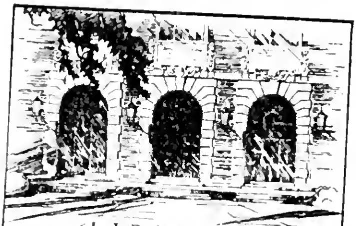

RUBBER MOLDS AND PLASTER CASTS IN THE PALEONTOLOGICAL LABORATORY

BY

JAMES H. QUINN
ASSISTANT IN PALEONTOLOGY

FIELD MUSEUM of NATURAL HISTORY
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INTRODUCTION

Accurate plaster casts of fossils are of recognized value in paleontology. They serve as useful substitutes for rare specimens and types, making copies of such fossils available to various museums for purposes of comparison and exhibition.

Such casts are ordinarily made by the use of plaster piece-molds or of flexible glue or gelatine molds. Both techniques are intricate and they present many difficulties, especially when complicated objects such as skulls are cast. The risk of damage to fragile fossils is considerable when either of these casting methods is used. Furthermore, the production of good casts depends to a great extent on the skill and experience of the molder. Therefore, any method that is calculated to simplify the casting of fossils should be of interest to paleontologists and also to plaster molders, as such a process is applicable to other fields in which plaster casting is used.

Liquid rubber was first introduced into Field Museum's laboratories in 1934 as a casting medium for the preparation of brain casts, and a brief account of the process was published by Patterson (Field Mus. Nat. Hist., Geol. Ser., **6**, pp. 273–274, 1937). Several brain casts were prepared by means of the technique there described. The facility with which this otherwise difficult operation was performed indicated that liquid rubber might well prove to be a reliable material for the construction of molds from which a high grade of plaster casts could be produced with a minimum of labor, and with little risk of damage to fragile fossils.

A method of constructing flexible rubber molds was not as easily developed as the brain cast procedure had led us to expect. Since the interiors of the skulls from which the brain casts were taken were somewhat inaccessible to measurement, no suspicion of the possibility of shrinkage or distortion was entertained. This serious fault of the material became apparent as soon as an attempt was made to construct molds of rubber. It was also found that the color in certain of the liquid rubber compounds stained the models,[1] and

[1] The term "model" as used in this paper indicates the specimen of which casts are being made.

that the water in the rubber tended to loosen joints when mended bones were used as models. Except for these faults, rubber molds produced casts of such attractive appearance that persistent efforts were made to find a means of eliminating the objectionable features. After much experimentation, simple techniques for constructing rubber molds were perfected.

This paper is intended to describe the technique of using liquid rubber in plaster-casting in so far as it is applicable to making casts of fossils, especially of fossil bones. It is beyond the scope of the present account to discuss the uses of liquid rubber in other branches of museum preparation, a field in which numerous possibilities are being explored.

I wish to express my thanks to Mr. Elmer S. Riggs for aid and encouragement in both the experimental work and in the writing of this paper. Thanks are due to Mr. John R. Millar, Mr. Karl P. Schmidt, and Mr. Bryan Patterson for advice and criticism. The drawings are the work of Mr. John Conrad Hansen.

LIQUID RUBBER

Collection and preparation.—Rubber is derived principally from the sap of trees of the genus *Hevea*. The sap, or "milk," as it is commonly called, is a thin fluid, white in color and alkaline in reaction. After standing a few hours it ferments, becomes acid in reaction and coagulates. Owing to this characteristic it was formerly impracticable to transport liquid rubber. Since it was collected by natives, over widely separated areas, it was always coagulated, dried, and brought to market in lumps. The development of rubber plantations has made it feasible to process and prepare the rubber for export in the liquid state, so that it is now available in quantity for use in the manufacture of numerous articles formerly made from dried rubber.

On the plantation, the sap is collected into tanks and a 5 per cent solution of ammonia is added as a preservative. It is then concentrated by removing about 30 per cent of the water content. The concentration is accomplished in much the same manner as that employed in separating butter fat from milk. After standing a few hours in a vat the rubber rises to the top of the solution, just as cream rises on milk, and is drawn off. A second method of separating the rubber and water is by centrifuging, as in the mechanical method of skimming milk by the cream separator. Both processes are known as "creaming." After the solution has been creamed it may be preserved for considerable periods in air-tight containers without danger of spoiling.

