

June 16, 1936.

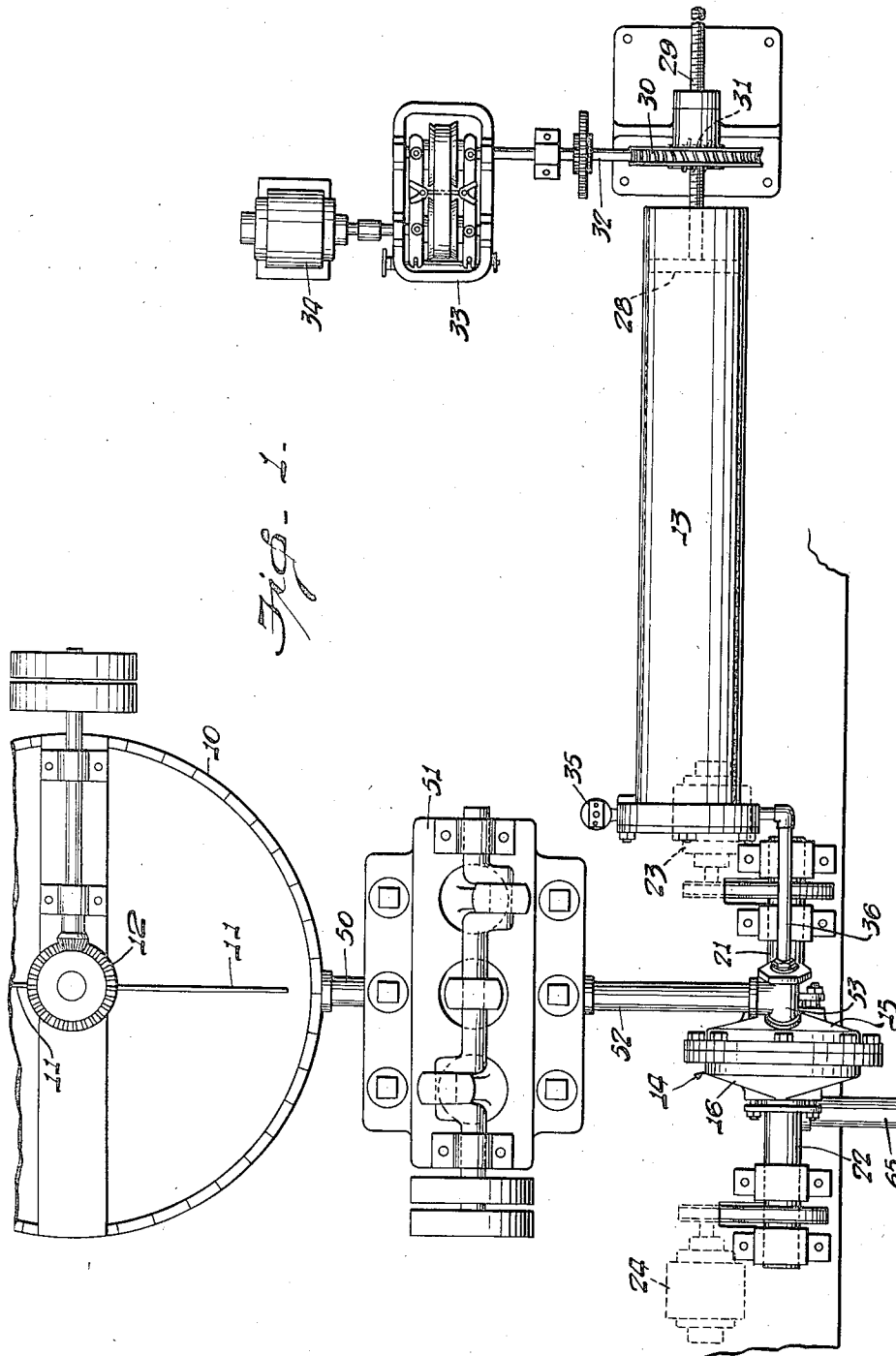
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2,044,332

APPARATUS FOR FORMING CERAMIC PRODUCTS

Filed July 13, 1934

4 Sheets-Sheet 1



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4 Sheets-Sheet 2

Fig. 2.

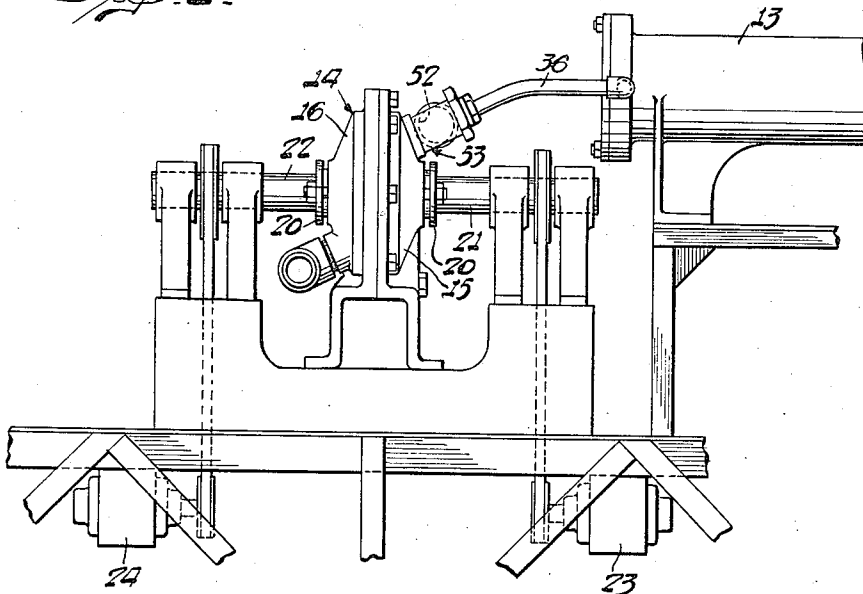


Fig. 3.

