United States Patent

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Continuation-in-part of application Ser. No. 737,480, June 17, 1968, now abandoned.

[54] **EXPANSION GAP COMPENSATING SYSTEM FOR A DIE**
23 Claims, 8 Drawing Figs.

[52] **U.S. Cl.** **164/137,** 18/44, 164/303, 164/342, 249/82
[51] **Int. Cl.** **B22d 17/24,** B29c 11/00
[50] **Field of Search** .... 164/47, 113, 137, 303—305, 339—343; 18/35, 38, 42—44, (Digest 29); 249/80, 82, 165, 166; 29/405

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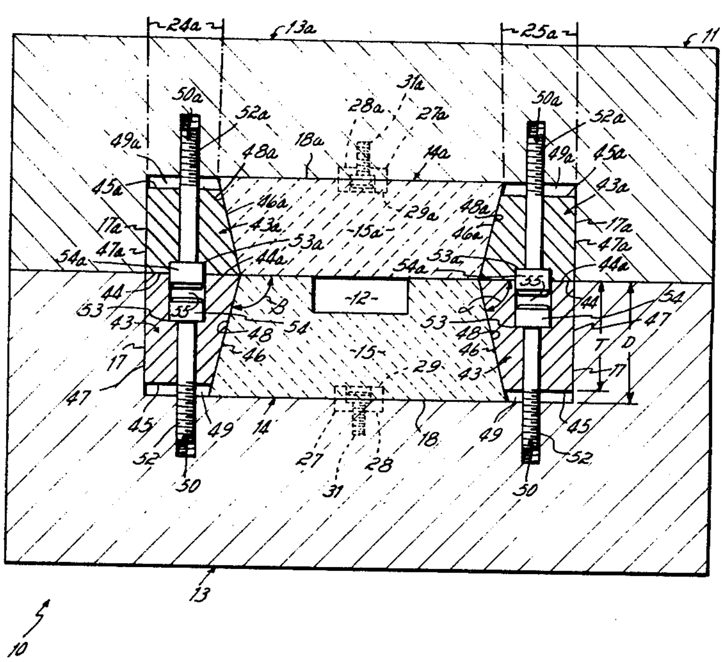
ABSTRACT: An expansion gap compensating system for a die that is especially useful in the area of high-temperature diecasting, e.g., at temperatures of about 1,300° F. and up. When a die's impression block is fabricated of a metal having a different expansion coefficient than that of the die's holding block crevasses or expansion gaps tend to open between the two blocks upon heating of the die assembly to high temperature from room temperature. The width of these expansion gaps may vary from thousandths of an inch to hundredths of an inch or more, and is mainly dependent on the difference in expansion coefficients of the block metals and on the casting or operating temperature. The system of this invention permits an impression block and a holding block fabricated of, for example, a refractory metal and a steel respectively, (a) to be simply and easily assembled and maintained together as a die in tight and safe operating relation without damage to either, and (b) to be maintained in an exact centered or preset position relative one to another, at all times throughout a casting run. Thus, the expansion gap compensating system acts to compensate for expansion gaps that tend to open between related impression and holding blocks as the die assembly is heated up to and operated at high temperatures, as well as to compensate for the contracting of those gaps as the die assembly cools after the casting run.



