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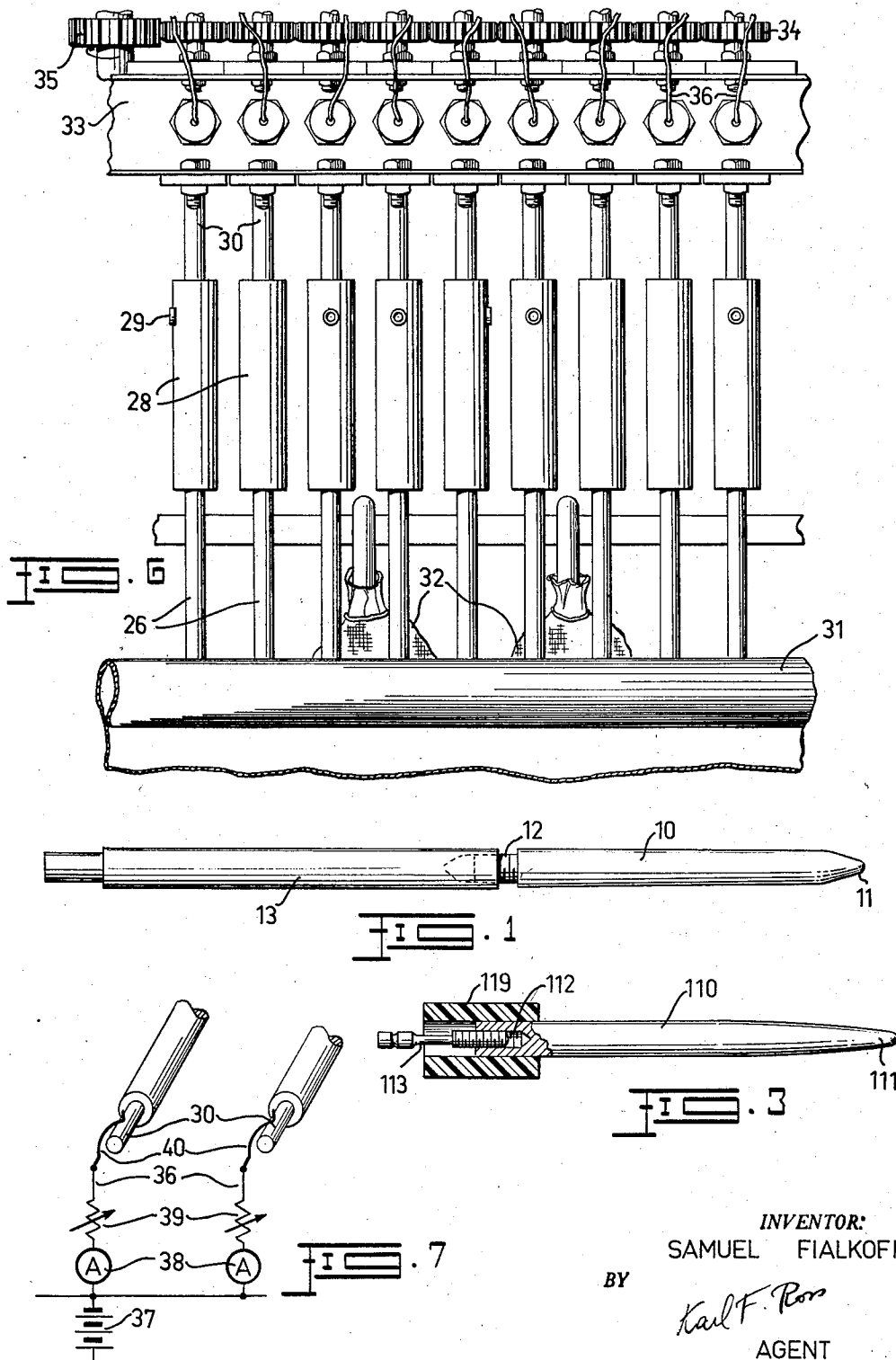
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ELECTROFORMING SYSTEM

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2 Sheets-Sheet 2



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ELECTROFORMING SYSTEM

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1 Claim. (Cl. 204—9)

My present invention relates to a process and an arrangement for electroforming hollow bodies adapted to be used as cavities for the serial production of molded objects, especially of objects requiring precise dimensioning and having such shapes as to make impractical the production of a female die by casting and machining. Objects of this character include, by way of example, precision gears made from plastic material (e.g. nylon), plastic reflectors with a multiplicity of tiny facets, or individual components of larger units designed to fit closely together, such as fountain pen barrels.