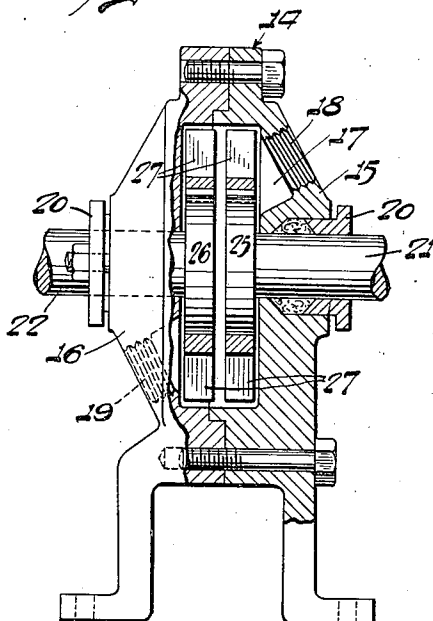
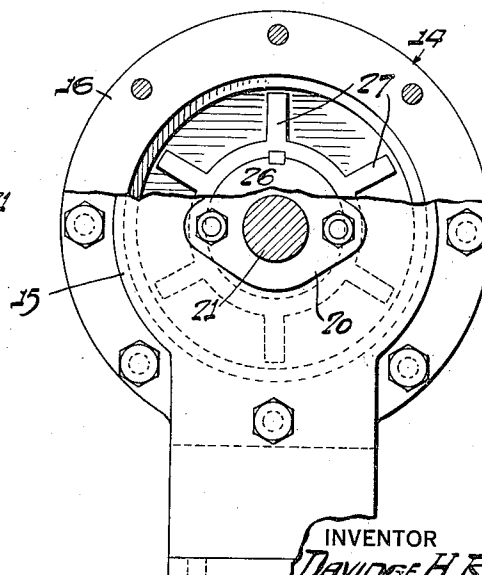


Fig. 4.



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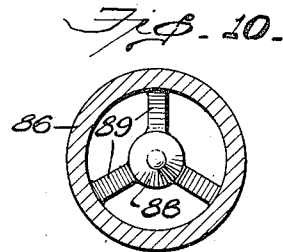
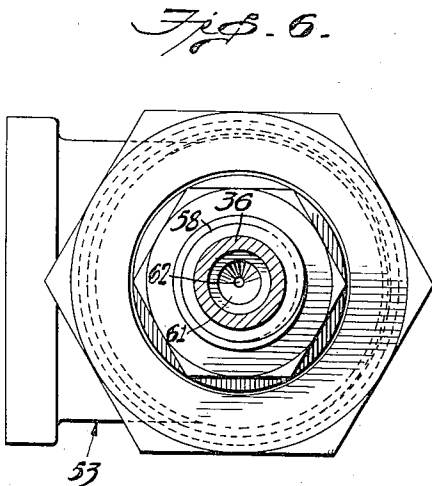
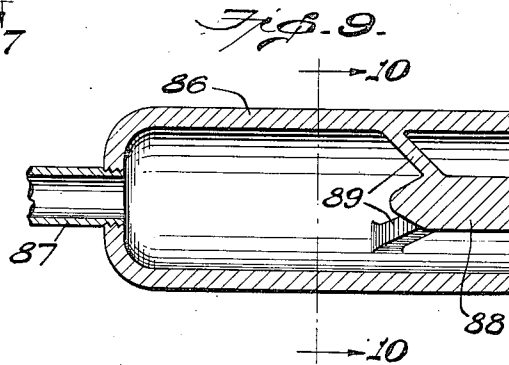
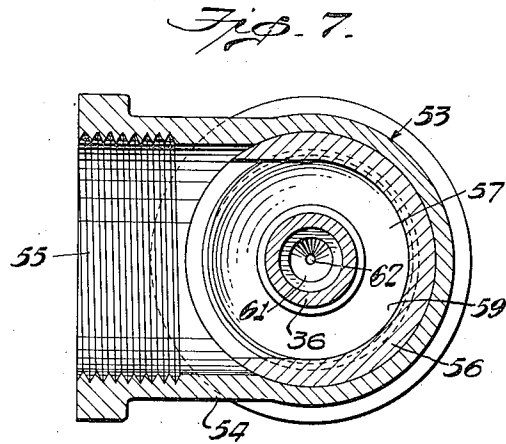
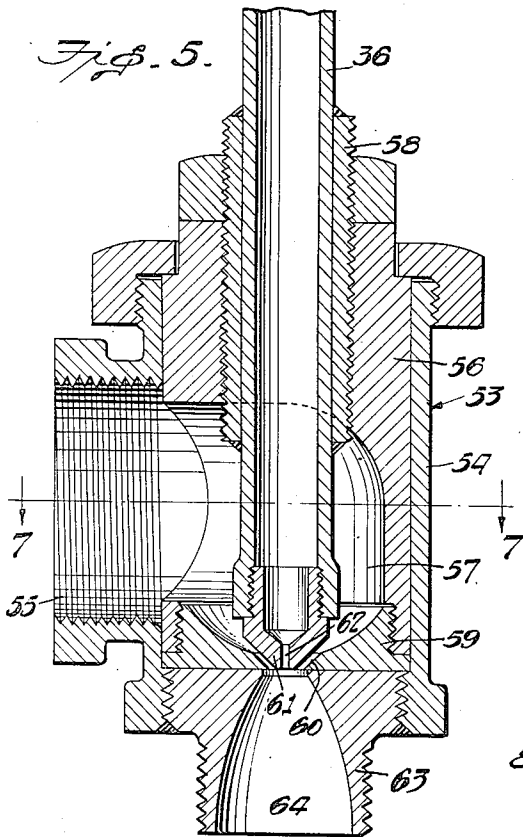
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4 Sheets-Sheet 3



