed cupboards under the serving area. Glasses are stored in an inverted position on trays, while cups are stored upright in the same cupboards with the dishes. Silverware is placed in dispensing bins at the end of the serving table.

Steam and Water Supply: The steam supply is that of the university, while the water comes from the domestic city sources. The hot water for the machine comes from a boiler in the basement at 140°F., and for the rinse end of the equipment, the temperature is raised to about 180°F. by a steam jacket booster immediately under the dishwashing machine.

General Comments: Since space limitations prevent the air-drying of the eating utensils as they come from the machine, all items are towelled dry with cloths used for no other purpose. Wet towels are placed on the dishwashing machine for drying.

Utensils used in the preparation and serving of foods are washed and stored in the kitchen. At no time do they come in contact with the equipment used by the residents of the dormitory.

The dishwashing equipment is a single tank type machine: see Figure 1.

Racks for processing the utensils through the machine are constructed of wood with wire mesh bottoms supported by wooden rods approximately one-half inch in diameter. The racks for dishes are also made of wood, but without wire bottoms. These racks have two rows of wooden rods about one inch in diameter that run parallel to each other and serve as a support to keep the dishes in a vertical position. A third row of rods the same size is placed perpendicular to the bottom row of supporting rods, and serves as the bottom of the rack.

Washing Operation: Glasses are washed by hand. This is accomplished by immersing the glasses in warm soapy water and rubbing the rims with the fingertips. The glasses are rinsed in clear warm water to which has been added a varying amount of Diversol, a commercial bactericidal preparation. The temperature of both the wash and rinse waters is slightly warm to the touch, being about 120°F.

The remainder of the eating utensils are processed through the machine. Temperature control of the wash and rinse waters has been aided quite a bit by the addition of a baffle under the curtain rinse which has a separate drain, thereby partially preventing the 180-220°F. rinse water from falling into the wash water tank and elevating the temperature of that water above the desired level. There is still a certain amount of mixing, but this is due to the fact that the baffle is not of a sufficient size. This overflow of the hot rinse water has on occasions raised the wash water as high as 165°F. There is no cold water inlet to the machine that would enable the operator to correct this effect. In order to raise the wash water temperature to 140°F. as desired, should it be necessary, an arrangement for the admission of live steam into the surrounding jacket is available.

The fact that the rinse temperature quite frequently climbs to 220°F. is a time-saving device; but even with this high temperature the time of rinsing should not be reduced. In training the operators, short cuts should be eliminated insofar as is possible in order to prevent carelessness and overconfidence in the equipment. This high temperature is definitely advantageous, and it is not necessary to control it further since it seldom drops below 180°F.

B. Results and Interpretations:

The following are the two sets of data gathered on the dishwashing operation at Wilson Hall. The set of data gathered from a previous investigation is shown for the purpose of comparison.

The temperature of the wash water varied from day to day within a range of 145-175° Fahrenheit. The high temperature was found on a day that the relief operator was in charge of the machine. He was not properly trained as to the use of the steam heating device for raising the wash water temperature, consequently, he allowed the temperature to go too high. The low of 145°F. is about the average temperature of operation with a variance of plus or minus five degrees.

The rinse water temperature ranged from a low of 160°F. to a high of 220°F., with the average in the neighborhood of 170-185°F. The low of 160°F. was observed just as the machine had been put into operation, but the temperature rose rapidly to the level desired. This temperature was noted, however, because specimens were taken at that time.

Table I

Results of the Previous Investigation at Wilson Hall

Date	Cup	Glass	Spoon	Plate
Feb. 24	6	2	560	32
Feb. 28	250	21	200	163
March 3	60	48	115	71
March 7	20	47	114	82

Table II

Results of the Present Investigation at Wilson Hall

Date	Cup	Glass	Spoon	Plate	Wash Water
Nov. 14	4	3	41	12	TNC
Nov. 17	23	48	TNC	0	TNC
Nov. 18	12	224	57	3	TNC
Nov. 22	5	188	TNC	2	TNC
Nov. 24	4	7	4	1	TNC
Nov. 27	27	9	54	6	TNC
Nov. 28	11	1	8	18	TNC
Nov. 30	12	TNC (x)	TNC	7	TNC

TNC denotes that colonies were too numerous to count.

(x) This count was obtained from unwashed glasses.

Cups: The low counts for the cups are attributable to the fact that at no time were the cups packed tightly in the trays for processing. This permitted maximum exposure to the wash and rinse waters.

Spoons: The counts that were too high to determine on the 17th and 22nd are attributed to the fact that the silverware was rinsed only. The exposure to the rinse water, which was above 170°F. on both occasions, was not of sufficient length of time to permit any bactericidal action. The high count occurring on the 30th of the month is believed to be due to the fact that the silverware was packed tightly in the trays and not shaken. On the 24th and 28th of the month, the silverware was placed in single and double layers respectively, with the latter being shaken while under the wash spray. On the 14th of the month, the silverware was packed tightly in the tray, but the low count is attributable to the fact that the relief operator left the silver to rinse for nine minutes at a temperature of 180°F. This is proof of the fact that long exposures to high temperatures, although not feasible, will reduce the counts obtained from silverware. On the remaining days, the silverware was packed loosely in the trays and not shaken; these counts are within acceptable limits.

Wash Water: Wash water specimens were too contaminated to make counts. These high counts seem to be of little importance, since the rinse produced relatively good bactericidal effects.

Plates: Although all counts from plates were well within the acceptable limits, the count of 12 colonies on the 14th of the month is probably due to the fact that the dishes were stacked at an angle of about 60° from the horizontal, thereby partially blocking some of the surface that was to be washed and rinsed. This same procedure was again followed on the 28th of the month; and the count rose to 18 colonies, which is considerably higher than that usually obtained from this machine. The fact that the relief operator was running the machine on both days is evidence that the operator is directly responsible for the counts that are obtained by swabbing the utensil. The counts on the remaining days reflect the mechanical efficiency of the machine, plus the good technique of the regular operator who always placed the dishes in a vertical position.

Glasses: the counts for the 14th and 28th of the month resulted from swabbings taken after the glasses had been washed by the regular operator, but before the glasses had been towelled; while on the 17th, 24th, and 27th of the month, the glasses were washed by the same operator, but the specimens were obtained after the glasses had been towelled. On the 18th and 22nd of the month, the counts, which are by no means acceptable, were the result of the glasses having been washed by the relief machine operator and before being towelled. On Nov. 30 the extremely high count was obtained by swabbing glasses before they had been washed. It might also be mentioned that on the 24th of the month, mild soap chips were introduced along with wash cloths to replace the strong commercial alkali that had been used. This former product irritated the operators' hands, and they probably did not give the glasses as thorough a cleansing as was necessary. The temperature of the wash and rinse waters was slightly warm to the touch, and was found to be about 120°F. Diversol was used in the rinse water.

Organisms Present: A total of 153 representative colonies were selected, subcultured in peptone broth, incubated for 24 hours, and smears were made and stained by Gram's method. As a result of these stains, the following types of organisms were found to be present:

Gram positive cocci....in clumps, clusters, and short chains.

Total times encountered....63.

Gram positive cocci....in tetrads.

Total times encountered....34.

Gram positive rods....singly and in chains.

Total times encountered....47.

Gram positive spore forming rods.

Total times encountered....3.

Gram positive rods, pallisaded.

Total times encountered....4.

Cultures failing to produce growth....2.

The four cultures that were suspected of being corynebacteria because of their morphology were subcultured into Hiss Serum water, dextrose, maltose, and lactose to determine if they were of human or pathogenic origin. As a result of this subculturing, two of the organisms were identified as Corynebacterium xerose, a common skin contaminant, while the other two failed to be classified. These latter two may be of soil origin, and are probably Bacterium globiforme.

The sixty-three Gram positive cocci that appeared in clumps, clusters, and short chains were subcultured into gelatin, agar slopes, mannitol, and rabbit plasma. On the agar slopes, four cultures developed a yellow pigment and one developed a cream pigment within seventy-two hours. Two more developed a cream pigment and one more developed a yellow pigment by the end of five days. The remainder showed a white pigment at the end of seventy-two hours. Thirteen of the mannitols had fermented by the end of seventy-two hours, with three more fermenting at the end of five days. Six of the gelatins liquefied in seventy-two hours and four more liquefied in five days. Eighteen of the cultures coagulated rabbit plasma.

It is generally felt that these four tests give an indication of possible pathogenicity in staphylococci. However, there was no relation between the tests, that is, the same organisms did not give positive results in all four of the tests. But, since eighteen of the cultures coagulated plasma, this is taken as an indication that these are possibly pathogenic strains.

These results would seem to indicate that the organisms present were Staphylococcus pyogenes, varieties, albus, aureus, citreus; and Staphylococcus aurantiacus.

C. Recommendations:

The following recommendations are made and considered to be minimal:

1. The internal alignment of the machine should be rearranged as discussed for the machine at Douglas Hall--see Figure 3.
2. The staff should be more closely supervised and the relief man should be more thoroughly trained.
3. Towelling should be kept at a minimum.
4. Silverware should be packed loosely in the trays and shaken while under both the wash and rinse sprays.
5. Dishes should be placed vertically in the racks provided for washing in order that the entire front and back surfaces may be exposed to the wash and rinse sprays.
6. Smoking in the dishwashing room should be discouraged.
7. Cups should be stored in an inverted position.

Particular attention should be given to the silverware in this case. Space and facilities do not permit the installation of equipment that would allow boiling the silverware; therefore, the burden of lowering the high counts for this particular item rests directly on the operator. The trays must not be packed too tightly, and they must be shaken while being washed and rinsed.

ROYAL VICTORIA COLLEGE

II. ROYAL VICTORIA COLLEGE DINING HALL

The following is a resume of the conditions in existence at the Royal Victoria College residence for women. Meals are served in two places: a formal dining hall for residents, and a cafeteria for day students.

Personnel: There is an adequate staff as far as numbers are concerned, but training is by no means sufficient. The personnel seem capable of absorbing instructions, but more thorough and adequate supervision is definitely needed for a time for further training in better methods. Two mature women act as operators of the mechanical dishwashing machine, and, although they seem competent, they need closer supervision, with changes in some of their techniques. The waitresses are responsible for the washing and towelling of the cups and glasses, and the towelling of the silverware.

Lavatory Facilities: Adequate facilities for both sexes are maintained in the basement of the building. The cleanliness of both rooms is the responsibility of the building janitor, and not the personnel of the dining hall. Both rooms are well lighted by natural and artificial means, and have adequate natural ventilation. Signs distributed by the city board of health stressing the importance of washing the hands before leaving the lavatory are prominently displayed in both rooms.

Dishwashing Room: This is, unfortunately, only a small and inadequate corner of the general serving room. Cups are washed by hand in the same room, but in a more remote section. Glasses are washed by hand in a sink located in a small room that occupies a corner of the main dining room.

The main serving room is adequately lighted by natural and artificial sources; ventilation is rather poor, being furnished by windows on the north side of the room only. The dishwashing machine is across the room from the windows, and being situated in a corner, obtains very little benefit from the inadequate ventilation.

The floors of the washing-serving room are of asphalt tile. The walls are of smooth construction half way up, and are painted a cream color. This facilitates cleaning and proves restful to the eyes.

