THE DESIGN OF A COMBINATION FOOD CUTTER FOR HOME AND RESTAURANT USE

Thesis

by

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In Partial Fulfillment of the Requirements for the Professional Degree of Industrial Designer

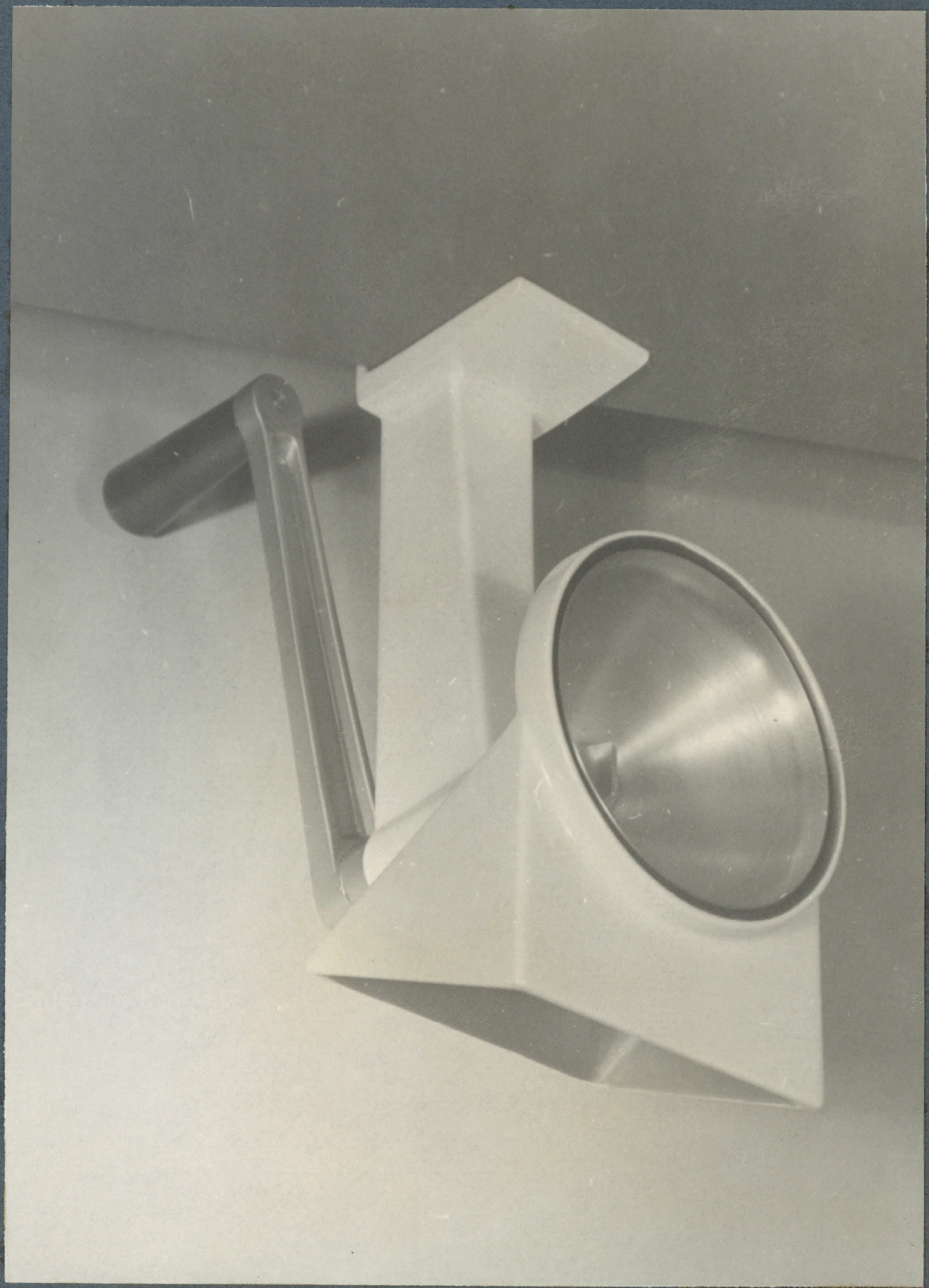
CALIFORNIA INSTITUTE OF TECHNOLOGY

Pasadena California

1949

ACKNOWLEDGEMENTS

The author wishes to express his appreciation for the guidance and invaluable criticism received from the faculty of the Industrial Design Section and the members of his thesis committee - Mr. David F. Welch, Mr. Salvatore Merendino, and Dr. Donald S. Clark. Also to Dr. Craig Taylor of the Engineering Department at the University of California at Los Angeles, to Mr. Carl G. Thiene, and to the many manufacturers who gave so freely of their interest and time the author wishes to express his indebtedness.



ABSTRACT

A combination food cutting machine has been developed for use in homes and small restaurants.

Preliminary examination of the consumer market suggested the need for an improved small size combination food cutting machine. Subsequent consumer surveys were made which verified this demand.

Consumer, manufacturer, and distributor surveys were made to determine the specific features that a cutting machine should embody in order to meet the widest consumer acceptance in the market.

The development of a design that would best meet the market requirements included research into the principles of cutting food, examination of competitive products, and a study of materials and processes.

The final design evolved from detailed consideration of all of these factors. Meat chopping, vegetable slicing, and ice chipping operations are incorporated into this design. The unit is assembled with a crank for hand operation or with a motor for power driven operation. The body of the machine is made of aluminum. This material reduces the weight of the unit and in addition provides a model that may be sold at a lower price.- as a protective surface coating is not a

functional requirement. For a slightly higher price a surface coating of baked white enamel with chromium trim may be provided.

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INTRODUCTION

STATEMENT OF THE PROBLEM

A food chopper of the type used in homes and small restaurants is to be redesigned and improved. Additional features similar in method of operation are to be incorporated into the design where it is found feasible to do so. These additional features will raise the price of the hand operated unit above the cost of the present individual machines that perform the separate cutting operations; however, the price of this combination cutter unit will be much lower than the total cost of the three separate machines that are now required to perform the same operations. The motor driven unit will also sell at a much lower price than the cost of a food mixer with the necessary attachments.

SELECTION OF THE PROBLEM

The food chopper has a very large market, and it involves all the various phases of design. Research has revealed that there is a definite need for an improved unit for the home and small restaurants. One has merely to look into the average kitchen today to confirm this need. This kitchen is quite different from that of two decades ago when all operations were performed by hand. Today it is much more inviting to the person who works there, for much of the work is now done by well-designed machines. Amidst the attractive looking mixer, the dishwasher, and the numerous other modern machines, however, one will still see an

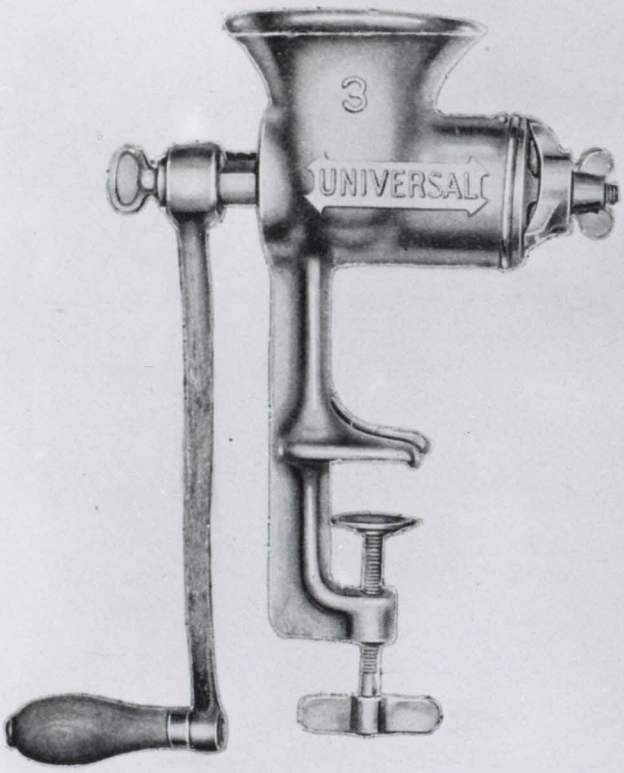


FIGURE I. TYPICAL FOOD CHOPPER

antiquated object - the food chopper. This is a product that has seen essentially no change in the past half century (See Figure 1).

SCOPE OF THE PROBLEM

In analyzing the food chopper it seemed quite logical that a number of similar features might be combined so that a more versatile tool might be provided and one which at the same time would be less expensive and less cumbersome to use than the separate utensils used individually to perform the same operations. It was decided that slicing, grating, and ice chipping operations might quite logically be combined with the food chopper in this way. In addition to these features a simple low cost metal stamping for extruding Danish pastry shapes might be provided - in the event the redesigned chopper used a method of cutting similar to that used by present models. It was further decided that it would be desirable to design this kitchen machine so that the basic component could be assembled as a hand operated unit to sell to consumers living in smaller homes, or could, by simple modification, be assembled with a motor to sell at a higher price for use in larger homes and restaurants.

PRINCIPLES INVOLVED IN THE CUTTING OF FOODS

IDEAL METHOD

A food is a nutriment in solid form. All of the various types of meats and vegetables consist of a mass of cells. These cells are the structural and functional units of plant and animal organisms. Each cell contains a small, usually microscopic, mass of protoplasm, and this protoplasm generally includes a nucleus. Surrounding this protoplasmic mass is a semipermeable membranous surface, or cell membrane, which in most plants and some animals secretes an external, more resistant but permeable covering. This covering is called the cell wall. In cutting operations on food this cell structure is quite important. Vegetables, having the more resistant cell covering, offer much less of a problem in precision cutting than do meats - especially when the cutting is done by mechanical means. The firm structure of the vegetable permits a knife edge to shear through it with a precise clean cut, whereas the flaccid structure of meat reacts in the opposite manner to inhibit the action of the blade.

The cutting action that is best adapted to the cutting of meat is described by Mr. M.O. Cullen in his book on carving[1]. In the book he describes the structure of meat - how it consists of long prism-shaped tubes which are packed together into small tight bundles that are held in place by connective tissue - and he points out that the way this structure should be cut is across these bundles (across the graim) with nice clean draw-cut strokes.

By "draw-cut" is meant a combined pressure-slicing action similar to that used with a butcher knife. This method of cutting, he states, not only improves the appearance of the meat but also gives it a better flavor and makes mastication easier. The ideal meat chopper then would be designed to divide the meat into minute cubes which are cut across the grain by sharp knife edges that employ a draw-cutting action. This action produces a texture with a definite cut, which is the thing desired. The conventional grinder tears the meat and produces a torn texture which is not desired.

METHODS USED IN COMPETITIVE PRODUCTS

Meat Choppers - Meat choppers - or food choppers - of the type used in homes and restaurants all operate on the same principle of cutting. The components of these choppers consist of a cylindrical body into which a hopper is built. An Archimedean screw rotates within this body to feed the meat or food forward to the front end. At the front end the food is forced through a flat perforated steel plate and is cut by a four bladed knife which rotates with its edges in contact with the plate. The knife on the inexpensive home model food chopper rotates outside the cylinder, whereas the knife on the restaurant type food chopper rotates within the cylinder. With the knife in the latter position the meat is squeezed less before it is cut into small pieces. This results in better chopping of the food; however, it is still squeezed considerably by being extruded through the holes of the plate.

Vegetable Slicers - All of the smaller home type of machines for doing grating, slicing, and shredding operations involve the same principle of cutting. The basic component of each machine is a cutter that rotates. The food is pressed against this cutter as it rotates and as each succeeding cutting edge passes through the food, the food is processed in one of the above ways - the specific type of operation depending merely upon the cutter selected. The only basic difference in the various machines is in the shape of the cutters - one type of cutter being constructed in the form of a disk, another type as a truncated cone, and a third type as a cylinder. The position of the cutting edge in relation to the food being cut has been found to affect the efficiency of the cutting action - the most efficient cutting action being obtained when the cutter edge tends to advance progressively from one end to the other. This provides a better shearing action which causes the cutter actually to slice or draw-cut its way through the food rather than press its way directly through the substance. This action is accomplished on the three shapes of cutters merely by constructing the cutting edges in the correct relation to their rotating surfaces. On the disk the blades are placed in such a manner that the edges are not along the radii but are at an angle to the radii. The edges of the blades on the cone take the form of a helical spiral, and on the cylinder the edges are in the form of a helix.

Ice Chippers - Ice chippers of the type used in the home - either hand operated or motor driven - involve the same principle of

operation. In each case the ice is chipped by prongs successively being forced into it - each prong breaking away chips of ice. The arrangement of these prongs may be in either of two different ways - either along a spindle that rotates or radially on the surface of a disk that rotates. In the latter case the prongs project out from the surface of the disk. The former type is used most often on hand operated machines which are so constructed that two different finenesses of ice may be produced. This feature is made possible by providing a pointed edge on one side of the prong and a saw tooth edge on the other. Thus when the crank is turned in a clockwise direction with the pointed sides in the operating position finer ice chips will be produced. For coarser chips a counterclockwise direction of turning is required. The prongs rotate between fixed projections which are located on either side of the body and which are integral parts of the body. These projections are on the same horizontal plane as the axis of the rotating blades. The hopper is immediately above this plane. In operation the ice is caught between the prongs and the projections and is chipped into small pieces. One variation that accomplishes the same thing but with an even greater variety of fineness is a housing that is provided with an adjustable projection mechanism. The disk type of chipper mentioned above is made to fit into the disk type of vegetable slicer housing. With both types of machines the ice is deposited in the hopper provided, and the chipped ice is discharged by gravity to the container below.