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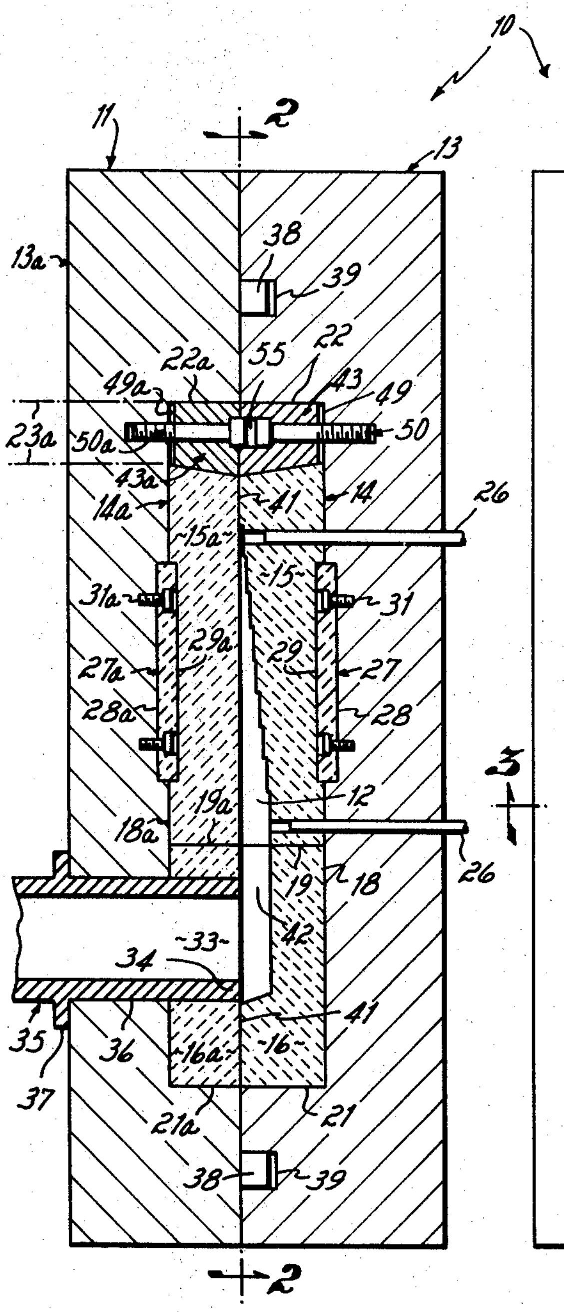