Latex may be vulcanized while in the liquid state, so that on coagulation it displays the characteristics of processed, vulcanized rubber. Some latex compounds manufactured for use in molding or for other commercial purposes, contain vulcanizing agents and accelerators so combined that vulcanization takes place after the compound has coagulated and dried. Such compounds behave like unvulcanized rubber for a considerable period of time, and may be considered as such in so far as the making and curing[1] of molds is concerned. The degree of vulcanization, the time of coagulation, and the content of water in rubber solutions play an important part in the processing of rubber molds. The cause and effect of these properties are interesting and some knowledge of them will prove of value in selecting or preparing a suitable molding material.

Properties of liquid rubber.—Liquid rubber coagulates on losing a small amount of its water content, and acquires the characteristics of solid rubber. It becomes elastic and cohesive, and begins to develop resistance to alteration of form. Thus, most of the adjustment in the volume of a film of liquid rubber spread on a model must take place after it has lost the property of fluidity. Since the water, which ranges from 25 to 40 per cent of the total original volume, is nearly all lost in drying, considerable adjustment necessarily takes place. As water is lost, the rubber tends to reduce its volume. Since the model resists any reduction in dimension, the film can shrink only in thickness. A tension is thus set up in the rubber to compensate for its inability to reduce its area. The major difficulties encountered in making rubber molds arise from this tendency of rubber to build up tension while drying, a characteristic that causes the film to draw away from the surface of the model in depressions, and to contract on removal from the model.

The amount of tension that may be acquired by the solid film depends on its thickness and on the rapidity of drying. The *rate of accumulation of tension* depends directly on the rapidity of drying.

Since rubber is not perfectly elastic, it also has the ability to lose tension. The loss of tension in the rubber mold is a slow process not directly connected with the rate at which it has been accumulated, and depends, to a great extent, on the degree of vulcanization of the rubber.

[1] The term "curing" designates the period of time allowed for the rubber film to lose its tension.

Vulcanizing makes rubber more perfectly elastic, but also makes it progressively harder and likewise less susceptible to alteration of form by any applied force. The degree of vulcanization may range from that in slightly vulcanized products, such as rubber bands, to that in highly vulcanized objects, such as hard-rubber pipe stems.

It may readily be seen that, given an equal application of force, the form of an ordinary rubber band can be altered much more quickly and to a greater degree than can that of a similar band of more highly vulcanized rubber; for example, a rubber band that is stretched as far as possible without being broken will not regain its original form when released, but will be appreciably thinner and longer. The same effect would be obtained by allowing it to remain in a less stretched condition over a period of time. A more highly vulcanized piece of rubber would require more force to stretch it, would not stretch as far, and would more nearly regain its original form after relaxation of the force. The greater the degree of vulcanization the more extreme these tendencies become. In practice, molds made of vulcanized rubber must be dried more slowly than those made of unvulcanized rubber so as to prevent or reduce the danger of pulling away in depressions. A long period of time must be allowed for loss of tension in order to minimize the possibility of contraction (approximately a month should be allowed for curing a mold having a thickness of one-eighth of an inch). A further defect produced by vulcanization in molding compounds lies in the reduction of their adhesive qualities. Vulcanized rubber does not adhere to the model as closely as unvulcanized. The rubber must be applied in successive layers when making a mold, and there is a tendency towards separation of the layers when vulcanized rubber is used.

The unvulcanized latex is a much more satisfactory medium to work with than vulcanized latex, since the tension is lost more rapidly and more nearly keeps pace with its accumulation. Molds of unvulcanized rubber dry quickly, do not pull away in depressions, and usually lose all tension in about two weeks. There is less danger of separation of the successive layers, since the unvulcanized rubber is more adhesive. Molds may be built up and reinforced with cloth with greater facility and with more satisfactory results, when used in conjunction with an unvulcanized compound.