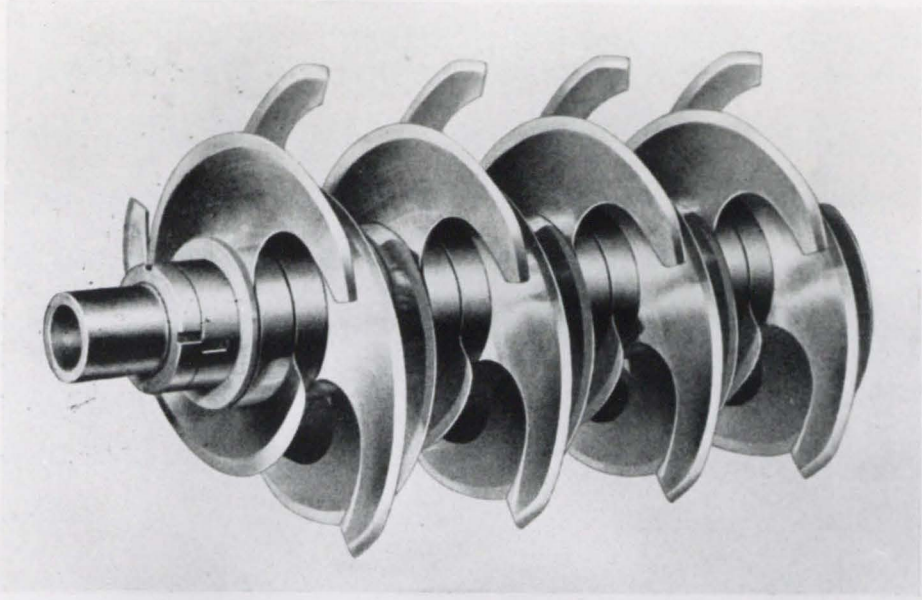


FIGURE 2. SET OF ROTATING KNIVES

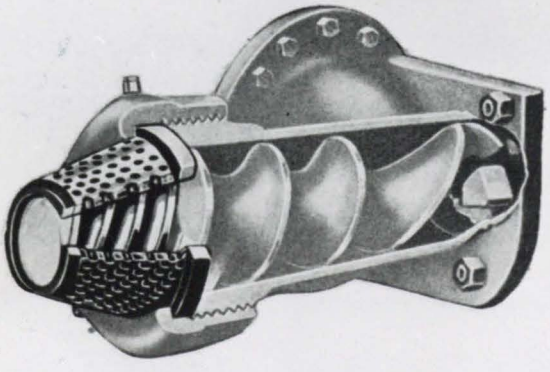


FIGURE 3. TRUNCATED PERFORATED CHOPPER CONE

RECENT DEVELOPMENTS

Some improvements in the methods of cutting foods are being adapted to food choppers but thus far these improvements are such that they are only adaptable for use in large machines. These machines are of the type used by packing houses where a very large volume of food is processed. One machine of this type is used for making sausage, luncheon meat and similar products (See figure 2). It consists of a rotating cylinder in the bottom of which is a set of knives placed close to the circumference of the cylinder. The knives rotate in the same direction as the cylinder but much faster, the knives rotating at 2500 r. p. m. while the cylinder rotates at 110 r. p. m. The meat is fed into the machine automatically by means of a ribbon belt conveyor and distributed uniformly by centrifugal force over its entire inner surface. By this method the meat and fat cells are cut into minute cubes, and these cubes have the definite cut texture that is desired.

A variation of the standard type meat chopper, which is an attempt to improve the cutting action, is one that replaces the flat perforated steel plate by a truncated perforated steel cone (See figure 3). A conically shaped cutter conforming to this cone rotates within it and performs the cutting action. This cutter is attached to the feed screw and is itself a helix in shape, but it has less pitch than the helix of the feed screw. In this case again, however, the food is extruded through similar perforations, and food is necessarily squeezed in the pro-

cess. This meat chopper has also only been made in large sizes for handling a large volume of food, and as yet it has not been widely used. The few opinions obtained about it indicate that it is an improvement over the conventional chopper but only to a slight degree.

One machine which is used by large restaurants involves a different cutting action(2). This machine is used principally in cutting vegetables for salads. The cutting action is accomplished by means of two curved blades which rotate at a high speed within a steel bowl. The bowl has a hemispherical shape so that the blades just clear the surface, and it rotates simultaneously with the blades but at a much slower speed. This causes all of its contents to pass under the blade and be cut. Finer cuts are accomplished by rotating the vegetables under the cutters two or more times. A power take-off is also provided with this machine so that the standard meat chopping and vegetable slicing attachments may be used.

Patents - (See Appendix C) - A study of patents revealed that no improvements in methods of cutting have been adapted to the smaller size meat choppers. The improvements that have been patented within recent years relate principally to larger equipment and in this equipment to other features such as methods for keeping the cylinder refrigerated while the meat is being ground or methods for changing the plane of rotation of the screw feed mechanism so that it rotates in a vertical plane. This change of plane enables the screw feed to be assisted by gravity and

also makes it impossible for meat juices or other food juices to leak out around the back as they do all too often in the home type food choppers.

MARKET STUDY

DISTRIBUTION CHANNELS

Hand operated food choppers and vegetable slicers and ice chippers are distributed to the consumer in two different ways. The larger retail stores, such as department stores, buy in large lots directly from the manufacturer. Restaurant supply houses also buy directly from the manufacturer. The smaller retail stores are supplied by local jobbers who can provide fast delivery. Electric food mixers and attachments are distributed through these same channels, and in addition are sold directly to the consumer through manufacturers' outlets which the larger electrical companies have.

The largest volume of sales for this combination food cutting machine will be for the hand operated unit. For this reason a manufacturer of meat choppers or vegetable slicers - rather than a large electrical appliance company - would most probably produce this combination food cutter. For this manufacturer the former method of distribution would be best.

COMPETITIVE PRODUCTS

Food Choppers[3] - The construction and the performance of the home type food chopper was found to be deficient.

In the older type of food choppers the body, the feed screw, the crank arm, and the ring that holds the perforated steel plate are made of cast iron or malleable iron or steel, and they are tinned inside and out to aid in preventing corrosion. The

four bladed knives and the perforated steel plates are made of high carbon knife steel. The perforations on the standard size plate are 3/16 of an inch in diameter and other plates with various size holes are available. A few of the less efficient types of choppers have the plate incorporated in the body and have an assortment of knives available - these different knives varying as to the number of cutting edges. The hardwood handle for the crank is provided with a metal end ferrule adjacent to the crank arm, and this handle is free to rotate about a pin or bushing which is securely fastened to the crank. The other end of the crank arm is attached to the screw feed device by means of a steel thumb screw. The mechanism for clamping the food chopper to a table consists of a steel screw with a free swivelling steel washer attached to one end of it and a wing nut head attached to the other end. In assembling the unit the screw is first screwed into the lower threaded end of the chopper body, and then the pin through the washer is peened in place. The mechanism acts in the same manner as a vise to clamp the machine to a table - the washer acting as one jaw of the vise and a projection of the chopper body serving as the other jaw.

Some of the more recent food choppers are being made of aluminum castings - all three types of castings being used.

The food chopper attachments for the home mixers do not differ from other food choppers in principle of operation or in form except that they are so constructed that they may be attached

to the food mixer power take-off.

Vegetable Slicers - The cone type cutter unit is the most common type of hand operated machine on the market today. This unit consists of an aluminum body - either sand cast or permanent mold cast - a cutting cone, and a crank for operating the machine, and a means of attaching the machine to a table. The hopper forms the larger part of the body, and it is on only one side of the cutter so that the opposite side of the cutter is exposed. This hopper is located on the side on which the cutter is turning in a downward direction so that there is a wedging action on the food when it is being cut. This body also provides a housing for a bronze bearing within which the shaft turns. This shaft has the crank attached at one end and a lug mechanism at the other - this mechanism being used to attach the various cutting cones. The cutters are made of heavy gauge cold rolled steel and are plated or tinned to prevent corrosion of the surface. The body has a standard clamp-on device similar to that of the food chopper. One added feature, however, is a tripod device to which the unit may be attached. This tripod has suction cups on the feet so that the unit may be used on almost any flat surface.

A variation of the cone type of vegetable slicer is one model that is made in France and imported into this country. The body of this model is a heavy aluminum casting made in a permanent mold. A cone shaped cutter fits into a circular opening in the front of this body, and the shape of this opening

or cutter housing, conforms to that of the cutter. This shape is that of a cone that is low in height in relation to the diameter of its base. The upper third of the back surface of the cutter housing opens directly into the hopper above. The cutters are made of a stamped cold rolled steel, and they are tinned to protect them from corrosion. Each one has a spindle attached to its center, and this spindle fits into the housing and acts as the drive shaft - the opposite end being attached to the crank by means of a nut. Every place in the machine that is subject to wear by friction of moving parts has a steel insert. A clamp-on device is also provided on this model for attaching it to a table.

The cylindrical cutter has been adapted principally to grating operations, although some units are made that do all the operations that are done by the cone or disk type of cutters. The models observed were not as well constructed - being made of stamped metal parts in most cases. The same basic components were used, however - a body with its hopper and clamp-on device, a cutter, and a crank. The appearance of these cutter units approximates that of a conventional food chopper. The best cylindrical cutter model that does all the vegetable slicing operations is one that is designed as an attachment for a motor driven unit. The body of this unit, which is an aluminum die casting, consists of a housing for the cutter and a hopper attached to the housing as an integral part of it. Each cutter is provided with a spindle to act as the drive shaft when it

is interlocked with the power take-off of the motor driven unit. One small French grater that uses a cylindrical cutter is much simpler in construction than other models. It is a small model designed to be held in the hand while operating it. This model consists of stamped steel parts which are fitted over a bent wire frame. The hopper is attached to the forward end of the frame and swivels forward to allow the cutting cylinder to be inserted on the frame. This hopper in conjunction with the frame below it - in the hopper's operating position - form a circular space into which the cutter fits. The lower part of the handle is a steel stamping sttached to the frame, and the upper part of the handle is a steel stamping which acts not only as a part of the handle but in addition is formed at the forward end so that it will fit into a slot in the back of the hopper and act as a feeding device. This forward end is shaped to fit inside the hopper, and it has a concave lower surface to conform to that of the cutter. The rear end of this handle is attached to the frame at the back so that the pressure of the hand will cause it to swivel downward. The crank is attached directly to the cutter, and consequently no shaft or housing is required. All of the metal parts are tinned to prevent corrosion.

The flat disk type of cutter is used principally on attachments for motor driven vegetable slicer units. These attachements consist essentially of a body and front which are made of aluminum - usually die cast - or cast iron or steel plate. The front is hinged to the body and is provided with a lockable catch

suitable for securing the front to the body. This front has an integral hopper for vegetables and usually a hinged press for feeding the food into the cutter. There is an opening in the bottom of the slicer suitable for gravity discharge of the sliced or shredded material. The cutters rotate inside the body, or cutter housing, of this attachment. They have securely attached spindles or drive shafts which interlock with the power take-off of the machine and thus are caused to rotate. The cutter disks vary in diameter from 6 to 9 inches for the smaller size units, and they are made either of aluminum alloy or plain carbon steel or corrosion resistant steel - the carbon steel disks being coated with tin. Detachable and adjustable knives are cutlery grade high carbon corrosion resistant steel. The shredder and grater disks have their cutting edges stamped out of the metal of the disks.

Ice Chippers - The hand type ice chippers have an aluminum or zinc die cast body and are either painted or plated on the outside to produce a better appearance. The prongs are made of steel and are joined together into one correctly arranged unit by means of metal die cast around them. The disk type chipping plate has either the disk made out of a heavy gauge steel, out of which the prongs are stamped, or it has sets of steel prongs which are detachable from the plate by means of screws.

Motor Driven Units - Practically all of the smaller motor driven units for performing meat chopping, grating, slicing, and ice chipping operations are of the home mixer type. These mixers

either have a power take-off unit provided within the motor housing or have a separate reduction unit through which the attachment is driven by the motor. A universal motor of from 1/12th to 1/8th horsepower is used on these mixers. This series wound motor is used to provide the high torque required for the various operations - especially for the meat chopping operation. Variable speeds are required - the range being from 50 to 250 r. p. m. for meat chopping, vegetable cutting, and ice chipping operations. The motor speed is reduced to the maximum required speed through a gear train, and then a governor control mechanism of the centrifugal mechanical type provides the speed adjustment within this range. The motor housing is die cast, and it houses the reduction gears and the governor control mechanism, as well as the motor.