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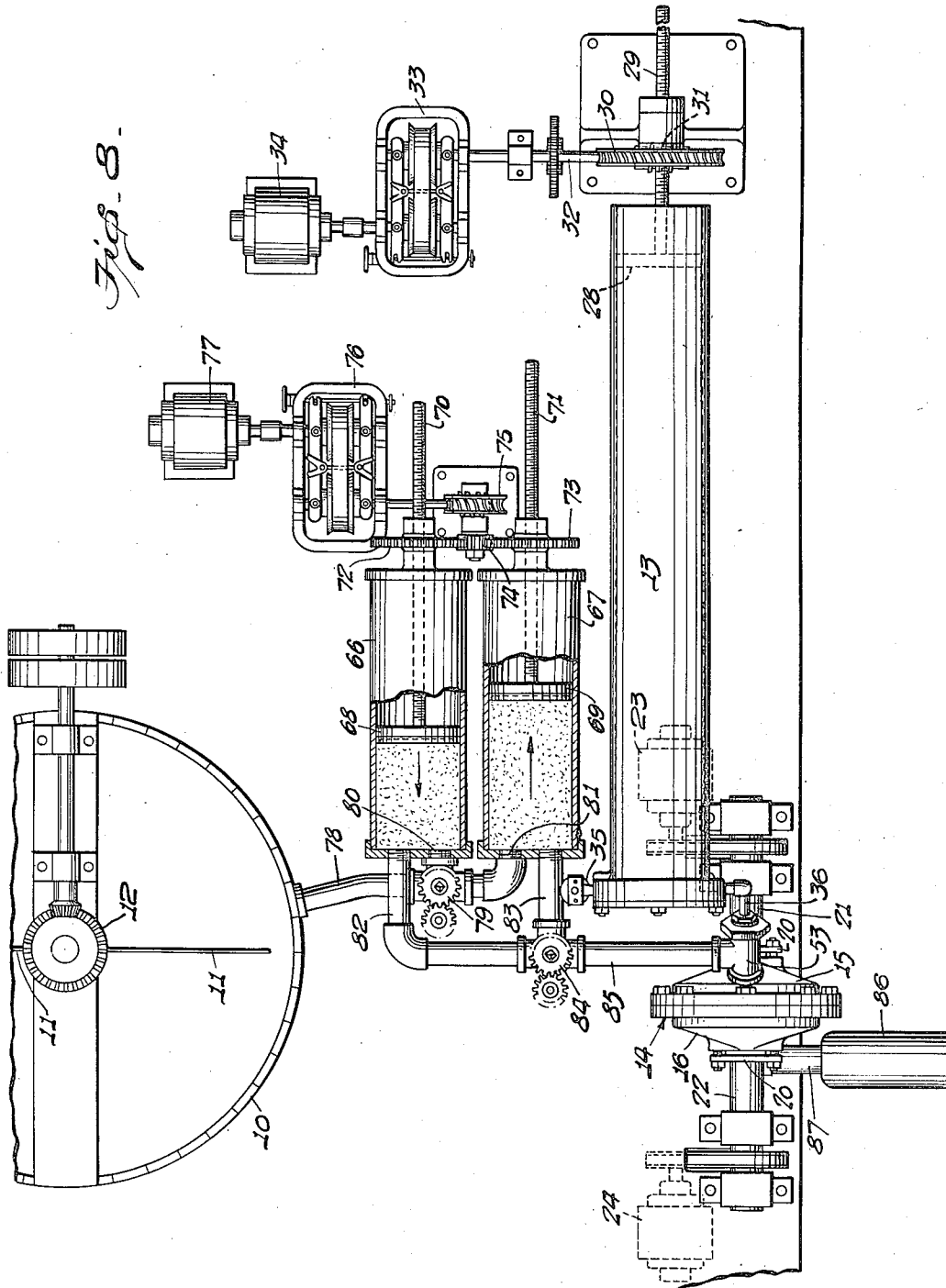
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APPARATUS FOR FORMING CERAMIC PRODUCTS

Filed July 13, 1934

4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE

2,044,332

APPARATUS FOR FORMING CERAMIC PRODUCTS

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Application July 13, 1934, Serial No. 735,087

7 Claims. (Cl. 259—9)

The invention relates to the manufacture of ceramic ware from porcelain or its equivalent and has special reference to the production of porcelain insulators particularly designed for high tension transmission lines and equivalent adjunctives thereto.

Before proceeding with the specific disclosure of the apparatus dealt with in this application, it will be necessary to describe in some detail the methods heretofore in general use among insulator manufacturers.

Porcelain used for high voltage work is a vitrified material obtained by the combination of certain types of finely ground feldspar, silicon oxide, and plastic clays which after proper shaping, is fired to a high temperature. The quality of the final product is absolutely dependent upon a homogeneous mixture of the raw materials before firing. There are, essentially, two methods in general use for bringing this about.

In the wet process plastic method the proper proportions of ingredients are weighed out and introduced into a large ball mill where they are ground together with a certain amount of water. The water content is of great importance as it has been found that enough must be used to produce a thick cream-like mass in the mill if the required mixing uniformity is to be maintained. Ordinarily, the density of the "slip" which is the name commonly used to designate the mixture in the mills, is kept around 1.5.

In order to form the desired insulator shapes it is now necessary to reduce the water content of the slip to the point where a plastic mass is produced, capable of holding its shape after molding. This is accomplished by pumping the slip into filter presses, thereby removing all but approximately 20 to 22% of the water, the material thus produced being termed "clay". The clay comes from the filter presses in the form of cakes which are subsequently run through a pug mill which mixes the cakes together and extrudes the mass as a clay cylinder which is cut off in individual lengths of sufficient size for pressing to shape in plaster molds. After pressing, the clay is left in the plaster mold which gradually absorbs moisture from the clay, causing the clay to harden sufficiently so that in a few hours it may be removed and handled through the subsequent plant operations.