It is known that a cavity accurately reflecting the shape of a desired object can be produced by electroforming a metallic body around a mandrel corresponding to such object. This process, however, is expensive especially when used for the production of a multi-cavity die, owing to the necessity of providing separate, identical mandrels for the several cavities; alternatively, of course, a single mandrel might be used in succession for all the cavities, yet the length of time required (usually of the order of several days per cavity) generally renders such a procedure impractical.

My present invention has for its object the provision of an improved electroforming system enabling the substantially simultaneous formation of a plurality of cavities with the aid of a single mandrel.

In accordance with this invention, I form only a relatively thin shell around the mandrel which is just strong enough to resist deformation in handling; this shell is then stripped from the mandrel and is thereafter used as a cathodic core upon which additional material is electrodeposited until a cavity of desired wall thickness is obtained. At the same time the original mandrel becomes available for the formation of any number of additional cavities in like manner.

Preferably, according to another feature of this invention, the inner shell is formed as a relatively hard deposit whereas the rest of the hollow body is of a softer composition that can be produced more cheaply. Thus, a dense, stress-free nickel deposit from a sulfamic-acid solution, as described in U. S. Patent No. 2,318,592, might be used for this inner shell; the outer layer may then be formed, for example, from a nickel bath containing a mixture of boric and hydrofluoric acids. The invention is applicable, however, to metals other than nickel.

Reference will now be had to the accompanying drawing for a more detailed description of an arrangement for carrying out the process according to the invention. In the drawing:

Fig. 1 shows a mandrel adapted to be used in my process, together with a holder therefor;

Fig. 2 shows, somewhat diagrammatically, a plating bath for the formation of the inner shell;

Fig. 3 illustrates an alternative manner of preparing the mandrel of Fig. 1 for use in the bath of Fig. 2;

Fig. 4 shows a device for stripping the inner shell off the mandrel;

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Fig. 5 illustrates the mounting of the inner shell on a holder preparatorily to the deposition of an outer layer thereon;

Fig. 6 illustrates part of an array for the simultaneous buildup of a plurality of cavities from inner shells mounted as in Fig. 5;

Fig. 7 diagrammatically illustrates the electrical connections to the shell holders of Fig. 6; and

Fig. 8 shows, partly in section, the finished cavity.

The mandrel 10, Fig. 1, has been shown as in the form of an elongated rod pointed at one end 11 and provided with screw threads 12 at the opposite end for attachment to a holder 13. The original diameter of this mandrel is slightly less than that of the object to be reproduced, so as to allow for a passivating coating, such as a chrome layer, of small wall thickness (e.g. of the order of 0.01 mm.) to be applied to its surface. Also, the mandrel should be somewhat longer than such object at its threaded end. The body of mandrel 10 is preferably not cylindrical but slightly tapered to facilitate the subsequent stripping of the electroformed shell therefrom. A preferred material for the mandrel is oil-hardened tool steel.

In Fig. 2 the lower end of holder 13, along with the joint between the holder and the chrome-plated mandrel, has been wrapped in adhesive plastic tape 19 and the mandrel 10 has been immersed in an electrolytic solution 14 within a container 15. A suitable anode, e.g. of nickel, is enclosed within an electrolyte-permeable bag 16 and connected to positive potential via a lead 17. Another lead 18 connects negative potential to holder 13 and, thereby, to mandrel 10.