Fig. 1

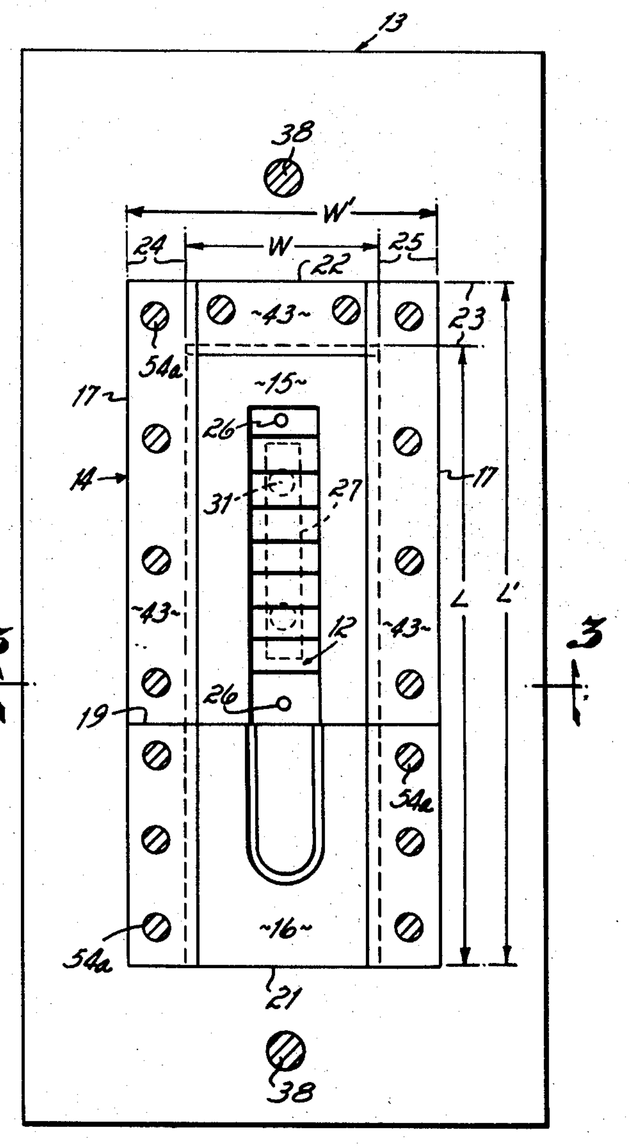

Fig. 2

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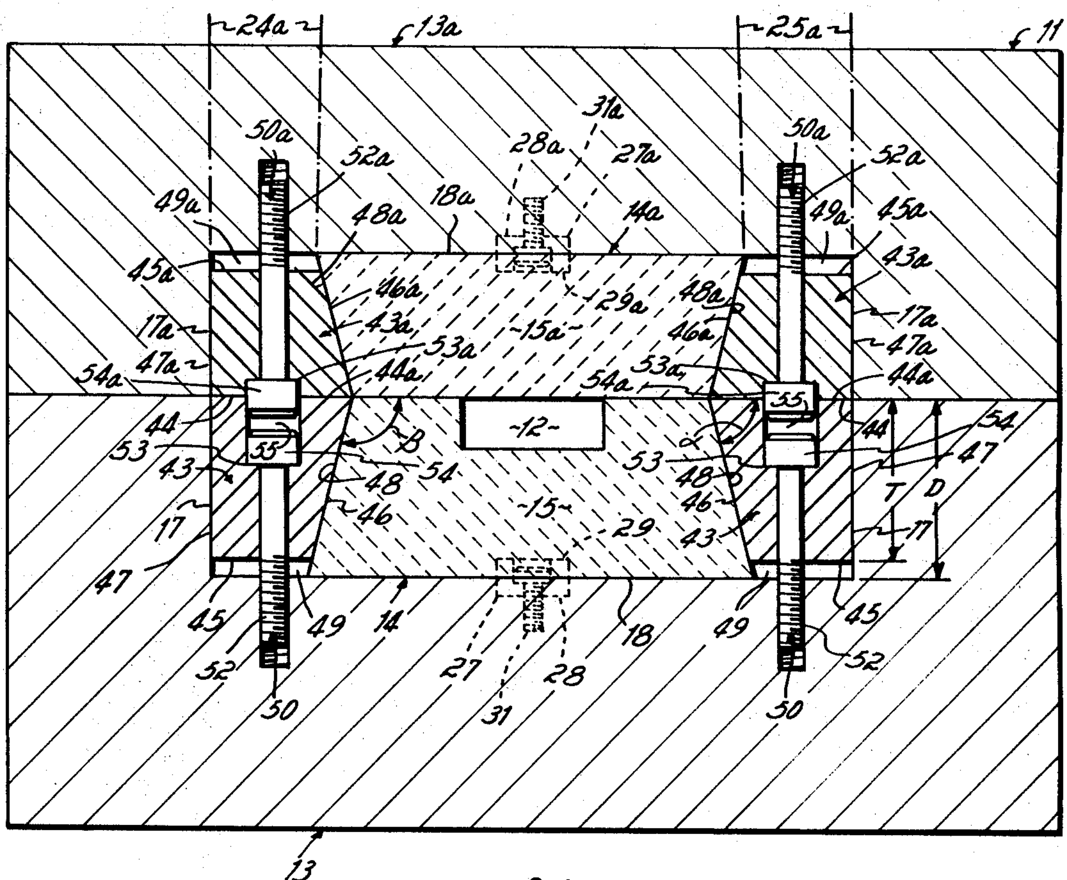