The room where the glasses are washed is adequately lighted solely by artificial means. Ventilation is satisfactory in that the walls of the room extend only about half-way to the ceiling of the relatively high-vaulted dining room.

Storage facilities: Dishes are stored under the serving area in closed cupboards. Cups are stored in an upright position in a closed cupboard near the sink in which they are washed. Glasses and silverware are placed on the tables in preparation for the next meal.

Steam and Water Supply: The steam supply is that of the college proper, being maintained at a pressure of about 40 pounds. The water is supplied by the city. Hot water comes from a boiler located in the basement and is held at a temperature of about 140°F.

General Comments: The general situation prevailing in the dishwashing and serving room is one of mild chaos. There are countless instances of unnecessary crossing of paths, congestion of passageways, and gross overcrowding of facilities. These are due directly to the poor arrangement of facilities at hand. As could be expected, counts obtained are erratic and quite poor at times. The time element in this instance is quite important, since the meals are served at tables, resulting in the dirty utensils arriving at the dishwasher all at once. This creates a tense atmosphere, resulting in the tendency to rush, which further negates the possibilities of obtaining adequate washing and disinfecting of the eating utensils.

One set of towels are used per meal; and after use they are soaked in javel water and washed.

Racks for processing the utensils through the machine are constructed of wood with wire mesh bottoms supported by wooden rods approximately one-half inch in diameter. The racks for dishes are also made of wood, but without wire bottoms. These racks have two rows of wooden rods about one inch in diameter that run parallel to each other, about two inches apart vertically, that serve as supports for the dishes to hold them in an upright position. A third row of the same size rods is placed perpendicular to the bottom row of supporting rods, and serves as a bottom for the rack. Racks used in the dishwashing procedure are the same as those described in the section for Douglas Hall.

The mechanical dishwasher is a single tank type machine: see Figure 1.

Utensils used in the preparation of the food are washed and stored in a separate room and at no time are they mixed with those used by the residents of the College.

Washing Operation: Glasses and cups are washed and rinsed by hand in sinks, with waters that have a temperature of about 120° Fahrenheit. In both instances the utensils are submerged in soapy water and the rims are rubbed with the finger tips. Both are towelled after rinsing.

The machine is used for silverware, plates, saucers, etc., and for nothing else.

A jacket steam booster has been added to the rinse water line, thereby enabling the rinse temperature to stay above 160° Fahrenheit. However, the fluctuation in temperature is great and rises as high as 212°F. at times. This high temperature of the rinse water results in the wash water being raised above 140°F., and there is no method of lowering this temperature.

Utensils are processed in the machine rather rapidly, and silver is packed in the trays in large quantities, which results in poor washing. However, after passing through the machine, the silverware is placed in a deep sink, rinsed with soapy water by agitation, and then rinsed under warm tap water before towelling.

B. Results and Interpretations:

The range of the wash water temperature was 140-160°F., with the mean temperature in the neighborhood of 150°F. The rinse water temperature ranged from a low of 145°F. (occurring only on one day) to a high of 220°F. The usual temperature was within the narrower range of

160-180°F., with the higher temperature being more prevalent.

Two sets of data are presented, and, as previously explained, results from an earlier investigation will be presented for general interest without any attempt to make an analysis of them.

Table III

Results of the Previous Investigation
at Royal Victoria College Dining Hall

Date	Cup	Glass	Spoon	Plate
Feb. 28	5	2	78	27
Mar. 3	28	2	4	14
Mar. 7	116	1	18	4
Mar. 10	140	13	6	85

Table IV

Results of the Present Investigation
at Royal Victoria College Dining Hall

Date	Cup	Glass	Spoon	Plate	Wash Water
Oct. 20	TNC	273	185	24	TNC
Oct. 21	QNS (x)	20	48	cont. (#)	TNC
Oct. 25	3	11	288	18	TNC
Oct. 26	22	15	TNC	5	TNC
Oct. 27	32	22	TNC	3	TNC
Oct. 28	45	8	11	5	TNC
Oct. 29	QNS	38	41	17	TNC
Nov. 1	7	173	19	28	TNC
Nov. 3	162	448	TNC	9	TNC
Nov. 5	QNS	9	TNC	13	TNC

x - The symbol QNS signifies that there were not enough cups used to obtain specimens.

- Contaminated.

<u>Cups:</u> Counts on the cups seem to be relatively satisfactory. The two exceptions (on Oct. 20 and Nov. 3) are explained by the fact that a new operator was employed for the purpose of washing the cups, and the rinsing process was omitted.

<u>Glasses:</u> The counts from the glasses were generally satisfactory. The high count on Oct. 20 cannot wholly be explained. It is thought, however, that the drop in count on the next day may be due to the fact that a little laxity had been involved in the operation, but disappeared when the representative of the Department of Bacteriology arrived on the scene. On Nov. 1 and Nov. 3, a different person was responsible for washing the glasses. However, on Nov. 5 the same person performed the operation and a satisfactory count was obtained. It is felt that these two high counts were due to overconfidence. A pre-soak in javel water had been instituted on these two days, explaining that the chlorine present in this solution would aid in killing the bacteria. No effort was made to determine the concentration of chlorine in the soak water, for it was added merely to determine what, if any, psychological effect it had on the operator. As a result,very little soap was used those two days, and only a token wash was performed. The counts were completely out of line with the general trend of previous samples. On Nov. 5, the pre-soak in javel water was discontinued and the operator used about twice the amount of soap, plus a dish cloth,

with the result that the counts dropped to within acceptable limits.

Spoons: The spoon counts in general were most unsatisfactory, with only four counts (Oct. 21, 28, 29, and Nov. 1) falling within acceptable limits. The count of Oct. 21 is explained by the fact that the specimen was taken before towelling. The other three counts are explained by the fact that a longer period of exposure to the rinse (in excess of two minutes) and a higher temperature was used (180°F., 210°F., and 220°F. respectively).

Plates: The plate counts are all within acceptable limits. This is proof of the fact that the mechanical efficiency of the machinery is satisfactory. The specimen for Oct. 21 was accidentally contaminated during plating, and was therefore discarded.

Wash Water: All specimens of wash water were grossly contaminated with organisms.

Organisms Present: A total of 246 representative colonies were selected, subcultured in peptone broth, incubated for 24 hours, and smears were made and stained by Gram's method. As a result of these stains, the following types of organisms were found to be present:

Gram positive cocci.....in clumps, clusters, and tetrads.

Total times encountered.....175.

Gram positive rods.....singly and in chains (no spores found).

Total times encountered.....49.

Gram positive rods.....pallisaded.

Total times encountered......9.

Yeasts.....1

Cultures failing to produce growth.....5.

The organisms whose staining morphology suggested that they may be some of the corynebacteria were subcultured into Hiss serum water dextrose, maltose, and lactose to determine if they were of human or pathogenic origin. None of these nine colonies produced coagulation of the Hiss serum waters, so it is therefore thought that they may be of soil origin in the classification of Bacterium globiforme.

One hundred of the Gram positive cocci were subcultured into gelatin, mannitol, rabbit plasma, and agar slopes. On the agar slopes, six cultures produced yellow pigment and one produced orange pigment after 72 hours with two more producing a yellow pigment and one more producing an orange pigment at the end of five days. Sixteen of the cultures fermented mannitol at 72 hours, and 27 of the cultures liquefied gelatin in the same time. There was no further liquefication of gelatin or fermentation of mannitol after 72 hours. None of the cultures coagulated plasma, therefore these data are taken as an indication that the organisms tested are probably Staphylococcus pyogenes, varieties aureus, citreus, albus, and aurantiacus of non-pathogenic strains.

Certain changes were made in the washing technique in an attempt to reduce the colony counts on silverware and glasses.

On Nov. 9, 11, and 13, the silverware was shaken while being washed, and counts of 17, 52, and 115 were obtained. The first two counts were obtained before the silverware (spoons) had been towelled, and the last count was obtained from a specimen taken after the silverware had been towelled. This shows two things: 1. that agitation during the washing cycle is of definite benefit, and 2. that towelling is a possible source of further contamination.

For the glasses, the use of a dish cloth and more soap was further tested to determine its benefit. Two specimens were taken each day, before and after towelling, on Nov. 9, 11, and 13. The results showed a much higher count after towelling: see Table V.

Table V

The Effect of Towelling on Bacterial Counts

Date	Nov. 9	Nov. 11	Nov. 13
Before towelling	15	12	3
After towelling	48	28	18

This shows the possibility of towels acting a source of contamination. At the same time, it can be seen that there is no appreciable difference in counts obtained by using more soap and a wash cloth than those counts obtained when a wash cloth was not used. However, it is felt that by using a cloth, a little more care in the procedure might result.

C. Recommendations:

The following recommendations are made and considered to be minimal:

1. The internal alignment of the washing machine should be revised according to plans discussed in the experimental work at Douglas Hall (See Fig. 3).

2. A baffle with a separate drain should be installed under the rinse end of the machine in order to prevent the hot rinse water from raising the temperature of the wash water.
3. A steam coil should be installed in the deep sink now used for silverware. After the last tray of silver has been processed through the machine and deposited in the sink, water should be added to completely cover the silverware, the steam should be turned on, and the water heated to the boiling point and maintained at that temperature for at least five minutes.
4. Towelling should be kept at a minimum.
5. More thorough and regular supervision should be arranged to see that plenty of soap is used in the machine, in the washing of cups, and in the washing of glasses. Cloths should be furnished for the washing of cups and glasses, and these cloths should be washed thoroughly in javel water after each use as is the practice for the towels.
6. Cups should be stored in an inverted position.

The following suggestions, although not absolutely essential, would aid in correcting the congestion now in existence in the serving room:

7. The dishwashing machine should be placed under the window. This would enable the flow of utensils to be in a straight line and would facilitate the handling of silverware since it could be removed from the machine and deposited in the

deep sink without having to carry it across the room.

8. The equipment in the central part of the room should be rearranged to eliminate as much of the crossing of paths as possible.

III. ROYAL VICTORIA COLLEGE, CAFETERIA

A. Resume:

The following is a resume of the conditions in existence at the Royal Victoria College Cafeteria.