Unvulcanized compounds containing vulcanizing agents and accelerators so compounded that vulcanization takes place after the mold has cured, are the most satisfactory media for molding, since they have all the advantages and none of the disadvantages of either of the other types. Such rubber molding material produces accurate replicas with a minimum of failure or damage to the model. The chief advantage of this type of compound over ordinary unvulcanized latex is that it may be applied more easily and smoothly.

Nevertheless, it should be noted that ordinary unvulcanized latex is capable of producing molds equal in every way to those made of prepared molding compounds of the above type, except that the rubber may deteriorate more quickly and the mold may be more easily distorted by excessive stretching. These faults are not serious, since all the casts desired can be made long before the rubber begins to break down and excessive stretching of the rubber can be avoided by proper construction of the mold. For these reasons, wherever a suitable prepared compound is not available, unvulcanized latex, which is obtainable almost everywhere, may be substituted and will, with only a little more care, yield entirely satisfactory results.

MAKING RUBBER MOLDS

General procedure.—Basically, the process of constructing a rubber mold consists of the following simple steps:

(1) The model is prepared by cleaning, repairing cracks, and hardening the surface with shellac or with any other substance commonly used for the purpose.

(2) The liquid rubber molding material is applied to form a reasonably uniform film over the entire surface of the model. Ordinarily, the rubber is applied with a brush in successive layers, and reinforced with cloth wherever necessary.

(3) The mold thus formed is allowed to dry and cure.

(4) The mold is opened, the model removed, and an orifice arranged of sufficient size and in a suitable position for the purpose of pouring plaster into the mold when casting.

In practice, the method of applying the rubber varies but little. Provision for opening and closing the mold and for handling the model during construction of the mold, however, imposes the necessity of varying the method to suit the need. In accordance with the type of construction used, and for the sake of convenience, molds may be grouped in two general types: (*a*) The one-piece or continuous mold, and (*b*) the two-piece mold, constructed in two separate sections, each covering roughly half of the model.

Before a mold can be made, it is necessary to decide on the type of mold to be used and the manner in which it shall be arranged, so that the completed mold can be removed without breakage from the model and from the casts to be formed in it, and in order that the joints or seams left by the edges of the mold may be as inconspicuous as possible. For these reasons the types of rubber molds and their application are discussed below in considerable detail.

Continuous molds.—The simplest type of rubber mold is prepared by applying the molding material over the entire model in a continuous film so that it completely encloses the model. The opening and closing of such a mold presents a major problem in its construction. Ordinarily, the opening is provided by cutting the mold (after it has cured) along a line that will be as inconspicuous as possible on the finished cast. The most feasible method of closing this type of mold for casting is accomplished by cementing the edges with rubber cement. Since the rubber mold is usually quite thin (one-eighth inch or less) there is little contact surface, and the joint thus made will not withstand the pressure of a large quantity of plaster. Furthermore, dried rubber cement accumulates on the edges of the mold (since it must be applied each time a cast is made) with the result that with continued use they become rough, do not fit closely, and cause undesirably conspicuous seams on the casts. This method is suitable for small molds intended to yield only a limited number of casts. On larger models, where other types of molds cannot be used, the continuous mold may be employed in conjunction with a device that will increase the contact area and thus strengthen the joint.

Two methods devised for increasing the contact area in continuous molds may be described as follows:

(1) A strip of thin celluloid (set at a right angle to the surface) is attached to the model with celluloid cement so that the strip follows the line of the desired opening. The edges of the mold are built up to any required width on the face thus provided. Joints of this type have considerable strength even when cemented with a very thin solution of rubber cement. A thin rubber cement solution may be used to better advantage than a thick one, since it accumulates more slowly on the contact faces of the mold.

(2) A flap arrangement may be constructed. After half the thickness of the rubber film has been built up, a strip of paper one-half inch wide is laid on, one edge coinciding with the line along which the mold is to be opened. The paper acts as a separator, so that

FIG. 1. Skull of *Mesembriornis*. The jugal bar and quadrate were removed and cast separately.

after the mold has been completed the outer half may be cut along one edge of the paper strip and the inner half along the other edge, thus forming a "lap" joint.