Fig. 3

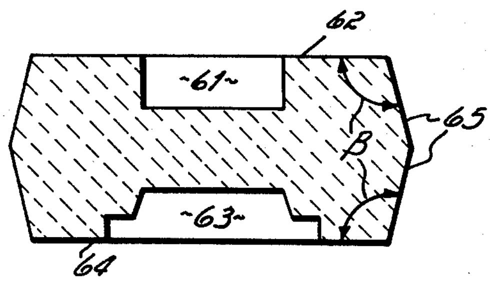

Fig. 4

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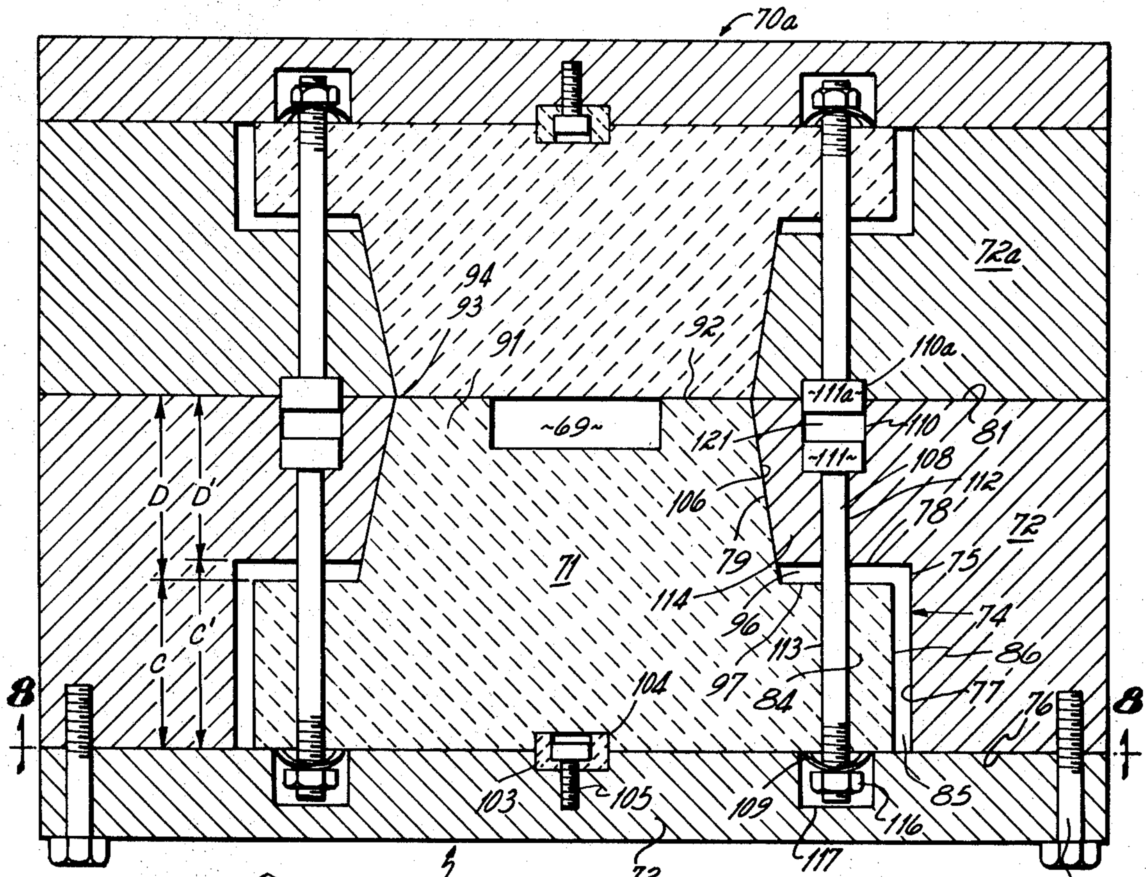

Fig. 5

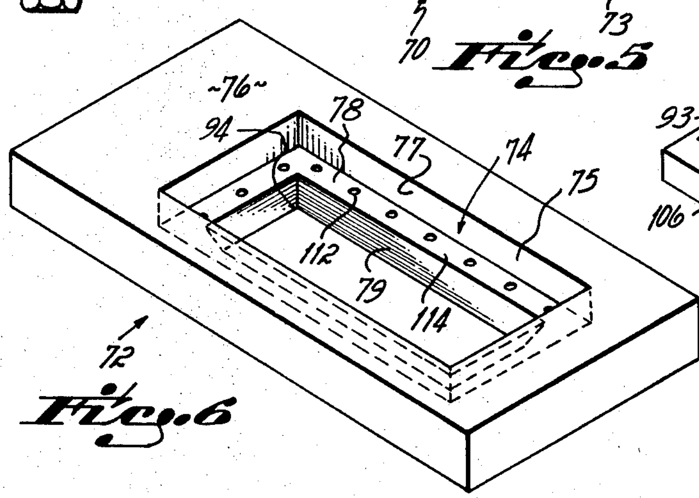

Fig. 6

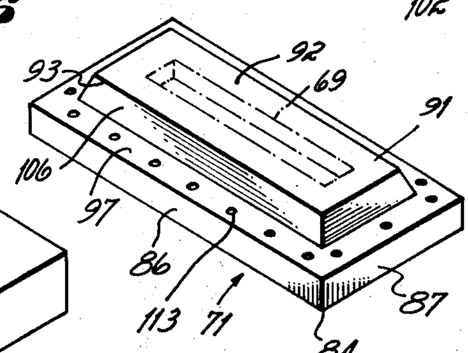

Fig. 7

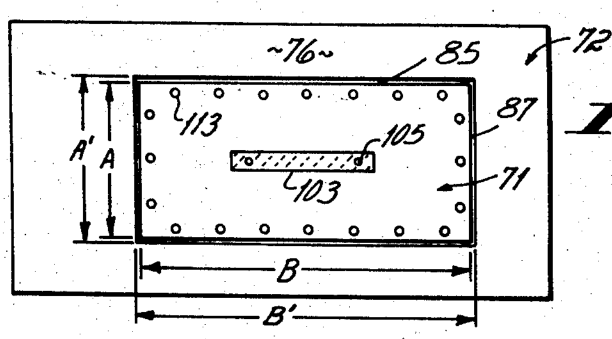

Fig. 8

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EXPANSION GAP COMPENSATING SYSTEM FOR A DIE

This application is a continuation-in-part application of U.S. Ser. No. 737,480, filed June 17, 1968, now abandoned.