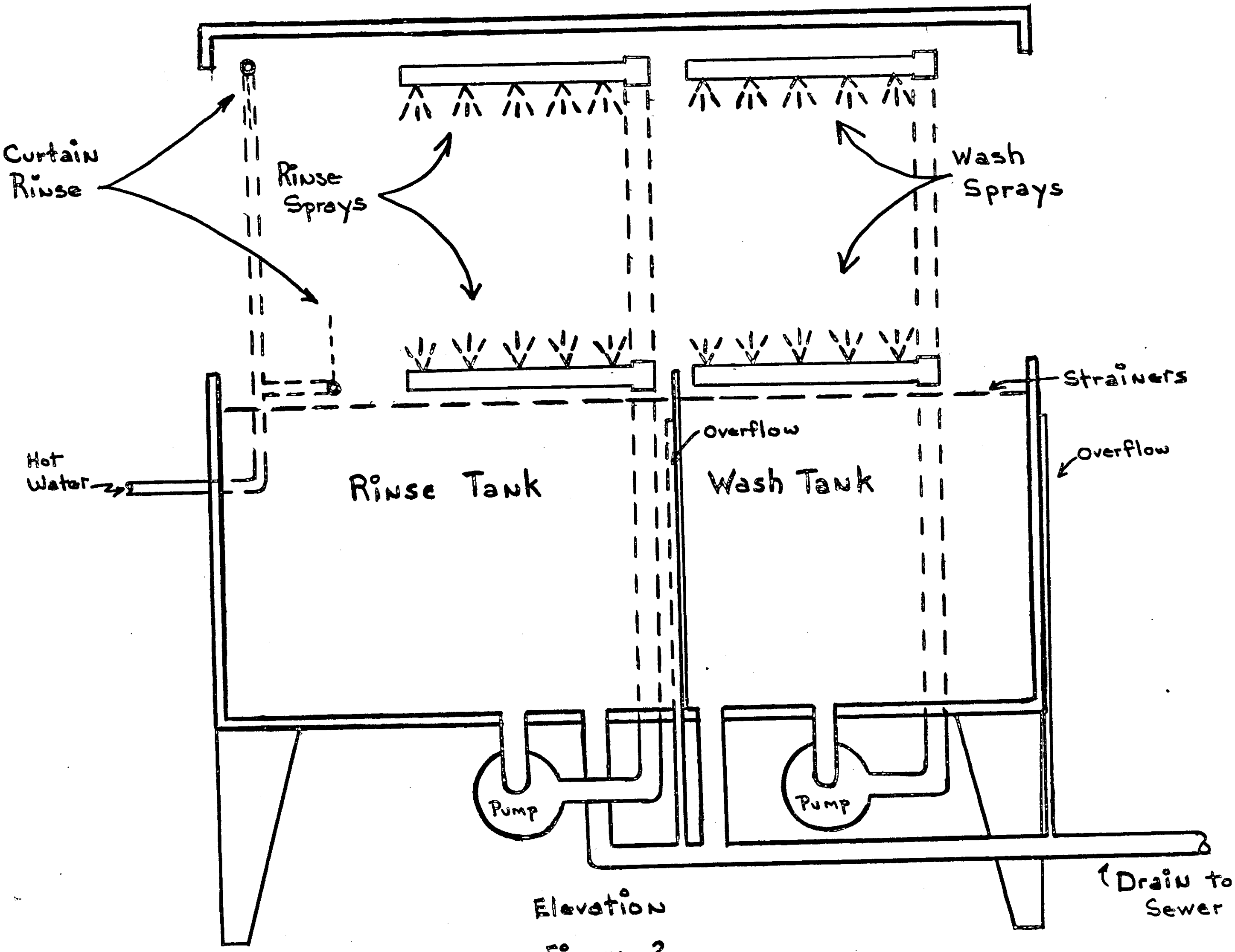
Personnel: The staff is well trained. They were most cooperative during the taking of specimens, and they showed genuine interest in the day by day results. During the period of sampling, a new relief operator was hired. This man, however, seems to be quite capable of quickly absorbing instructions, and no undue difficulties were encountered.

Lavatory Facilities: Adequate lavatory facilities are maintained for both sexes on the same floor of the building, but at a distance from the dishwashing room. The cleanliness of these rooms is left in charge of the building janitor and not the cafeteria personnel. Hand washing signs are prominently displayed in both rooms.

Dishwashing Room: This is a rather compact, but well arranged room, that is used for no other purpose, lighted by artificial means. There is no ventilation except that offered by the door and the entry ramp, which at the best is quite inadequate. The steam from the dishwashing machine is removed by exhaust fans placed at both ends of the machine. The walls are of smooth plaster and painted a cream color. The floors are of smooth concrete painted dull gray.

Storage Facilities: Dishes and cups are stored in closed cupboards immediately under the serving area, the cups being placed in an upright position. Glasses are inverted on trays. The silverware is

Internal Alignment of Two-Tank Dishwashing Machine



Elevation

Figure 2

placed in dispensing bins at the end of the serving counter.

Steam and Water Supply: The steam supply is that of the University, while the water is derived from the city supply. The hot water for washing comes from a boiler in the basement maintained at $140^{o}F.$, and the temperature is raised to $180^{o}F.$ for rinsing by means of a jacket steam booster.

General Comments: Towels are used for drying all utensils. These towels are soaked in javel water and washed after each meal, and they are used for no other purpose than that for which they are issued. Utensils used in the preparation and serving of food are washed and stored in the kitchen, and at no time do they come in contact with the utensils used by the patrons of the cafeteria.

Racks used for the machine washing of the utensils are the same type as those described for the Royal Victoria College Dining Hall.

The dishwashing machine is a two tank type in which the wash water in the first tank and the first rinse water in the second tank are both recirculated (Figure 2). The final rinse is a curtain formed by streams of water issuing from fine holes in two pipes, one in the top and the other in the bottom of the machine.

Washing Operation: All utensils used in the cafeteria are washed in the machine. The glasses are first washed with warm soapy water (about $120^{o}F.$) and rinsed before finally washing in the machine. Silverware is also given a brief pre-soak in warm soapy water prior to machine washing.

Javel water, as well as soap powder, is added to the washing tank manually at the discretion of the operator.

The wash water is supplied from boilers, with the temperature maintained at 140°F. In case the temperature should fall below this point, steam can be admitted to the washing tank. Although the first rinse water is from the same supply as the wash water, a steam jacket booster has been installed immediately under the machine to elevate the temperature to 180°F. The final rinse, in the form of a curtain spray, does not have an adequate temperature control.

B. Results and Interpretations:

Two sets of data are presented, with the earlier results being shown for comparison only. Temperature ranges during observations were as follows:

1. Wash water.......from a low of 135°F. to a high of 150°F.
2. Initial rinse....from a low of 160°F. to a high of 180°F.
3. Final rinse......from a low of 135°F. to a high of 160°F.

The daily variation in temperature observed was never over the entire range presented, but in most instances covered a range of only five degrees, the largest variation noted being ten degrees.

Table VI

Results of Previous Investigation at Royal Victoria College Cafeteria

Date	Cup	Glass	Spoon	Plate
Feb. 24	292	15	125	10
Feb. 28	34	102	54	5
Mar. 3	218	1	3	5
Mar. 7	400	13	336	TNC

Table VII

Results of Present Investigation at
Royal Victoria College Cafeteria

Date	Cup	Glass	Spoon	Plate	Wash Water
Oct. 20	10	230	39	3	TNC
Oct. 21	36	13	22	3	23
Oct. 25	15	1	14	7	54
Oct. 26	31	3	37	3	420
Oct. 27	14	3	10	4	118
Oct. 28	2	9	14	3	93
Oct. 29	6	1	4	2	57
Nov. 1	109	5	28	13	TNC
Nov. 3	6	1	3	1	11
Nov. 5	24	4	3	2	115

Cups: Colony counts from the cups are satisfactory with the exception of the one obtained on the 1st of November. This high count is probably due to the fact that a new operator was in charge of the machine and he failed to add the javel water to the wash tank as is the custom. There was no obvious difference in the technique of the new operator as compared with the others.

Glasses: As can be seen, the counts on the glasses are satisfactory with the exception of the count obtained on the 20th of October. This is possibly due to the fact that the glasses had been placed in the wash trays on their sides instead of inverted. Consequently, a large portion of the glass rim was blocked from the spray of the wash and rinse cycles.

Spoons: Colony counts from the spoons are satisfactory. It should be noted that the silverware is run through the machine with the dishes. The flatware, however, receives a pre-soaking in warm soapy water before it is processed through the machine. The mixing of flatware with the other articles being processed is, in this instance, a feasible practice, since the whole operation is a rather leisurely one and there is seldom any opportunity for overcrowding a tray with utensils. Since the flatware is made of stainless steel, the javel water added to the wash tank does not have a tarnishing effect.

Plates: Colony counts from plates are satisfactory throughout the present set of specimens. The higher count of thirteen obtained on the 1st of November is also probably explained by the fact that the new operator had failed to add the javel water to the wash tank before starting the day's operations.

Wash Water: The variations in the wash water may be explained by the fact that the specimens were taken at various times during the operation of the machine. The high count on the 1st of November is again probably due to the lack of javel water in the wash tank.

Organisms Present: A total of 186 smears from broth subcultures were made and stained by Gram's method. The microscopic examination of the smears revealed the following types of organisms to be present:

Gram positive cocci....in clumps, clusters, and tetrads.

Total times encountered.....132.

Gram positive rods....long and short forms and in chains.

Total times encountered.....33.

Gram positive spore forming rods.

Total times encountered......2.

Corynebacterium....pleomorphic (coccobacillary) and in pallisaded forms.

Total times encountered......7.

Yeasts....total times encountered.....3.

Blanks (cultures that did not grow in broth).....7.

The corynebacterium encountered were tested to determine if they were of human or pathogenic origin. None of the seven encountered proved pathogenic or of human origin. They may possibly be classified as <u>Bacterium globiforme.</u>

Growth on MacConkey's medium was very rare, and when it did occur, the smears and microscopic examination revealed the organisms to be in one of the groups discussed.

Of the cocci found, ninety-six were subjected to the plasma coagulase test and none were found to be positive. The same ninety-six organisms were subcultured into mannitol, gelatin, and onto agar slopes.

Twenty-one of the organisms had liquefied gelatin after seventy-two hours. The remainder failed to do so after five days.

Eighteen of the organisms fermented mannitol at the end of seventy-two hours, the remainder remaining negative at the end of five days.

Six of the organisms developed a yellow pigment and eight showed orange pigmentation after seventy-two hours. The others remained white up to five days.

From the above data, it is assumed that the cocci encountered are non-pathogens of the *Staphylococcus pyogenes* group, varieties *albus*, *aureus*, *citreus*, and *Staph. aurantiacus.*

C. Recommendations:

Operations are quite satisfactory. This two-tank machine functions well, and the personnel responsible for the operation of the machine and the general work in the dishwashing room are perhaps better than average, in that they take more interest in their work, are more mature, and are much more cheerful as a group than the others encountered during the present investigation. There is no element of rush about this operation, due to the fact that the service is strictly that of a cafeteria and the eating utensils do not come to the dishwashing room in large quantities. Therefore, small amounts of equipment are processed at one time, resulting in a better overall operation.

On the basis of the data presented, the following recommendations are made; not as corrective measures, necessarily, but as precautionary measures for the future:

1. The temperature of the final rinse should be boosted to at least 180°F., and the pressure of this rinse should be raised so that it will flow at least three-quarters of the height of the machine from the bottom spray. At present, the pressure is so low that the bottom spray does not reach half the height of the machine.
2. It is desirable that towelling be kept to an absolute minimum. The use of towels could be eliminated entirely

if the final rinse water temperature were raised to such a point that it did not have a cooling effect on the eating utensils as they come from the initial rinse, thereby permitting the utensils to dry in air. There is ample space for air drying.

3. Some methods of ventilating the dishwashing room should be devised, for even in cool weather, the room becomes overheated to such an extent that the staff is prone to perspire freely. This can be considered a source of contamination in that it breeds carelessness. Also, in hot weather, the situation becomes almost unbearable, which is degrading to the morale of the staff. These personnel factors cannot be overlooked if the present satisfactory state of operations is to continue, for discomfort leads to discontentment, and this leads to carelessness which has already been shown to defeat the purpose of the operation.