In order that the entire surface of the model may be covered with rubber in a single operation, a rigid holder or "handle" should be attached so that the molder may hold or turn the

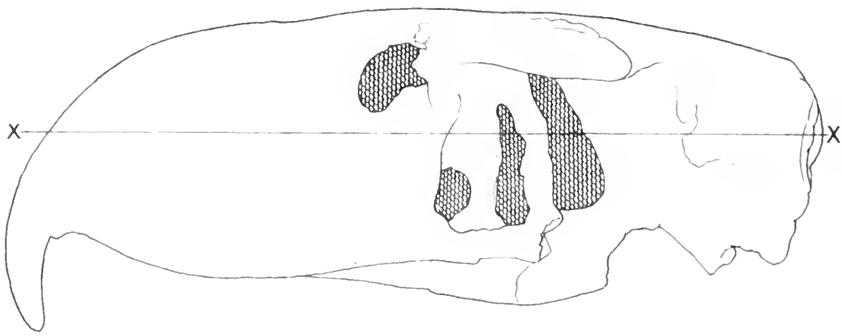

FIG. 2. Diagram of skull, showing areas blocked off with plasteline (cross-hatched). X–X denotes line of section shown in fig. 3.

model in any position desired, without touching any part of the mold. The handle may be attached by cementing a rod in a natural opening, on a broken surface, or into a hole drilled in a restored area. Models that are too large to be treated in this manner, or that offer no opportunity to attach a handle, should be enclosed in a two-piece mold.

Two-piece molds.—Two-piece molds require more time and care in construction than continuous molds. For this reason they are not generally used in cases where only a few casts are to be made. They become necessary when, due to the nature of the model, a simpler sort of mold is unsuitable, or when a large number of casts is desired from a mold. It is unnecessary to provide the model with a handle since only one half of the mold is made at a time. The contact edges of the mold can readily be constructed with guides or keys to produce an accurate register. The molds may be removed from the model or casts with greater facility, since no cutting is necessary.

Mold-making may vary considerably in detail according to the features presented by the model and the individual preference of the molder. For this reason an illustrated account of the preparation of the molds of a representative fossil appears to be the most useful and lucid method of describing the process. For this purpose a skull of the phororhacoid bird *Mesembriornis* has been chosen. This specimen is fairly well preserved, with the bone hard and dense, except for a section of the occipital region and the interorbital septum which has been cracked and softened by weathering (fig. 1).

Preparation of the model.—The fossil was given a coat of thin white shellac (cut to 1 lb. per gallon of alcohol) to harden and protect the surface. The various openings such as the internal nares, that portion of the orbital area not divided by the septum, the space behind the lachrymals, and all other openings bridged over by bone, were blocked off with plasteline (fig. 2). Since the mold was to be made in two sections, the skull was set up on a board and blocked with plasteline (fig. 3). A wall of this material, about five-eighths of an inch wide, was built up around the skull. The flat upper surface of the wall was made to follow the median line of the skull as closely as possible, dividing it longitudinally. A plasteline dam, one-fourth of an inch thick and three-fourths of an inch wide, was then attached to the outer surface of the wall to form

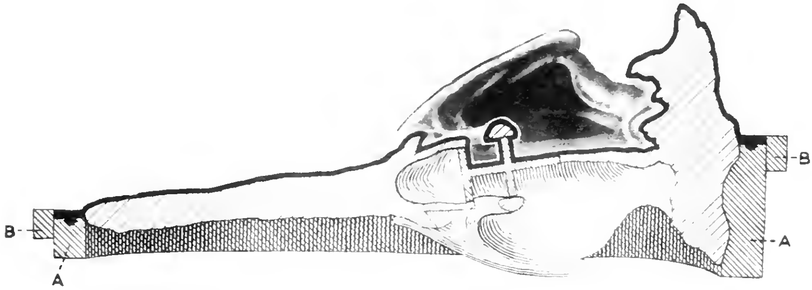

FIG. 3. Longitudinal horizontal section of skull, upper half covered with rubber. Solid black line, cross section of rubber; widely spaced diagonal hachures, cross section of bone; closely spaced diagonal hachures, cross section of plasteline units A (wall) and B (dam); cross hachures, internal view of plasteline wall, A.

one side of a trough, the skull forming the other. Cone-shaped depressions were punched in the floor of the trough to act as guides in assembling the completed mold (a continuous V-shaped groove might also have been added for the same purpose). All the plasteline surfaces intended to come in contact with the rubber were shellacked and allowed to dry.