This invention relates to dies and, more particularly, relates to an expansion gap compensating system that is especially advantageous for dies used when casting high melting point materials.

Diecasting is a well-known method of forming cast metal parts; it basically involves injecting a molten metal charge under pressure into a die cavity. The basic components of a diecasting-type machine are a die assembly of two halves or dies that together define a negative impression or cavity of the object that is desired, a chamber for holding a charge of molten metal, and a plunger for transferring the metal charge under pressure from the chamber to the die. The basic functions of such a machine are to close and hold the two halves or dies of the die assembly tightly together for establishing the die cavity; to inject the molten metal under pressure into the die cavity; and then to open the die assembly and eject the finished casting from the cavity.

The die assembly for diecasting-type machines basically consists of two separate halves or dies, each containing a part of the casting impression, plus cores if needed for the part to be cast. The die halves are mounted on the diecasting machine and are so arranged that one is stationary (called the cover die) while the other is movable (called the ejector die). The mating surface or front face of each die is finished so that the dies fit snugly together at an interface to form the die cavity when in the closed position. When the machine is closed the two halves of the die assembly are locked tightly together in precise register, after which the molten metal is injected from the injection apparatus under pressure into the die cavity so formed through a gate in the assembly. Subsequently, the two die halves are drawn apart to allow ejection of the casting. Proper means for rapidly ejecting the casting from the die assembly is provided in the form of ejector pins mounted to an ejector plate reciprocably assembled with the ejector die. Thus, the movable or ejector die usually contains, in addition to a portion of the casting impression, movable elements such as cores, slides, and ejector mechanism.

The material from which the die cavity is formed is one factor in determining the commercial success of the diecasting process. Dies are, of necessity, expensive and the money expended in fabricating them must be justified by good service life as measured by number of castings produced. Since the molten metal is forced into the die cavity under pressure the die must be capable of withstanding impact and mechanical shock, and because the metal is molten and at a relatively high temperature the die must be capable of withstanding thermal shock as well. Also, and very importantly, the die must be able to resist washing or erosion of the cavity configuration by the metal being cast. The combination of these three factors, plus others, means that the die cavity must be constructed of very good quality steels. With the lower melting point alloys used in diecasting, for example, tin, lead, and zinc, the problem of securing a long life for the die at an economical per casting cost is not so acute. However, with the higher melting point alloys, for example, magnesium, aluminum, gray iron, and copper-zinc alloys, the die steel must be of the best possible grade tool steel and must be produced to quite rigid specifications to overcome, in particular, the cavity erosion or wash problem.

With the casting of such high melting point metals as are presently used in the diecasting industry, for example, the magnesium, aluminum, gray iron, and copper-zinc alloys, and with diecasting technology rapidly approaching that point where even higher melting point metals will be diecast, the problems of eroding and washing of the die cavity configuration and thermal shock to the die are particularly acute because of those metals' high melting points. In an effort to combat this problem there has been developed a structural die design which comprises a separate impression block for each of the ejector and cover die halves. The impression blocks together define the casting configuration, each impression block being carried in a pocket or nest defined by its associated holding block. Thus, the ejector die half and the cover die half is each comprised of an impression block and a holding block mated or nested together. To hold the two blocks of each die together the impression block is usually friction fit into the pocket of its related holding block, i.e., the outer periphery of the impression block is substantially equal to the periphery of the holding block's pocket. In general practice, both blocks have been formed from steel. The system of providing an impression block-holding block structure for a die half admits of substantial economy because only the impression block need be replaced, and not the entire die, when the cavity configuration becomes so eroded or washed out that an undesirable percentage of castings being produced is out of tolerance limits.