DOUGLAS HALL

A. Resume:

Douglas Hall residence for men was selected for use as an experimental unit. An investigation was made into the operation of the original equipment, and through the cooperation of the Department of Buildings and Grounds, certain alterations were made and followed by testing to determine the improvement in the efficiency of the equipment.

Personnel: The staff is well trained, although there is still room for improvement. Most of the members have had several years experience at this one place; therefore, they are familiar with the routines in existence and more or less familiar with what is expected of them. They were found to be most cooperative at all times during the present investigation.

The man who is in charge of the dishwashing machine is very well trained in his duties and responsibilities pertaining to dishwashing. He made several suggestions during the course of the investigation that indicated that he knew the operation of the machine fairly well. His most outstanding complaint was that there was an inadequate temperature control for the wash water, which at times was so high that food was baked to the utensils, necessitating re-washing. Generally, there seems to be no rush about the dishwashing operation, and the main operator moves with deliberateness in well ordered motions.

Lavatory Facilities: Adequate lavatory facilities are maintained for both sexes in the basement of the building. The cleanliness of these rooms is left up to the staff, and was found to be satisfactory. Hand washing signs are prominently displayed in both rooms.

Dishwashing Room: This is a well ventilated room, being subject to cross ventilation from four sides. The actual washing area is adequately lighted artificially. The walls of the room are of tile and plaster construction, the tile extending half-way up the walls in order to facilitate cleaning, and the floors are of smooth tile. In the immediate washing area, wooden slatted platforms are in place to raise the workers' feet about four inches off the floor. This aids in reducing fatigue and prevents tracking mud about the room from the shoes having come in contact with water on the floor.

Storage Facilities: Dishes are stored in closed cupboards immediately under the serving area. Cups are stored in the same location but in an upright position. Silverware is placed on the tables in preparation for the next meal. Glasses are stored in an inverted position on trays that are set on the end of the serving counter.

Steam and Water Supply: The steam supply is that of the college proper, being maintained at a pressure of about 40 pounds. The water is supplied by the city. The hot water used in the dishwashing room comes from a boiler located in the basement of the building, maintained at approximately 140°F and raised by a jacket booster to 180°F. for the rinse operation.

General Comments: Since there is insufficient space to permit air drying of the utensils, one set of towels are used per day. When towels become too moist, they are placed on top of the dishwashing machine to dry. These towels are used for no other purpose than that of drying the utensils as they come from the machine.

Utensils used in the preparation and serving of food are washed and stored in a separate room. At no time do they come in contact with the eating utensils used by the residents of the dormitory.

The dishwashing machine is a single tank type: see Figure 1.

Wooden racks with wire bottoms are used for washing the utensils in the machine. Racks used for dishes and other flat or semi-flat pieces, have two rows of supporting rods about one-half inch in diameter that hold the articles being washed at a slight angle to the vertical. The bottoms of these trays are made of the same size wooden rods. Racks used for silverware have wire mesh bottoms, supported by wooden rods about one-fourth inch in diameter.

Washing Operation: Glasses are literally washed by hand. This is accomplished in a variety of manners, the most predominant being to immerse the glasses in warm soapy water and to rub the rims with the fingertips. The glasses are then rinsed in clear warm water and allowed to drain for a few minutes before towelling, which is done to prevent spotting. The temperatures of both the wash and rinse waters runs about 120^{o}F.

All other utensils are washed in the mechanical dishwasher. This machine is large enough to accommodate two of the present size trays loaded with dishes, but the internal position of the spray arms was such that (prior to mechanical changes) the common practice of placing two trays in the machine at the same time prevented either from being adequately covered by the wash and rinse sprays.

The internal alignment of the machine prior to alterations may be seen in Figure I. The rinse used in this machine was not at all satisfactory from the standpoint of time of exposure or the extent of exposure.

Figure I shows the original system of how the trays were serviced while in the machine. Figure 3 shows how the machine would operate if certain changes were made. As shown, with the original alignment, trays could only be moved about one-third the distance of the machine at one time in order to insure that each tray is subjected completely to the wash and rinse action. With the proposed changes (see recommendations) a tray could be moved the distance of its length at one time, thereby making short movement unnecessary and ultimately increasing the time saved by the use of the mechanical dishwasher.

As illustrated, there was approximately ten inches of dead space inside the machine at its entrance. This was space that was being wasted as far as the operation and the efficiency of the machine was concerned. Also, the arrangement of the spray arms was such that only a token rinse was obtained if trays were pushed through two at a time as was then the practice.

The time that the operator is on duty may, at first glance, seem a trivial matter. However, as will be shown later, the human equation in an operation like that of mechanical dishwashing cannot be overlooked or underestimated.

Temperature control of the wash and rinse water was most unsatisfactory. In fact, there was no actual control of either except to raise the temperature of the wash water by the admission of live steam into the tank which subsequently raises the rinse temperature. According to the U. S. Public Health Service, the wash water temperature should be no less than 110°F., and the rinse water temperature should be no less than 170°F. However, under the original set-up, these conditions were impossible to obtain, and in order to meet these minimum requirements suggestions were made for the correction of the existing circumstances.

No method was provided to lower the wash water temperature. This, particularly on days when the hot water supply has a temperature higher than that desired, results in baking of food particles to the service, thereby increasing the amount of work for the operator who has to re-wash the dishes, increasing the time that the operator must be on duty, and it also results in a delay for the drier who must inspect each article as it is dried.

Wash water is recirculated with a constant overflow provided. Soap is added manually at the rate of about three-fourths of a drinking cup every fifteen to twenty minutes throughout the operation, depending entirely upon the discretion of the operator.

B. Results and Interpretations:

The following are two sets of data gathered on the dishwashing machine at Douglas Hall prior to alterations. The counts from the earlier investigation are included for comparison only.

Table VIII

Results of Previous Investigation at
Douglas Hall Prior to Alterations

Date	Cup	Glass	Spoon	Plate
Feb. 24	69	21	28	TNC (x)
Feb. 28	20	230	21	1
March 3	500	5	8	37
March 7	22	20	230	9

(x) - Denotes that the count was too high to determine.

Table IX

Results of Present Investigation at
Douglas Hall Prior to Alterations

Date	Cup	Glass	Spoon	Plate	Fork	Knife	Wash W
Sept. 12	TNC	32	218	7	192	TNC	broke
Sept. 14	TNC	7	TNC	18	TNC	TNC	TNC
Sept. 16	39	TNC	39	3	39	broken	TNC
Sept. 17	23	12	165	9	403	TNC	TNC
Sept. 19	38	235	96	1	204	68	TNC
Sept. 21	TNC	TNC	92	60	39	59	TNC
Sept. 28	TNC	72	14	7	12	123	TNC

Cups: It was noted that much higher counts were obtained when the cups were packed tightly than when placed loosely in the trays, which will accommodate twenty-five cups when placed rim to rim. On the 16th, 17th and 19th of September, the cups were placed in the trays in such a manner that the rims did not touch; while on the other days they were packed rim to rim. It is believed that the resulting reduction in count is due to the fact that a larger area of the cup rim was exposed to the wash spray and the rinse. Also, in packing the cups tightly, they not only came in contact with four other cups, but they have a large part of the rim area blocked by the supporting rods in the bottom of the tray.

Glasses: Variations in operator technique are believed to be the explanation for the difference in counts obtained from the glasses. For example, on the 16th and 21st of September, when the counts were too high to determine, the same person washed the glasses. This person was called from the kitchen to wash the glasses on these days.

On the 19th of September, when the count was 235, the glasses were washed by the machine operator from Wilson Hall who was acting as a relief operator at Douglas Hall until a permanent man could be engaged. On the remaining days, when the counts were all within acceptable limits, the regular machine operator for the washing room was responsible for washing the glasses.

Spoons: In the current series of samples, the spoons were packed tightly in the trays. However, in comparison, on the 16th and 19th of September, the silverware was packed loosely and agitated three times during the course of the washing, and a noticeable drop in the count was obtained. On the 17th of September, the silverware was again packed loosely, but not agitated, resulting in a rise in the count. On the 21st, the silverware was packed tightly, but not agitated. The rinsing period on this date was extended to six minutes at a temperature of 170°F. Again, the counts dropped. Finally, on the 28th of the month, one layer of spoons was placed in the rack and the usual two minute exposure time was used. This resulted in the lowest count obtained to date. From this, it is obvious that there are three ways of lowering the count on silverware:

1. by agitating a loosely packed tray while being washed;
2. by prolonged exposure to a high temperature; and
3. by the use of single layers of silverware without agitation.

Of these three methods, number one is the most practical from the standpoint of time, particularly in mass operations such as that at Douglas Hall.

Forks and Knives: The same comments that applied to the spoons are applicable for these two utensils.

Plates: The counts obtained from specimens from plates would seem to indicate that the mechanical efficiency of the machine is relatively good in that removal of bacteria by force is fairly complete on flat surfaces. The high count obtained on the 21st of September, which is below 100 and therefore considered to be acceptable, might be explained by the fact that the operator was in a bit of a rush and did not thoroughly scrape the plates before washing them. It should be noted that this count is not the result of the work of the regular operator.

Wash Water: All samples of wash water were too contaminated to make counts. Dilutions were not made of the wash waters for preliminary evaluations revealed such gross contamination that it was felt that the only value obtained from dilution counts would be of little use in the present investigation. It seems to make no difference at what time during the washing period the samples were taken......that is at five, ten, fifteen, or thirty minutes after the operation was begun.

<u>Organisms Present:</u> Smears were made from the broth subcultures and stained by Gram's method. A total of 372 subcultures and stains were made. The microscopic examination of the films revealed the following organisms to be present:

Gram positive cocci.....in clumps, clusters, and tetrads.

Total times encountered.....259.

Gram positive rods.....from short to long forms, singly and in chains (some may be spore formers, although no spores were found).

Total times encountered.....76.

Gram positive spore forming rods.

Total times encountered.....18.

Molds.....one present in the entire series.

Contaminated subcultures.....4.

Subcultures without growth.....14.

Growth was rare on MacConkey's medium. When it did occur, the organisms were subcultured in broth and later stained. All were found to fit into one of the above groupings. No Gram negative organisms were present at any time during the current series of samplings. Classification of organisms was not attempted because, at the time, procedures were undecided and the primary interest was in numbers rather than types of organisms.

C. <u>Recommendations:</u>

On the basis of the data presented, the following recommendations were offered, and certain alterations were made which will be discussed later.

1. A cold water line should be run to the machine in order to maintain the wash water temperature at 140°F. or below.
2. A steam jacket booster for the rinse water line should be installed to raise the temperature to a minimum of 170°F. which is the necessary temperature to keep the bacterial counts within acceptable limits.
3. The spray arm for the wash cycle should be reversed and set over about ten inches (see Figure 3) so that it completely covers the tray as it enters the machine.
4. An additional rinse spray arm should be installed in the upper portion of the machine to give more effective rinsing. This can easily be done without any crowding if suggestion Number 3 is followed.

It was felt that these recommendations were minimal, particularly since space limitations prevented the installation of a pre-rinse operation. Furthermore, if these changes were made, towelling could be eliminated by raising the rinse water to such a temperature that air drying of the utensils would be a matter of seconds instead of minutes.