Process of making the mold.—The American Anode Company's Formula No. 10099A was the molding compound used. The first coat was applied with a small brush, care being taken to work the rubber into all depressions in order to eliminate bubbles and air pockets. This application was followed immediately by a second one to insure complete covering of the surface. The thin film thus made was allowed to dry over night. Since a thin film of rubber dries quickly and contains only a small amount of water, it does not wet the bone appreciably, most of the water being given off into the air. When dry, it is fairly waterproof, serving to resist the tendency of the heavier following coat to drive its contained water inward as it dries and contracts.

Pre-shrunk cheesecloth was cut into strips from two to three inches wide and about six inches in length. These were laid on

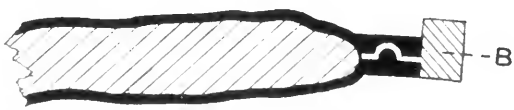

FIG. 4. Detail section through beak region showing second half of the mold and the plasteline dam in place. B, plasteline dam.

over a fresh coating of rubber and brushed down so that they adhered closely to the surface of the mold. About four layers of cloth were successively applied, except in areas where some stretching of the rubber would be required to remove the mold. The cloth does not reduce the flexibility of the mold, but it does prevent the rubber from stretching.

In areas where cloth was not applied, the rubber was built up to a somewhat greater thickness than on the parts of the mold containing cloth. The mold was then allowed to dry for six days. At the end of this period the skull was turned over and the wall of plasteline removed, leaving the dam in place and exposing the edge of the first section of the mold (fig. 4). All the rubber surfaces intended to come in contact with the new section were shellacked, the shellac acting as a separator, and allowed to dry. The second half of the mold was then made in the same manner, so that the entire skull was covered with the molding material. Two weeks were allowed thereafter for the completed mold to dry and cure.

This mold was made as thin-walled as possible in order to reduce the danger of damage to the skull which, in spite of its size, is fragile due to the many slender processes and thin sections of bone comprising much of its posterior area. A somewhat heavier mold (six or

FIG. 5. The two halves of the completed mold.

seven layers of cloth and rubber) would otherwise have been more satisfactory and easier to work with in casting.

A plaster matrix might also have been constructed as an additional support for the mold. In this case a matrix was not made, since it was thought inadvisable to subject the skull to any treatment not absolutely necessary in obtaining accurate casts. On larger models it is often advisable to use a plaster matrix in conjunction with the rubber mold.

THE PLASTER MATRIX

The plaster matrix serves the three-fold purpose of acting as a guide for orienting the parts of the mold, as an agent for closing the mold without the use of cement, and as a rigid reinforcement for the flexible rubber mold. It is ordinarily employed over large molds that are required to yield a considerable number of casts. The matrix may be constructed after the mold is completed, or each half may be made after the completion of the corresponding half of the rubber mold. In either case, it is constructed before the model has been removed from the mold.

After the first half of the mold has dried thoroughly, the plasteline dam (fig. 6) around the edges of the mold is removed and a second wall is set up in such a way that its upper surface falls about one-half inch below the first wall that forms the edge of the rubber mold. All undercuts on the mold are filled in with plasteline so that the completed matrix can be lifted off. The rubber surfaces intended to come in contact with the plaster should be covered with tissue paper, which acts as a separator, so that the matrix will be easily removable. Strips of burlap or coarse cheesecloth are then soaked in plaster and water and laid on over the mold until a thickness of about one-fourth inch is reached. In very large molds, the matrix should be somewhat thicker. After the plaster has hardened, the work may be turned over and the plasteline wall removed. The rubber surfaces intended to form part of the joint in the rubber mold are then coated with shellac to act as a separator, and the second half of the rubber mold applied. The projecting edge of the plaster matrix will be found to act as a dam for the second half of the mold (fig. 7). After the second half of the mold has dried, the matrix may be completed. The rim of the first half of the matrix should project about one-fourth of an inch above the edges of the mold. Its inner surface should be trimmed so that it slopes outward in order that the second half of the matrix, which fits inside the rim of the first half, can be loosened easily.