It has been found that the present steels known from which dies for diecasting-type machines can be made do not themselves have a high enough melting point, nor are they sufficiently rugged, to withstand the eroding and washing characteristic and thermal and mechanical shock characteristics of the high melting point alloys so as to yield a desirable economic production life. To solve this problem it has been proposed to provide impression blocks of refractory metals because that group of metals is relatively resistant to thermal shock and cavity erosion at high diecasting temperatures. In the interest of economy, the holding blocks are still fabricated from high quality steels because of the high refractory metal cost. However, refractory metals are particularly brittle at room temperature. Because the only known practical method of maintaining the impression block and holding block in operable engagement is by friction fit techniques, it will be seen that breakage of such impression blocks during the engaging and disengaging of those blocks with their related holding block pockets is a definite problem and economic hazard. Also, when the outer periphery of a refractory metal impression block is configured to conform to the steel holding block pocket in a friction fit relationship at, for example, room temperature, once the die assembly has risen to its operating temperature distinct expansion gaps or crevasses may occur between the periphery of the refractory metal impression block and the periphery of the pocket in its associated steel-holding block. Such expansion gaps may vary from thousandths of an inch to hundredths of an inch or more. This for the reason that the expansion coefficients of the normal steels from which holding blocks are usually fabricated are substantially greater, for example, up to three or four times greater, than the expansion coefficients of the refractory metals from which the impression blocks are fabricated. Such expansion crevasses or clearances or gaps created between the impression block and associated holding block at high die-operating temperatures may cause alignment or registry difficulties for the cover and ejector impression blocks during repeated openings and closings of the die halves because of slippage or movement of one or both impression blocks within their holding block pockets, thereby rendering out of tolerance a substantial percentage of the castings produced by the die assembly. The expansion gaps created between the impression block and the holding block of the ejector die half at high die temperatures may even be great enough so that the ejector impression block will actually be ejected from the ejector-holding block by the ejector pins, after the die halves have been opened, during ejection of the formed casting. Also, during a production run the molten metal to be cast may squirt out between the interface of the cover and ejector impression blocks and run into and solidify in the expansion crevasses or gaps created, thereby preventing the impression blocks from being removed from the holding block pockets other than by breaking or otherwise cutting out the impression block.

Accordingly, it has been one objective of this invention to provide an expansion gap compensating system associated with the impression block and holding block of a die, that is, a die half, that adequately retains and prevents movement of the impression block in the holding block pocket when the expansion coefficient of the impression block material is substantially different from the expansion coefficient of the holding block material.

It has been another objective of this invention to provide an expansion gap compensating system for a die's impression and holding blocks, when those blocks are made of materials having different expansion coefficients, that is easily and readily adjustable during a casting run whereby, as the die assembly rises to operating temperature from room temperature upon startup, as well as during the casting run, the system is adjusted as required to compensate for expansion gaps or crevasses that may tend to open, i.e., to compensate for the differential expansion of the materials, and as the die assembly declines from operating temperature the system is adjusted as required to compensate for the contracting of those expansion gaps, i.e., to compensate for the differential contraction of the materials.

It has been still another objective of this invention to provide an expansion gap system for a die's impression and holding blocks, when those blocks are made of materials having different expansion coefficients, which precludes undesirable molten material that may squirt out between the interface of the cover and ejector impression blocks during a casting cycle from filling or running into any expansion gaps between sides of each die's impression and holding blocks adjacent the face of each die caused by the difference in the blocks' coefficients of expansion.

It has been a further objective of this invention to provide an expansion gap system for a die's impression and holding blocks, when those blocks are made of materials having different expansion coefficients, that precludes movement of each impression block relative to its associated holding block even during repeated adjustments to the system so as to permit opposed impression blocks of a die assembly to be maintained in proper registry throughout a casting run.

These objectives have been attained in this invention by providing an expansion gap compensating system for a die comprising, in combination and in preferred embodiment form, (a) a holding block (fabricated of, for example, a steel) with a pocket defined therein, (b) an impression block (fabricated of, for example, a refractory metal) receivable within the pocket, the impression block having a substantially shorter peripheral length than the pocket so that when the two blocks are assembled a continuous fixed gap equal in length to at least one-half the peripheral length of the impression block is created between the impression block and the holding block, (c) a chock positionable in wedging fashion within the fixed gap for maintaining the blocks together as a die, and (d) a key engageable with keyways in the bottom of the pocket and the impression block for establishing and maintaining accurate relative position of the blocks one to the other. Each chock is provided with adjustment means so that it can be tightened or loosened within the fixed gap depending on the relative expansion or contraction of the blocks and the crevasses or expansion gaps between the blocks that tend to be formed thereby. The expansion gap compensating system of this invention's preferred embodiment permits the impression block and the holding block of a die, each of which is fabricated of a material having a different expansion coefficient from the other, to be simply and easily assembled and maintained together as a die in tight and safe operating relation without damage to either, to be maintained in an exact centered or preset position relative one to the other even during repeated adjustments of the system, and to preclude undesirable molten material from filling any expansion gaps that occur between sides of the blocks adjacent the face of the die half, at all times throughout a casting run.