The following recommendations were offered as supplements to the first four. They were by no means to be considered as optional, but they were listed separately because they would be involved over a long period of time.

5. Partitioned racks for silverware that would permit the utensils to remain in an upright position would be the best means of reducing the counts on these items. However, this would involve a great deal of time on the part of the operator. Gram (37) has advocated boiling all silverware, but this procedure was later modified to the collecting of all silverware in wire baskets in a vertical position (38) as suggested above. However, for the present, it is suggested that the supporting rods be removed from the bottom of the silverware trays, and that agitation should be carried out at least three times during the two minute wash and rinse cycles, with the silverware packed loosely in the trays. If the supporting rods were removed, the tray would not be appreciably weakened; for two or three strategically placed rods or wire braces would serve the same purpose that the many rods now serve.
6. Wooden trays are to be discouraged. As they deteriorate, they should be replaced with seamless, non-corrosive metal racks with wire mesh bottoms of sufficient gauge to permit the maximum flow of water from both the wash and rinse sprays.
7. Towelling, where it is absolutely necessary, should be kept at a minimum. Towels should be used for no other purpose than that of drying the eating utensils. Placing the wet towels on the machine to dry should be discontinued, for they often fall to the floor and are used again after being picked

up. Operators should be instructed not to use the towels for drying their hands. A fresh set of towels should be furnished for each meal.

8. Operators should be instructed further as to their duties. Only a few hours instruction would be needed to convince them that operations were not satisfactory. This instruction applies particularly to those who wash glasses.
9. Personnel should be more closely supervised during the operation.
10. Glasses should be pre-rinsed in the sinks now used for washing them, and then processed in the machine. If this is not practical, the chlorine rinse used earlier in the year should be reinstituted.
11. The practice of placing cups tightly in the trays should be discontinued. No more than sixteen cups should be placed in the rack at one time.
12. An automatic timing device that would ring every two minutes should be installed so that the operator may give the trays their full processing time; two minutes for the wash and two minutes for the rinse.
13. Soap, which is added manually, should be added at least every ten minutes, without fail.
14. Dishes should be more thoroughly scraped, and the use of a brush dipped in warm soapy water, used at times, should be continued and made routine procedure.

EXPERIMENTAL ALTERATIONS AND RESULTS AT DOUGLAS HALL

Since it was believed that the mechanical efficiency of the machine was relatively high, a series of tests were designed to determine this factor.

First, an examination was made to determine the combined effect of the washing spray force and detergent in reducing bacterial counts. It would have been desirable to have tested the washing spray force alone, but this would have involved extra work on the part of the staff and would have caused considerable delay in normal operations, therefore the combined effect of the force and detergent action was studied.

A series of samples were taken, part of them immediately after fresh detergent had been added, and the remainder just prior to the addition of more detergent. The period of time lapse between detergent additions varied from operator to operator, but was generally within the range of fifteen to twenty-five minutes. Plates were the only utensil used for this test.

Table X.

The Effect of Wash Spray Force and Detergent

Date	Sept. 29	Oct. 2	Oct. 4	Oct. 6	Oct. 8
Washed, fresh detergent	12	1	30	23	3
Washed, prior to adding detergent	66	29	2	omitted	34

This set of data seems to substantiate the assumption that the mechanical efficiency of the machine is relatively good, by virtue of the fact that no count obtained exceeded 100 colonies per utensil. It must be borne in mind that even though these counts are higher than those usually obtained, they result directly from a two minute washing period without the benefit of a disinfecting rinse period of equal length. These data further demonstrate that the detergent has a decided effect on the bacterial plate count, since, in all cases except one, the counts obtained at the end of the cycle (that is, just prior to the addition of fresh detergent) were higher than those obtained just after the addition of fresh detergent. There is apparently no explanation of the low count of 2 obtained on the fourth of the month at the end of the cycle.

This test procedure was repeated but with the addition of a two minute rinse period. The results are shown in Table XI.

Table XI.

The Effect of Wash Spray Force and Detergent Followed by Rinsing.

Date	Sept. 29	Oct. 2	Oct. 4	Oct. 8	Oct. 8
Rinsed, fresh detergent	1	1	1	2	6
Rinsed, prior to adding detergent	6	26	8	omitted	17

Even though the curtain rinse in use is considered inadequate for other utensils, this set of data shows that it has a definite disinfecting potential in that all counts (with the exception of one at the beginning of the operation on the 8th of October and one at the end of the cycle on the 4th of October) were reduced in comparison with the results obtained by washing alone. However, in explaining these two variances, it must be remembered that all plates perhaps do not carry the same initial amount of contamination, and therefore the reductions shown are considered valid for indicating the efficiency of the machine as an entity.

With further regard to the subject of variations, differences in counts were not considered to be significant unless they were obvious departures or unless the variations occurred within a controlled series of tests.

The same series of tests performed for plates was followed for cups, to determine if there was any difference in the efficiency of the machine with respect to various utensils (see Table XII).

Table XII

Effect of Loose Packing on Bacterial Counts from Cups

Date	Sept. 29	Oct. 2	Oct. 4
Washed, fresh detergent	25	7	5
Washed, prior to adding detergent	83	QNS (x)	23
Rinsed, fresh detergent	broken	18	6
Rinsed, prior to adding detergent	9	QNS	QNS

x - The symbol QNS connotes a "quantity not sufficient"; that is, four cups were not available.

All counts obtained in this series of tests are with an acceptable range, that is, they are below 100 colonies per utensil. However, once again it is seen that the counts increased at the end of the cycle, showing that the detergent has a definite effect in the washing operation. There is no significance attached to the counts obtained by rinsing after fresh detergent has been added, other than the fact that the relatively low counts speak again in favor of the efficacy of the rinse, even though it is considered to be inadequate. Further, these low counts, shown throughout the whole cycle, indicate that cups should never be packed rim-to-rim.

Table XIII

Effect of Tight Packing on Bacterial Counts from Cups

Date	Sept. 29	Oct. 2	Oct. 4	Oct. 6	Oct. 8
Washed, fresh detergent	197	6	5	126	37
Washed, end of cycle	TNC (#)	51	TNC	QNS (x)	QNS
Rinsed, fresh detergent	16	15	10	7	39
Rinsed, end of cycle	14	76	78	QNS	QNS

- TNC - Too numerous to count.
x - QNS - Quantity not sufficient.

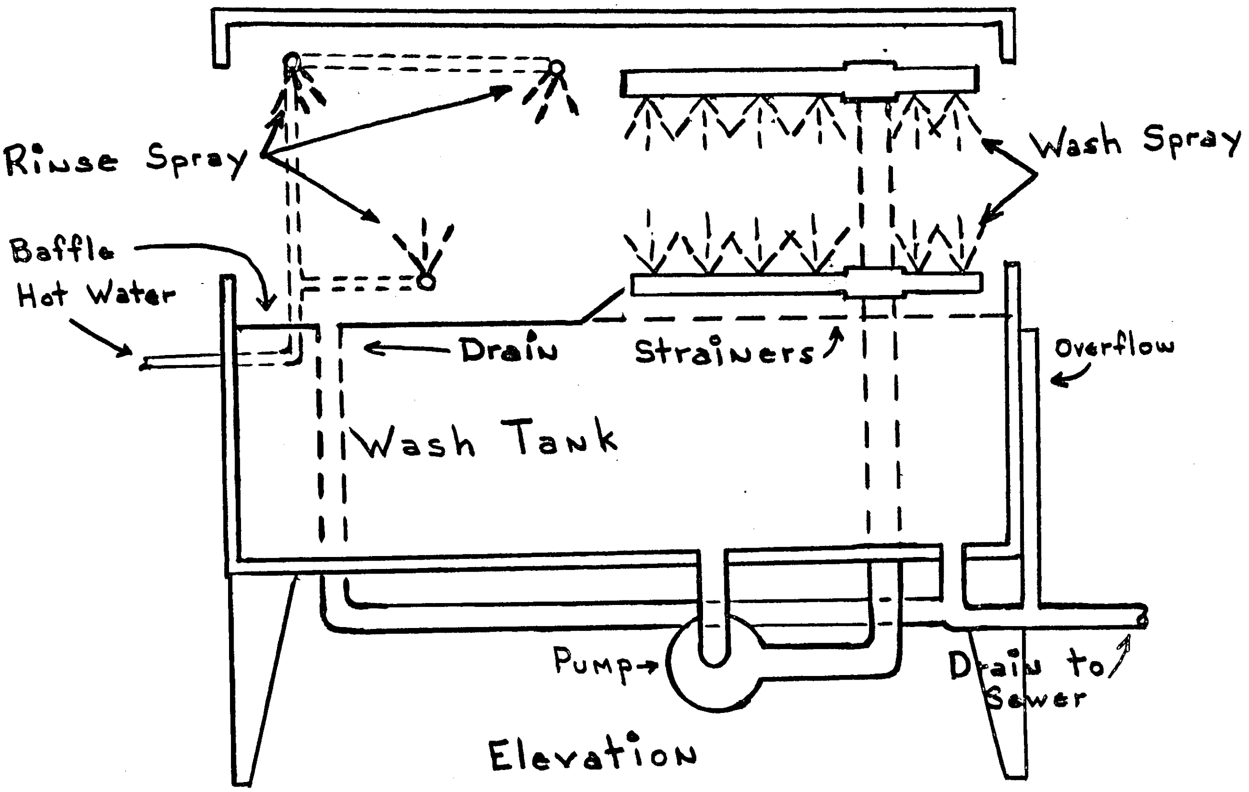
The two low counts obtained at the beginning of the cycle on the second and fourth of the month are explained by the fact that in the washing process some of the cups were jarred out of their arrangement and an increased rim exposure was obtained.

In comparing the washing of cups packed loosely in the trays, it is readily seen that counts increase with the depletion of the detergent, yet the counts do not go quite as high if the cups are packed tightly in the trays.

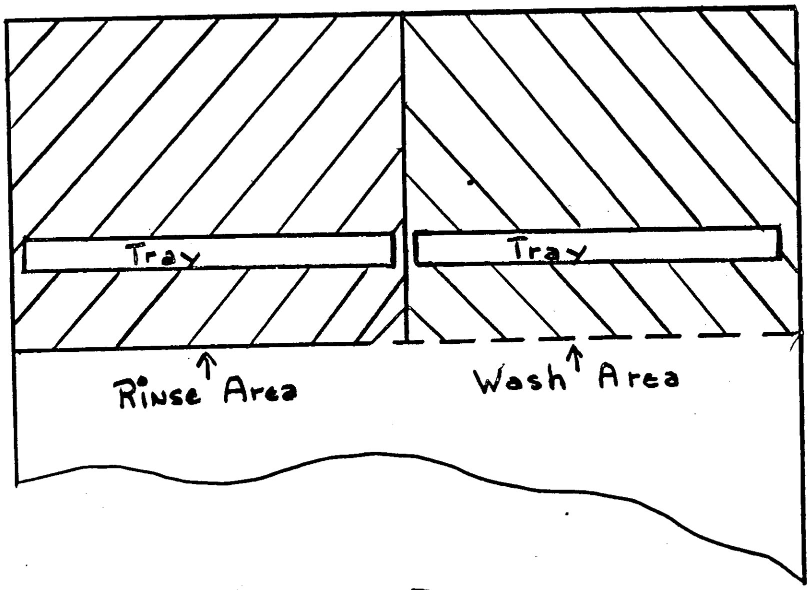
With the ever-increasing stringency of the health laws now being enacted with reference to restaurant sanitation, it was decided to change the internal structure of the machine in order to determine how much more efficiently it could be made to operate. Also it was felt that further rinsing area was needed to negate as much as possible the human factor. With these thoughts in mind, the following changes were made (see Figure 3):

1. The existing wash spray arms were shortened at the inner end. Extensions were made toward the entrance of the machine.
2. A baffle was installed to prevent the rinse water from diluting the wash water and raising the temperature of the latter. This baffle extended half-way through the machine.
3. The bottom rinse arm was placed in the middle of the baffle and another rinse arm was installed in the top of the machine.
4. The temperature of the rinse water was raised to about 180°F.
5. The rinse end of the machine was provided with a separate drain in order to prevent the hot rinse water from entering the wash tank and raising the wash temperature to such a point that food would be baked on the utensils being washed.