The plaster surfaces intended to come in contact with the new section of the matrix may be coated with vaseline or some other separator, care being taken to keep the separating agent (if it is oily) away from the rubber (p. 16).

The rubber surfaces intended to come in contact with the matrix are treated as they were in the first operation, and the plaster jacket

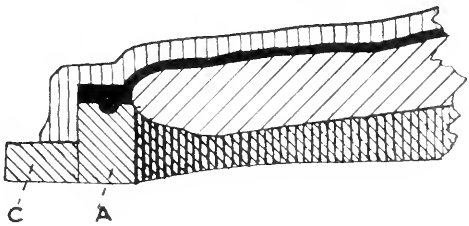

FIG. 6. Detail section through beak region showing suggested arrangement for first half of plaster matrix. Vertical hachures, cross section of plaster matrix. A, plasteline wall; C, secondary plasteline wall.

is applied in the same manner as the first section. After the plaster has hardened, the entire matrix may be removed and allowed to dry (very large matrices should be dried on the mold to prevent warping). The inner surfaces of the matrix are then treated with several coats of shellac to harden them and to facilitate the removal of any plaster that may leak out of the mold in the process of casting.

In certain cases it may be necessary to construct the matrix in more than two sections in order to remove it from the mold. It is generally better to avoid increase in the number of pieces, if it is at all possible, since the danger of misfitting the parts of the

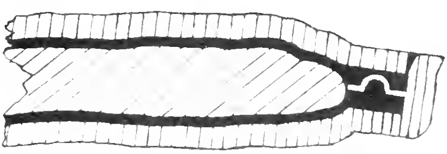

FIG. 7. Detail section through beak region, showing completed plaster matrix. Vertical hachures, cross section of matrix.

matrix and mold is thus increased. Many variations of the process described are of course possible. However the matrix is designed and constructed, it should hold the mold so that its parts are properly oriented, and should bear on the projecting edges of the mold in such a way as to reduce the possibility of leakage, thus relieving the molder of the necessity of cementing the edges of the mold. These two functions of the matrix are of greater importance than that of support for the mold, and they should be given first consideration in designing the matrix.

CARE OF RUBBER MOLDS

Casts should be removed from the mold as soon as possible after they have hardened. If allowed to remain in the mold for too long a time they may acquire a chalky surface, and leave a thin coating of plaster on the inside of the mold. This plaster residue may be removed by washing the mold with a weak solution of hydrochloric acid (5 per cent), followed by a water rinse.

It is better not to use new molds until they have been allowed to stand open for a few hours after removal from the model. If the molder wishes to use them immediately, he should employ the acid wash and water-rinse just mentioned or he may again be confronted with a chalky surface and a plaster coating on the mold.

SEPARATING AGENTS

The use of separating agents in rubber mold making is limited to the contact areas between the halves of a two-piece mold, and to the cases in which a rubber mold is formed over a rubber model. White shellac serves effectually for this purpose. Oils or greases cannot be applied directly to rubber as they cause it to soften and swell.

Sometimes the internal surfaces of a new mold stick together if they come into contact. This may be prevented by dusting talc or dry plaster into the mold as it is removed from the model. After a cast has been made in the mold the tendency to stick disappears. The necessity of putting tissue paper on the outer surface of a mold over which a matrix is to be constructed has been mentioned above.

BRUSHES

Brushes used in applying rubber compounds should be of rather coarse texture. They must be kept clean, should be dampened with water before they are used, and must be washed out with clean, cold water immediately afterwards. Any rubber that may coagulate in the brush can be removed by soaking the brush in benzine for a short time.

THINNING THE COMPOUND

Rubber compounds that are too thick for brushing onto the model may be thinned by the addition of a very little clear, cold water. If a considerable amount of the ammonia has evaporated from the compound, it may be thinned by using a 5 per cent solution of ammonia to insure against coagulation.

