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 260/38

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**UNITED STATES PATENTS**

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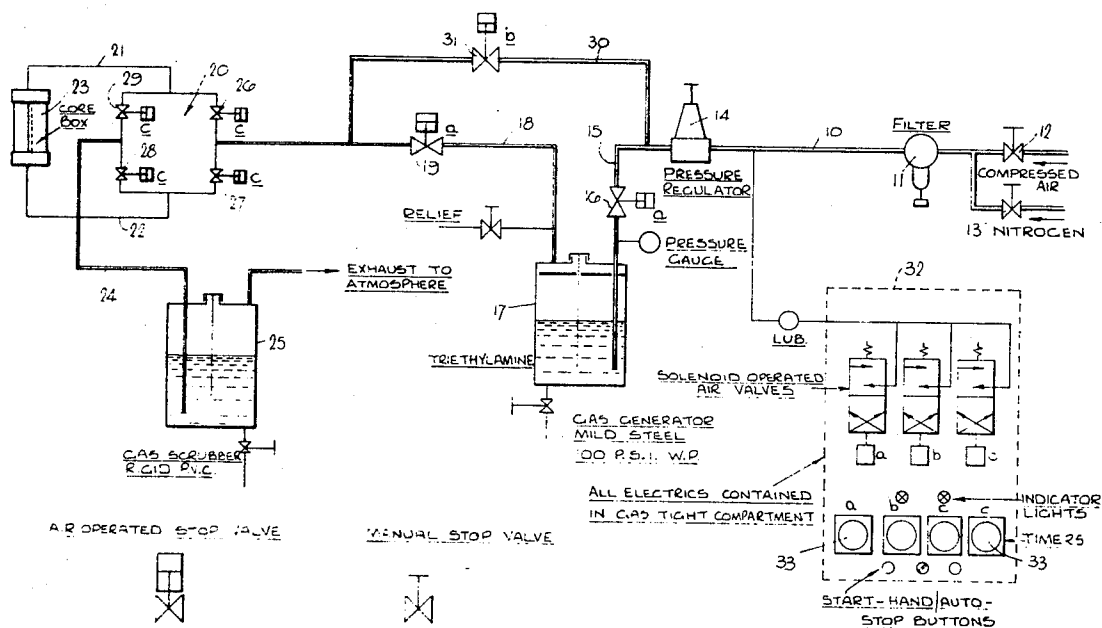
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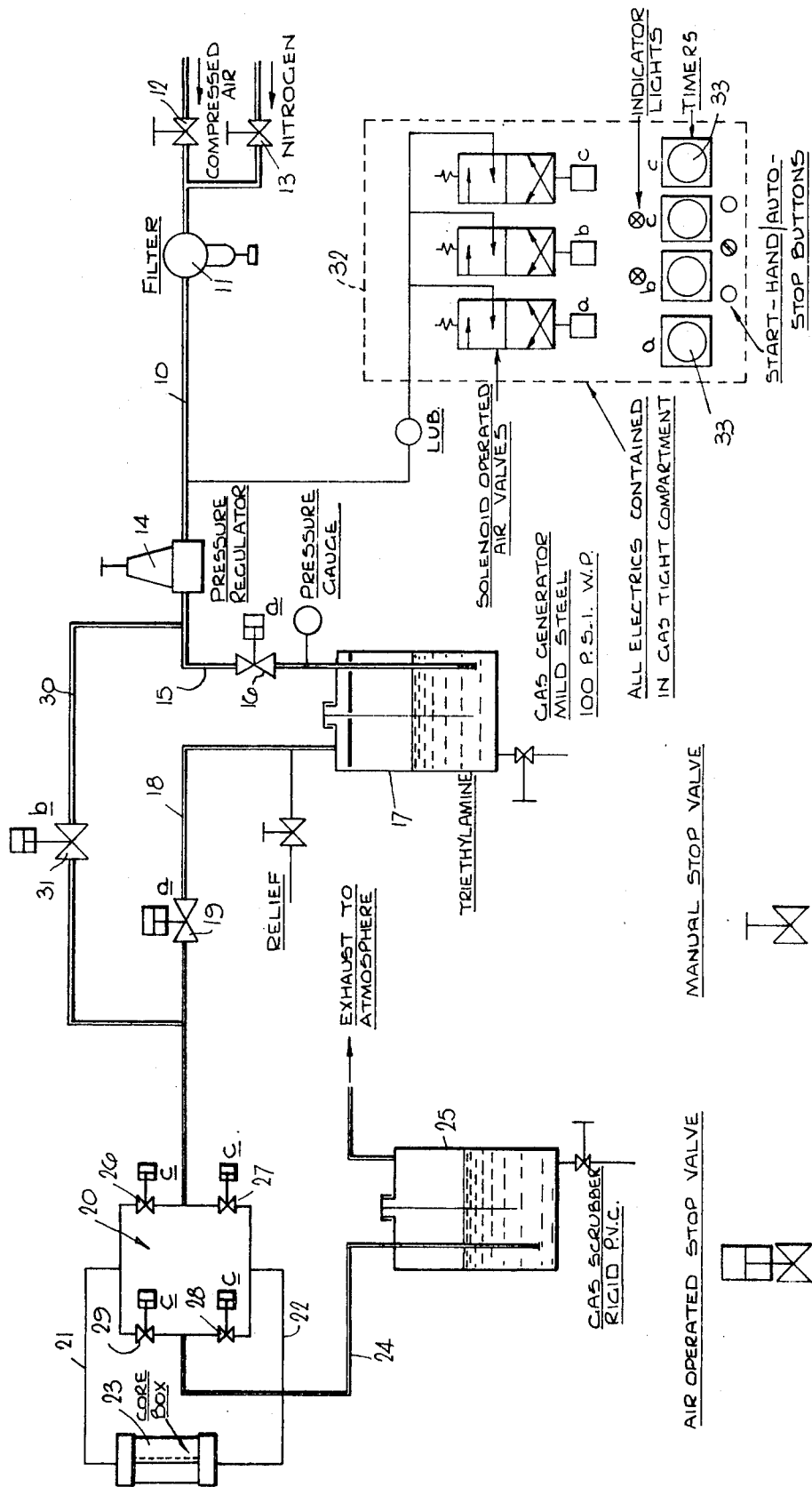
[54] **PRODUCTION OF FOUNDRY CORES AND MOLDS**  
 15 Claims, 1 Drawing Fig.

