TECHNICAL REPORT 6519

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DEVELOPMENT OF AN ACRYLATE NIPPLE FOR SMALL ANIMALS

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ABSTRACT

A new device is presented for the feeding of small newborn animals under germ-free conditions. Materials of construction and methodology are given in detail.

I. INTRODUCTION

This report covers the development of a miniature nipple with which newborn small animals (hamsters in this instance) might be given their initial feedings. The project was initiated at the request of Dr. Robert J. Fitzgerald, Chief, Gnotobiotics Section, Laboratory of Microbiology, National Institute of Dental Research, National Institutes of Health, under a letter dated 26 March 1965.

Particularly, the present development is directed toward improvement in the feeding methods for small animals under germ-free conditions as part of the program for propagating germ-free animals for research purposes.

II. EXPERIMENTAL

A. Selection of material of construction

The selection of an elastomeric material for this application was predicated on the ability of the material to withstand repeated sterilization in the steam autoclave.

Another consideration was that the material should be inert and should not undergo decomposition from loss of an ingredient by extraction such as a plasticizer or from degradation due to heat or oxidative influences. It should be strong enough for the purpose, yet soft and pliable, otherwise the animals would not accept it as substitute for the natural nipple. The material should not have an undesirable taste or should be tasteless.

Considering these facts and the cost of processing this item, the most likely candidate for the application, among the elastomeric materials, appeared to be the terpolymer of butyl acrylate/methyl/methacrylate/methacrylamide.[1] Some modification to prevent or minimize the stiffness caused by heating in the steam chamber was first necessary.

An RTV Silicone that was known to be acceptable to the animals had a Durometer hardness of 45 which was easily matched by the acrylate terpolymer before it was cured in the autoclave. Prior to this treatment it had a hardness of 35 on the same scale. After curing at 260°F for 20 minutes under steam, the hardness nearly doubled. Since this was considered to be too high, the methacrylamide content was reduced to one part from the customary 2.5 parts in one instance

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1 Leonard, F., et al, "Vulcanizable Saturated Acrylate Elastomers" Ind. Eng. Chem. 50, 1053-8 (1958)

and eliminated altogether in another. A slight improvement was obtained in the first instance, but the hardness became even greater when the methacrylamide was removed entirely. Figure 6 shows the stress-strain properties of the two materials. (Note the interesting behavior of the copolymer of butyl acrylate/methyl methacrylate before and after autoclaving). It became readily apparent that to achieve a feeling of softness comparable to that of the silicone, the walls of the nipple would have to be very thin.

B. Size Requirements

In order to be acceptable to the animal, the nipple not only had to meet the foregoing requirements, but also had to be very small. The amount of food in liquid form given to the animal at the first feeding amounted to 1/200th of a cubic centimeter. The nipple had to be designed so as to be able to deliver the fluid in controlled amounts and without the risk of drowning the animal. To insure control of the fluid, tubes small enough to have capillary action were designed to prevent free flow of liquid except when under pressure delivered from a syringe or applied by suction from the animal.

III. PROCEDURE

A. Development Phase I

Construction of the molds and dies:

For the sake of simplicity of processing, it was decided to make the nipple in two parts: the nipple itself and the silicone plug that supports the body of the nipple on the needle of the syringe. Figure 3 shows in sequence, (a) the shape of the die or dipping form whose actual dimensions are given in 3aa, (b) the nipple itself, consisting of a circumferential flared tab and a tubular member (body) joined to it and extending to a capillary tube at the other end.

The object of this construction was to be able to create the whole nipple in a single operation, in which case it would only be necessary to invert the tubular member thereby bringing the capillary into position inside the body of the nipple as shown in Figure 3d. However, this construction resulted in a nipple that was too large for the newborn animals although the feeling was expressed that this nipple could well serve the more mature animals.

B. Development Phase II

Particular attention was now directed toward the construction of the tip of the nipple since its acceptance or rejection by the animals depended on its size and the consistency of the material.