CONSUMER SURVEY

The consumer acceptance of any product is the ultimate test of whether that product is a success. The consumer survey is of basic importance to a designer in determining the type of product that will be most favorably received by the public. It is for this reason that a relatively large percent of the designer's time is devoted to this phase of his work.

In this consumer survey it was considered that the people in home economics departments of packing houses, cooking schools, and colleges throughout the country should be the best of the various consumer survey sources of information (See Appendix A).

The people in these departments are constantly confronted with all types of cooking problems, and their opinions, in most cases, are based on a summation of opinions from several different people. Consequently their requirements should be more representative of what the American consumer wants in a machine for the kitchen. In view of this, the information from these sources was generally given more weight in the design considerations than were the opinions and suggestions obtained locally through conversations with housewives.

Consumers express a definite desire for a kitchen machine of the type proposed in this thesis. The three basic requirements they make for a cutting machine are that it be sanitary, efficient, and reasonable in cost.

Of the various makes of hand operated food choppers the Universal model is the most popular and is sold in the largest volume. Among the electric food mixers that provide attachments for food chopping, grating, slicing, and ice chipping operations the Mixmaster is sold in the largest volume; however, the performance of the Kitchen-Aid machine is preferred - both for its greater efficiency and especially for its much easier adaptability for use with the attachments. The prices paid for hand operated 2 1/2 pound home model food chopper units range from $3.50 to $5.00, with a price of $4.00 being the most common. For the hand operated 3 pound model used by small restaurants the price is from $6.50 to $7.50. These prices are not considered too high by the consumers. For food choppers for electric machines

the prices are as high as $10.50, and this of course does not include the cost of a special gear reduction mechanism which many of these machines require. This price is considered much too high - especially so since the electric machines alone have prices ranging up to $57.50.

The survey that was made on vegetable slicer units revealed that the majority of people are very well satisfied with their performance; however, the prices are considered quite high - both for the electric food mixing machines with their attachments, and for the "Griscer" hand operated type. The price range for these is from $9.00 for the hand operated unit to approximately $35.00 for the attachments alone for the electric unit.

The survey in regard to ice chippers revealed very much the same results as for the vegetable slicer units. The performance of the units is quite acceptable, both for the small hand operated units and for the motor driven units. Here again, however, the price is a barrier to many sales. A price of $5.00 for a hand unit is a minimum. This increases up to $10.00 for a hand unit that has an adjustable mechanism for controlling the fineness of the ice. The ice chippers for electric units are within this same price range, providing one already has purchased the vegetable slicer housing in which the chipper operates. If this housing is not required for vegetable slicing operations, it is quite impractical for one to consider using this ice chipping unit by itself.

In regard to attachments for electric food mixers there are two main factors that have been found to limit consumer enthusiasm. The first of these is the large number of parts which make the preparation of a meal a chore just to assemble and disassemble the various units that are used. Along with a greater number of parts one naturally has a more difficult cleaning problem. The second factor is the storage problem for both the mixer and the attachments(4).

ESTIMATED VOLUME OF SALES

Little information pertaining to volume of sales could be obtained directly from the manufacturers, and sources of information on annual sales of kitchen and food machinery were not sufficiently categorized as to type of machine to be useful in estimating the potential volume of sales for this combination food cutter. For this reason more indirect methods of estimating had to be employed. An estimation based on the annual number of marriages in the United States appeared to be the best basis for this estimate (See Appendix B). The principal reason for this is that now, with the housing shortage much less acute, the large majority of newly married couples are starting their own homes. Most of these new homes will require kitchen equipment. Making conservative estimates on the basis of these assumptions the estimated volume of sales would be:

	Number of Units
For 1950:	
Hand operated machines	18,521
Motor driven machines	4,347
For 1951 and following years:	
Hand operated machines	55,563
Motor driven machines	13,141

Very few products today have as little advertising and sales promotion devoted to them as does the food chopper. It is because of this present market situation that the manufacturers of this combination food cutter unit would be especially wise to initiate an extensive sales campaign. Such a campaign would undoubtedly result in a greatly increased volume of sales. More active sales competition is met from the manufacturers of the hand operated vegetable slicers; however, the most active sales competition is among the manufacturers of the electric food mixers. The competition in this latter case, however, is principally over the mixing feature of the machines and not so much over the attachment features.

DESIGN

DESIGN CONSIDERATIONS

The food cutter unit is designed to do three different operations - meat chopping, vegetable slicing, and ice chipping. The detailed consideration of the requirements for this unit and the subsequent application of knowledge of materials and processes to the development of the machine to satisfy these requirements lead to the final design of the combination food cutter. The following requirements were considered:

1. Improvements in the meat chopping unit so that the meat will be cut and retain its juices rather than be ground and have its juices squeezed out.
2. Easily cleaned.
3. Simple to operate.
4. Small number of parts.
5. A price range of approximately $10 to $12 for the hand operated unit and $20 to $25 for the motor driven unit.
6. Eliminate the need for a clamp-on device so that the unit may be used any place in the kitchen and also so that tables will not be marred.
7. Should not contaminate the food.
8. Should not corrode.
9. Should not leak or drip juices.
10. Should have adequate room provided below the cutter discharge so that a mixing bowl may be used as the receptacle for the food, and the place of discharge

should be over the center of the bowl so that the food will not run over the side.

11. Light in weight.
12. Clean lines.
13. Eliminate heating of the food while being cut.
14. Should occupy a small amount of space.
15. Should not be noisy.

COMPONENTS OF THE MACHINE

The final design consists of eight basic parts - the body, the drive shaft, the crank, the electric motor, the cutter, the hopper attachment for chopping meat, the base plate for the motor driven unit, and the mechanism for attaching the machine to a table or working surface (See Appendix F). Of these eight only six are used on any one machine. On the hand operated machine the crank and table attachment mechanism are included, and on the motor driven unit these two components are replaced by the electric motor and the base plate respectively.

SYNTHESIS OF THE DESIGN

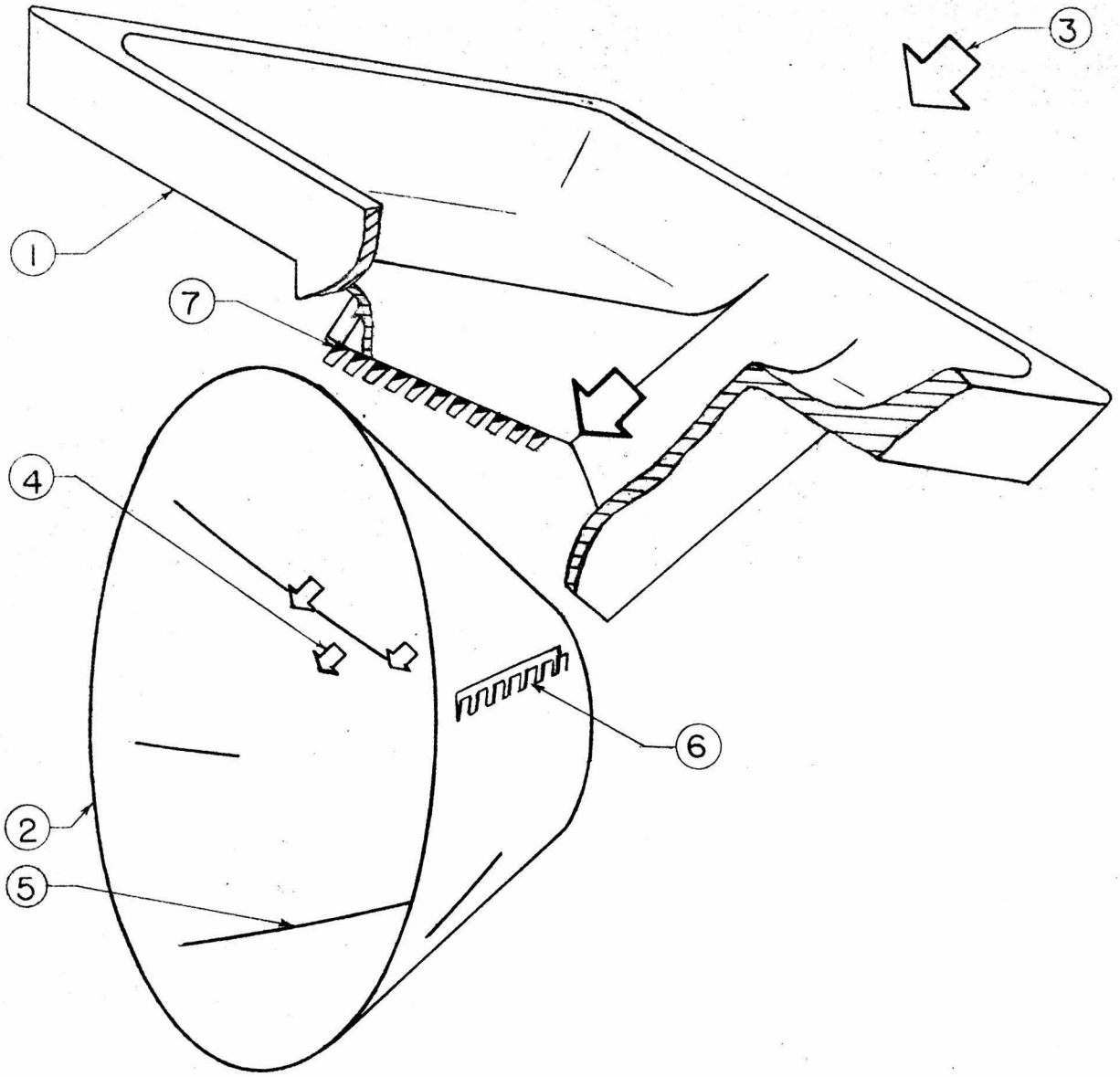
Physiological research revealed that a rotating motion in a vertical plane is the least tiring action for the hand and arm to perform[5,6]. This same action is directly adaptable to a motor, and consequently a rotary power drive is used on the machine. In considering this form of drive in relation to the cutter, the motion could either be transmitted directly to the cutter as a rotating motion, or it could be translated to some form of linear motion. The direction of either type of motion

could be changed from one plane to another by the use of suitable mechanisms. Such mechanisms, however, increase sanitation problems, increase the cost, require more space, and usually increase the weight. For these various reasons, and also because a linear motion in a machine essentially precludes the continuous cutting action that is desired, it was decided that the driving power should be transmitted directly to the cutter in the form of a rotating motion. A cold rolled steel drive shaft is used for this purpose.

Of the various types of blades or cutters that are adapted to a rotating motion, three were found to offer possibilities for use in this machine. These three are the cylindrically shaped cutter, the cone shaped cutter, and the disk shaped cutter. The selection of the particular shape involved two factors - the method of cutting to be employed and the shape of cutter that would be best adapted to the requirements of the hopper. In the case of the disk shape the close proximity of the drive shaft housing would greatly restrict the size of the hopper. Use of the cylindrical shape would not facilitate the changing of cutters in as easy a manner as would the cone shape. Consequently, the cone shape was selected for the cutters. Not only is the changing of blades accomplished more easily in this case, but also the slanting side provided by the cone permits the use of an adequate size hopper.

In order to determine the efficiency of the cone type of cutter, cutting tests were made in which different foods were processed

MEAT HOPPER AND CUTTER



(1) MEAT HOPPER
(2) CUTTER CONE
(3) MEAT
(4) CUT MEAT PARTICLES
(5) BLADE ARRANGEMENT ON CUTTER
(6) TYPICAL CUTTER BLADES
(7) SET OF STATIONARY BLADES
(8) BLADES 6 ROTATE BETWEEN BLADES 7

FIGURE 4. CUTTING ACTION FOR MEAT

through a cone cutter. These tests, which supplemented the knowledge gained from the various surveys, proved that this type of cutter is quite satisfactory for cutting vegetables and other firm foods, but it is not an efficient cutter for chopping meat. Consideration was then given to various possible modifications that might be made on the cutter to make it adaptable for cutting meat. Upon careful analysis of the problem it was conceived that the proper cutting action for meat could possibly be achieved by providing a series of shearing planes or blades at right angles to the shearing plane or blade of the cone cutter. This could be accomplished in the machine by providing evenly spaced gaps in the projecting blades of the cone cutter, and into each of these gaps would project a blade that would be held in a stationary position by its attachment to the body of the machine (See Figure 4). The sharpened edges of these blades would face towards each other, and in operation the meat would be caught between the two sets of blades as the cone rotated and thus the double shearing action provided would produce a nice clean cut. The blades on the surface of the cone would have an angle of rake, as would also the stationary set of blades, to provide the most efficient shearing action. A cutting unit of this description was constructed, and cutting tests were made on meat to determine the efficiency of such a cutter (See Appendix C). This test proved that the method was successful, and therefore it was incorporated into the final design.