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**ABSTRACT:** A foundry core is prepared by coating said with a mixture of a novolac resin and a polyisocyanate the coated sand being introduced into a core box, mold or pattern and a volatile amine, such as triethylamine, passed into the core box, mold or pattern to obtain a rapid cure.





## PRODUCTION OF FOUNDRY CORES AND MOLDS

### BACKGROUND OF THE INVENTION

#### 1. Field of the Invention

This invention relates to the production of cores and molds for use in the production of metal castings, which cores and molds comprise a foundry aggregate such as sand which has been formed into a coherent mass with a binder.

#### 2. Description of the Prior Art

Cores and molds for use in making metal castings are normally prepared from mixtures of an aggregate material, such as sand, and a binding amount of a polymerizable or curable binder. The binder allows the mixture to be molded or shaped into the desired form and thereafter cured or allowed to cure to form a self-supporting structure. Minor amounts of modifier materials such as iron oxides, ball clay and other inorganic substances may be included in these mixtures to give a bond at high temperatures, i.e. when the binder has been destroyed. Hot strength properties are of importance to the foundry industry because of the requirement of producing dimensionally accurate castings of an acceptable surface finish.

After the aggregate and binder have been mixed, the resultant mix is rammed, blown or otherwise introduced into a core box, mold or pattern (hereinafter referred to for convenience as a core box), so as to take the shape of the internal surfaces of the core box and the formed shape then has a given setting or hardening time, i.e. the time which must elapse before sufficient strength has developed in the formed shape to enable it to be removed from the core box. Previously it was the practice to remove the core from the box while in the "green" state, i.e., while unhardened, and the core was later subjected to a stoving operation which cured the binder and produced a strong, hard shape which could withstand the handling to which it was later subjected. This process suffered from the disadvantage of the cores losing dimensional accuracy due to sagging before and during the stoving cycle.

It is accordingly required that curing or hardening of the core should take place while this is still in the core box. There are two main classes of processes for effecting this, those carried out in heated boxes and those carried out in cold boxes. The former class, while capable of producing dimensionally accurate cores at a rapid rate of production, has a number of disadvantages, i.e., the cost of heating the boxes, expensive boxes are required, there are high equipment maintenance costs and there is considerable operator fatigue.

The present cold box methods can be divided into two types, firstly those using organic binders and catalysts and secondly those using inorganic binders, such as sodium silicate, and gassing techniques. The first type suffers from the disadvantage of the need for the binder system to possess an adequately long bench life, i.e., the time interval between the time at which the mix is prepared and the time at which the mix has become so agglomerated that it can no longer be readily and effectively fed into the core box, this resulting in a long setting or curing time, of the order of 30 minutes or an hour or longer.

The second type of cold-setting process has a number of disadvantages, i.e., lack of breakdown (i.e. decomposition of binder and collapse of bonded sand) after casting, excessively high hot strengths, and comparatively low cold strengths, these being associated with the use of inorganic binders. Gassing techniques have a number of advantages and it has been proposed in, for example, U.S. Pat. No. 3,179,990 to provide a gassing method of producing a core in which the aggregate is mixed with an organic binder. The particular type of binder disclosed in that specification is, however, quite complex and not one of the normal types of binders normally employed in the foundry industry.