PLASTELINE MODELS

Rubber molds are often made over plasteline models. The rubber and plasteline usually adhere so that the mold is coated internally with plasteline on removal. It may be cleaned by scraping and by washing the plasteline off with alcohol. This difficulty can be entirely avoided by thoroughly chilling the work before removing the mold. If possible, it should be frozen. The mold will then be found to separate cleanly from the plasteline.

PLASTER-CASTING

Essentially, the process of making a cast consists of mixing plaster and water together, pouring the mixture into a mold, and allowing it to set. Most of the defects occurring in casts (given an accurate mold) are caused by bubbles and pockets of air trapped against the surface of the mold.

In order to reduce the number of air bubbles to a minimum, it is important that the plaster mixture be prepared as free from air as possible. It should also be smooth and creamy (free from lumps), so that it will flow into constricted areas. The process of mixing plaster in water is generally accomplished in the following manner:

A quantity of clean water (about two-thirds the volume of "mix" desired) is placed in a clean, suitable container, usually an enameled pan or rubber plaster bowl. The plaster is sifted in so that it settles into the water almost as rapidly as it falls. The mixture is rich enough for most purposes when a thin scum of plaster begins to form on the surface, or when no more plaster will settle freely into the water. The mixture is allowed to stand until the surface scum has become saturated. The bowl is then jarred to cause the surface plaster to settle into the mixture. The mix may then be stirred slowly until it has a creamy appearance and is free from lumps. It is then ready to be poured into the mold.

In pouring the plaster, the mold should be tilted so that the plaster may flow gently down the inside rather than falling directly to the bottom.

The time required for plaster to set varies somewhat, according to the temperature of the water, the richness of the mixture, and the grade of plaster used. Molding plaster sets in fifteen or twenty minutes. Dental plaster sets more quickly. Higher temperature of the water promotes quicker setting. Dirty tools or water, or tools coated with set plaster usually quicken the setting time. Salt acts as an accelerator. Glue or alcohol acts as a retarder, slowing the setting of the plaster according to the amount added to the mixture.

Casting in rubber molds.—The process of making hollow casts is exactly suited to the characteristics of the rubber mold, and by making use of this process the casting may be done successfully with or without a rigid matrix. Rubber molds although flexible are elastic and have considerable ability to retain the shape in which they are formed. For this reason thin rubber molds are capable of producing accurate casts without being entirely supported by a matrix. It is often impracticable to construct a matrix so that it completely supports the mold, since in the case of complicated models the matrix would need to be made in almost as many sections as a plaster piece-mold in order to be removable.

To obtain hollow casts of uniform thickness, the plaster is poured into the mold in successive batches. The first application should form a thin shell approximately one-sixteenth of an inch thick inside the mold, all excess plaster being drained off. The second application clings to the freshly set plaster in the mold with greater facility, and forms a considerably thicker shell. If the process is repeated a third time, the shell attains a thickness of one-fourth inch or more, which will be found sufficiently strong for all practical purposes.

The process is adaptable to the molding technique here described because the rubber is sufficiently rigid to support the weight of the small quantity of plaster required for the initial coating without distorting the mold. On setting, it adds to the rigidity of the mold, and serves as a sort of internal matrix. When pouring the second application care needs to be taken in handling the mold so as to prevent damage to the thin first coating. The plaster should be poured in small quantities, rotating the mold each time in order to distribute the weight of the fresh plaster over the mold. Allowing too much plaster to accumulate in the lowest portion of the mold is likely to crack the initial coating. After the second batch of plaster has set, the final application may be made in a sufficient quantity to produce a cast of suitable strength. If desired, the mold may be completely filled.

The hollow-cast technique provides a highly successful means of reducing the danger of imperfections caused by air traps in complicated molds. The act of turning or rotating the mold in every direction aids the plaster to flow into every part of the mold. In this connection it is advisable to use a rather thin mixture for the second coating in casts where the passages between relatively large areas are very constricted; otherwise, the second coating may fail to reach some areas, since it loses its ability to flow rather quickly on contact with set plaster as the latter quickly absorbs water from the fresh mixture.

Treatment of hollow casts.—Hollow casts have the advantage of being light to handle and they require less plaster in the making. They are sufficiently strong and serviceable for most purposes. They have the disadvantage of being more easily damaged than solid casts. However, certain precautions may be taken to increase their durability.