An analysis of the conditions to be met in designing the hopper revealed that one hopper would not satisfy the requirements for both meat and vegetables. A large hopper is needed for vegetables, and a smaller hopper is needed for meat. The smaller size hopper is needed for meat in order to allow the cutter to come into contact only with that portion of the meat which is to be cut at the particular moment. This results in much less frictional contact of the meat with the rotating cutter, and this prevents the tendency of jamming that is generally encountered when large portions of meat are forced against the cutter. It also reduces the frictional heating of the meat to a minimum.

To solve the problem of two different size hoppers it was decided to design the basic hopper as a large unit integral with the body of the machine, and a separate unit with a restricted size hopper was designed to be inserted into the larger hopper. This separate unit was designed not only to serve as a hopper but also to serve as the carrier for the stationary set of blades discussed above. These blades are made as a unit, and this unit has a dovetail groove which permits the unit to slide onto the dovetail provided on the side wall of the meat hopper opening so that the blades are held in a position immediately adjacent to the hopper. This hopper has a dished or concave surface around the opening to the cutter, and this surface serves to hold the meat until it is pushed into the hopper opening and chopped.

The shape of the larger hopper has to satisfy three main requirements. These are that it be large enough to permit access of

the food to the cutter, that it permit insertion of the meat hopper unit, and that the insertion of the hopper unit be at such an angle that the attached blades would be inserted in a direction perpendicular to the top surface of the cutter. The wedge shape shown in the drawings was determined to be best adapted to meet these requirements.

Two wooden stuffers were designed for use with the two different size hoppers. The shape of each of these stuffers is adapted to the respective hopper with which it is used.

The internal shapes for the drive shaft housing, the cutter housing, and the hopper were determined strictly by the functional requirements in each case. The external shapes for these same elements were not so critical, but to lessen the sanitation problem and to facilitate production, it was found advisable for the external shapes to conform fairly closely to that of the internal shapes.

The length of the drive shaft housing was determined by the requirement that sufficient space be provided under the machine so that a bowl can be placed under it to catch all the cut food. The shape of the back end of this housing had to be adapted for use either with the crank or with the motor. A short cylindrical projection of the housing was found to be best suited to the needs of both forms of drive. The motor housing is provided with a hole that fits the cylindrical projection as a tight fit. The end of the drive shaft projects into the housing through

this hole, and it is attached to a gear on the inside. This gear is one in the train of reduction gears that are connected to the motor. When the crank is used with the machine, a ferrule is forced onto the cylindrical projection, and the ferrule serves as a bearing surface for the rotating crank. The crank is held in place on the drive shaft by means of a tapered steel pin.

The principal requirements of the pedestal are that it provide a rigid support for the machine and that it allow space below the machine for the bowl. To give this support the pedestal should, for the sake of appearance and also to lighten the weight, have some form of hollow section rather than a massive solid structure. A pedestal having a channel cross section is used as it provides a hollow section that can easily be produced and can, by the use of a simple insertable plate, be completely enclosed. This is a desirable feature inasmuch as it will prevent the accumulation of dirt within the channel section and will also give a cleaner appearance to the machine.

The bottom of the pedestal had to be designed in such a way that it could be adapted for use either with a clamp-on device or with a base plate. This is accomplished by providing a broad base at the bottom of the pedestal and attaching the clamp-on device immediately below this. When the base plate is used, the clamp-on device is eliminated, and the plate is attached directly to the broad base of the pedestal.

In regard to the method of holding the hand operated machine, various means of eliminating the clamp-on device were considered; however, it was discovered that none of the substitutes really replace the device in overall efficiency, and consequently it was retained.

The size and shape of the base plate was designed to afford a stable support for the machine but to occupy a minimum of table space. A dovetail slot is provided in this base plate to facilitate assembly of the unit. The slot is open at the back end and closed at the front end. The pedestal base and the bottom of the motor housing are made with the male dovetail that fits into this slot. This facilitates assembly of the motor driven unit.

Four different cutting cones have been designed for this machine - one for cutting meat, one for slicing vegetables, one for grating, and one for chipping ice. The cutting edges are on the cone surface, and they are stamped out of the metal. These cutters have a square hole at the center which fits over the square end provided on the drive shaft. A thumb screw that screws into the drive shaft holds the cutter in place on the shaft.

A neoprene pad is provided on the hand operated machine to prevent marring of a surface by the attachment of the machine to it. This pad is bonded to the under side of the pedestal base.

MATERIALS AND PROCESSES

Refer to Appendix F for drawings of the machine.

Analyzing the various components of the machine to determine suitable materials and the best methods for manufacturing the different parts led to the conclusion that the main body of the machine could be made in one part by casting it. This main body includes the cutter housing, the hopper, the drive shaft housing, the pedestal, and the frame for the clamp-on device at the base of the pedestal. Since light weight and corrosion resistance in materials are essential features, an aluminum alloy was selected as the basic material to be used. This is Alcoa Number 81 which is an inexpensive general purpose alloy suitable for electroplating with chromium[7]. All three types of castings - sand castings, permanent mold castings, or die castings - could be used for producing this main body casting; however, die casting was found to be best adapted to meet all the requirements. It is predominately a high production method, and it insures uniform castings which have close tolerances with a good surface finish. Also the part of the die for the clamp-on device frame can be blocked off to provide the flat broad base on the pedestal which makes it possible to attach it to the base plate for the motor driven unit.

The meat hopper, the motor housing, the crank arm, and the base plate are also die cast of aluminum alloy Alcoa Number 81 for the same reasons, and the set of blades that attaches to the meat hopper has its blades as inserts in an aluminum die

cast unit. The thumb screw for holding the cutters on the drive shaft is made of die cast aluminum with a steel screw insert.

The cutters are made of S.A.E. 1045 steel. They are blanked out, drawn to the cone shape, and then the cutting edges are stamped out of this cone. The cutters are then heat treated to a Rockwell C 24 hardness. The blades in the stationary unit are stamped from the same steel, then heat treated, and the edges are sharpened on the side that has an angle of rake.

The drive shaft for the cutters is made of cold rolled S.A.E. 1020 steel, and it is produced on an automatic screw machine.

The two bronze bushings that are used in the drive shaft housing to act as bearing surfaces for the drive shaft are powdered metal bearings. These are oil impregnated.

The complete motor unit with a governor and a capacitor are standard units and are purchased from a manufacturer of electric motors. This unit is fitted into the die cast motor housing made for this machine.

The two steel spur gears, the bronze worm wheel, and the steel worm used in the reduction gear train are standard parts and can be cut or purchased from a gear manufacturer.

The plate that is inserted in the back of the pedestal is made of cold rolled S.A.E. 1020 steel and is a stamped piece.

The thumb screw for the clamp-on device is made of steel screw stock. It is a standard item that is purchased.

The 3/8 inch pin with a 1/4 inch turned end for attaching the handle to the crank arm is made of S.A.E. 1020 steel and is produced on an automatic screw machine.

The ferrule that is used on the back end of the drive shaft housing is made of S.A.E. 1020 steel and is produced on a screw machine.

A neoprene pad is used as the protective pad under the pedestal base because it provides a good cushion to prevent marring of the table and in addition it has excellent abrasion resistance and also excellent resistance to water and oils. An adhesive with a neoprene base is used to bond this pad to the metal. This forms a very good bond.

Urea formaldehyde plastic is used for the handle and motor control knob as it has excellent molding qualities, high strength, and unlimited color possibilities. Also it has a hard surface; it is odorless, tasteless, and resistant to organic solvents, and the molded section is rigid and extremely light in weight.

Machine Assembly - Before assembling the machine a few machining operations have to be performed on some of the parts, and then a finish must be applied to most of the parts. The finish used on these parts is discussed in the next section (entitled "The Finish") and therefore will not be discussed in further detail here.

The lower projecting end of the clamp-on device frame must be drilled and tapped for the 3/8 inch, 16 thread per inch thumb screw. The thumb screw in screwed in, and the washer is headed in place on the upper end of this screw.

The cored hole for the drive shaft housing is reamed, and the bronze bushings are forced into place at the two ends of this housing. The drive shaft is inserted into its housing, and then the steel ferrule is placed on the back of the housing. The crank is fitted to the shaft and fixed in place by means of the tapered pin (The hole for this pin has previously been located and drilled in the crank arm and the drive shaft). Before attaching the crank arm to the drive shaft, the plastic handle is attached to the crank arm. This is done by placing the 3/8 inch steel pin through the handle and pressing the 1/4 inch end of the pin into the hole provided in the crank arm. This end of the pin is then headed in place in the crank arm.

The neoprene pad is bonded to the under side of the pedestal with the neoprene adhesive.

The plate for the back of the pedestal is a pressed fit.

The cutter thumb screw is screwed into place in the drive shaft, and this completes the assembly of the hand operated unit. For shipping purposes it would be better to attach the crank arm to the drive shaft at the point of sale. This would save shipping space and would be quite practical since the operation is quite simple and would involve no special tools.

The main die cast body of the machine (except for the clamp-on device frame) is also used with the motor driven unit. The same machining operations are performed on the drive shaft housing, and the same bronze bushings are used in it.

The base plate is attached to the cutter unit and the motor housing by means of the dovetails provided on these components. In assembling the unit the pedestal base of the cutter body is placed in the dovetail slot and moved forward to the other end. It is locked in this position by means of a machine screw that is screwed in from the bottom of the base plate. Next, the motor housing is placed into the dovetail slot and pushed forward as far as it will go. At this point it butts up against the pedestal. This motor housing is also held in place by means of a screw inserted from the bottom of the base plate. The holes in the base plate for the machine screws are provided in the die casting. The tapped holes in the pedestal base and the bottom of the motor housing are drilled and tapped previous to the assembly of the unit.

The motor unit, which is mounted in a vertical position, is assembled in its cylindrical housing with the gear train at the top end, the motor in the center, and the speed control governor at the lower end. For the purpose of assembly the upper end of the housing is provided with a hole which permits the insertion of the cutter drive shaft to the gear train and also provides a means of attaching the motor housing to the back end of the drive shaft housing. The drive shaft projects through

the hole and is inserted into position at the time the motor unit is attached to the machine. The spur gear is fitted over it at this time. This gear is locked in place on this shaft by meams of a steel pin that is driven into place after the motor housing has been secured to the machine as described above.

The neoprene pad is not used on the motor driven unit on the pedestal base; however, neoprene feet are provided on the base plate to serve the same purpose. These are placed in holes which are provided in the die cast base plate. The other parts of the machine are the same as those for the hand operated machine.

The two wooden food stuffers are the same for both machines. These are formed from maple.

THE FINISH

The application of three different surface coatings to various parts of this machine is recommended. These three are baked white enamel and chromium plating and anodizing. The baked white enamel is used on all external parts of the body, the main body of the motor housing, the base plate, and the clamp-on device frame. The crank arm, the gear cover plate on the motor housing, the steel ferrule for the back end of the drive shaft housing, the thumb screw for the clamp-on device, the cutter thumb screw, and the cutters are chromium plated.

The interior parts of the hopper and the cutter housing are water anodized to prevent contact of the food with the aluminum. This is not absolutely essential, but it is desirable as it prevents any slight discoloration of the food that might result from contact of the food with the uncoated aluminum. The handle and the control knob for the speed control governor are molded of a red plastic.

The color combination of white with chromium trim has wide consumer appeal. The consumer questionaire revealed that this color combination for food machines is the choice that is most popular with consumers. The red color on the speed control knob adds the bright color that is needed for contrast. It also aids in attracting a customer's attention to the machine.

ENGINEERING

See Appendix C for engineering data and calculations and for the description of the test that was made to determine the cutting efficiency of the cutting action that is incorporated into this machine.

A 1/10 horsepower, 115 volt, series wound electric motor is used with the motor driven cutter unit. This motor has a speed of 10,000 r.p.m. It is provided with a thrust bearing, a small fan blade for cooling, and it has a centrifugal speed control governor to regulate the speed within the desired range. A capacitor is added to cut down arcing at the gover-

nor contacts. This size and type of motor is used on most electric home food mixers for performing the same cutting operations, and manufacturers of electric motors recommend this motor as being best for this purpose. It provides high torque. It is compact in size, and the low speed range desired is easily obtained through a simple reduction gear train. The adjustment of speeds within this range is accomplished through the use of the speed control mechanism. The motor housing is designed to house the motor, the speed reduction gears, and the speed control mechanism. It is mounted on the machine in a vertical position to form a more compact unit.

Stress analyses are made at critical points on the pedestal of the machine and on the crank.

EVALUATION OF THE DESIGN

In this thesis a combination food cutting machine has been developed which provides higher cutting efficiency, a greater versatility of kitchen operations with fewer parts, and a simplified method of adapting the machine for either hand operation or motor driven operation.

Throughout the development of the design careful consideration was given to the methods and materials which could advantageously be used in the production of a marketable product of this type. For any specific manufacturer some changes would be necessary in adapting the cutting unit to his particular facilities; however, the design as set forth in this thesis would serve as a basic point of departure for the manufacturer.