Proposed Alterations of Internal Alignment in Single Tank Dishwasher



Elevation



Spray Pattern

Figure 3

In making these changes, it was thought that some of the mechanical removal of bacteria would be lost since the washing section of the machine was shortened considerably, thereby shortening the time of exposure to the force of the wash sprays. However, it was hoped that even with this sacrifice in mechanical removal, better results would be obtained through the addition of extra disinfecting sprays. The primary purpose in the changes was to reduce bacterial counts with particular regard to the silverware and the cups. As shown in previous data, little difficulty was encountered in the cleansing of plates, but the cups and silverware presented many problems. Further, it was hoped that by the addition of more rinsing area, the shaking of the silverware trays could be eliminated, provided the silverware was not packed too tightly, and that more cups could be processed at the same time than was found to be practical under the previously existing design of the machine.

Various rinsing patterns were designed and proposed studies were undertaken to determine their efficiency. The first design tested consisted of two pipes in the upper portion of the machine with a single row of 1/16th inch holes.....the bottom rinse pipe being slotted with five slots one inch in length, the two at the extremes being on an angle of forty-five degrees with the lengthwise axis. This bottom pipe was placed half-way between the two upper pipes. Three sets of samples were taken, and the following results are shown in Table XIV.

Table XIV

Results of Experimental Rinse Pattern Number One

Date	Jan. 19	Jan. 22	Jan. 24
Spoon	230	24	184
Cup	69	67	190
Plate	380	120	210

This spray rinse pattern is obviously of little value. The use of slots in the bottom pipe depleted the pressure to such an extent that water issued from the upper pipes in drops rather than a steady stream. However, it should be noted that the silver count obtained on the 22nd of the month resulted from loosely packing the silverware, thereby exposing it to large quantities of water that flowed freely without the benefit of much pressure. High bacterial counts from plates are explained by the fact that the rinse spray pattern simply did not cover the plates. The spray from the bottom pipe did not reach the plates, and the amount of water from the upper pipes was insufficient for the job.

The next test pattern to be examined consisted of the same arrangement of pipes, but with a different spray pattern. The two upper pipes were replaced with pipes containing two rows of 1/16th inch holes in a staggered fashion so that the extremes of the patterns would form an angle of approximately seventy-five degrees at the origin. The bottom pipe was replaced with one that contained two rows of the same size holes alternating on lines whose planes would intersect at an angle of approximately seventy-five degrees. The results of this pattern are shown in Table XV.

Table XV.

Results of Experimental Rinse Pattern Number Two

Date	Jan. 27	Jan. 28	Jan. 30
Spoon	90	17	328
Cup	47	15	16
Plate	14	12	38

From this data, it can be seen that the spray pattern has a relatively high degree of effectiveness. The spoon count of 90 was obtained from a tray that had been packed with three layers of silverware; whereas the count of 17 was obtained from a single layer of silver. The count of 328 was obtained from a tray in which the silverware had been packed as is the custom, i.e. to the rim of the tray. Plate and cup counts were satisfactory. The temperature range for this pattern was found to be between 174-184°F. The variation was observed daily, and the entire fluctuation took place in intervals of as little as thirty seconds. It was discovered that a recirculation line to the booster was causing this fluctuation, but this line was subsequently blocked and the fluctuation decreased considerably, leaving a range of variation within normal limits to be expected by a small jacket booster.

Six sets of further data were obtained every other day beginning on the first of February. Controls were run with each set with the exception of one. All controls were negative. However, the swabbings from the utensils on all six days were grossly contaminated. A drop in water pressure had been noted on the first day, but it did not seem sufficient to be the cause of the trouble that was encountered. The machine was given a thorough cleaning with javel solution at a temperature of 190°F. for ten minutes. Even this treatment did not improve the results that were being obtained. Therefore, since controls were negative and the machine was being operated solely by the investigator, it was concluded that the drop in water pressure was the cause of the unacceptable results being obtained. It was further noted that at one time during the operation of the machine no pressure at all was found in the rinse end. Obviously, this accounts for the extremely high bacterial plate counts found. The complete absence of rinse water lasted only about thirty seconds, but upon the return of the water there was insufficient pressure to counteract the effect of the short termed absence. Exactly how many times this complete absence of water in the rinse end of the machine occurred during the normal operation is not known.

The exact reason for the depletion in water pressure was not known. However, it was felt that unusually heavy demands at certain times during the day which overburdened the existing supply, plus the fact that Douglas Hall is situated quite high as compared to the rest of the city, were contributing factors to the situation. But, with such fluctuations in water pressure being unpredictable and the time element entering the picture, it was deemed advisable to terminate experimentation at this time.

SUMMARY AND CONCLUSIONS

The results of an investigation into the dishwashing procedures in use in four of the dining halls at McGill University have been presented. The purpose of this investigation was two-fold: first, to correlate the responsibility of the operator and his equipment with the results obtained, using a bacteriological plate count as a means of grading, and secondly, to determine what changes, if any, could be made in the existing equipment to improve the operation as a whole.

Data have been presented that directly relate the results obtained to the technique of the operator, both with mechanical and non-mechanical equipment. Factors of time, over-confidence in the equipment, and carelessness have been shown to have deleterious effects on the cleansing and disinfecting of eating utensils.

Data concerning the structural change in mechanical dishwashing equipment are scant, but they are believed to be an indication of potential improvements in operational conditions. A depletion in water pressure caused a cessation of experimental changes after only six sets of data were obtained from two predetermined sets of conditions.

The method of obtaining and plating specimens by swab technique was patterned after the procedure set forth by the U. S. Public Health Service in Bulletin No. 280. Only two modifications were made, namely, 1. the template used for swabbing flat surfaces was not used, and 2. the suspension solution was sterilized in bulk and added to the swab containers with a sterile technique, rather than sterilizing the solution in the containers.

Bacterial plate counts resulting from the investigations were not acceptable in all cases, but improvements in operator techniques were shown to result in more acceptable counts. There is still room for considerable improvement in conditions, but the situation is by no means hopeless.

As a result of the general investigation into the procedures in use at the four dining halls, the following conclusions were reached:

1. Towelling in all places should be kept at an absolute minimum, and where possible discontinued entirely. Towels should be used for no other purpose than that for which they are issued; and fresh towels should be supplied for each meal. Racks for drying should be provided in order to prevent the towels from falling to the floor as a result of having been placed on the mechanical dishwashing machines for drying.
2. A means of dividing the rinse end of the machine from the wash end (in single tank machines) by the use of a separately drained baffle should be installed in all single-tank type machines. This will prevent the hot rinse water from entering the wash water and thereby raising the temperature of the latter to such a degree that food is baked onto the utensils during the washing process.
3. Soap, since it is added manually in all cases investigated, should be added in sufficient quantities at periods not exceeding fifteen minutes.

4. All operators should be thoroughly trained as to their responsibilities and as to the proper handling of the mechanical and manual equipment.
5. There should be more direct supervision of the operations.
6. Short cuts with the object of saving time should never be tolerated.
7. Personnel should be made thoroughly aware of the relationship of their own hygeine to their job in the dining hall.

Recommendations for specific changes in regard to the individual needs of the various washing rooms have been made in the respective discussions of these places.

GENERAL DISCUSSION

Although it is not the purpose of this report to discuss in detail all the issues that might arise in an investigation into the dishwashing procedures used in institutional dining halls, it should be remembered that such things as detergents, general cleanliness of the premises, personal sanitation of the personnel involved, etc., do play a major role, even though indirectly, on the bacterial efficiency of the dishwashing equipment. These items have been discussed briefly in the section titled "Review of Public Health Regulations". However, it is thought that the question of personnel should be more thoroughly discussed at this time.

In considering the methods of spreading intestinal and salivary infections through dishes as a vector, the manner of distribution of the causal organisms should be defined. This can be divided into three parts:

1. For the spread of salivary infections only:
   This is accomplished by the direct contamination of the utensil by saliva. It may be considered to be a three-link chain, that is, from the mouth to the utensil and to the mouth. Contamination may be by actual contact with the mouth or by coughing, sneezing, or even talking over clean utensils.
2. For the spread of intestinal and salivary infections:
   A. Here is a four-link chain, with the hand serving as the

intermediate vector, from the source of contamination to the eating utensil, thence to the mouth.

B. This may be classified as another four-link chain with the hand serving as the vector between two subsequent carriers, that is, from the contaminated utensil to the hand, from the hand to a clean utensil, and from the clean utensil to the mouth.

The hand can enter into these chains of contamination in many more ways than those mentioned, but it is felt that these three methods are perhaps the most common ones that might be encountered.

In considering that the common vectors of disease transmission in public eating and drinking establishments are the eating utensils, which are exposed to frequent and large doses of organisms, it can be readily seen that improperly cleansed utensils can become a major avenue of infection. This avenue of infection should be brought under continued and permanent control (25). On the other hand, assuming that the dish-washing procedure results in utensils that are within acceptable bacteriological standards, another factor enters the picture, namely, that of the personnel involved in the washing procedure and the general staff of the restaurant. Uncleanliness on their part, such as failing to wash the hands after lavatory functions, a carrier condition existing, smoking, etc., will only be another means of perhaps defeating the purpose of very expensive dishwashing equipment. All too frequently, carelessness in personal habits has been observed. Articles which had been dropped to the floor were picked up by the dishwasher or dryer. Furthermore, these contaminated articles were not rewashed, and the operators resumed their duties without washing their hands. On one occasion, smoking was observed in the dishwashing area, with the cigarette butts being placed anywhere that was convenient to the operator at the time. Too often, food handlers and other outside personnel have been observed bringing dirty dishes to the kitchen and then stopping to dry clean utensils without having previously washed their hands. It is relatively obvious from these examples, that a person who is a carrier of some disease or one that is in the later pre-symptomatic stages of a disease affords an excellent opportunity of spreading the causal organism for that particular disease through the use of his hands.