As a consequence the construction shown in Figure 2(g) was decided upon. In this one, the body of the nipple was modified to include a small tip which is the actual nipple. Otherwise the construction is similar to the one previously described.

It was necessary to develop new dies (a, b, c, d) of Figure 2 whose actual dimensions are given in the corresponding figures 2aa, 2bb, 2cc, and 2dd. Die number 2dd was an additional one required to make the capillary tube shown in Figure 2(f) and joined as shown in Figure 2(g).

No change was made in the design of the silicone supporting plug (Figure 4b) This item was made from Silastic[R] 382 Medical Grade Elastomer, a room temperature curing silicone rubber selected because it can be steam sterilized. Details of the polyethylene mold from which the plug was fabricated are given in Figure 4.

C. Latex Composition

The terpolymer butyl acrylate/methyl methacrylate, methacrylamide compound prepared according to the method of Leonard et al[1] gave the best balance of properties for the immediate application. A product having a lower Durometer after steam sterilizing would enable the processor to have greater latitude during the dipping operation with regard to time of dwell in the latex and would be more desirable than the present one. Although films are produced from this latex which are borderline in the property of softness, it appears to be acceptable to the animals if the wall thickness is kept to a minimum value.

The elastomer is prepared by emulsion polymerization using the following composition:

Ingredient	Parts by weight
Butyl acrylate	9.5
Methyl methacrylate	7.5
Methacrylamide	1.0
Santomerse sx	2.5

R - Reg trade mark Dow Corning Corp.

Ingredient	Parts by weight
H_2O	155.0
KCl	0.344
$Na_2S_2O_3$	0.04
$K_2S_2O_8$	0.04
H_2SO_4	0.06

Following polymerization, this latex is compounded with a latex dispersion of polyethyl methacrylate containing 47.7% solids in the ratio of 289 ml of polyethyl methacrylate latex added to 1000 ml of the base latex. The film cast from this latex is known as the acrylate film.

One mole of formaldehyde for each mole of methacrylamide was added and the batch heat aged for 3 hours at 95°C.

D. Fabrication of the nipple

A 25% solution of calcium nitrate in ethanol was chosen for the coagulant.

The metal dies or dipping forms were prepared to receive the coagulant by first giving them a light sand blasting followed by washing in a detergent cleaner and rinsing in water. They were then dipped in the coagulant solution, removed and drained. Draining consisted of letting all free excess liquid flow away by gravity and the remaining excess forced from the die by shaking it away manually. This operation takes at the most about 30 seconds. It is important that any visible excess coagulant be removed from the dipping form before dipping it into the latex to prevent distorted imperfect films and to obtain uniform thicknesses of coagulated latex.

Since the amount of material that is deposited by this method is time dependent, it is necessary to adhere to strict dwell time schedules if products having uniform wall thicknesses are to be obtained.

In this case an elapsed time of 15 seconds was allowed between entry of the die into the latex and its removal. The die with its film of coagulant was dipped into the latex to a depth that would include about 2-3 millimeters of that part of the shank immediately above the flared portion of the die. This depth was reached as fast as possible so that the tip which entered the latex first and was the last to leave, thereby receiving the heaviest deposit, would receive the least amount possible during this cycle. It was determined that 15 seconds would be the least time within the capability of an operator to complete this step in a practical manner. When ten seconds of this cycle had elapsed

the step of removing the die from the latex was begun. Withdrawal was done slowly to permit the latex to coagulate at about the same rate. Near the end of the 15 seconds the tip was nearly exposed at which point the die was rapidly removed and quickly upended so that the uncoagulated latex would flow back from the tip and coagulate elsewhere. Only by this procedure was it possible to keep the wall thickness of the tip within prescribed limits.