The manufacture and subsequent marketing of this cutter unit would determine several factors that can not be definitely established in the earlier design phase of the product's development. For example, the machine finish that would result in the largest number of sales could only be definitely determined by testing the market. The result of such tests might prove that a larger market exists for the natural aluminum finish model than for the white and chromium finish model, or it might show that there is a definite market for both models. It is only through marketing tests of this nature and

through adapting the production methods to the facilities available that the ultimate production model or models would be determined and consequently the actual production and selling costs established. With such knowledge, along with the adaptation of the product to a specific production line, it would undoubtedly be possible to reduce the manufacturing cost of the cutters units below the cost estimates that have been made in this thesis (See Appendix D).

APPENDIX A

QUESTIONNAIRE - FOOD CHOPPER

1. What different makes of food choppers have you used?

   _____ _____ _____ _____ _____

2. What make of food chopper do you now use? _____

3. What was the cost of your present food chopper? $_____

4. Defects in present food chopper:

   _____ Are you satisfied with its performance?
   _____ Does it chop food properly?
   _____ Is it too difficult to operate?
   _____ Is it too heavy?
   _____ Is it too difficult a job to clamp it to a table?
   _____ Is the clamping device on your food chopper adaptable enough for your kitchen use?
   _____ Is there much danger that one might catch his fingers in the chopper while feeding food into the hopper?
   _____ Would you desire an automatic feeding device to eliminate this danger?
   _____ What is the principal thing you use the food chopper for?

   Do you have any further comments on any question in this group? _____

   _____

   _____

   _____

5. Do you have mechanical equipment that does one or all of the kitchen operations listed below?

   _____ Grates, slices, or shreds food?
   _____ Chips ice?
   _____ Forms various shapes for Danish pastry?

6. New type of combination food chopper (adaptable either to hand operation or motor drive):

   _____ Would you like to have one combination piece of kitchen equipment that would perform the operations listed in question 5?
   _____ Would you be willing to pay $10 for this piece of equipment? (Hand operated)

_____ Do you think this same equipment - motor driven- would be purchased by restaurants and larger homes if it could be made to sell for about $20?
Do you have any further comments on any questions in this group? _____

_____

_____

_____

7. Design of food chopper:
Color preference:

_____ White? _____ White and chromium?
_____ Pastel? _____ Natural Metal Color?
_____ Other?

Do you have any comments pertaining to color or design of a food chopper? _____

_____

_____

_____

8. General comments: Please add any additional comments regarding food choppers and also mention, if you will, what features you would like to see incorporated in a food chopper to make it more adaptable to your use - both aesthetically and functionally. (Please use the back of this sheet if more space is required.)

RESULTS FROM QUESTIONNAIRE

1. Various makes that have been used (hand operated type):

Universal	Sears Roebuck
Keystone	Ideal
Griswold	Sensible
Russwin	Best Made

2. Makes now being used and number of users for each:

Universal	14
Griswold	1
Sears Roebuck	1
Keystone	1

3. Cost of present food choppers (hand operated type):

$3.50 to $5.00

4. Percentage of likes and dislikes about present features:

	%Yes	%No
Satisfied with its performance	33	67
Chops food properly	53	47
Too difficult to operate	13	87

	%Yes	%No
Too heavy	27	73
Clamping to a table too difficult	60	40
Clamping to a table adaptable enough	40	60
Danger of catching fingers	33	67
Desire an automatic feeding device	31	69

Principal foods that are used in food choppers are:

Meat	Cheese
Bread	Nuts
Vegetables	Dried Fruits

5. Percentages that have equipment that does the following:

	%Yes	%No
Grates, slices, or shreds food	67	33
Chips ice	64	36
Forms various Danish pastry shapes	9	91

6. Percentages that would like new type combination food cutter:

	%Yes	%No
Desire new model	95	5
Would pay $10 for it	52	48
Think restaurants would pay $20 for it	87	13

7. Design of food chopper - color preference:

	% Favoring
White and chromium	37
Natural Metal	30
White	22
Chromium	7
Stainless steel	4

The above consumer questionnaire form was mailed to the heads of the home economics departments of fifty-nine colleges, universities, and cooking schools throughout the United States. Of these fifty-nine sent out, twenty-eight were returned; and of these twenty-eight, twenty-three were suitable for use - although only sixteen of these had every question answered completely. The five that were returned unanswered were ones that had been addressed to cooking schools that had closed.

Personal letters received from various large meat packers, from the American Meat Institute, from many manufacturers in the food

machinery business, and from large chain retail stores contained valuable information as to what they had found the consumer requirements to be.

A portion of two of the letters mentioned in the previous paragraph are worthy of notation here. The first of these letters was from the Director of the Consumer Service Department of Armour and Company of Chicago. It stated: "that it is highly important to have a food chopper that has a sharp enough cutter to actually cut meats rather than squeeze all the juice out of them as they are ground." The second letter was from the Housewares Buyer of Sears, Roebuck and Company of Chicago. It stated: "The need of a meat chopper is for one that will do a good cutting job and will not lose the juices of the meat as it is ground out. This of course will not give you meat coming out of the chopper that looks as nice as it does in present advertisements; however, there will be more quality contained in the meat than at the present." From these and other letters and from other surveys it was determined that the inefficiency in cutting was the biggest fault in the food chopper.

APPENDIX B

VOLUME OF SALES ESTIMATE

This estimate is based on marriage statistics for the years 1945 and 1946[8]:

Number of marriages in 1945	1,718,224
Number of marriages in 1946	2,347,233

Due to the war the 1945 figure should be below average, and the 1946 figure should be above average. For this reason the average of these two figures is used here in the estimate of the number of marriages for 1950:

Number of marriages for 1950	2,032,729

Of this number of marriages it is estimated that 75% will move into their own homes:

Number moving into own homes	1,524,547

Of this 75% that move into new homes it is estimated that 75% will buy food choppers:

Number of food choppers that will be bought as a result of marriages	1,143,410

Of this number a conservative estimate for the sales volume of a new product for the first year will be 1%. On the basis of 1%:

Number of new combination food cutters that the manufacturer may expect to sell to newly married couples	11,434

Of the 11,434 that are purchased for or by newly married couples the larger percentage will be the hand operated type. It is estimated that 95% will be of the hand operated type and 5% will be of the motor driven type. The annual sales figures then according to the two types will be:

Number of hand operated machines	10,860
Motor driven machines	574

Replacement sales to housewives (as learned from several retail stores and large retail chains) are high in volume. These sales, combined with sales to small restaurants, should equal the volume of sales to newly married couples:

Replacement sales and sales to restaurants	11,434

Of these sales it is estimated that 67% will be hand operated units, bought in the largest volume by housewives. The remaining 33% will be motor driven units, purchased largely by restaurants. These figures are:

Hand operated machines	7,661
Motor driven machines	3,773

The total volume of sales for the first year for each type will be:

Hand operated machines	18,521
Motor driven machines	4,347

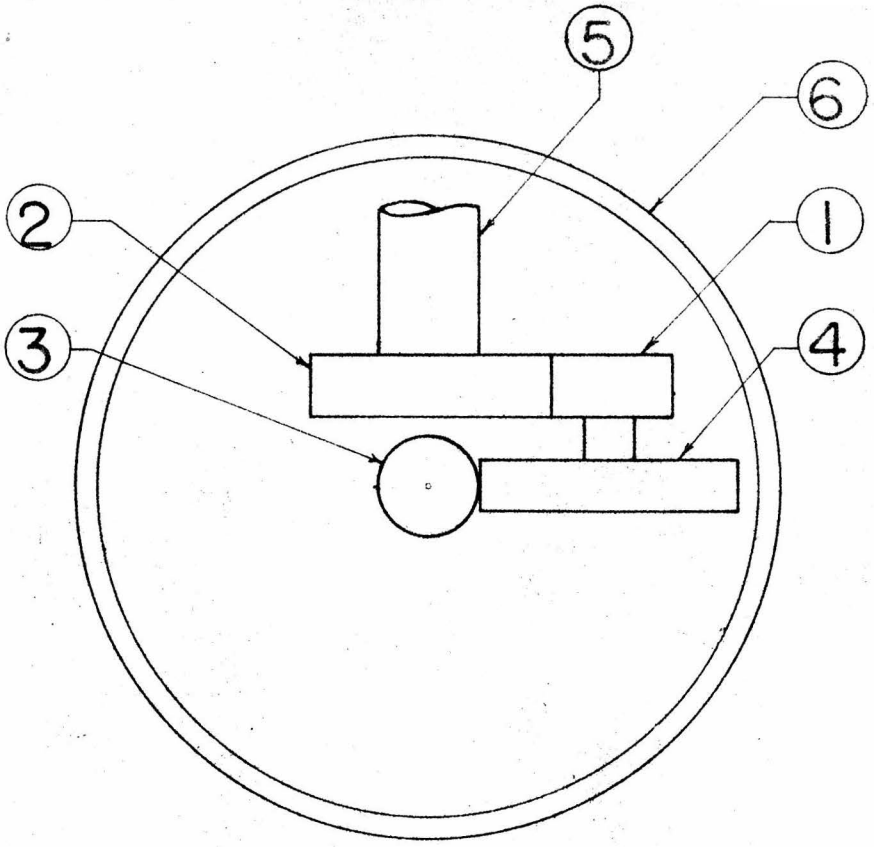
With extensive advertising combined with active sales promotion the volume of sales should increase from 1% to 3% after the first year. The total annual sales after the first year then would be:

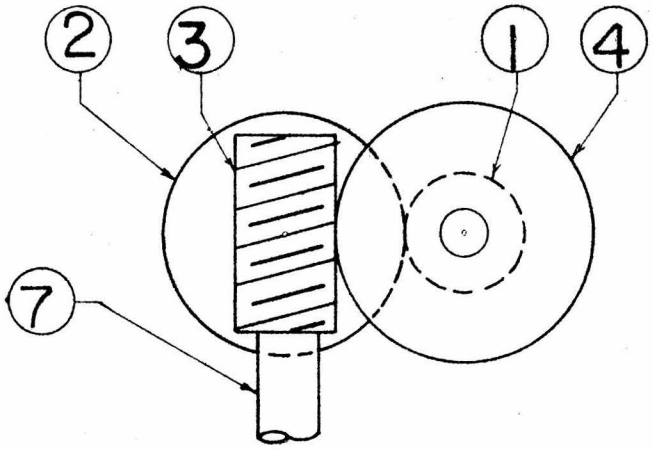
Hand operated machines	55,563
Motor driven machines	13,141

APPENDIX C

ENGINEERING DATA

Test of New Type Cutter - A model of the meat cutting unit was constructed in the Industrial Design Workshop to test the cutting action that is incorporated into this machine. The basic parts of this model consisted of two stationary blades placed close together in parallel planes, a rotating blade that passed between the two stationary blades, and a crank mechanism that provided the means of rotation for the blade. Knife edges were used for the two stationary blades and sharpened flat spring steel was used for the rotating blade (as it had to be shaped to go between the other blades). In testing the cutter a large piece of meat was held in a position in front of the stationary blades, and the other blade was rotated between these blades. The combined shearing action of the rotating blade cutting at right angles to the other blades produced nice clean cut particles of meat. The angle of rake that was provided on each of the blades added to the efficiency of this cutting action. The cutting action on the machine would consist of a series of similar moving blades (on the cutter cone) rotating between a series of stationary blades (on the set in the die cast unit).





1 SPUR GEAR

2 SPUR GEAR

3 WORM GEAR

4 WORM WHEEL

5 DRIVE SHAFT OF CUTTER

6 MOTOR HOUSING

7 MOTOR SHAFT

FIGURE 5. DIAGRAM OF GEAR TRAIN

Gear Reduction Mechanism - Refer to Figure 5 for the diagram of the gear train.

A 10,000 r.p.m. electric motor is used on this machine. It is necessary to reduce this speed to the low speed range of 50 to 250 r.p.m.