A layer 20, deposited cathodically on mandrel 10, constitutes the inner shell that is to be stripped from the mandrel after having attained a suitable wall thickness which should be not more than about one-half the wall thickness of the finished cavity, e.g. about 2.5 mm. When this shell has been completed, holder 13 and mandrel 10 are withdrawn from the bath 14 and the wrapping 19 is removed to expose a shoulder 21 at the upper end of the shell. Next, all surface irregularities such as burrs and dendrites are removed from the shell 20, after which the holder 13 is detached from the mandrel 10 and a plate 22 (Fig. 4), having an aperture with a diameter slightly larger than that of the chrome-plated mandrel, is brought down over the threaded end 12 thereof into contact with shoulder 21. Plate 22 forms part of a stripper mechanism comprising a chuck 23 adapted to engage the threaded end 12, this chuck being movable with respect to a set of bars 24 bearing from above upon plate 22. Thus, when the chuck 23 is raised relatively to the bars 24 as indicated in dotted lines, shell 20 is stripped off mandrel 10.

In Fig. 3 there has been shown a modified mandrel 110 whose end 112 is threaded internally rather than externally. A holder 113 is screwed into this threaded end, serving (as does holder 13 of Figs. 1 and 2) both for the suspension of the mandrel and for the establishment of electrical contact thereto. A plastic sleeve 119 takes the place of wrapping 19 by surrounding the threaded end of the mandrel and defining the location of the upper edge of the shell to be formed thereon. The portion of holder 113 projecting beyond sleeve 119 may be engaged directly by a suitable stripping device, similar to chuck 23, for removing the shell from the mandrel by pushing the sleeve 119 toward the pointed end 111 thereof.

Once the shell 20 has been formed with the aid of mandrel 10 or 110, it is filled almost to the top with water as shown at 25 in Fig. 5. A tightly fitting rod 26, e.g. of brass, is then inserted into the open upper end of the shell and pushed down into contact with the

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water level. A wrapping 27, similar to tape 19, is wound around the joint between shell 20 and rod 26, after which the assembly shown in Fig. 5 may be placed along with a number of other, identical units in a plating bath serving for the final buildup of the cavities, such as a nickel bath containing boric and hydrofluoric acids as mentioned above. Rod 26 is provided, for this purpose, with an extension 28 having a setscrew 29 enabling its attachment to an individual, vertical shaft 30 as shown in Fig. 6.

In Fig. 6 the lower ends of the rods 26, with their respective shells 20 (not visible) attached, are immersed into a plating tank 31 containing a suitable electrolytic solution as well as anodes enclosed in permeable bags 32. The shafts 30 are rotatably lodged in a mounting frame 33 and carry meshing pinions 34 driven from a main gear 35. Current is supplied to the shafts 30 and, thereby, to rods 26 and shells 20 over individual conductors 36. The water core 25 prevents the collapse of the shell 20 in the tank under hydrostatic pressure from the electrolyte and at the same time improves the conductivity of the shell.

It is desirable, though not essential, that the current supplied to each conductor 36 be individually adjustable. For this purpose there has been illustrated in Fig. 7 a source of power, shown schematically as a battery 37, whose negative terminal is connected through respective ammeters 38 and associated rheostats 39 to the several conductors 36 (only two shown) terminating in brushes 40; these brushes make conductive contact with respective ones of the shafts 30. In this manner it will be possible to vary the current density at each cathode, whereby different densities may be employed at different stages of formation even if electrodeposition was not started simultaneously for all the shells 20.

The final product is shown in Fig. 8. It comprises the inner nickel shell 20, defining the cavity 41, and an outer nickel layer 42 in intimate contact with this shell.

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The surface of cavity 41 is, of course, an exact replica of the surface of the chrome-plated mandrel 10 (or 110). The density of layer 42 may be appreciably less than that of shell 20.

5 The invention is, of course, not limited to the specific arrangements described and illustrated but may be embodied in various forms without departing from the spirit and scope of the appended claim.

I claim:

10 A process for forming a hollow body adapted to serve as a cavity for the molding of replicas of an object to be reproduced, comprising the steps of preparing a mandrel conforming to the desired object, electroforming a complementary metallic shell of limited wall thickness
15 around said mandrel, removing said mandrel from said shell, filling said shell with water, immersing the so filled shell in an electrolytic solution, and cathodically depositing additional metal from said solution on the outer surface of said shell until the wall thickness of the latter
20 has been at least doubled.

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