Having thereby produced a coagulated film on the die it was necessary to remove it. Two methods were available to accomplish this. In one method, the film was allowed to dry on the die until it reached considerable strength at which time it was removed. In the other method, the film was removed immediately after forming. The latter method was chosen because it lent itself to rapid production with but a single die whereas in the former process a multiplicity of dies and considerable time would be needed to remove the dried film, to leach, redry, and assemble it.

To prevent the mutilation of the film, which in this stage of wetness is very weak, one precaution had to be taken. It was necessary to remove it by floating it off the die into a water bath by means of a gentle stream of water. This was easily accomplished by holding the die under the surface of the water in a position that would permit the stream of water to flow under the film causing it to lift and follow the stream of water into the water bath.

E. Fabrication of the capillary tube

Essentially the same procedure was followed in making this part as that of the nipple, only the time cycle was different.

The die shown in Figure 2(dd) was used to make this part. It was prepared in the same manner as the other dies and the same concentration of coagulant was used. Dipping and draining the coagulant was likewise done in the same manner. Forming of the capillary from the latex was done in two stages instead of one as follows. The coagulant coated die was first dipped into the latex to the full length of the thin stem and including about 3 millimeters above the part where the stem is joined. The length of time allowed for this dip was 15 seconds. To obtain the necessary thickness of material for the capillary it was necessary to redip the stem portion in the coagulant but only to a point within about 1-2 millimeters of where the tube joins the enlarged portion of the die. The die was held in this position

momentarily and removed. Excess coagulant was shaken off and the die returned to the latex and submerged to the same depth as the first dip where it was allowed to dwell f[illegible]0 seconds. This second dip in coagulant and latex was necessary because the samll dimensions of this particular die would not enable it to retain enough coagulant to develop the required thickness of material. At the end of the 30 second dwell, the die was removed at a rate faster than the rate at which the latex would coagulate so that the excess latex would flow to the end of the tube and collect in the shape of small spherical mass. As soon as the latex had thus accumulated the die was quickly returned to the coagulant for the purpose of solidifying the little spherical enlargement. Having thus developed the capillary, it was then floated off the die in the water bath by means of a small stream of water in precisely the same manner as the nipple.

One important operation, though seemingly trivial, applies to both items. Both dies have had the ends fashioned to relatively sharp points which was done to prevent the deposition of latex in this region. In spite of this, closure at the ends would often occur which would interfere with or prevent the removal from the die. To obviate this it was customary to gently press the tips against a piece of smooth polyethylene which would force the ends of the dies through the deposit of the latex film. It should be emphasized that this was done very gently especially in the case of the tip of the nipple because only a very small opening was desired and equally as important, the smoothness of the material must not be disturbed lest the animal refuse the nipple or lest a rough edge be created that could cut the animal's delicate membranes. Polyethylene was chosen for this step because it would yield slightly to the pressure and would not adhere to the acrylate.

F. Processing the Acrylate

In order to remove the coagulant that was absorbed into acrylate during the dipping operation together with the soluble ingredients present in the latex from the polymerization, particularly the emulsifier, it was necessary to leach the material in water for extended periods. The length of time required to remove these substances was not determined with any degree of accuracy because it was dependent upon such things as the amount of water, its temperature and whether or not agitation was used and if the water was changed frequently. It was felt that an end point had been reached when the bitter taste had been removed and that this was a requirement that had to be met.

For this reason it is recommended that the elements of this device be made up in quantities in advance of their expected use so that they can be retained in water that will be changed frequently. This should insure the removal of the objectionable ingredients. It is further recommended that when the nipples and capillary tubes are transferred to a fresh change of water that the water be brought to the boiling point. This not only speeds the removal of soluble solids from the acrylate film but also precludes or lessens the chance for invasion by fungus or bacteria.

It will be noted that as the acrylate reaches the dry state it will have become much smaller than when first removed from the die. This is a natural consequence of the removal of water from the film. This shrinkage has been compensated for in the design and sizing of the dipping forms and is of no concern, it is an inherent part of the process.