It has also been proposed in French Pat. specification No. 1,132,248 to provide a binder system which includes a drying oil, such as oiticica oil, and a polyisocyanate which increases the rate at which the core develops sufficient stripping

strength to enable it to be removed from the core box. It is an object of the present invention to provide an improved method for the production of foundry cores which involves using a gassing technique for effecting rapid cure of an organic binder, the binder being such that the aggregate/binder mixture has an adequate bench life, the binder also being such that a high cold strength can be obtained with a minimum of binder thus ensuring maximum economy and lowest possible gas evolution during casting, the cured core being sufficiently rigid to enable it to maintain dimensional stability both at the core-making stage and at the casting stage.

### SUMMARY OF THE INVENTION

A method for the production of a foundry core which comprises mixing a foundry aggregate with a novolac resin binder, the novolac being either used alone or in combination with a resole or other binder ingredients, and a polyisocyanate, introducing the mixture into a core box and passing a volatile amine into the core box to effect curing of the core.

### BRIEF DESCRIPTION OF THE DRAWING

The single FIGURE of the accompanying drawing is a diagrammatic representation of apparatus for use in effecting curing of a core.

### DESCRIPTION OF THE PREFERRED EMBODIMENTS

In one example of the present invention a phenolformaldehyde novolac resin having a phenol to formaldehyde ratio of 1 to 0.65 is prepared by reacting together 940 grams of phenol and 535 grams of a 36.6 percent by weight aqueous solution of formaldehyde in the presence of 6 grams of 20 percent hydrochloric acid. The reactants are heated to a reflux temperature of 101° C., care being taken to control the exothermic reaction which is initiated on heating the mixture, and the mixture maintained at the reflux temperature for 3 hours. After the 3-hour refluxing the resin solution is distilled atmospherically and distillation continued until the temperature of the mixture reaches 150° C. When this temperature is reached 970 grams of cyclohexanone are added and the resin solution then cooled.

To 4,530 grams of Chelford W.S. sand are added 45 grams of the resin solution prepared as described above and 45 grams of a solution of 4,4 diphenylmethane diisocyanate and the whole is mixed in a batch mixer for 2 minutes. The resin-coated sand is then discharged and standard A.F.S. compression test pieces are prepared by ramming the sand/binder mixture into a core box using a standard Dietert sand rammer and curing of the test pieces is effected by passing an airstream carrying with it entrained amine vapor through the test pieces for 10 seconds. The test pieces were then broken upon a Hounsfield Tensometer immediately following passage of the amine vapor and also after being allowed to stand for 30 minutes.

The bench lives of the sand/binder mixture prepared are assessed by:

- making compression test pieces of the sand/binder mixture after the mixture has been allowed to stand for predetermined time intervals and,
- by assessing the sand/binder mixture by feel.

Standard tensile test pieces are made in like manner and the tensile strength of the cores determined.

The following results have been obtained:

- Compression strength immediately after passage of the amine—715 lbs. per square inch.
- Compression strength after the cured core has been allowed to stand for 30 minutes—735 lbs. per square inch.
- Strength immediately after passing the amine vapor—120 lbs. per square inch.
- Tensile strength of a cured core allowed to stand for 30 minutes—122 lbs. per square inch.
- Compression strength of a test piece prepared from a sand/binder mixture allowed to stand for 30 minutes, be-

fore introduction thereof into the core box—735 lbs. per square inch.

6. Compression strength of a test piece prepared from a sand/binder mixture allowed to stand for 60 minutes before introduction thereof into the core box—740 lbs. per square inch.
7. Compression strength of a test piece prepared from a sand/binder mixture allowed to stand for 90 minutes before introduction thereof into the core box—722 lbs. per square inch.
8. Compression strength of a test piece prepared from a sand/binder mixture allowed to stand for 120 minutes before introduction thereof into the core box—685 lbs. per square inch.
9. Compression strength of a test piece prepared from a sand/binder mixture allowed to stand for 150 minutes before introduction thereof into the core box—560 lbs. per square inch.
10. Compression strength of a test piece prepared from a sand/binder mixture allowed to stand for 180 minutes before introduction thereof into the core box—450 lbs. per square inch.

The compression strengths given at 5 to 10 above indicate a bench life in excess of 2 hours and the normal visual assessment of bench life is obtained at about 2½ hours.

The particular phenolformaldehyde resin described above has a molar ratio of phenol to formaldehyde of approximately 1 to 0.65 and similar procedures have been carried out to prepare phenolformaldehyde resins having molar ratios of phenol to formaldehyde of 1 to 0.55 and 1 to 0.75. Each sand/binder mixture had a bench life in excess of 2 hours.

When using a resin having a phenol to formaldehyde molar ratio of 1 to 0.55 a standard A.F.S. compression test piece had a compression strength, immediately after curing, of 791 lbs. per square inch and after standing for 30 minutes the compression strength of the core had increased to 800 lbs. per square inch. A further test piece prepared for carrying out tensile strength tests gave a tensile strength of 123 lbs. per square inch and, after the cured core had been left standing for 30 minutes this had increased to 128 lbs. per square inch.