In the casting process, the preparation of the materials is the same up to the ball mills. Here, however, advantage is taken of a chemical phenomenon called "deflocculation". It has been known for a long time that the addition of cer-

tain alkaline salts such as sodium carbonate and sodium silicate to a clay slip will produce a rather startling effect on the viscosity. Such a marked decrease will take place in the latter characteristic as to make possible a slip that will readily pour, but which may have no more or less water content than the pugged clay, which has been described. The casting process is based upon this fact.

About .1 to .3 of 1% of an alkaline salt is added to the water in the ball mills which as a consequence may be considerably reduced, the usual casting slip having a density of approximately 1.8. In spite of this increase in weight such slip is little more difficult to pump and handle than that used for making a plastic body due to the effect of the salts. After lawning and passing over an electro-magnet which removes any iron particles, the casting slip is stored in tanks and is ready for use. The casting process ordinarily consists of pouring this slip into plaster molds of the required shape, with or without a plaster core. After a certain length of time the plaster absorbs sufficient moisture to harden the cast enough to allow it to be removed from the mold and handled through the rest of the factory routine.

All of the above sounds relatively simple and only those who have worked in ceramics can appreciate the difficulties attendant upon the various manufacturing steps. The filter cakes that go to make up the wet process body must be absolutely uniform. If, for any reason the canvas bags which do the filtering are not uniform, or if they are not scrupulously washed out at regular intervals, the different cakes will have uneven water contents and after pugging the clay will have a tendency to shrink unevenly, thus causing strains and cracks of various sorts. Again, if the slip which is pumped into the presses varies in viscosity due to infinitesimal amounts of soluble salts, so hard to control, in mined materials, the pressing will be irregular and this may be reflected in various types of trouble, through the shop. Extreme care must be exercised to prevent dirt and all types of foreign matter entering the mix at any point.

It is obvious that irregularity of the filter cakes will make trouble in the pug mills. Many special devices have been tried in an effort to correct pug mill difficulties but in the final analysis the proper functioning of a mill depends upon the physical characteristics of the clay. Thus, plant control is of the greatest importance during the preliminary preparation. If the body delivered

to the pug mills is too soft, occluded air pockets will be found in the extruded clay. On the other hand, if it is too hard a crumbly laminated structure will result. It has been found that the proper maintenance of equipment and painstaking supervision of every step in the preparation of the mix are factors upon which all the subsequent manufacturing steps depend. Necessarily, considerable expense is involved in plant equipment and technical supervision and in spite of everything, there is much to be desired from a uniformity standpoint. In addition, pug mill laminations have been a source of trouble in every branch of the ceramic industry and it is only by the strictest plant control that they may be controlled.

In the wet process casting method the molds which are used must of necessity be very bulky. The time interval necessary between the pouring and removal of the casts is in some cases as much as forty-eight hours for the bigger pieces. Moreover, the shapes which can be made are limited because of the fact that the moment the clay comes in contact with the plaster shrinkage commences and unless the mold is designed in such a way as to take care of this the clay will pull itself apart. Great attention must be given to gating the molds, more even than for casting iron. Very often the cost involved is prohibitive, even if the resultant product successfully meets all other requirements.

It may be readily conceded that there is a place in the industry for both the casting and the plastic process, each of which is essential to the manufacture of certain designs. To make this point clearer, an ordinary fuse cut-out box can be made only by casting (the dry process method not being considered) while a small threaded pin-hole distribution insulator cannot be cast but may be readily manufactured by the plastic plunging method. The present invention deals with a fundamental improvement in the latter process.

Deflocculation has been briefly described. It is with the converse or reversal of this action that I am concerned in the present invention. If, for instance, a small amount of acid is added to a quantity of casting slip the alkalinity of the slip will be destroyed and immediately flocculation of the particles will occur which will make itself apparent by a curdled appearance much on the order of curdled milk. The reaction is so sudden that the resultant mixture is far from uniform. If, however, a milder reagent is used, it is possible to mix it up sufficiently to produce a fairly homogeneous mass somewhere between casting slip and plastic clay. The value of this reaction was recognized by Dr. A. V. Bleininger some time prior to 1924, who made use of it in speeding up the casting time of certain ceramic materials, his method being disclosed in Patent No. 1,528,908, granted March 10, 1925.

In the companion application of myself and Kurt Wetzel there is disclosed a method of mixing up a porcelain body and shaping it without the necessity of using filter presses or pug mills. It occurred to us, as set forth in said application, that if a flocculent or reflocculent could be discovered which would have an action sufficiently delayed to allow thorough mixing with a clay slip without curdling and which would then react completely to restore the full plasticity of the clay so that it could be plunged or "jiggered" in the usual manner that the problem might be solved. As already pointed out, a casting slip

may be readily mixed until it is homogeneous throughout, although its water content may be the same as or less than that of a plastic body. If, therefore, the plastic characteristics of such a slip could be satisfactorily restored, the necessity for filter presses could be eliminated.

In the actual carrying out of the method set forth in said companion application, the casting slip is prepared in accordance with usual ceramic practice by adding plastic clays and other ingredients to a measured amount of water to which a fraction of 1% of alkali has been previously added. The viscosity and specific gravity of the clay slip must be observed and governed very closely. Reflocculating agent necessary for the successful carrying out of the process or method is the difficult problem.

Flocculation or gelation of a deflocculated slip can be accomplished by a great variety of chemicals such as organic or inorganic acids, or salts, or an excess of alkali or alkali salts. All of these substances, however, have an immediate reaction upon the slip, that is, they "ball up", or curdle the slip instantaneously. Action of this nature makes the flocculating process impossible to operate. Of the large number of chemicals examined, only a small group of earth alkali compounds seem to offer possibilities. It was finally discovered that calcium and magnesium compounds such as limestone, magnesite or dolomite, when fired to a temperature sufficiently high to form the oxides, gave results which were very promising. Compounds of this nature introduced into the slip by means of the apparatus which has been described do not curdle the slip and after a certain length of time which can be regulated by the chemical and physical characteristics of the compound render the clay which has been poured into molds sufficiently plastic for plunging. This was the result I have been working for.