G. Assembling the Parts

The nipple and the capillary tube, having been thoroughly leached, were air dried, sometimes at room temperature, and sometimes at 60°C in a circulating air oven. Hypodermic needles (23 gauge) were used on which to mount the capillary tubes. Silicone lubricant (Dow Corning Stopcock Grease) was applied to the needle sparingly and the capillary was drawn on the needle until the ends of both needle and tube were even. The end of the tube was moistened with just enough acrylate latex to make it wet, any sign of excess was carefully avoided. The tube was then inserted into the body cavity of the nipple and carefully joined to it at the point where the tip of the nipple met the body. (Fig. 5) The end of the needle was then made to protrude beyond the end of the capillary to prevent its being closed by the latex. The entire assembly was set on the base of the needle and supported while union was made in the joint between the capillary and the nipple by the drying of the latex.

The composite structure now presented these distinguishing features: a cylindrical body flared at one end to produce a circular tab for purposes of handling, a small projection emanating from the opposite tapered end and constituting the nipple itself, this part forming a small distinct chamber separated from the body cavity at the juncture of the capillary tube, a capillary tube flared at the end to facilitate the insertion of a hypodermic needle.

IV. TESTING AND INSPECTING

A. Each nipple was tested for flexibility of the tip or the nipple itself. If it was too stiff because the wall thickness was too great, it was rejected.

B. If they gave off a bitter taste, they were leached for a longer period of time.

C. The joint between the capillary tube and the nipple was tested by mounting the nipple on a 23 gauge hypodermic needle on a syringe containing water and forcing water through the system. If there was a leak at the juncture of the capillary and water was forced back into the body cavity the nipple was resealed or rejected.

D. Each nipple was examined to make certain that its opening was intact.

V. PREPARING THE NIPPLE FOR USE

A. Each nipple was steam sterilized for 20 minutes at 260°F (20 lbs pressure) while immersed in a small quantity of water. The principal reason for doing it in water was to buoy the nipple in the water to prevent distortion of it and to keep it uncontaminated until used. The sterilized silicone plug, needle, syringe and nipple were then assembled as shown in Figure 1, and in the photograph.

VI. SUMMARY

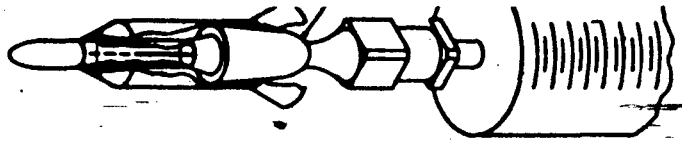
A functional and practical device for feeding small newborn animals in a germ-free research program was developed and constructed from a terpolymer of butyl acrylate/methyl methacrylate/methacrylamide.

VII. RECOMMENDATION

It is recommended that further synthesis and work be done to keep the Durometer to the lowest figure possible for this application.

ACKNOWLEDGEMENT

Our gratitude is due Mr. James Eaton for his part in preparing the latices, Mr. Stanley Baker for machining the molds and dies, and to Mr. Arthur Fisher for preparing the drawings and diagrams.



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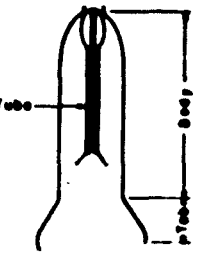

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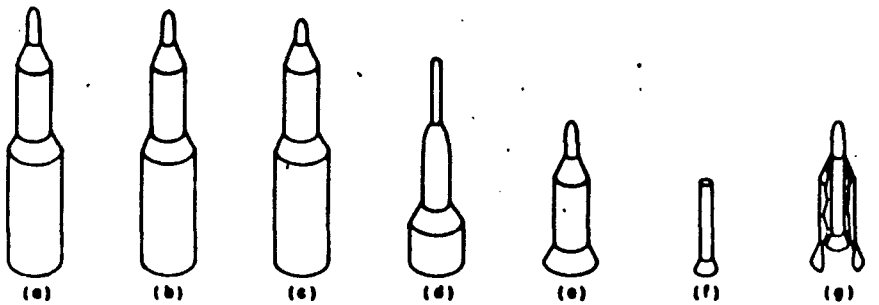