Similar tests were carried out using a phenolformaldehyde resin having a molar ratio of phenol to formaldehyde of 1 to 0.75 and test pieces prepared using this resin gave a compression strength immediately after curing of the core of 720 lbs. per square inch and this increased to 735 lbs. per square inch after the cured core had been allowed to stand for 30 minutes. Tensile tests carried out on a core prepared using this resin gave a tensile strength immediately after curing of 125 lbs. per square inch and after the cured core had been allowed to stand for half an hour this increased to 130 lbs. per square inch.

In order to compare the effectiveness of the novolac binder system with a binder system using a thermosetting resole phenolformaldehyde resin having a molar ratio of phenol to formaldehyde of 1 to 1, such a resole was prepared and a solution of the resole in cyclohexanone was admixed with 4, 4-diphenylmethane diisocyanate in the same proportions as described above and sand coated with this binder was used to prepare compression test pieces and tensile test pieces as described above. The sand/binder mixture including the resole resin had a most unsatisfactory bench life, i.e., only 10 minutes. The compression test results gave a figure of 143 lbs. per square inch both immediately after curing and after the cured core had been allowed to stand for 30 minutes. Tensile strength tests were carried out on a core immediately after curing and after the cured core had been allowed to stand for 30 minutes but the tensile strengths were too low to enable them to be determined. A phenolformaldehyde novolac resin consists of a series of benzene nuclei each having a hydroxyl group, the benzene nuclei being interconnected by methylene groups which may be connected to the benzene nuclei at the 1, 3 and 5 positions relative to the hydroxyl groups. When a phenolformaldehyde novolac is mixed with a polyisocyanate a

complex polyurethane is formed in which the isocyanate effects cross-linking between chains of the benzene nuclei. The rate of reaction of the isocyanate and the novolac is increased by the presence of a catalyst, such as triethylamine so that introduction of the amine vapor into a core box containing sand coated with the novolac/isocyanate binder results in very rapid curing of the binder to form a cross-linked polyurethane, the degree of cross-linking depending on the number of functional groups of both the novolac and the polyisocyanate the greater the number of functional groups the more rigid the resulting polyurethane. The isocyanate is preferably limited to a diisocyanate since diisocyanates are more readily available and are less toxic than tri-, tetra- and higher polyisocyanates. The degree of rigidity of the resulting polyurethane can thus be varied by varying the functionality of the novolac and the functionality of the novolac depends on the molar ratio of phenol to formaldehyde and on whether or not any further resins or analogous products are admixed with the novolac. The preferred molar ratio of phenol to formaldehyde is within the range of from 1 to between 0.5 and 0.9. One additional binder which can be admixed with the phenolformaldehyde novolac is a phenolformaldehyde resole as described in the following example.

One thousand and five hundred grams of a standard aqueous solution of a phenolformaldehyde novolac resin having a molar ratio of phenol to formaldehyde of 1 to 0.7 was distilled to remove 210 grams of water. Sixty grams of a 50 percent by weight solution of formaldehyde in methanol were then added followed by 65 grams of salicylic acid and 330 grams of phenolformaldehyde resole resin having a molar ratio of 1 to 1. The solution was then cooled to between 40 and 50° C. and 6.1 ml. of 20 percent hydrochloric acid were then added and the solution heated slowly to reflux, refluxing being continued for 2 hours. The solution was then distilled until the distillation temperature reached 160° C. by which time 170 grams of water had been removed by distillation. The molten resin was then poured into cooling trays and dissolved in an equal weight of cyclohexanone.

Tests were carried out as described above and the novolac/resole binder system gave cores having a compression strength immediately after curing of 785 lbs. per square inch which increased to 795 lbs. per square inch 30 minutes after curing. A tensile strength of 130 lbs. per square inch was obtained on a core immediately after curing thereof and a further tensile test carried out 30 minutes after curing gave a tensile strength of 128 lbs. per square inch. Sand coated with the novolac/resole resin and with the isocyanate had a bench life in excess of 2½ hours.

A further resin was prepared including a phenolic novolac having a phenol to formaldehyde molar ratio of 1 to 0.66 in admixture with a modifying agent.

Nine hundred and forty grams of phenol and 535 grams of 36.6 percent by weight aqueous formalin solution were reacted in the presence of 6.0 grams of 20 percent hydrochloric acid and the reactants were taken to a reflux temperature of 101° C., care being taken to control the exothermic reaction which is initiated on heating the reactants. The mixture was maintained at this temperature for 3 hours and 194 grams of a residual material obtained as a byproduct of the manufacture of pentaerythritol was then added, the residual material consisting of 24 percent by weight of poly-pentaerythritols and formals, 11 percent by weight pentaerythritol, 8 percent by weight calcium formate and approximately 50 percent water. The resulting mixture was then distilled until the distillation temperature reached 150° C. The molten resin was then poured into cooling trays and later dissolved in an equal weight of cyclohexanone.