Needless to say, flies, vermin, and insects, as well as dust, that is allowed to gather about the place immediately defeats the purpose of effective dishwashing. Even if the clean utensils are stored in closed cupboards, thereby minimizing the distributive effects of dust, the hands of the operators once again come into the picture as the transmitter of the organisms likely to be found in the contaminated surroundings. Thus, the personnel employed in a place that serves food cannot be overlooked as a source of contamination. They must be thoroughly trained not only to perform their duties with care, but also to be clean at all times and to eliminate as much carelessness in their personal habits as is possible. Personal habits play a very important role in successful machine dishwashing, for the operator must function as a team with his equipment.

Narrowing the discussion to the dishwasher and the equipment, many interesting results have been uncovered from the recent investigation. It has been demonstrated several times that the operator is directly responsible for the results obtained, regardless of how nearly perfect the functioning of the equipment may be. In other words, the equipment is no better than the man who operates it. Mallmann (61) has long advocated the adequate training of personnel in order to function with the equipment as a team. Bryan (11) has further pointed out that the proper scraping and stacking of dishes for processing through mechanical equipment is of the utmost importance. Such things as the stacking of two trays of glasses on top of each other for washing (111) and the scraper removing and drying the cleansed utensils (53) have been reported in the literature. These factors of carelessness in operator technique have been substantiated in this investigation. For example, the practice of packing cups rim to rim in the trays for processing through mechanical dishwashers was found to be the general procedure. The results were counts that were not acceptable. However, when the cups were packed loosely in the trays, the counts dropped to within bacteriologically acceptable ranges. This shows that through carelessness or lack of proper technique, the purpose of the machine can be defeated. For in packing the cups tightly in the trays, a large part of the rim area was blocked from the force of the wash and rinse sprays due to the fact that the rims touched each other and also due to the fact that the supporting rods in the bottom of the trays were so placed that when cups were placed rim to rim, four rods were directly under each cup.

With regard to packing utensils tightly in the trays, the same practice was found to be the general rule concerning silverware. The counts resulting from such procedures were, in most cases, too high to determine. Experimentation revealed that if the trays were packed less than half full and were shaken two or three times during the washing operation, the counts dropped dramatically to within acceptable limits. On one occasion, it was observed that the operator, being in a hurry, pushed the silverware tray into the rinse end of the machine for just a brief period and then withdrew the silverware for towelling. The counts resulting from this action were again too high to determine. In 1943, Gram (37) advocated the boiling of all silverware that was used in public eating and drinking establishments, feeling that this was the only solution. However, he later amended this statement (38) to permit the silverware to be collected in wire baskets, in a vertical position, in order that it may be given a pre-wash in a vat before processing through a mechanical dishwashing machine.

It is believed that the difference in operator technique is also responsible for some of the variations in counts obtained during this investigation. For instance, in the washing of glasses by hand, the regular machine operator in one of the dining halls was responsible for this operation. His work resulted in counts that were within acceptable limits. However, when another machine operator from one of the other dining halls came as a relief man for a brief period, he assumed the duties of glass washing. The result of his technique produced a count that was three times higher than the highest count obtained from the regular operator.

A false sense of security was thought responsible for high counts obtained from glasses washed by hand in another of the dining halls investigated. The glasses were given a pre-soak in water that had added to it about one-half cupful of javel water, a commercial chlorine-containing preparation. It was explained to the personnel that the chlorine would aid in killing the bacteria present and reduce the counts to within acceptable limits. The personnel had also been warned that the counts that had been obtained were by no means acceptable, which in actuality was not the case, since all counts had been quite low for hand-washed glasses. Nevertheless, for two days straight, using the chlorine pre-soak, the counts soared well above the one hundred mark. Although the chlorine concentration of the pre-soak was not determined, it was felt that it could do no harm, and should have been enough to perhaps give a little bactericidal effect. Yet the counts jumped. It was observed that the operators on these two particular days used less soap in the washing process, and actually did a far less thorough job of washing. The chlorine pre-soak was discontinued without forewarning, more soap and a wash cloth was added to the operation, and counts fell again to their normal level for this institution.

From these examples, it can readily be seen that laws are useless without enforcement. Enforcement alone cannot be effective without preliminary education. Education of the employees and employers of public eating and drinking establishments must be stressed if conditions are to improve and remain in an improved state. It does not seem presumptuous to expect the equipment and the operators to function as a team, for it has been shown that a good operator can obtain good results even from mediocre equipment, whereas the careless or untrained operator can expect nothing but poor results from relatively good equipment. Time and training must always be considered. Training must be thorough and boosted by refresher courses and constant supervision. Time must be stressed in that it is of the utmost importance not to try to save it through short-cuts in procedures. These short cuts can be disastrous from a bacterial viewpoint, and as was frequently the case, short-cuts also resulted in having to rewash utensils that were not thoroughly cleansed from the visible standpoint.

As long as the insufficiency of proper equipment and the lack of knowledge on the part of the operators continue to exist, utensils used in public eating and drinking establishemnts will continue to remain a probable source of infection.

APPENDIX

NATIONAL RESEARCH COUNCIL

Division of Medical Sciences

Committee on Sanitary Engineering and Environment

MINIMUM REQUIREMENTS FOR EFFECTIVE MACHINE DISHWASHING

14 February 1950
(Revised)

Procurers of mechanical dishwashers, including military and other Federal agencies, are concerned about securing the optimum in operating efficiency in new installations of dishwashing machines. Studies of the efficiency of such machines from the viewpoints of sanitation and public health have been reported by Committees of the American Public Health Association[1] and by the National Sanitation Foundation[2].

To make it possible for Federal agencies to take advantage of the latest knowledge on this subject in making new installations of dishwashing machines, this Committee, through its Subcommittee on Food Supply, developed and presents herewith recommended minimum requirements for machine dishwashing. The general adoption of these minimum standards by institutions, hotels and restuarants would simplify for all users the problem of procuring the types of dishwashing machines and auxiliary equipment required for dishwashing and installations that can be operated with consistently good results.

It is not anticipated that these standards will be applied to existing installations of dishwashing machines. The remodeling of an old machine to meet a single item of the minimum requirements may accomplish nothing. Among the few items that may be singled out to improve efficiency is that of pre-rinsing the dishes. Otherwise full compliance with all details of these requirements is essential to make old installations operate efficiently. In general it is likely to be cheaper to install new equipment meeting the requirements than to overhaul old installations.

Recommended Minimum Requirements for Machine Dishwashing

Status

This is a tentative functional specification designed to incorporate the results of recent studies of the efficiency of mechanical dishwashers.

Objective

To treat soiled eating and drinking utensils so as to remove all visible soil, wash water, and detergent, leave them clean and reasonably dry, and effectively reduce the public health hazard.

Scraping

Food remains shall be removed from the dishes by hand or suitable mechanical device.

Preflushing

The preflushing of dishes with warm water, with or without detergent, is highly desirable. This may be done in a preflush section of the dishwashing machine of demonstrated effectiveness or as a separate operation. The warm water containing detergent overflowing from the wash water tank or overflow rinse water may well be utilized for preflushing.

Racks and Racking

The dish racks shall be of such design as to minimize masking of the sprays. Construction with non-marking corrosion-resistant welded wire is recommended. The number of each type of utensil per rack shall be limited as overcrowding prevents effective washing. A sufficient number of racks shall be provided to permit continuous operation under maximum load. Means shall be provided for returning empty racks without damage or contamination from the outlet to the inlet end of the machine.

Washing

The temperature of the wash water shall be not less than 140°F. With good preflushing, higher temperatures, i.e. 160°F. or more, are desirable. Means shall be provided to maintain the temperature of the wash water at not less than 140°F.

The minimum time of washing shall be 20 seconds, during which time each rack of dishes shall be sprayed from above and below in about equal amounts with a total of not less than 12 gallons of wash water per 100 square inches of tray area under not less than three pounds flow pressure at the top manifold.

In single tank machines the time of washing shall be controlled automatically at not less than 40 seconds and in multiple tank machines such time shall be controlled at not less than 20 seconds by timed conveyors with effective method to prevent racks from being pushed through.

Means should be provided to maintain the concentration of detergent in the wash water automatically and continuously at not less than 0.1 per cent by weight in excess of that necessary to satisfy the hardness of the water.

In multiple-tank dishwashing machines excessive spilling or carry-over of water shall be prevented by providing at least 15 inches of space between the beginning of the wash tank and the center of the first spray arm opening, at least 20 inches between the centers of the last wash spray arm opening and the first rinse spray arm opening, at least 5 inches between the center of the last rinse spray arm opening and the curtain rinse opening, and not less than 10 inches between the center of the last curtain rinse spray opening and the end of the rinse tank. When necessary, because of extended spray patterns or otherwise, baffles shall be installed between the wash and rinse tanks to prevent further intermingling of wash and rinse waters.

Rinse

A power or recirculated rinse (two-tank machine) is desirable wherever the quantity of utensils to be washed justifies the cost and the space available for installation permits.

The temperature of such rinse water shall be not less than 180°F. at the inlet to the spray arm. The minimum time of rinsing shall be 10 seconds, during which time each rack of dishes shall be sprayed from above and below in about equal amounts with a total of not less than 12 gallons of rinse water per 100 square inches of area under not less than 3 pounds flow pressure at the nozzles. Where this rinse is used as the sanitizing rinse provision shall be made to stop the machine automatically and to display a warning light whenever the temperature of the rinse water drops below 180°F. A key-operated device shall be provided to permit starting and operating the machine in emergencies at less than the recommended temperature.

When a recirculated rinse is not provided, as in single-tank machines, the fresh water rinse from the pressure line shall be maintained at a temperature of not less than 180°F. at the inlet to the spray arm and provided with automatic stop and warning light as above. The minimum time of rinsing shall be 10 seconds during which time each rack of dishes shall be sprayed with not less than 3/8 gallons of fresh water per 100 square inches of area under not less than 15 pounds flow pressure at the nozzles. Provision shall be made to stop the machine automatically and to display a warning light whenever the temperature of this rinse water drops below 180°F. A key-operated device shall also be provided for emergency operation.

Curtain Rinse

A curtain rinse is not required. A top limit of two gallons of water per minute is proposed for such a rinse, if provided, in order to limit this ineffective use of hot water.

Removal of Vapors

Where excessive moisture accumulates and causes condensation, the installation should include suitable means for ventilation and removal of the excess vapor.

Valves

The water and steam valves shall be of dependable construction, easily accessible, marked with standard designating colors in accordance with A.S.A.: A 13-1928 "Scheme for the Identification of Piping System," labeled as to purpose, and shall not so protrude as to be easily broken off. Valves shall be suitable for the purpose and built to withstand 125 pounds operating pressure. The water valves shall be of globe type with removable seats.

Thermometers

A dial type thermometer with 180°F. visibly marked, showing final rinse water temperature, shall be installed at eye level near the discharge end of the machine where it is protected against breakage. The bulb shall be located so as to show the temperature of rinse water entering the spray arm. Similarly, a thermometer shall be installed to show the wash water temperature.

Pressure Gages:

Gages shall be provided to show the flow pressure as near as practical to the spray arm openings of both the wash and rinse water systems.

Scrap Trays:

Scrap trays shall have openings smaller than those in the spray arm and shall be readily accessible and removable for cleaning. A strainer, accessible for cleaning, shall also be provided on the pump suction.