The compounds used consist of calcium oxide or magnesium oxide or a combination of both, either pure or with a certain percentage of silicon oxide, iron oxide, aluminum oxide, or alkali oxides, which occur either naturally in the compound used or which are introduced by intimate mixing previous to firing. It was found that the percent of silicon oxide, aluminum oxide, etc., present in the calcium or magnesium compound and the firing temperature had a very marked effect upon the setting time of the slip and that these factors had to be kept within certain limits dependent upon changes in the chemical and physical characteristics of the slip in order to maintain the desired setting time of the slip.

These combinations as described above are fired in the kilns. After this they are weighed out in the desired proportions and combined in a ball mill with kerosene and some kind of grease such as lanolin or vaseline so that a consistency is obtained approaching that of thick cream. The kerosene and grease serve as a carrier for the dry powder and eliminate the possibility of air bubbles and lack of homogeneity which occur if attempts are made to mix the dry powder with the slip. Besides this an organic carrier as mentioned above will penetrate the flocculent thoroughly and form an impermeable film on each particle which will further delay the reaction of the flocculent with the clay slip until sufficient time elapses for the mixture to run from the machine into the molds. Many organic fluids can be used for this purpose such as benzol, benzine, gasoline, coal oil, paraffin oil, fuel or lubricating oil, wax, cersin, carbon tetrachloride and animal

and vegetable oils. Such carriers prevent the flocculating reagent from absorbing moisture from the air and it, therefore, may be prepared ahead of time and stored indefinitely.

As an actual example of what I am using with great success the following combination may be given. Natural limestone (calcium carbonate) containing approximately 97% calcium oxide and 3% of silicon oxide, iron oxide, aluminum oxide, magnesium oxide and alkali oxides fired in the kiln. This fired compound was mixed with kerosene and lanolin as has already been described so that the final product has the consistency of cream. However, as mentioned above, there may be considerable variation and this illustration is not to be considered limitative.

In order to use such a deflocculating reagent it was necessary to develop a means of mixing it thoroughly and quickly with the casting slip. Batch mixing is unsatisfactory since it is impossible to get a homogeneous mixture in the time interval before setting commences and moreover, after every batch the residue sticking to the container must be thoroughly cleaned off, as otherwise hard lumps would be mixed into the succeeding batch.

It is with all of the above facts in view that I have devised the present invention which has for its general object the provision of an apparatus by means of which the foregoing described method, fully set forth in said companion application, may be carried out.

An important object of the invention is to provide an apparatus involving the combination of means for pumping clay slip at high speed into a mixer which likewise operates at tremendously high speed, and slow acting high pressure means for injecting into the stream of clay slip a flocculating or reflocculating agent which is introduced immediately prior to the admission of slip to the mixer so as to obtain a thorough permeation of the deflocculated slip by the flocculating or reflocculating agent.

Another object of the invention is to provide an apparatus for carrying out the above described method and which in one form involves simply a pump means for supplying clay slip to the rapidly acting mixer and which, in another form, involves the provision of extremely high pressure feed means for the clay slip, this high pressure means being used under circumstances where an ordinary pump would be inadequate, such as for instance when extruding the reflocculated clay in tubular form, such high pressure means embodying alternately acting motor driven pistons which are screw operated and which reciprocate within cylinders into which the clay slip is drawn and from which it is subsequently expelled into the mixing device, the system including an arrangement of synchronously operating control valve means.

Another object of the invention is to provide a mechanical means for mixing the flocculating or reflocculating agent with the previously deflocculated clay slip at such a tremendously high speed that thorough permeation of the clay slip by said agent will result so that homogeneity in the output from the mixing device will be obtained.

A still further object is to provide an apparatus of this character in which the mixing device may have associated therewith any one of a selected number of different types of nozzles depending upon whether it is desired to express or form solid or tubular porcelain members, certain types of

nozzles being usable for producing, but in better form, the type of clay piece extruded from a pug mill and another or other types of nozzles being usable in case it is desired to form porcelain tubes for various purposes such as are required for bushings, strain insulators of certain varieties, and the like.

A still further object is to provide an apparatus for carrying out the method involving the combination of the various instrumentalities above mentioned, together with change-speed drive mechanisms for the valves, etc. and other auxiliary or ancillary devices for governing the movement of the various parts in order to attain the best results which can possibly be accomplished by the employment of the apparatus.

An additional object is to provide a mechanism or apparatus of this character which will, when the ultimate result is considered, be comparatively simple and easy to manufacture, assemble and control, positive in action, efficient and durable in service, and a general improvement in the art.

To the attainment of the foregoing and other objects and advantages, the invention preferably consists in the details of construction and the arrangement and combination of parts to be hereinafter more fully described and claimed, and illustrated in the accompanying drawings, in which:

Figure 1 is a plan view of an apparatus capable of carrying out the invention, parts being broken away for the sake of clearness,

Figure 2 is a side view of a portion of what is shown in Figure 1,

Figure 3 is an end elevation, with most of the parts in vertical section, of the mixing device,

Figure 4 is a side elevation of the mixing device with portions broken away,

Figure 5 is a longitudinal sectional view through the means for mixing the flocculating or reflocculating agent with the clay slip,

Figure 6 is an end elevation thereof,

Figure 7 is a cross section taken on the line 7-7 of Figure 5,

Figure 8 is a plan view, with parts broken away and in section, showing a modified form of the invention,

Figure 9 is a longitudinal section through a discharge nozzle of a type to form tubular extrusions,

Figure 10 is a cross section taken on the line 10-10 of Figure 9.