Test pieces were prepared as described above and the compression strength of a core obtained using the novolac pentaerythritol waste/polyisocyanate binder was 796 lbs. per square inch immediately after curing and this increased to 820 lbs. per square inch after the cured core had been allowed to stand for 30 minutes. Test pieces were also prepared for carry-

ing out tensile strength tests and these gave a tensile strength of 140 lbs. per square inch immediately after curing which increased to 150 lbs. per square inch after the cured core had been allowed to stand for 30 minutes. The novolac/pentaerythritol waste/polyisocyanate binder had a bench life of 2½ hours.

Other modifying agents can be admixed with the novolac resins, for example wood resins but the effect of most additional modifying agents which have been tested to date has been to shorten the bench life of the sand/binder mixture and to lower the compression and tensile strengths of the cured cores. Some modifying agents may however be required to produce specific effects with certain types of castings.

The preferred solvent in which the novolac is dissolved is preferably cyclohexanone though other solvents may be used, for example, n-butyl acetate or isobutyl acetates and tests have been carried out using a phenolformaldehyde novolac having a molar ratio of phenol to formaldehyde of 1 to 0.66, the resin being dissolved in the solvent to form a resin solution having an approximately 40 percent by weight solids content and being used in conjunction with an equal weight of 4,4-diphenylmethane diisocyanate solution having an approximately 50 percent by weight solids content, the resin and isocyanate being admixed with the sand, the amount of resin and the amount of isocyanate being about 1 percent of the weight of the sand.

Compression tests and tensile tests were carried out using each solvent, the bench life of the sand/binder mixture was assessed using each solvent and the curing time of a standard sized core was also determined.

The following results were obtained:

- a. using cyclohexanone as the solvent,  
average compression strength—725 lbs. per square inch,  
average tensile strength—120 lbs. per square inch,  
average curing time—9 seconds,  
bench life approximately 3 hours.
- b. using n-butyl acetate, isobutyl acetate or isopropyl acetate as solvent,  
average compression strengths, 610 lbs. per square inch,  
average tensile strengths—110 lbs. per square inch,  
average curing time—11 seconds,  
average bench life—1 hour.
- c. using diacetone alcohol as solvent,  
average compression strengths—580 lbs. per square inch,  
average tensile strengths—95 lbs. per square inch,  
average curing time—15 seconds,  
bench life 1 hour.
- d. using a mixture of xylene and cyclohexanone containing equal volumes of xylene and cyclohexanone as solvent,  
average compression strengths—510 lbs. per square inch,  
average tensile strengths,—85 lbs. per square inch,  
average curing time—17 seconds,  
bench life 1½ hours.
- e. using methoxyhexanone as solvent,  
average compression strengths—700 lbs. per square inch,  
average tensile strengths—105 lbs. per square inch,  
average curing time—11 seconds,  
bench life 2 hours.
- f. using a mixture containing equal volumes of methoxyhexanone and cyclohexanone as solvent,  
average compression strengths—700 lbs. per square inch,  
average tensile strengths—115 lbs. per square inch,  
average curing time—9 seconds,  
bench life 2½ hours.
- g. using a mixture containing equal volumes of cyclohexanone and isophorone as solvent,  
average compression strengths, 625 lbs. per square inch,  
average tensile strengths—105 lbs. per square inch,  
average curing time—11 seconds,  
bench life 2½ hours.
- h. using a mixture containing equal volumes of cyclohexanone and chlorobenzene as solvent,  
average compression strengths 630 lbs. per square inch,  
average tensile strengths—95 lbs. per square inch,

average curing time—17 seconds,  
bench life 1½ hours.

From the above figures it can be seen that the best results to date have been obtained using cyclohexanone as the solvent and tests have been carried out in which the resin solids content of the cyclohexanone solution has been varied. The tests have been carried out using a phenolformaldehyde novolac having a molar ratio of phenol to formaldehyde of 1 to 0.66, the amount of resin solution mixed with the sand being 1 percent of the weight of the sand and the resin solution being used in conjunction with 4,4-diphenyl methane diisocyanate also present in an amount equal to 1 percent of the weight of the sand.

When a cyclohexanone solution of the resin having a resin solids content of 40.9 percent an average compression strength of 725 lbs. per square inch was obtained and the average tensile strength obtained was 125 lbs. per square inch. Using a resin solution having a 41.5 percent by weight resin solids content the average compression strength obtained was 713 lbs. per square inch and the average tensile strength was 120 lbs. per square inch.

Using a resin solution having a 42.2 percent by weight resin solids content an average compression strength of 695 lbs. per square inch was obtained and an average tensile strength of 115 lbs. per square inch. Using a resin solution having a 35.6 percent by weight resin solids content an average compression strength was obtained of 582 lbs. per square inch and an average tensile strength of 82 lbs. per square inch. With a resin solution having a resin solids content of 46.5 percent by weight an average compression strength was obtained of 535 lbs. per square inch and an average tensile strength of 85 lbs. per square inch. Using a resin resin solution having a resin solids content of 47.1 percent by weight an average compression strength was obtained of 530 lbs. per square inch and an average tensile strength of 80 lbs. per square inch.