Spray Arms:

Spray arms shall be made of the material that is relatively non-corrodible in warm detergent solution and shall be easily removable and accessible for cleaning. The slots or jet openings shall be large enough not to clog easily, and shall be so placed as to completely spray every part of every utensil in racks of the standard size delivered with the machine.

Either the spray arms shall move or the dish racks shall be moved during washing and rinsing to increase the coverage of the sprays.

Construction:

The tanks and hood shall be constructed of monel metal, stainless steel or equally corrosion-resistant material in such a manner as to be easily cleaned.

Sharp angles, unnecessary ledges, and open seams shall be eliminated. To facilitate cleaning of the interior, consideration should be given to locating as much of the piping as possible on the exterior of the dishwashing machine.

Each tank <u>including the pump</u>, shall be easy to drain. The pump suction shall be at least two inches above the bottom of the tank.

Each tank shall be provided with a water level indicator.

The supporting frame, motors, and pumps shall be of smooth construction with all parts accessible for cleaning. Adequate guards shall be placed over moving parts.

The bottom platform of the machine shall be not less than six inches off the floor.

Side clean-out doors or removable panels not less than 16 inches in width shall be provided for convenience in cleaning the tanks.

All valves, fittings, and pipes shall be so placed as to avoid obstructing door openings.

Conveyors shall be so timed that the fixed speed will provide at least the minimum holding times herein specified for the various operations.

<u>Water Supply:</u>

Water meters that are too small and water mains that are too small or too badly encrusted to deliver sufficient water for the sanitizing rinse under the existing conditions of installation are a frequent cause of failure of dishwashing operations.

When the hardness of the water exceeds five grains per gallon (85.5 ppm) a hard water detergent should be used; when it exceeds 10 grains (171 ppm), softening to five grains or less is recommended.

In order to secure uniform water pressure the installation of a pressure-reducing valve on the hot water line to the fresh water rinse of the dishwashing machine is recommended, so set as to give 15 pounds flow pressure at the upper rinse arm openings while in operation.

The water connections to the dishwashing machines shall be so made as to prevent back-siphonage of dish water, sewage or wastes, and in accordance with A.S.A.: A 40.6-1943, "Black-flow Preventers."

The hot water storage tank shall be of ample capacity and the heater shall have sufficient recovery capacity to supply the amount of water, at not less than 140°F., needed for maximum length dishwashing periods and other operations for which it is designed to provide water, if carried on simultaneously.

Means shall be provided, as by booster heater with or without storage tank, to supply not less than 2¼ gallons per 100 square inches of tray area per minute of water at 180°F. or higher at the inlet to the spray arms for single tank machines, and as much as two gallons per minute of water at 180°F. for each curtain rinse on a multiple tank machine. Adequate provisions shall be made to prevent the delivery of water at less than 180°F. at the spray arms when operation starts after the machine has stood idle for one hour.

<u>Sewer Connection:</u>

There shall be an airbreak in the line carrying drainage and overflow from the machine to the sewer to prevent possible backflow of sewage into the machine.

<u>Placing:</u>

The machine shall be so installed that all parts are easily accessible for repair, servicing, or replacement.

Operating Instructions:

Complete operating instructions shall be provided. Such instructions shall stress draining the tanks empty after the dishes from each meal are finished, cleaning the tanks and spray arms, and leaving them dry until the next use.

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APPENDIX
Table XVI

STATE	WASH CYCLE TIME MIN.	WASH CYCLE TEMP °F.	RINSE CYCLE TIME MIN.	RINSE CYCLE TEMP °F.	PERSONAL HEALTH CHECK-UP	EQUIPT. STAND-ARDS	PLATE COUNT	TYPE LAW	DETG. SPEC.
ALA. (1)	N.S.	110-120	1	170	N.S.	YES	N.S.	S.	D.
ARK. (7)	N.S.	N.S.	2	170	N.S.	YES	N.S.	S.	D.
ARIZ. (6)	N.S.	110-120	2	170	YES	N.S.	100	L.	D.
CAL. (15)	N.S.	N.S.	1/2	180	N.S.	YES	N.S.	S.	D.
COL.	NO REPLY RECEIVED TO QUESTIONNAIRE								
CONN.	NO REPLY RECEIVED TO QUESTIONNAIRE								
DEL. (27)	1/2	130	1/3	170	YES	YES	N.S.	L.	D.
D.C. (114)	General regulations of local origin								
FLA. (31)	N.S.	N.S.	2	170	N.S.	YES	100	S.	D.
GA. (35)	N.S.	140	N.S.	180-190	YES	YES	100	S.	D.
IDA. (48)	N.S.	110-120	2	170	N.S.	YES	100	S.	D.
ILL. (49)	N.S.	120-140	2	170	N.S.	YES	100	L.	D.
IND. (50)	N.S.	120-140	1/6	170	YES	YES	100	L.	D.
IOWA (51)	N.S.	N.S.	2	170	N.S.	N.S.	100	S.	D.
KAN	NO REPLY RECEIVED TO QUESTIONNAIRE								
KY. (52)	N.S.	140	2	170	N.S.	YES	N.S.	S.	D.

Table XVI (cont.)

STATE	WASH CYCLE TIME MIN.	WASH CYCLE TEMP °F.	RINSE CYCLE TIME MIN.	RINSE CYCLE TEMP °F.	PERSONAL HEALTH CHECK-UP	EQUIPT. STANDARDS	PLATE COUNT	TYPE LAW	DETG. SPEC.
LA.	NO REPLY RECEIVED TO QUESTIONNAIRE								
ME.	NO REPLY RECEIVED TO QUESTIONNAIRE								
MD. (66)	N.S.	N.S.	1	180	NO	YES	100	S.	D.
MASS. (67)	3	120	2	170	YES	YES	100	S.	D.
MICH. (69)	N.S.	N.S.	N.S.	N.S.	YES	YES	N.S.	N.S.	N.S.
MINN. (71)	N.S.	110-120	2	170	N.S.	YES	100	S.	D.
MISS. (72)	1/4	110-140	1/4	170+	YES	YES	N.S.	S.	D.
MO. (73)	N.S.	110-120	2	170	N.S.	YES	N.S.	L.	D.
MONT.	NO REPLY RECEIVED TO QUESTIONNAIRE								
NEB. (75)	General regulations of state origin.								
NEV.	NO REPLY RECEIVED TO QUESTIONNAIRE								
N.J. (79)	State law specifies only health check on personnel.								
N.H. (78)	2/3	110-120	2	170	N.S.	YES	100	N.S.	D.
N.M. (80)	N.S.	120	2-3	180-170	N.S.	N.S.	100	L.	D.
N.Y. (81)	N.S.	140	1/6	180	YES	YES	N.S.	S.	D.
N.C.	NO REPLY RECEIVED TO QUESTIONNAIRE								
N.D. (83)	N.S.	110-120	2	170	N.S.	YES	100	S.	D.

Table XVI (cont.)

STATE	WASH CYCLE TIME MIN.	WASH CYCLE TEMP °F.	RINSE CYCLE TIME MIN.	RINSE CYCLE TEMP °F.	PERSONAL HEALTH CHECK-UP	EQUIPT. STANDARDS	PLATE COUNT	TYPE LAW	DETG. SPEC.
OHIO (87)	N.S.	140	1/2	170	N.S.	N.S.	100	L.	D.
OKLA.	NO REPLY RECEIVED TO QUESTIONNAIRE								
ORE. (89)	N.S.	140-160	1/6	170	YES	YES	100	S.	D.
PA.	NO REPLY RECEIVED TO QUESTIONNAIRE								
R.I. (97)	N.S.	120-140	1/4	180	YES	YES	100	S.	D.
S.C. (102)	General regulations of state origin.								
S.D. (103)	N.S.	110-120	2	170	N.S.	YES	100	L.	D.
TENN. (108)	N.S.	110-120	2	170	N.S.	YES	100	S.	D.
TEX. (107)	N.S.	N.S.	3	170	YES	YES	N.S.	L.	D.
UTAH (115)	N.S.	110-120	2	170	N.S.	YES	N.S.	S.	D.
VER. (116)	N.S.	130-140	2	170+	YES	YES	100	S.	D.
VA. (117)	1/2	140	1/4	170	N.S.	YES	100	S.	D.
WASH.	NO REPLY RECEIVED TO QUESTIONNAIRE								
W.VA.	NO REPLY RECEIVED TO QUESTIONNAIRE								
WIS. (119)	N.S.	N.S.	N.S.	170-180	N.S.	YES	100	S.	D.
WYO. (120)	N.S.	110-120	2	170	N.S.	YES	100	S.	D.

Table XVI (cont.)

PROV. OR TERR.	WASH CYCLE TIME MIN.	WASH CYCLE TEMP °F.	RINSE CYCLE TIME MIN.	RINSE CYCLE TEMP °F.	PERSONAL HEALTH CHECK-UP	EQUIPT. STAND-ARDS	PLATE COUNT	TYPE LAW	DETG. SPEC.
ALT. (3)	N.S.	110	2	170	YES	N.S.	100	P.	D.
B.C. (9)	N.S.	110	2	170	N.S.	YES	51	P.	D.
MAN. (64)	N.S.	110	2	170	N.S.	YES	100	L.	D.
NFLD. (77)	General regulations of provincial origin.								
N.S.	NO REPLY RECEIVED TO QUESTIONNAIRE								
ONT. (88)	N.S.	110	2	170	YES	YES	100	P.	D.
PEI. (92)	General regulations of local origin.								
QUE. (95)	N.S.	110-120	2	170	N.S.	YES	100	N.S.	D.
SASK.	NO REPLY RECEIVED TO QUESTIONNAIRE								
N.B. (76)	N.S.	N.S.	3	190-212	N.S.	N.S.	N.S.	P.	N.S.
T.A. (2)	N.S.	110-120	2	170	N.S.	YES	N.S.	T.	D.
T.H. (42)	N.S.	110-120	2	170	N.S.	YES	100	T.	D.
P.R. (94)	N.S.	110-120	2	170	YES	N.S.	N.S.	T.	D.

Table XVI (Cont.)

COUNTRY	WASH CYCLE TIME MIN	WASH CYCLE TEMP °F.	RINSE CYCLE TIME MIN	RINSE CYCLE TEMP °F	PERSONAL HEALTH CHECK-UP	EQUIPT. STAND-ARDS	PLATE COUNT	TYPE LAW	DET. SPEC
SWEDEN	NO REPLY RECEIVED TO QUESTIONNAIRE								
ENGLAND (70)	NO REGULATIONS YET....UNDER STUDY								
SWITZ. (105)	ONLY GENERAL REGULATIONS CONCERNING CLEANLINESS.								
NORWAY (85)	FEDERAL REGULATIONS OF GENERAL NATURE								
CUBA (19)	REGULATIONS UNDER REVISION								
BRAZIL	NO REPLY RECEIVED TO QUESTIONNAIRE								
PERU	NO REPLY RECEIVED TO QUESTIONNAIRE								
U.N.O.	NO STUDIES INCLUDED IN PRESENT AGENDA								

N.S.--NOT SPECIFIED
P. --PROVINCIAL LAW
S. --STATE LAW
L. --LOCAL LAW
D. --DISCRETIONARY
T. --TERRITORIAL LAW

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