Referring more particularly to the drawings, the numeral 10 designates a slip tank of any ordinary or preferred construction containing the usual paddles 11 driven by gearing 12 for the purpose of effecting agitation of the slip within the tank to prevent settling. The numeral 13 designates a tank or cylinder containing whatever flocculating or reflocculating agent is used, it being assumed, for the purpose of this description, that the slip within the tank 10 has been deflocculated by the addition of some proper percentage of an appropriate alkali.

In the carrying out of the invention I make use of a mixer of the rotary type designated as a whole by the numeral 14 and shown in detail in Figures 3 and 4. This mixer is represented as comprising a two or more part casing, the sections or parts being indicated by the numerals 15 and 16, these sections or parts being of such construction as to provide a space or compartment 17 having an inlet 18 and an outlet 19. Rotatable within suitable packing glands 20 at

opposite sides of the casing are shafts 21 and 22 which are individually driven through any appropriate transmission by motors 23 and 24 rotating in opposite directions. Within the chamber or compartment 17 the respective shafts 21 and 22 carry disks or wheels 25 and 26, respectively, provided with radial blades 27. It is intended that these wheels or disks 25 and 26 rotate in opposite directions, hence the reason for the separate motors 23 and 24. As a matter of fact it is intended that the wheels rotate at very high speed so that the blades 27 thereon will pass one another at the rate of something like 16,000 times per minute. Specific details of construction of this mixing device may of course be varied within wide limits, the only essential requirement being the high speed of rotation of the bladed wheels.

In association with this mixer I make use of a novel means for feeding to or injecting into the clay slip the flocculating or reflocculating agent contained within the tank or cylinder 13. Preferably this means comprises a reciprocatory piston 28 carried by a threaded piston rod 29. The rod 29 projects beyond the end of the cylinder and has threaded thereon a worm wheel 30, meshing with a worm 31 on a shaft 32 driven at a selected speed by a variable speed transmission mechanism 33 of a type known as the Reeves variable speed drive. The details of construction of this type of drive are shown but as it is a well known mechanical expedient it is thought that a specific description thereof should be unnecessary. The power for rotating the gears 30 and 31, and consequently moving the piston 28, may be conveniently derived from an electric motor 34 of suitable horsepower. The cylinder is provided with a fill pipe 35 which is of course normally closed, and is also equipped with an outlet pipe 36 leading to the mixing device 14 as will be explained.

This arrangement is so related that when the piston 28 is retracted within the cylinder 13 the cylinder may be filled with the flocculating or reflocculating agent which is introduced within the fill pipe 35. Of course it will be equally apparent that when by virtue of the motor 34 and change speed mechanism 33 the piston 28 is moved in the other direction the chemical within the cylinder 13 will be expelled through the outlet pipe 36.

It is intended that the flocculating or reflocculating agent within the tank or cylinder 13 be mixed with the clay slip at a point where the latter enters the mixing device 14. Connected with the slip tank 10 by a pipe 50 is a pump 51 which draws the slip from the tank 10 and forces it through a pipe 52 into the mixing device 14. Immediately in advance of the rotary mixing device 14 is a mixing nozzle indicated as a whole in Figures 1 and 2 by the numeral 53 and the pipe 36 connects with this nozzle. The preferred details of construction of this mixing nozzle are well illustrated in Figures 5, 6 and 7 wherein it will be observed that the device comprises a T 54 having a lateral inlet 55 with which the pipe 52 is connected. Within this T 54 is a body 56 having a passage 57 therein leading from the inlet 55 toward one end. Threaded through one end of this body 56 is a bushing 58 through which extends the pipe 36 leading from the cylinder 13. Within the opposite end of the body 56 is screwed a plug 59 having a central orifice or valve seat 60 with which cooperates a conical tip or nozzle 61 carried by the outlet end of the pipe 36, this nozzle having a very small hole 62 therein so that

it will be capable of ejecting a very fine stream of whatever flocculating or reflocculating agent is used and discharged from the cylinder 13 in the operation of the apparatus. It will be noted that the above described parts are adjustable and that there is a space between the conical tip 61 and the orifice or valve seat 60 through which space the clay slip must pass in order to enter the mixing device 14. The nipple 63 at the outlet end of the T 54, which nipple is screwed into the inlet 18 of the mixing device, is formed with an outwardly flaring recess 64 so that this entire combination is in the nature of a venturi. Connected with the outlet 19 of the mixing device 14 is whatever extrusion nozzle 65 is desired, depending upon the character of the intended product.

In the operation of the apparatus, it is of course to be understood that clay slip prepared in the usual or any preferred manner is contained within the tank 10 and is supposed to be in a deflocculated condition for instance such as results from the admixture of a small percentage of an alkali, in accordance with the discussion of the theory in the foregoing part of this specification. The clay slip is prevented from settling or is kept agitated by means of the rotary paddles 11. The pump 51 operates to draw the slip from the tank 10 and discharge it through the pipe 52 into the mixing nozzle 53 and thence into the rotary mixer 14. Owing to the constricted space between the conical tip 61 of the mixing nozzle and the orifice 60 it is apparent that the clay slip entering the mixing nozzle under high pressure will be ejected therefrom into the rotary mixer 14 at high velocity. At the same time, the motor 34 driving the variable speed transmission 33 will cause the piston 28 to be moved forward in the cylinder 13, or to the left when viewing Figure 1, and the flocculating or reflocculating agent will be ejected at very high speed and at high pressure through the small hole 62 in the tip 61. It is at this point, namely at the entrance to the flaring recess 64 in the nipple 63 which is at the entrance to the rotary mixer 14, that the flocculating or reflocculating agent is intimately commingled with the stream of clay slip, the pressure being the lowest at this particular point owing to the recess 64 which permits the intruding streams of clay slip and flocculating or reflocculating agent to come together. Immediately upon entering the rotary mixer 14, the mixture of clay slip and flocculating or reflocculating agent will be thoroughly agitated and commingled by the oppositely rotating bladed wheels 25 and 26 so that all portions of the clay slip will be subjected to the action of whatever chemical is used as the flocculating or reflocculating agent, absolute homogeneity being thereby obtained. Owing to the pressure behind the slip it will pass from the rotary mixer into the discharge nozzle 65 and as by this time the flocculating or reflocculating agent has been enabled to exert a chemical action on the clay slip which will operate to coagulate the same and restore its plasticity, a plastic clay will be extruded from the discharge nozzle 65.