From the above results it can be seen that the preferred resin solids content using a phenolformaldehyde novolac having a molar ratio of phenol to formaldehyde of 1 to 0.66 is less than 45 percent, preferably of the order of 40 percent. The preferred resin solids content will, however, vary with the molar ratio of phenol to formaldehyde in the novolac and will also vary depending on whether additional modifying agents are included in the resin solution, such modifying agents including resole resins and pentaerythritol waste as described above. The preferred resin solids content of the solvent will also depend on the particular solvent which is used and the preferred resin solids content can be varied within the range of from 20 percent by weight to 60 percent by weight, preferably within the range of from 30 percent to 50 percent by weight, the best results to date being obtained with a resin solids content of between 35 and 45 percent by weight.

The sand coated with the binder can be prepared as described above by simultaneously mixing the sand with the resin solution and with the polyisocyanate. Alternatively sand precoated with a phenolic novolac resin can be used, the precoated sand having added to it a solution in cyclohexanone of the polyisocyanate. In one example of this procedure sand was coated with a phenolic novolac resin, the amount by weight of resin being approximately 1 percent of the weight of the sand and the precoated sand was mixed with a solution in cyclohexanone of 4,4-diphenylmethane diisocyanate, the amount by weight of the diisocyanate solution being approximately 1 percent of the weight of the sand. The sand/binder mixture prepared in this way had a bench life in excess of 3 hours and sample test pieces had a compression strength in excess of 500 lbs. per square inch.

The polyisocyanate used is that which is commercially available which has an approximately 85 percent by weight solids content, the commercial isocyanate solution normally being used after having been diluted with xylene, nine parts by volume of the isocyanate solution being admixed with one part by volume of xylene so as to obtain a solution having an approximately 75.5 percent by weight solids content.

Tests have also been carried out to determine the effect of varying ratio of resin to isocyanate in the binder, the isocyanate used being that discussed above having a 50 percent by weight solids content and the resin used being a 40 percent by weight solution in cyclohexanone of a phenolic novolac having a phenol to formaldehyde molar ratio of 1 to 0.66. In carrying out these tests the resin solution and the isocyanate solution were mixed with the sand, the amount by weight of resin solution used being maintained at 1 percent of the weight of the sand and the amount by weight of the isocyanate solution being varied:

When the amount by weight of the isocyanate solution was 0.75 percent of the weight of the sand, test pieces were obtained having an average compression strength of 320 lbs. per square inch and an average tensile strength of 60 lbs. per square inch.

When the amount by weight of the isocyanate solution was 1 percent of the weight of the sand, test pieces had an average compression strength of 714 lbs. per square inch and an average tensile strength of 120 lbs. per square inch.

When the amount by weight of isocyanate solution was 1.25 percent of the weight of the sand, prepared test pieces had an average compression strength of 852 lbs. per square inch and an average tensile strength of 145 lbs. per square inch.

When the amount by weight of isocyanate solution was 1.33 percent of the weight of the sand, sample test pieces had an average compression strength of 700 lbs. per square inch and an average tensile strength of 120 lbs. per square inch.

When the amount by weight of isocyanate used was increased to 1.6 percent of the weight of the sand the prepared test pieces had an average compression strength of 610 lbs. per square inch and an average tensile strength of 115 lbs. per square inch.

With the particular resin solution used it can be seen from the above figures that the ratio of the amount by weight of isocyanate solution to the amount by weight of the resin solution is preferably within the range of from about 0.9 to 1.4 to 1, preferably within the range of from 1 to 1.33 to 1 and more preferably approximately 1.25 to 1. The preferred ratio will, of course, depend on the particular resin which is used.

In one practical example of the present invention sand is fed into a combined mixer and conveyor unit as described in U.S. Pat. No. 3,268,214, a solution in cyclohexanone of a phenol-formaldehyde novolac resin is introduced in a continuous stream into the combined mixer and conveyor unit, the novolac resin having a phenol to formaldehyde ratio of approximately 1 to 0.66 and the resin solution having a solid content of approximately 40 percent by weight, and a solution of 4,4-diphenylmethane diisocyanate in an organic solvent is also introduced into the combined mixer and conveyor unit at a continuous rate. The amount by weight of the resin solution introduced is about 1 percent of the weight of the sand, which is Chelford W.S. sand of A.F.S. fineness No. 55 and the amount by weight of the isocyanate solution is also about 1 percent of the weight of the sand.

The resin/isocyanate/sand mixture is introduced into a core box, there being a plurality of core boxes moving along the conveyor line and the core boxes being filled successively with the mixture as they are moved past the discharge outlet of the combined mixer and conveyor unit. After being filled with this mixture the core boxes are passed to a station at which a volatile amine is introduced into the core box. A stream of compressed air is blown through a vessel containing the amine, preferably triethylamine, the airstream containing the amine vapor then passing into the core box. The apparatus whereby the amine vapor is blown into the core box is hereinafter more particularly described with reference to the accompanying drawing.