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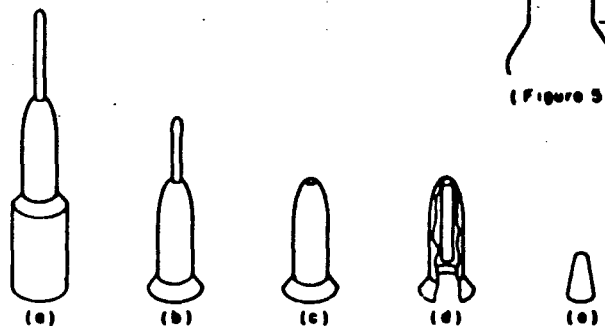

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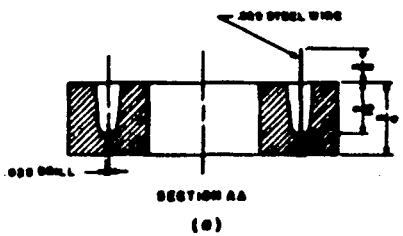
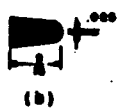
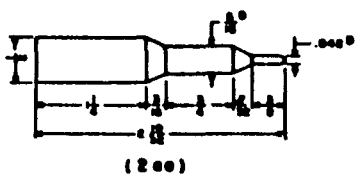
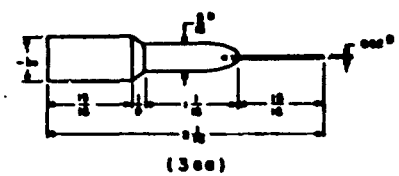
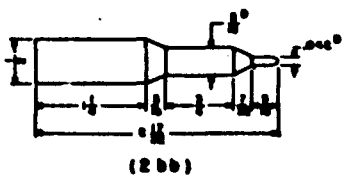
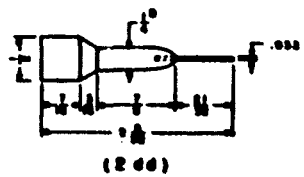