The above described form of the device is satisfactory for the extrusion of the clay in the form of a rod or column. However, when it is desired to extrude the clay in tubular form it is quite conceivable that the pump 51 will not develop sufficient power for the purpose. In such an event I resort to the construction and arrange-

ment shown in Figure 8 of the drawings. In this figure there is employed the same slip tank 10, flocculent ejecting cylinder 13 and mixing device 14 as in the first described form, the only difference being the replacement of the pump 51 by a peculiarly and specially constructed mechanism for drawing the clay slip from the tank 10 and injecting it into the mixer. In carrying out this modification, I provide a pair of elongated cylinders 66 and 67 containing reciprocating pistons 68 and 69, respectively, carried by threaded piston rods 70 and 71. These rods 70 and 71 project beyond the rear ends of the cylinders and have threaded thereon gears 72 and 73, respectively, meshing with an intermediate gear 74 rotating with a worm wheel 75 with which meshes a worm, beneath it in Figure 8, driven at a selected speed by a variable speed transmission mechanism 76 preferably of a type known as the Reeves variable speed drive. The details of construction of this type of drive are shown but as it is a well known expedient it is thought that a specific description thereof should be unnecessary. The power for rotating the gearing and the change speed mechanism may conveniently be derived from an electric motor 77 of suitable horsepower. The arrangement of this portion of the apparatus is such that when the motor 77 is in operation the pistons 68 and 69 in the respective cylinders 66 and 67 will be reciprocated in opposite directions and at a low speed.

Leading from the slip tank 10 is a pipe 78 which connects with a control valve 79 from which lead branches 80 and 81 connected with the respective cylinders 66 and 67. Leading from the cylinders 66 and 67 are branch pipes 82 and 83, respectively, which lead to a control valve 84 from which extends a pipe 85 for conducting the clay slip into the mixing device 14, this pipe being connected with the inlet 55 of the nozzle 53 above described. The valves 79 and 84 are intended to operate synchronously and they are preferably moved into open and closed position, in sequence, by some suitable electric motor means, not shown in detail though the necessary gearing is indicated in Figure 8.

This form of the device or apparatus works in identically the same manner as the first described form except that the clay slip is forced into the mixer 14 by the action of the pistons 68 and 69 which are reciprocated slowly within the cylinders 66 and 67. Owing to the fact that these pistons are screw operated it is apparent that there will be a tremendous power developed for ejecting the slip into the mixing device. It will of course be readily understood that as one piston is advancing and forcing out the clay slip from either cylinder 66 or 67 the other piston will be retreating and will suck in a charge from the slip tank 10, the operation of the two pistons being in alternation but there being no stopping of the action or hiatus at the end of the stroke of either piston. It is clear that the clay slip passing through the pipe 85 from either of the cylinders and entering the inlet 55 of the mixing nozzle 53 will be subjected to the chemical action of the flocculating or reflocculating chemical which is ejected from the cylinder 13 as described in connection with the first form of the apparatus.

The principal reason for the employment of the high pressure double cylinder and piston mechanism above described is when the mixing device 14 is equipped with an outlet nozzle 86, shown in Figures 9 and 10, intended for the production of tubular extrusions, such a nozzle 86 is connected

with the outlet 19 of the mixer by a pipe 87. The outlet end of this nozzle 86 is shown as provided with a conical ended central member 88 supported in concentric relation to the body as by radial ribs or webs 89. Of course this type of nozzle will offer a far greater degree of resistance to the extrusion of the replasticized clay than the ordinary type of nozzle shown in the first form of the invention but the substitution of the alternately acting screw operated pistons for the simple pump of the first described form will take care of this increase so that rapid production in a satisfactory manner will be insured.

From the foregoing description and a study of the drawings it will be apparent that I have thus provided a comparatively simple and easily controlled apparatus for carrying out my method of porcelain production in a very simple, inexpensive and expeditious manner. The screw operation of the piston provided in the cylinder for effecting injection of the flocculating or reflocculating agent into the stream of clay slip will insure a constant pressure at all times in contradistinction to the objectionable pulsations which are a natural concomitant to the employment of an ordinary type of pump. Moreover, in the second form of the invention the motor driven valves which control the inlet and outlet of the clay slip into and from the cylinders move but slowly and at intervals spaced a considerable time apart so that actually there will be but little wear on the moving parts. Every precaution has been taken to insure the mixing together and chemical combination of the deflocculated clay slip and the flocculating or reflocculating agent at a high speed and at a high pressure so as to insure homogeneity in the output. It is thought from the foregoing that the construction, operation and advantages will be readily apparent to one skilled in the art without further explanation.

While I have shown and described the preferred embodiment of the invention, it should be understood that the disclosure is merely an exemplification of the principles involved as the right is reserved to make all such changes in the details of construction as will widen the field of utility and increase the adaptability of the device provided such changes constitute no departure from the spirit of the invention or the scope of the claims hereunto appended.