The length of time for which the stream of air containing the amine vapor is passed into the core box will depend upon the size of the core, the air pressure used and the chemical characteristics of the binder system. The time for which the amine is introduced may be for small cores and with the particular

binder system described above, of the order of 10 seconds which compares quite favorably with the curing rates obtained in hotbox processes. After the amine has been blown into the core box for the required length of time, air not carrying the volatile amine is blown into the core box whereby any amine which has not reacted with the polyisocyanate in the mixture will be removed, and whereby dispersion of the amine throughout the core box is ensured, such blowing operation lasting for 10 or 20 seconds. It has been found that, with any particular binder system, there is a minimum gassing time and that, if the amine is blown into the core box for less than this time, parts of the core are not cured. If the amine is blown into the core box for longer than this minimum gassing time, hardly any increase in strength is obtained.

After blowing the amine into the core boxes these are passed successively to a stripping station at which the core boxes are opened and the cores removed. Alternatively the resin/isocyanate/sand mixture may be blown into a core box and the subsequent gassing and stripping operations carried out immediately at the core-blowing machine, such a practice allowing rapid repetitive production of cores.

The time taken to fill each core box with the sand/resin/isocyanate mixture is of the order of a fraction of a second when a core-blowing machine is used and the time that each core box spends at the station at which it is connected to the air line system may be of the order of 1 minute so that it can be seen that the time taken to produce each core is very small.

After curing each core can be subjected to a conventional core-washing process, the wash comprising, for example, an aqueous or alcoholic suspension of graphite or zircon. One aqueous wash is described in U.S. Pat. No. 3,275,460 and an alcohol-based wash is described in British Pat. No. 799,511.

The use of 4,4-diphenylmethane diisocyanate has been described above in detail since this is the most readily available polyisocyanate but other isocyanates which can be used include 2,4- and 2,6-toluene diisocyanate and triphenyl methane trisocyanate. The preferred amount by weight of polyisocyanate in the sand/resin/isocyanate mixture is within the range of from about 0.25 to about 5 percent of the rate of the sand, the preferred amount being about 1 percent of the weight of the sand. The amount by weight of the resin in the sand/resin/isocyanate mixture is preferably within the range of about 0.25 to about 5 percent of the weight of the sand, preferably about 1 percent of the weight of the sand.

The volatile amine can, instead of being triethylamine, be tertiary butylamine or isopropylamine and an exhaust line from the low-pressure side of the core box may include a trap containing a mineral acid such as hydrochloric acid for removal of excess amine vapor from the air stream discharged into the atmosphere. Conventional additives such as those referred to above may be added to the resin/isocyanate/sand mixture to give the core increased hot strength properties, e.g. iron oxide or ball clay may be added to give secondary binding properties when the binder burns away during the metal casting process.

Although the invention has been described above in relation to the mixing of the sand/resin and isocyanate in a continuous mixer and conveyor, such mixing operation can alternatively be carried out in a "batch" mixer.

The accompanying drawing shows apparatus for use in carrying out curing of the core within the core box and the apparatus includes an air line 10 containing a filter 11, the air line being selectively connectable to either a compressed air supply or to a supply of nitrogen, such selective connection being effected through a pair of manually operable stop valves 12 and 13. The air line 10 contains a pressure regulator 14 and a line 15 containing an air-operated stop valve 16 leads from the regulator 14 to a vessel 17 containing triethylamine. Gas is bubbled through the triethylamine contained in the vessel 17 so that a stream of gas carrying entrained triethylamine vapor issues from the vessel 17 through an outlet line 18 containing a further air-operated stop valve 19. The line 18 leads to a distributor 20 from which a pair of lines 21 and 22 lead to the

core box 23 for the passage of the gas stream carrying the entrained amine vapor through the core box, the exhaust from the core box returning to the distributor 20 and then passing through an exhaust line 24 to a trap 25 containing a mineral acid such as hydrochloric acid whereby any excess amine vapor is removed from the gas stream prior to passage thereof to the atmosphere.

The distributor 20 includes four air-operated stop valves 26, 27, 28 and 29 which are arranged to be operated in pairs, the arrangement being that when the valves 26 and 28 are open the stream of gas carrying the entrained amine vapor is passed through the core box in one direction and when the valves 27 and 29 are open the stream of gas carrying the entrained amine vapor is caused to pass through the core box 23 in the opposite direction.

There is a bypass line 30 containing an air-operated stop valve 31 extending between the pressure regulator 14 and the distributor 20 and the arrangement is that, when the stop valves 16 and 19 are open the bypass stop valve 31 is closed and the gas stream is caused to pass through the vessel 17 whereas, when the valves 16 and 19 are closed and the bypass valve 31 is open, the gas stream passes directly from the regulator 14 to the distributor 20 and thence to the core box so as to ensure that there will be a minimum of free amine vapor left within the core box after the required amount of amine vapor has been passed into the core box 23 to effect curing of the core.