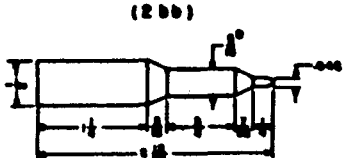


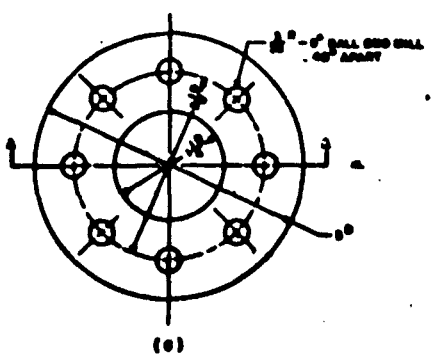


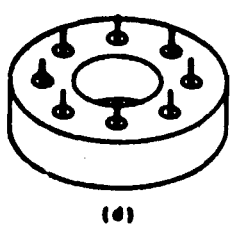












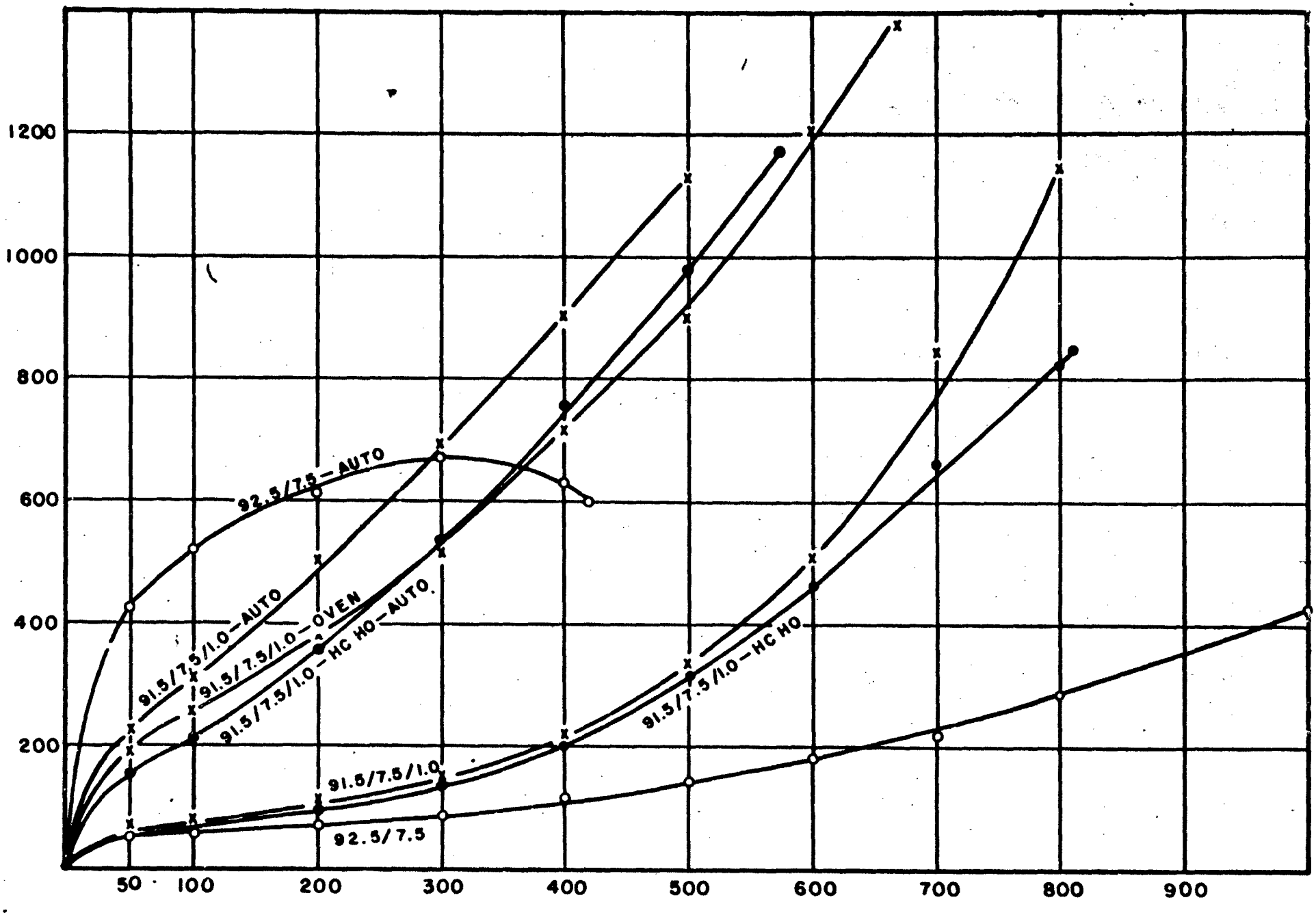
(Figure 4)