There are now on the market several brands of extra hard plaster of which Hydrocal[1] is an example. These hard plasters function very well in casting, and may be used for one or all the batches in the hollow cast. The strength of ordinary plaster may be greatly increased by mixing it in water near the boiling point. Treated in this manner it sets about 20 per cent faster than plaster in cold water.

A small amount of dextrine solution[2] may be mixed with the plaster intended for the secondary coatings. It acts as a bonding agent between the layers. It is not advisable to use dextrine in the first coat, since it increases the surface tension and viscosity of the plaster, thus increasing the danger of air bubbles.

The casts may be impregnated with a thin solution of white shellac, after they have been thoroughly dried. Since the walls of the cast are thin the shellac has an opportunity to penetrate the plaster completely, provided the casts are submerged in it and allowed to remain a few hours.

Large and small casts.—Molds too large to manipulate in distributing the plaster in the casting process require a special technique. The mold is made in two sections, each section being reinforced by a matrix constructed so that it supports as much of the mold as possible. In casting, each half of the mold is coated with an even thickness of plaster which may be either poured or brushed on. Care should be taken not to apply more plaster than the mold will bear in areas that are not reinforced by the matrix.

[1] United States Gypsum Company. Hydrocal cement plaster.

[2] Dextrine, Globe 160, Corn Products Refining Company, one part to five parts water, stirred cold, heated to about 190° F. and allowed to cool.

After the initial coating has set, it is reinforced with plaster and tow, or other fiber, so that the two sections will be light enough to handle and strong enough to be durable. The edges of the sections of the cast should correspond very closely with the edges of the molds. After the plaster has hardened, the molds are removed, and the two sections of the cast fitted together and cemented with plaster. If the work is carefully done the joints will fit closely and be hardly noticeable. At any rate, in such a case the advantage of having a light cast outweighs the disadvantage of possible slight mutilation along the joints.

Minute fossils, such as jaws and maxillaries of very small animals, present a special set of obstacles to be overcome in casting. The major one arises from the difficulty encountered in filling the interstices of the mold with plaster. Use of the separating agents required by most molding compounds almost invariably obscures detail. Also, it may be difficult to apply the molding compound to the model in a satisfactory manner. The rubber technique surmounts these obstacles so well that it is actually easier to cast very small jaws and maxillaries than it is to cast larger ones. For convenience in handling, a slender needle may be cemented to the model with celluloid cement. A thin solution of rubber is carefully brushed on to form the first coating. As soon as this coating has been applied, the surplus should be blown off as far as possible. This action will expose any uncovered areas or air bubbles. Such areas should be carefully filled and the entire model again coated. The mold is then built up to the required thickness and allowed to dry. After drying, the mold is cut open along the line of the needle, and far enough to permit easy removal of the model. In casting, the mold is turned inside out, thus exposing and opening the minute interstices which can then be readily coated with plaster. It is then returned to its normal form and the filling is completed. The excess plaster, if any, is drained off until the edges of the mold meet naturally. It may then be set aside until the plaster has hardened. Since no separating agent is used when making rubber molds, the surface detail of the model is so perfectly reproduced that the casts compare favorably with the model when examined under the microscope.

CONCLUSION

The technique herein outlined is not a solution to all the problems that may be encountered in making plaster casts. Nevertheless, rubber has proved of such usefulness that it may safely be said that no other material offers a comparable combination of advantages and of freedom from faults. The most outstanding advantages of liquid rubber may be enumerated as follows: simple technique of construction; adaptability; superior durability of molds; excellent reproduction of minute detail; and minimum damage to the object being cast.

The procedure of making rubber molds is adaptable to a laboratory routine in the hands of a single person. The work of constructing a mold may be carried on along with other projects on hand since the operations involved need but little time and attention to complete any one step. Furthermore, mold-making may be continued or interrupted at any stage; it can be done at odd moments, and need not represent a time-consuming burden. By the use of this technique it is feasible for any institution to produce useful and accurate casts without the necessity of obtaining the services of a skilled molder, or of maintaining a special casting department.