Having thus described the invention, I claim:

1. An apparatus for forming ceramic products, comprising the combination of a tank containing clay slip in a deflocculated condition, a reservoir containing a flocculating or reflocculating agent, a mixing nozzle connected with the reservoir, alternately operating pumps connected with the tank for forcing clay slip at high pressure into the mixing nozzle in the form of a stream, plunger means within said reservoir for injecting the flocculating or reflocculating agent in constant stream form at high pressure and at high velocity into the stream of clay slip transversely thereof at said nozzle, high speed rotary blade mixing means located beyond and connected with said mixing nozzle for mechanically mixing together the clay slip and said flocculating or reflocculating agent, and a discharge nozzle located beyond and connected with said mechanical mixing means for extruding the replasticized clay resulting from the chemical action of said flocculating or reflocculating agent on the slip.

2. An apparatus for forming ceramic products, comprising the combination of a tank containing clay slip in a deflocculated condition, a reser-

voir containing a flocculating or reflocculating agent, a Venturi mixing nozzle connected with the reservoir, pump means connected with the tank and mixing nozzle for forcing clay slip at high pressure into the mixing nozzle in the form of a stream, means operating within said reservoir for injecting the flocculating or reflocculating agent in constant fine stream form at high pressure and at high velocity into the stream of clay slip at the nozzle, high speed rotary means located beyond and connected with said mixing nozzle for mechanically mixing together the clay slip and said flocculating or reflocculating agent, a discharge nozzle located beyond and connected with said mechanical mixing means for extruding the replasticized clay resulting from the chemical action of said flocculating or reflocculating agent on the slip, said pump means comprising alternately acting cylinder and piston means, and synchronously operating power actuated control valves in the inlets to and outlets from said cylinder and piston means.

3. An apparatus for forming ceramic products, comprising the combination of a tank containing clay slip in a deflocculated condition, a reservoir containing a flocculating or reflocculating agent, a Venturi mixing nozzle connected with the reservoir, pump means connected with the tank for forcing clay slip at high pressure into the mixing nozzle in the form of a stream, means operating within said reservoir for injecting the flocculating or reflocculating agent in constant stream form at high pressure and at high velocity into the fine stream of clay slip in the nozzle, means located beyond and receiving from said mixing nozzle for mechanically mixing together the clay slip and said flocculating or reflocculating agent, and a discharge nozzle located beyond and connected with said mechanical mixing means for extruding the replasticized clay resulting from the chemical action of said flocculating or reflocculating agent, said mechanical mixing means comprising a casing having an inlet and outlet and enclosing rapidly oppositely rotated radially bladed wheels or disks disposed directly between the inlet and outlet for transversely cutting the stream of material passing through the casing.

4. An apparatus for forming ceramic products, comprising the combination of a tank containing clay slip in a deflocculated condition, a reservoir containing a flocculating or reflocculating agent, a Venturi mixing nozzle connected with the reservoir, pump means connected with the tank for forcing clay slip at high pressure into the mixing nozzle in the form of a stream, means operating within said reservoir for injecting the flocculating or reflocculating agent in constant fine stream form at high pressure and velocity and transversely into the stream of clay slip within the nozzle, high speed rotary means located beyond and connected with said mixing nozzle for mechanically thoroughly commingling the clay slip and said flocculating or reflocculating agent, and a discharge nozzle located beyond and connected with said mechanical mixing means for extruding the replasticized clay resulting from the chemical action of said flocculating or reflocculating agent on the slip, said mixing nozzle comprising a casing having an inlet at one side for the clay slip and having an axial outlet surrounded by a valve seat and leading to a flaring

discharge orifice, a pipe leading from the supply of flocculating or reflocculating agent and extending into the nozzle, and a small apertured tip on said pipe located adjacent said orifice and cooperating adjustably with said valve seat.

5. An apparatus for making plasticized clay objects, comprising, in combination, a tank containing clay slip in deflocculated condition, a reservoir containing a flocculating or reflocculating agent, a mixing nozzle connected with the reservoir, a pair of cylinders having inlet connections with said tank and outlet connections with said mixing nozzle, valves interposed in the inlet connections to the cylinders, outlet valves interposed between the outlet connections for the cylinders and said mixing nozzle, alternately acting power driven pistons reciprocable within said cylinders, the inlet and outlet valves for each cylinder being opened and closed alternately in accordance with the advance and recession of said pistons, a rotary mixer embodying oppositely rotating bladed disks and connected with said mixing nozzle, and an extruding nozzle connected with said rotary mixer.

6. A mixing apparatus comprising the combination of a tank containing fluent material, a reservoir containing a chemical to be mixed with said material, a Venturi mixing nozzle connected with the reservoir, pump means connected with the tank and mixing nozzle for forcing said material at high pressure into the mixing nozzle in the form of a stream, means operated within said reservoir for injecting the chemical therein in constant fine stream form at high pressure and at high velocity into the stream of material at the nozzle, high speed rotary means located beyond and connected with said mixing nozzle for mechanically mixing together said fluent material and said chemical, a discharge nozzle located beyond and connected with said mechanical mixing means, said pump means comprising alternately acting cylinder and piston means, and synchronously operating power actuated control valves in the inlets to and outlets from said cylinder and piston means.

7. A mixing apparatus comprising the combination of a tank containing fluent material, a reservoir containing a chemical, a Venturi mixing nozzle connected with the reservoir, pump means connected with the tank and mixing nozzle for forcing said material at high pressure and in stream form into the mixing nozzle, said pump means comprising alternately acting cylinder and piston means, means for varying the speed of movement of the piston means, synchronously operating power actuated control valves in the inlets to and outlets from said cylinder and piston means, piston means within said reservoir for injecting the chemical in fine stream form at high pressure and at high velocity into the stream of material at said nozzle, means for varying the speed of movement of said last named piston means independently of the speed of movement of the first named piston means, a rotary mixing device located beyond and connected with said mixing nozzle for mechanically mixing together the material and the chemical, and a discharge nozzle located beyond and connected with said mixing device for discharging the mixed material and chemical.

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