Mounting of the motor in a vertical position with its shaft at right angles to the cutter drive shaft facilitates the use of a worm gear for the initial large speed reduction. The worm (3), which is attached to the motor shaft (7), drives the worm wheel (4), which has 20 teeth. Since the worm is a single thread, the speed reduction is:

$$\text{Reduction} = \frac{\text{No. of teeth on worm wheel}}{\text{No. of threads on worm}}$$

$$= \frac{20}{1}$$

$$= 20$$

Therefore the turning speed of the worm wheel is:

$$\text{Worm Speed} = \frac{10000}{20}$$

$$= 500 \text{ r.p.m.}$$

To reduce the speed to the desired maximum of 250 r.p.m. the worm wheel (4) is connected directly to a spur gear (1) which drives another spur gear (2). This second spur gear (2) has a pitch diameter twice that of the first spur gear (1). Therefore the speed reduction is:

$$\text{Reduction} = \frac{\text{Pitch diameter of large spur gear}}{\text{Pitch diameter of small spur gear}}$$

$$= \frac{10/8}{5/8}$$

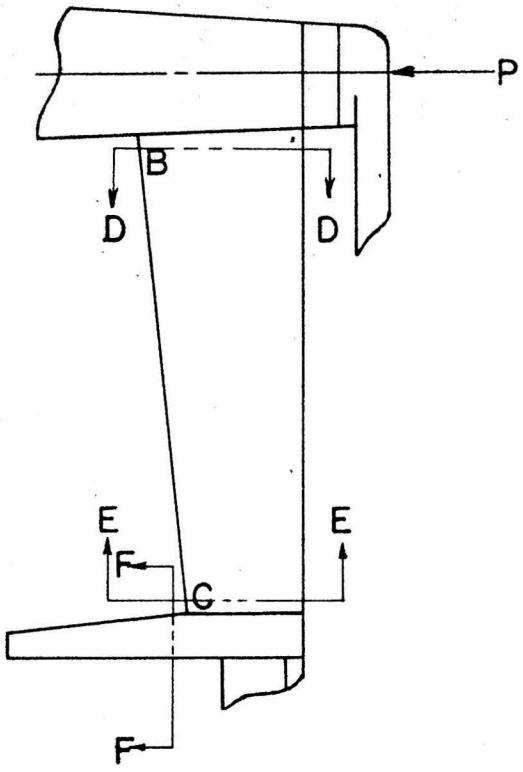
$$= 2$$

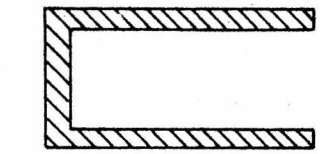
Therefore the maximum turning speed of the large spur gear (2) and the cutter drive shaft (5) attached to it is:

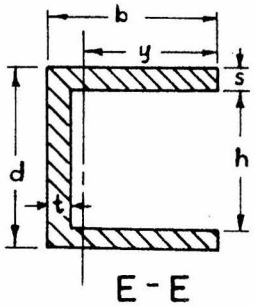
$$\text{Shaft Speed} = \frac{500}{2}$$

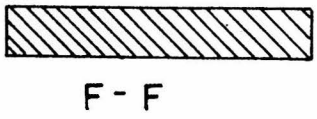
$$= 250 \text{ r.p.m.}$$

The lower range of speeds down to 50 r.p.m. is obtained through the use of the centrifugal speed regulating governor on the motor.



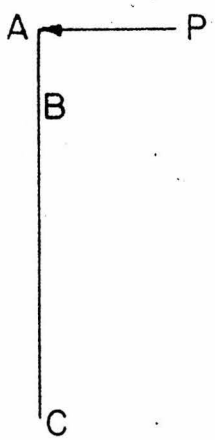






PEDESTAL SECTION OF MACHINE ANALYZED TO DETERMINE THAT SECTION AT CRITICAL POINT IS ADEQUATE FOR ALLOWABLE WORKING STRESS

b = 1.5"
d = 1.5"
h = 1.25"
s = 0.13"
t = 0.13"
y = ?



$M_b = P \times AC$

AC = 6.5"

DIAGRAM OF ABOVE SECTION

FIGURE 6. BODY DIAGRAM FOR STRESS ANALYSIS

Pedestal Stress Analysis at Critical Point

A maximum force would be exerted on the machine by a force P acting on it as indicated (See Figure 6).

Critical Point and Section:

The moment of forces (P x AC) is greater at C than at B. Also the cross sectional area (D-D) at B is greater than at C. Therefore the critical moment of binding would be at C. The cross sectional area (E-E) at C is less than the cross sectional area (F-F) at C. Therefore the moment of bending is calculated for the section (E-E).

Moment of bending at point C:

Let A = area of section

$$M_b = \frac{SI}{y}$$

where

S = permissible working stress in lbs./sq.in = 33000 lbs./sq.in.

I = moment of inertia

y = distance from neutral axis to extreme fibre

$$A = bd - h(b-t)$$

$$= 1.5 \times 1.5 - 1.25 (1.5 - 0.13)$$

$$= 0.54 \text{ sq. in.}$$

$$y = b - \frac{2b^2 s + ht^2}{2bd - 2h(b-t)}$$

$$= 1.5 - \frac{2 \times 2.25 \times 0.13 + 1.25 \times 0.02}{2 \times 1.5 \times 1.5 - 2 \times 1.25(1.5 - 0.13)}$$

$$= 1.36 \text{ inches}$$

$$I = \frac{2sb^3 + ht^3}{3} - A(b - y)^2$$

$$= \frac{2 \times 0.13 \times (1.5)^3 + 1.25 \times (0.13)^3}{3} - 0.54(1.5 - 1.36)^2$$

$$= 0.30 \text{ inches}^4$$

$$M_b = \frac{SI}{y}$$

$$= \frac{33000 \times 0.3}{1.36}$$

$$= 7300 \text{ inch pounds}$$

As stated above:

$$M_b = P \times AC$$

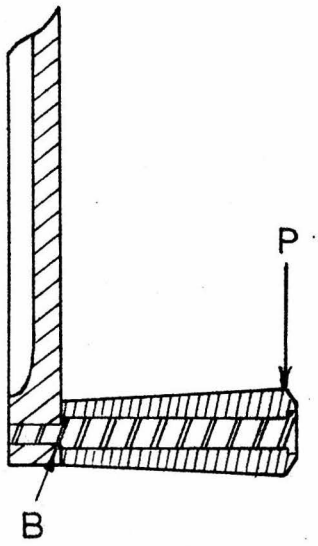
or $$P = \frac{M_b}{AC}$$

Substituting:

$$P = \frac{7300}{6.5}$$

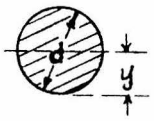
$$= 1120 \text{ pounds}$$

A force P of over 1120 pounds will be required to cause failure in the machine at the critical point C. This force is greatly in excess of any force that would be exerted on the machine in normal usage.



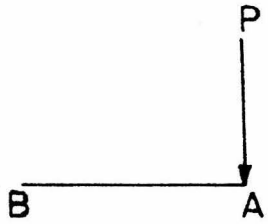
CRANK SECTION OF MACHINE ANALYZED TO DETERMINE THAT SECTION AT CRITICAL POINT IS ADEQUATE FOR ALLOWABLE WORKING STRESS.

1/4" ROUND STEEL PIN IS USED TO ATTACH HANDLE TO CRANK ARM. B IS THE CRITICAL POINT.



$d = 0.25"$

$y = 0.125$



$M = P \times AB$

$AB = 3"$

DIAGRAM OF ABOVE SECTION

FIGURE 7. HANDLE DIAGRAM FOR STRESS ANALYSIS

Crank Handle Pin Stress Analysis at Critical Point

A maximum force would be exerted on the crank pin by a force P acting on it as indicated. (See Figure 7).

Moment of bending at point B:

Let A = area of section

$$A = \frac{\pi d^2}{4}$$

$$= 0.785 \times (0.25)^2$$

$$= 0.049 \text{ sq. in.}$$

$$y = \frac{d}{2}$$

$$= \frac{0.25}{2}$$

$$= 0.125 \text{ inches}$$

$$I = \frac{\pi d^4}{64}$$

$$= 0.049 \times (0.25)^4$$

$$= 0.0038 \text{ inches}^4$$

S = permissible working stress = 47000 lbs./sq. in.

$$M_b = \frac{SI}{y}$$

$$= \frac{47000 \times 0.0038}{0.125}$$

$$= 1430 \text{ inch pounds}$$

$$M_b = P \times AB$$

or $$P = \frac{M_b}{AB}$$

Substituting:

$$P = \frac{1430}{3}$$

$$= 480 \text{ pounds}$$

A force P of over 480 pounds will be required to cause failure of the steel pin at the critical point B. This force is great-

ly in excess of any force that would be exerted on the machine in normal usage.

PATENTS

2,422,340	Food Chopper, Vertically reciprocating and intermittently rotating
2,399,153	Vertical Food Chopper
2,410,709	Food Chopper
2,333,669	Meat Grinder
2,288,473	Chopper and Slicer
2,293,872	Food Chopper Attachment
2,275,516	Meat Chopper
2,198,482	Chopper and Slicer
2,200,035	Food Chopper
2,216,936	Hand Operated Food Chopper
2,181,780	Food Chopper
2,183,114	Meat Chopper
2,106,626	Food Chopper
2,113,085	Food Chopper
2,138,203	Food Chopper

APPENDIX D

COST ESTIMATE

Hand Operated Unit:

Materials

Die Castings	Wt.		Cost
Hopper	0.28 lbs.		
Cutter housing	.26		
Drive shaft housing	.22		
Pedestal	.26		
Pedestal base and clamp frame	.36		
Meat hopper	.32		
Crank arm	.23		
Blade set and cutter thumb screw	.07		
Total =	2.00	@ $0.22/lb.	$0.44
Steel Stampings			
4 Cutters, set of blades, and pedestal cover plate	1.31	@ $0.07/lb.	$0.09
Screw Machine Products			
Drive shaft, handle pin, ferrule, and steel screw insert	0.54	@ $0.07/lb.	$0.04
Total Materials Cost (for own plant mfgd. products) =			$0.57

Mfg. Cost (for own plant mfgd. products), less tooling costs = 3 x $0.57 = $1.71

Tooling

Die Casting Dies	Cost
Cutter body	$5000
Meat hopper	1000
Crank arm	900
Cutter thumb screw	100
Set of blades	150
Total =	$7150

Cost per Unit = $7150/ 100000 = $0.07

Stamping Dies	Cost
Cutters and set of blades	$3000
Pedestal cover plate	300
Total	$3300

Cost per Unit = $3300/70000 = $0.05

Purchased Products and Processing	Cost
Clamp-on device thumb screw with washer	$0.15
Front porous bronze bushing	.15
Rear porous bronze bushing	.10
Plastic handle	.15
Neoprene pad	.03
Tapered pin	.01
2 Wooden stuffers	.35
Heat treating for cutters	.07
Chromium plating for cutters	.35
Total =	$1.36 = $1.36

Total Mfg. Cost = $3.19

Mfgr's. Selling Price = $3.19 + 12% x $3.19 = $3.57

Retail Price = 3 x $3.57 = $10.71

Additional charge (retail) for painted cutter unit with chromium trim and anodized interior parts:

Surface Coating	Cost
Anodizing (interior parts in contact with food)	$0.15
Baked white enamel	.20
Chromium plating	.15
Total =	$0.50

Total retail cost of cutter with finish =
3 x ($0.50 + 12% x $0.50) + $10.71 = $12.39

Motor Driven Unit:

Materials

Die Castings	Wt.		Cost
Cutter body	1.20 lbs.		
Meat hopper	.32		
Blade set and cutter thumb screw	.07		
Motor housing with cover plate	1.05		
Motor support bracket	.22		
Base plate	.61		
Total =	3.47	@ $0.22/lb.	$0.76
Steel Stampings			
4 Cutters, set of blades, and speed control arm	1.26	@ $0.07/lb.	$0.09
Screw Machine Products			
Drive shaft, steel screw screw insert, and gear shaft	0.32	@ $0.07/lb.	$0.02
Total Materials Cost (for own plant mfgd. products) =			$0.87

Mfg. Cost (for own plant mfgd. products), less tooling costs = 3 x $0.87 = $2.61

Tooling

Die Casting Dies	Cost
Cutter body	$5000
Meat hopper	1000
Motor housing unit	3000
Base plate	1500
Cutter thumb screw	100
Set of blades	150
Total =	$10750

Cost per Unit = $10750/100000 = $0.11

Stamping Dies	Cost
Cutters and set of blades	$3000
Speed control arm	50
Total =	$3050

Cost per Unit = $3050/70000 = $0.04

Purchased Products and Processing	Cost	
Electric motor	$4.75	
Speed governor	2.50	
Capacitor	.60	
2 Spur gears	.35	
2 Worm gears	.57	
Speed control knob	.03	
2 Porous bronze bushings	.10	
Electric wire	.05	
Neoprene feet	.08	
Machine screws	.03	
2 Wooden stuffers	.35	
Heat treating for cutters	.07	
Chromium plating for cutters	.35	
Total	= $9.83	= $9.83

Total Mfg. Cost =$12.59

Mfgr's. Selling Price $12.59 + 10% x $12.59 =$13.85

Retail Price = 2.5 x $13.85 =$34.63

Additional charge (retail) for painted cutter unit with chromium trim and anodized interior parts:

Surface Coating	Cost
Anodizing (interior parts in contact with food)	$0.15
Baked white enamel	.29
Chromium plating	.08
Total	= $0.52

Total retail cost of cutter with finish =
3 x ($0.52 + 12% x $0.52) + $34.63 =$36.34