Operation of the stop valves 16, 19, 26, 27, 28, 29 and 31 is effected by solenoid-operated air valves contained within a control housing 32, operation of the solenoids being under the control of timers 33 which are arranged to ensure that the appropriate valves are operated in the correct sequence. The control housing 32 also carries two indicator lights, one to indicate that the electrical supply is on and one to indicate that the cycle is operating, and there are stop and start buttons for stopping and starting the curing process.

In use, a core box filled with the sand/resin/isocyanate mixture is placed in position at the curing station and a stream of compressed air is introduced into the vessel 17 whereby it carries entrained amine vapor with it to the core box 23. If the core is of a simple shape the gas stream and amine vapor will be passed therethrough in only one direction but, if the core is of a complex configuration, the valves 26, 27, 28 and 29 will be operated so that the gas stream and amine vapor passes through the core first in one direction and then in the opposite direction. After a predetermined time, referred to as the gassing time, and after which the required degree of cure has been effected, the valves 16 and 19 are closed and the valve 31 is opened the air stream is passed direct through the bypass line 30 to the distributor 20 and thence through the core box 23 to remove any excess amine vapor from the core, any amine vapor contained in the exhaust from the core box air absorbed by the acid in the vessel 25 so that no amine fumes are exhausted into the atmosphere. By blowing the airstream through the core to remove excess amine vapor, the amount of gas evolution at the casting stage is reduced so far as possible.

In order to prevent the accumulation of an explosive amine vapor/air mixture in the vessel 17, the nitrogen supply can be connected to the system so as to blow nitrogen through the pipe lines 10, 15 and 18, such blowing of nitrogen through the pipe lines being effected when it is likely that the apparatus

will be allowed to stand for a period of time. Alternatively, the arrangement may be such that only nitrogen is used.

Instead of bubbling a gas stream through the amine liquid to obtain the amine vapor, the vessel containing the amine may be pressurized so as to introduce, under the control of a time system, a jet of amine into the air or other gas stream and this arrangement would avoid the requirement for a bypass line.

We claim:

1. In a process for the production of foundry molds and cores wherein a mixture comprising a foundry aggregate and a binder including a novolac resin and a polyisocyanate are introduced into a core box, mold or pattern to form a green core or mold and an amine is passed into the core box, mold or pattern to effect curing of the core or mold, the improvement wherein said novolac resin is dissolved in an organic solvent comprising cyclohexanone.

2. A process according to claim 1 in which the amine is passed into the core box, mold or pattern in the form of a vapor entrained in a gaseous carrier.

3. A process according to claim 2 in which the amine is triethylamine.

4. A process according to claim 1 in which the polyisocyanate is 4,4-diphenylmethane diisocyanate.

5. A process according to claim 1 in which the solution of the novolac resin in said solvent has a solids content of between 20 and 60 percent by weight.

6. A process according to claim 5 in which the solution of the novolac resin in said solvent has a solids content of between 25 and 50 percent by weight.

7. A process according to claim 6 in which the solution of the novolac resin has a solids content of between 35 and 45 percent by weight.

8. A process according to claim 1 in which the amount by weight of novolac resin in the aggregate/resin/polyisocyanate mixture is between 0.25 and 5 percent of the weight of the aggregate.

9. A process according to claim 1 in which the amount by weight of polyisocyanate in the aggregate/resin/polyisocyanate mixture is between 0.25 and 5 percent of the weight of the aggregate.

10. A process according to claim 1 in which the novolac resin is a phenolformaldehyde resin having a molar ratio of phenol to formaldehyde of 1 to between 0.55 and 0.9.

11. A process according to claim 10 in which the molar ratio of phenol to formaldehyde of the novolac resin is 1 to between 0.6 and 0.75.

12. A process according to claim 1 in which the novolac resin is admixed with a phenolformaldehyde resole resin.

13. A process according to claim 1 in which the novolac resin is admixed with a material containing polyphenylerythritol.

14. A process according to claim 1 in which the ratio of the amount by weight of novolac resin in the foundry aggregate/resin/polyisocyanate mixture to the amount by weight of polyisocyanate in said mixture is within the range of 1 to from about 0.9 to about 1.35.

15. A process according to claim 1 in which the novolac resin is a phenolformaldehyde resin dissolved in an organic solvent comprising cyclohexanone and at least one member selected from the group consisting of methoxyhexanone, isophorone, xylene and chlorobenzene.

UNITED STATES PATENT OFFICE  
CERTIFICATE OF CORRECTION

Patent No. 3,590,902 Dated July 6, 1971

Inventor(s) James Walker et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the title page after item "[73] Assignee Foseco Fordath A. G. Zug, Switzerland", insert

--The portion of the term of the patent subsequent to

February 18, 1986, has been disclaimed.--

Signed and sealed this 6th day of June 1972.

(SEAL)  
Attest:

EDWARD M. FLETCHER, JR.  
Attesting Officer

ROBERT GOTTSCHALK  
Commissioner of Patents