PART NO.	PART NAME	NO. REQ.	MATERIAL
			ACRYLATE

DEPARTMENT OF THE ARMY

TITLE:
ACRYLATE NIPPLE FOR SMALL ANIMALS

T-606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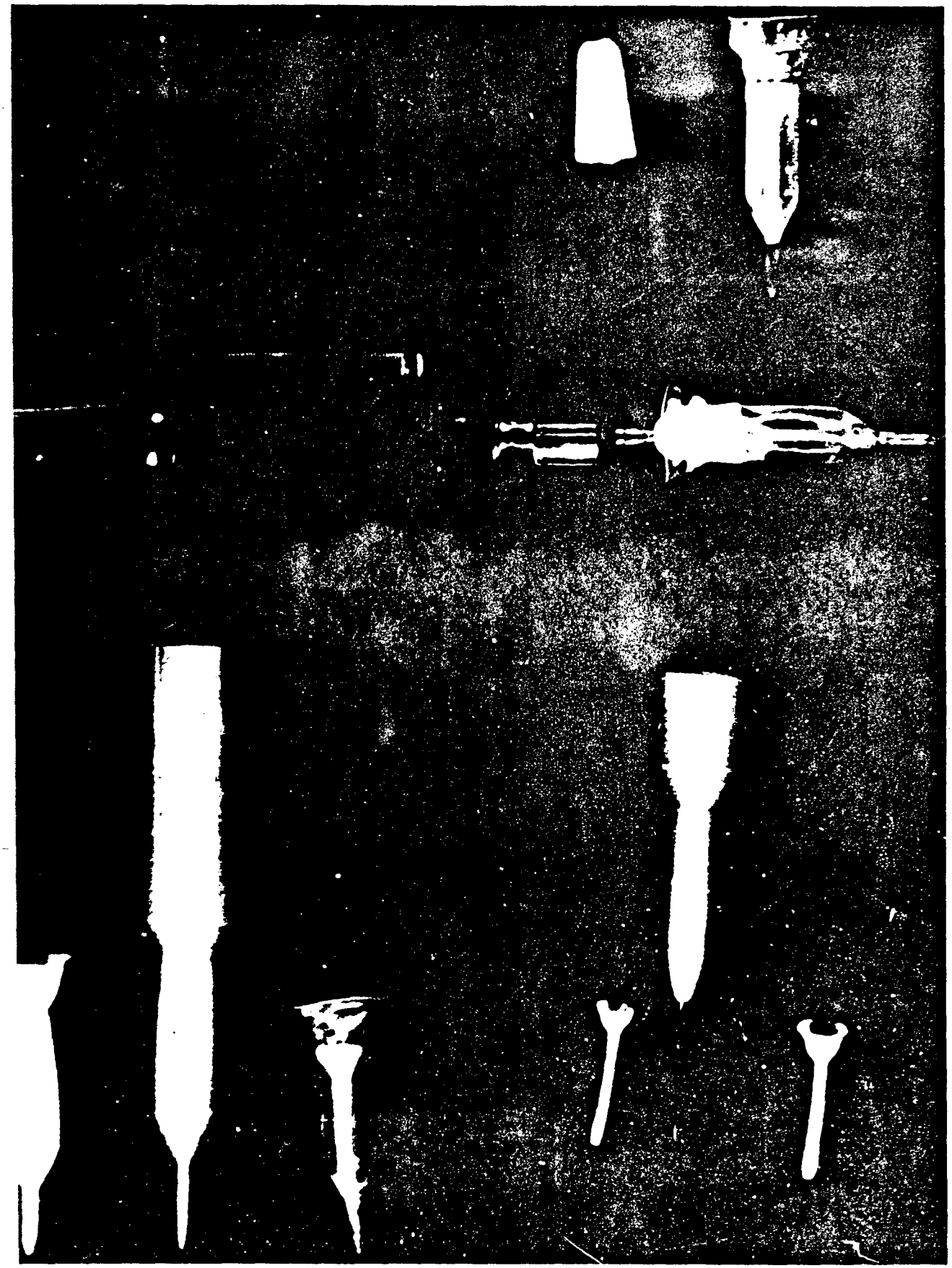
(Figure 6)



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13. ABSTRACT

A new device is presented for the feeding of small newborn animals under germ-free conditions. Materials of construction and methodology are given in detail.

KEY WORDS

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