APPENDIX E

REFERENCES

1. Max O'Rell Cullen, How To Carve Meat, Game, and Poultry, McGraw-Hill Book Co., New York, 1941.
2. Federal Standard Stock Catalog, 00-M-52, Section IV (Part 5), "Federal Specification for Machines, Meat - and Vegetable - Cutting, Electrically Operated", Superintendent of Documents, Feb., 1940.
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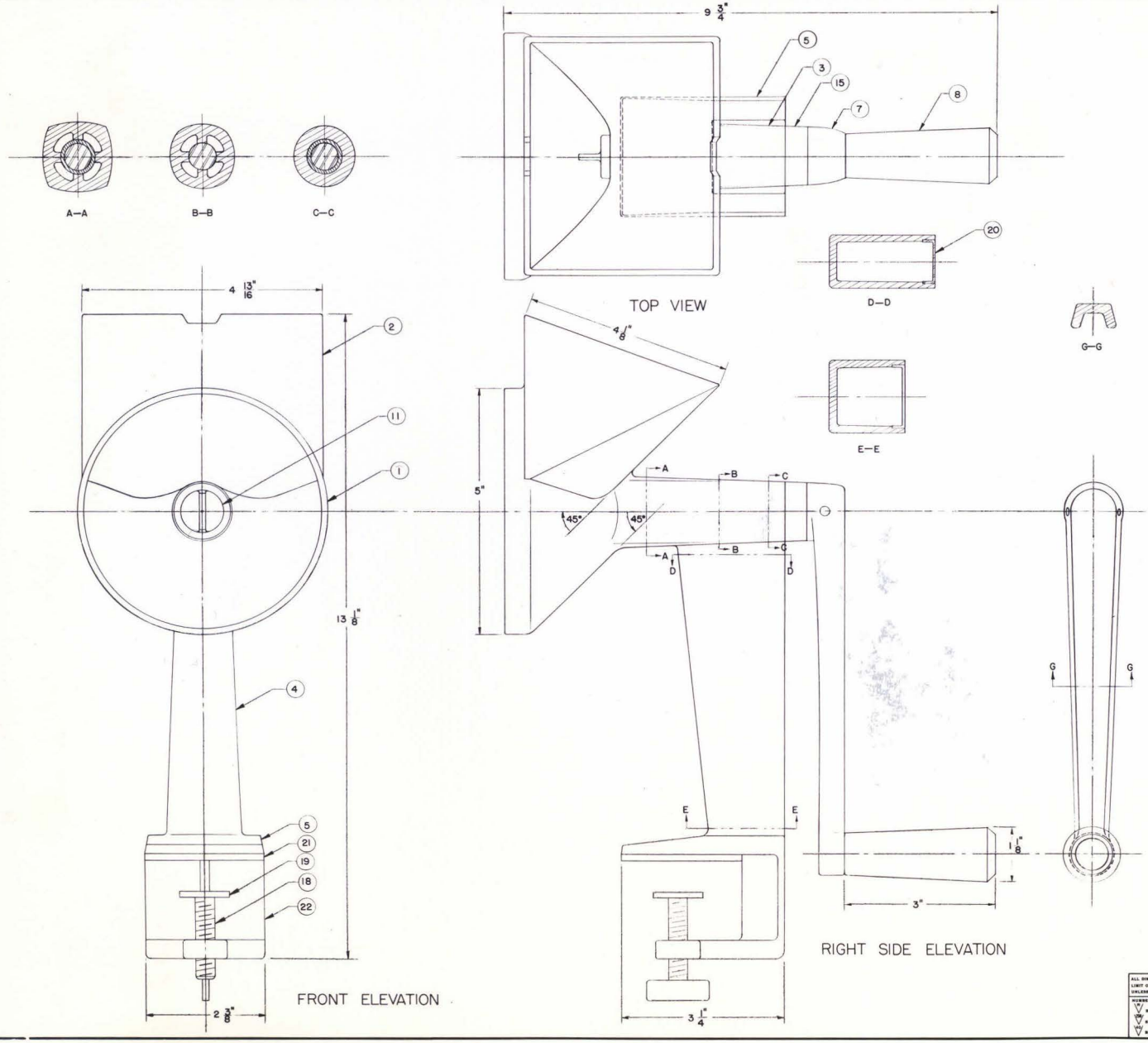
4. Redbook Magazine Market Reports, "The Household Market for Electric Food Mixers", Meredith Publishing Co., Des Moines, Iowa, Sept., 1948. p.1.
5. Wilbur Barden Bowen, Applied Anatomy and Kinesiology, New York, 1923, p. 326.
6. M. Gladys Scott, Analysis of Human Motion, University of Iowa Press, 1946, p. 89.
7. Materials and Methods, "Electroplating on Aluminum", Reinhold Publishing Company, October, 1948, p. 84.
8. United States Department of Commerce, Statistical Abstract of the United States, Washington, D.C., U.S. Government Printing Office, 1948.

APPENDIX F

DRAWINGS



PART	NAME OF PART
22	CLAMP-ON DEVICE FRAME
21	RUBBER PAD
20	PEDESTAL COVER PLATE
19	WASHER
18	CLAMP-ON DEVICE THUMB SCREW
15	FERRULE
11	CUTTER THUMB SCREW
8	HANDLE
7	CRANK ARM
5	PEDESTAL BASE
4	PEDESTAL
3	DRIVE SHAFT HOUSING
2	HOPPER
1	CUTTER HOUSING

ALL DIMENSIONS IN INCHES
LIMIT ON DIMENSIONS ——— UNLESS OTHERWISE NOTED
ANGULAR ± ½°
FRACTIONAL ± 1/64
DECIMAL ± .010
NUMBERS ARE SURFACE ROUGHNESS IN MICRONCHES
ROUGH MACHINE FINISH
SMOOTH MACHINE FINISH
ROUGH GRIND
FINISH GRIND
FINE GRIND, LAP
POLISH

FINISH
HEAT TREAT

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HAND OPERATED UNIT

DRAWN BY
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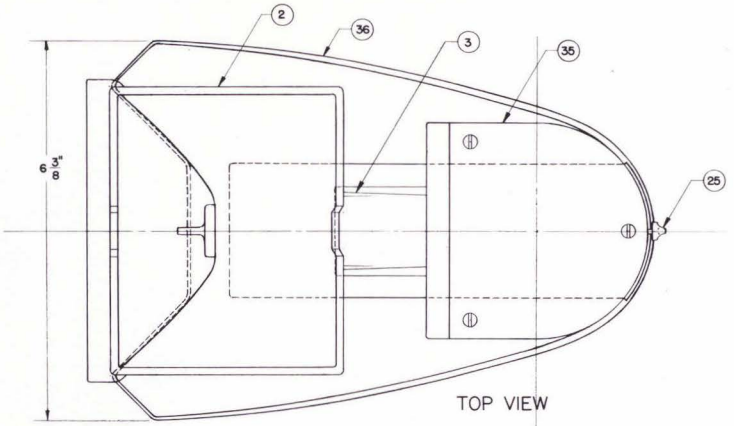
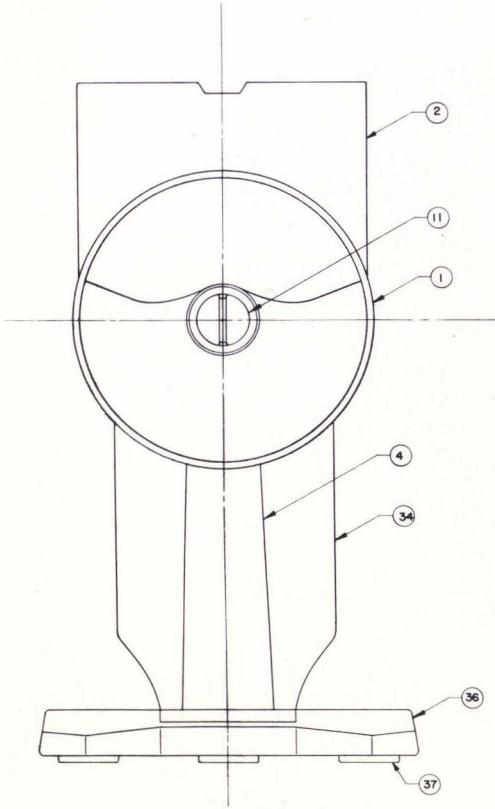
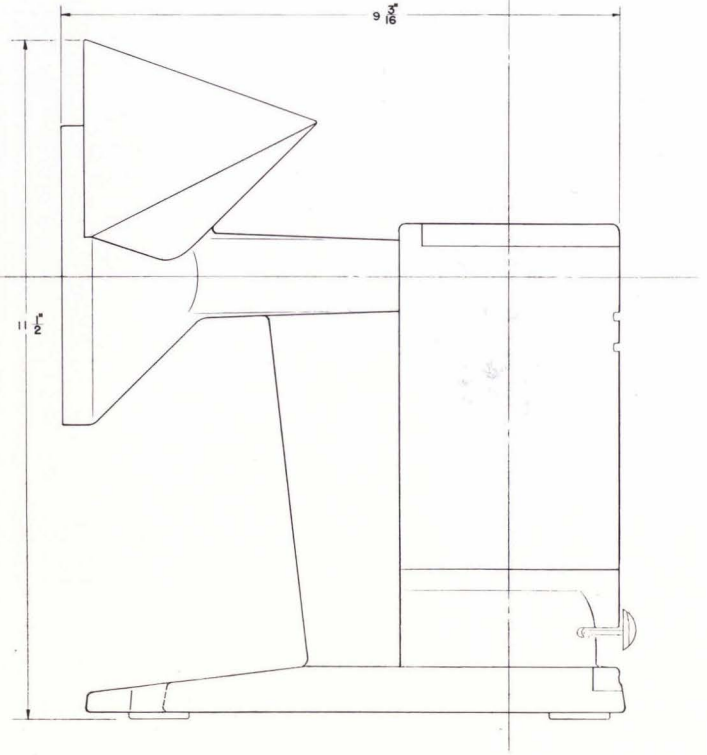
CHECKED BY
APPROVED BY
DATE
SCALE
COURSE NO.
SECTION NO.
DWG. NO. 1



TOP VIEW



FRONT ELEVATION



RIGHT SIDE ELEVATION

PART	NAME OF PART
37	RUBBER FEET
36	BASE PLATE
35	GEAR HOUSING COVER PLATE
34	MOTOR UNIT HOUSING
25	SPEED CONTROL KNOB
11	CUTTER THUMB SCREW
4	PEDESTAL
3	DRIVE SHAFT HOUSING
2	HOPPER
1	CUTTER HOUSING

ALL DIMENSIONS IN INCHES
LIMIT ON DIMENSIONS — UNLESS OTHERWISE NOTED
ANGULAR ± ½°
FRACTIONAL ± 1/64
DECIMAL ± .010

NUMBERS ARE SURFACE ROUGHNESS IN MICROINCHES
ROUGH MACHINE FINISH
SMOOTH MACHINE FINISH
ROUGH GRIND
FINISH GRIND
FINE GRIND, LAP
POLISH

FINISH

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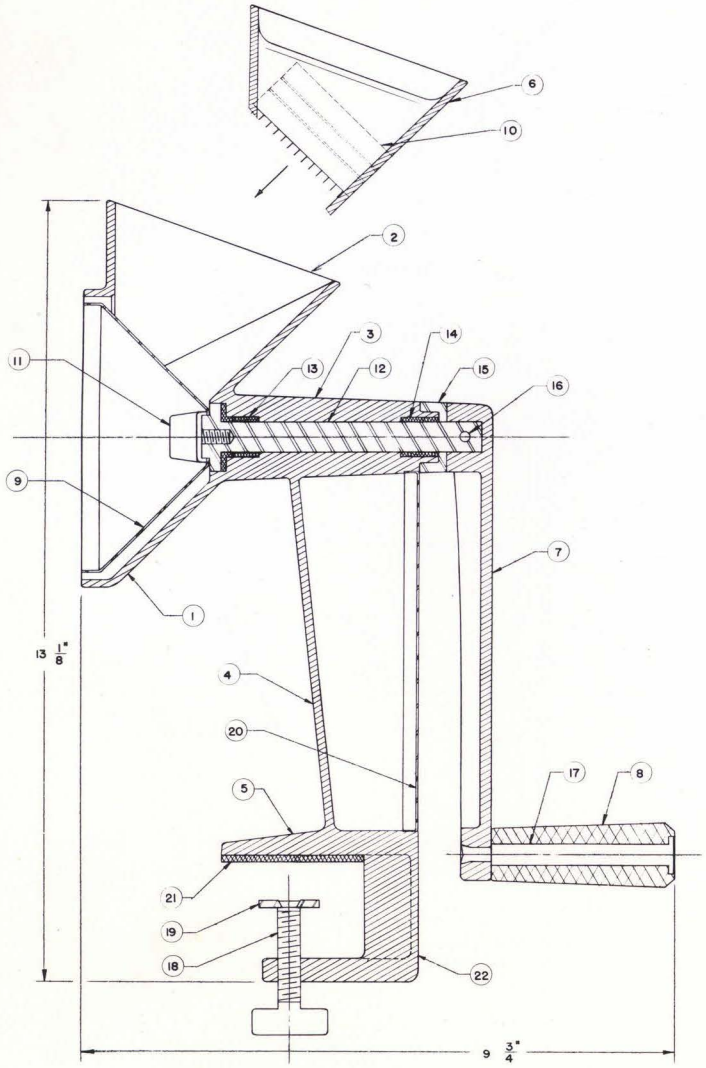
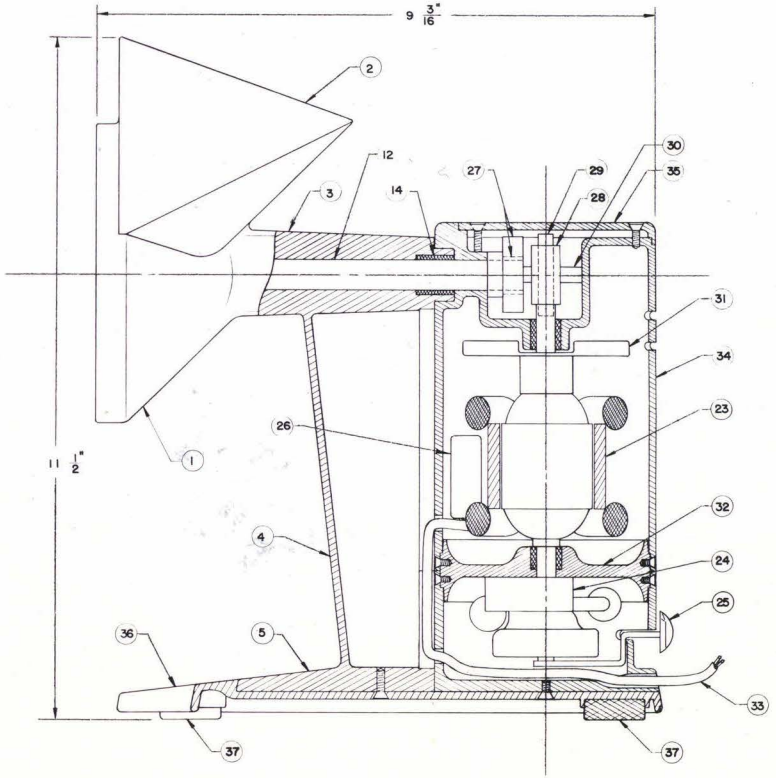
SECTION NO.

MOTOR DRIVEN UNIT

DWG. NO. 2



HAND OPERATED UNIT



MOTOR DRIVEN UNIT

PART	NAME OF PART	MATERIAL
37	RUBBER FEET	NEOPRENE
36	BASE PLATE	DIE CAST ALUM.
35	GEAR HOUSING COVER PLATE	DIE CAST ALUM.
34	MOTOR UNIT HOUSING	DIE CAST ALUM.
33	ELECTRIC WIRE	NO. 18
32	MOTOR SUPPORT BRACKET	DIE CAST ALUM.
31	FAN BLADE	1020 STEEL
30	GEAR SHAFT	1020 STEEL
29	WORM WHEEL	BRONZE
28	WORM	1040 STEEL
27	SPUR GEARS	1020 C.H.STEEL
26	CAPACITOR	0.08 M.F.
25	SPEED CONTROL KNOB	UREA PLASTIC
24	SPEED GOVERNOR	LEE ENGR.CO.
23	ELECTRIC MOTOR	1/10 HP. WSTNHSE.
22	CLAMP-ON DEVICE FRAME	DIE CAST ALUM.
21	RUBBER PAD	NEOPRENE
20	PEDESTAL COVER PLATE	1020 STEEL
19	WASHER	1112 STEEL
18	CLAMP-ON DEVICE THUMB SCREW	1112 STEEL
17	HANDLE PIN	1020 STEEL
16	TAPERED PIN	1112 STEEL
15	FERRULE	1020 STEEL
14	REAR POROUS BUSHING	BRONZE
13	FRONT POROUS BUSHING	BRONZE
12	DRIVE SHAFT	1020 STEEL
11	CUTTER THUMB SCREW	STEEL & ALUM.
10	SET OF BLADES	1045 STEEL
9	CUTTER CONE	1045 STEEL
8	HANDLE	UREA PLASTIC
7	CRANK ARM	DIE CAST ALUM.
6	MEAT HOPPER	DIE CAST ALUM.
5	PEDESTAL BASE	DIE CAST ALUM.
4	PEDESTAL	DIE CAST ALUM.
3	DRIVE SHAFT HOUSING	DIE CAST ALUM.
2	HOPPER	DIE CAST ALUM.
1	CUTTER HOUSING	DIE CAST ALUM.

ALL DIMENSIONS IN INCHES
LIMIT DIMENSIONS —— UNLESS OTHERWISE NOTED
ANGULAR ± ½°
FRACTIONAL ± 1/64
DECIMAL ± .010
RUBBERS ARE SURFACE ROUGHNESS IN MICROINCHES
ROUGH MACHINE FINISH
SMOOTH MACHINE FINISH
ROUGH GRIND
FINISH GRIND
FINE GRIND, LAP
POLISH

FINISH

HEAT TREAT

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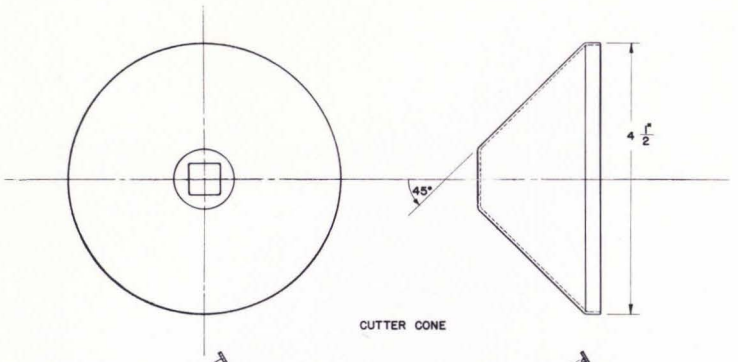
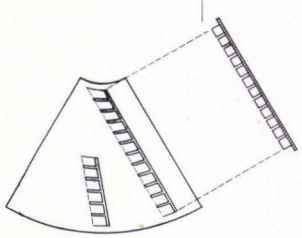
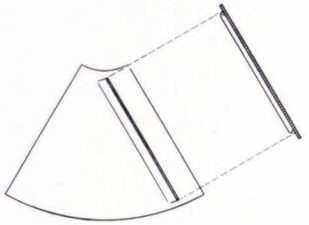


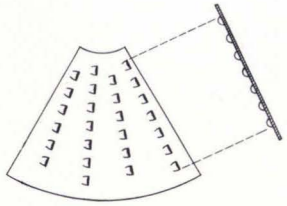
CUTTER CONE



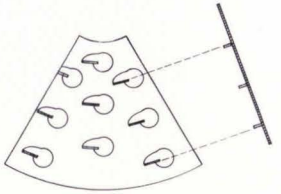
MEAT CUTTER



VEGETABLE SLICER

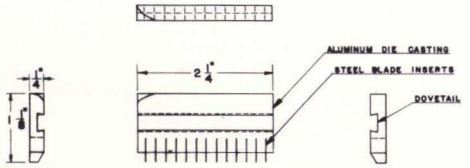


GRATER

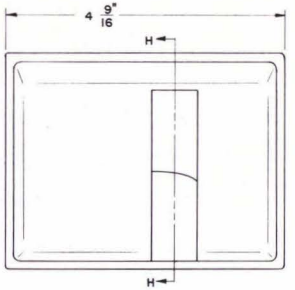


ICE CHIPPER

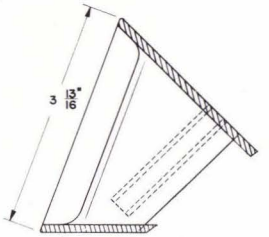
1/4 SECTIONS OF DEVELOPED CUTTER CONE SURFACE SHOWING BLADE PATTERNS



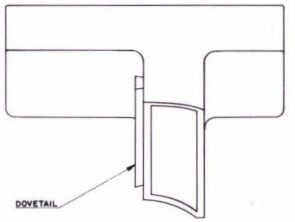
SET OF BLADES



TOP VIEW



H—H



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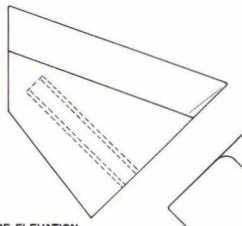
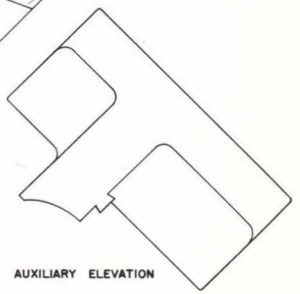


RIGHT SIDE ELEVATION



AUXILIARY ELEVATION

MEAT HOPPER

PART NO.	NAME	NO. REQD.	MATERIAL DESC.	MATERIAL SPEC.	WEIGHT	

ALL DIMENSIONS IN INCHES
LIMIT ON DIMENSIONS ——
UNLESS OTHERWISE NOTED

ANGULAR ± ½°
FRACTIONAL ± 1/64
DECIMAL ± .010

NUMBERS ARE SURFACE ROUGHNESS IN MICROINCHES

ROUGH MACHINE FINISH
SMOOTH MACHINE FINISH
ROUGH GRIND
FINISH GRIND
FINE GRIND, LAP
POLISH

FINISH

HEAT TREAT

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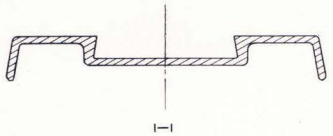
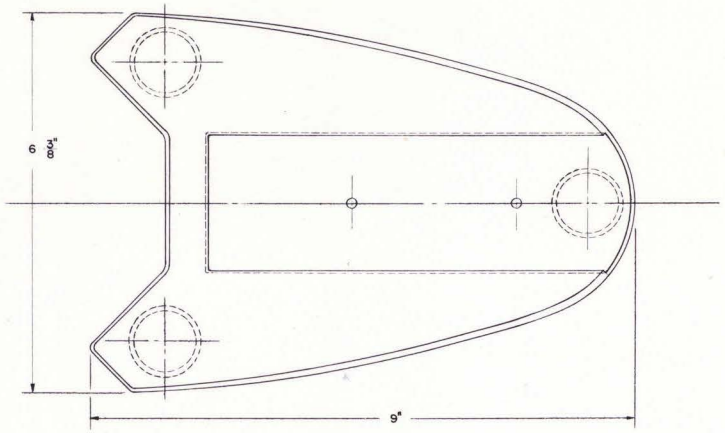
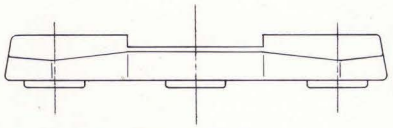
SECTION NO.

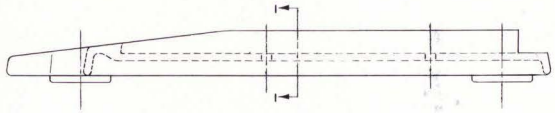




TOP VIEW

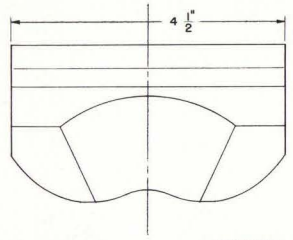


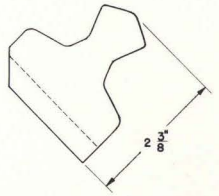
FRONT ELEVATION



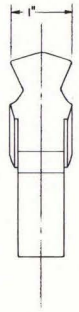
RIGHT SIDE ELEVATION

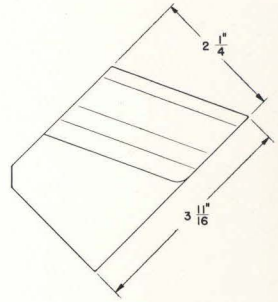
BASE PLATE



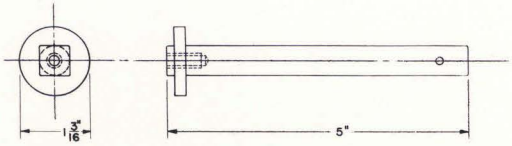


VEGETABLE STUFFER

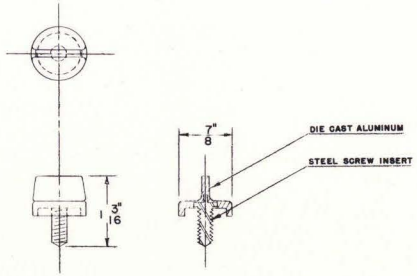




MEAT STUFFER



DRIVE SHAFT



CUTTER THUMB SCREW

PART NO.	NAME	NO. REQ.	MATERIAL DESC.	MATERIAL SPEC.	WEIGHT

ALL DIMENSIONS IN INCHES
LIMIT ON DIMENSIONS UNLESS OTHERWISE NOTED — ANGULAR ± ½° FRACTIONAL ± 1/64 DECIMAL ± .010

NUMBERS ARE SURFACE ROUGHNESS IN MICROINCHES
125 ROUGH MACHINE FINISH
63 SMOOTH MACHINE FINISH
32 ROUGH GRIND
16 FINISH GRIND
8 FINE GRIND, LAP
4 POLISH

FINISH

HEAT TREAT

CALIFORNIA INSTITUTE OF TECHNOLOGY

PARTS

DRAWN BY
TRACED BY
CHECKED BY
APPROVED BY
DATE
SCALE
COURSE NO.
SECTION NO.
DRWG. NO. 5