Other objectives and advantages of this invention will be more apparent from the following detailed description taken in conjunction with the drawings in which:

FIG. 1 is an axial cross-sectional view of a die assembly incorporating the expansion gap compensating system of this invention;

FIG. 2 is an elevational view, partially in cross section, taken along lines 2–2 of FIG. 1;

FIG. 3 is a cross-sectional view taken along lines 3–3 of FIG. 2;

FIG. 4 is a cross-sectional view of an alternate impression block embodiment useful with the expansion gap compensation system;

FIG. 5 is a cross-sectional view similar to FIG. 3 of an alternative embodiment of a die assembly incorporating the expansion gap compensating system of this invention;

FIG. 6 is a perspective view taken from the front of the alternative embodiment of the die assembly's impression block; and

FIG. 7 is a perspective view taken from the rear of the alternative embodiment of the die assembly's holding block with the back plate removed; and

FIG. 8 is a cross-sectional view taken along lines 8–8 of FIG. 5.

As illustrated in FIGS. 1—3, the principles of this invention are incorporated in a die assembly having an ejector or movable die **10** and a cover or fixed die **11**, the die halves being held in operational engagement one with the other so as to define a die cavity **12** by apparatus, not shown, associated with any known type of diecasting machine. The ejector die **10** is comprised of an ejector shoe or holding block **13** (fabricated of, for example, a tool steel) which establishes a rectangular nest or pocket **14** in the front face of block **13**. The pocket **14** is sized to receive an ejector impression block **15** and an ejector gate block **16** (both fabricated of, for example, a refractory metal) from the front face of holding block **13**, and is defined by vertical sidewalls **17** and a flat bottom **18** parallel to the front face of the holding block **13**. The bottom **18** of the pocket **14** provides structural support for the impression block **15** when a charge of molten metal is received in the die cavity **12**.

The impression block **15** and the gate block **16** are abutted end to end at joint **19** in the pocket **14**, and the free end of the gate block abuts gate end **21** of the pocket. It will be noted that the overall length L of the abutted impression block **15**—gate block **16** combination is substantially less than the length L′ of the pocket **14** so as to create an end gap **23** at one end between the impression block and the pocket end **22**, see FIG. 2. Also, it will be noted that the widths W of the impression block **15** and gate block **16** are substantially less than the width W′ of the holding block's pocket **14** so as to create side gaps **24, 25** on both sides between the sides of the impression block **15**—gate block **16** combination and the related pocket sides **17**, see FIG. 2. Thus, the abutted impression block **15**—gate block **16** combination has a shorter outer peripheral length than the peripheral length of the pocket **14**, thereby creating the fixed gaps **23—25** that establish a single, continuous, fixed gap between the impression block—gate block sides and three sides **17, 17** and **22** of the pocket's four sides when those blocks are assembled together. It is to be noted that the continuous fixed gap **23—25** is preferably equal in length to at least one-half the peripheral length of the impression block **15**—gate block **16** structure and, in the figures, is shown as being almost 90 percent the peripheral length of the gate block—impression block structure.

The ejector gate block **16** can move from one side to the other between sides **17** of the pocket **14** because very precise positioning of this block **16** within the pocket is not required, that is, if the gate block is off center by some hundredths of an inch this will not ordinarily adversely affect the quality of the castings produced. The ejector impression block **15**, however, is positioned within the pocket **14** by a rectangular key **27** extending lengthwise of the pocket, see FIG. 1. The key **27** is received in mating keyways **28, 29** sized to fit key **27**, the keyways being cut into the bottom **18** of the pocket **14** and into the bottom of the impression block **15** respectively. The key 27 is fixed to holding block 13 in keyway 24 by two bolts 31 the heads of which are recessed in the key. The key 27 serves to maintain the impression block 15 in a precise, preset position or registry within the pocket 14 at all times, thereby preventing movement of the impression block within the pocket relative to the holding block 13 in both the north-south and east-west directions even when expansion gaps on the order of thousandths of an inch or hundredths of an inch or more tend to open between the two blocks during use.

The ejector die 10 is also illustrated as having two ejector pins 26 that are selectively reciprocable into the die cavity 12 by ejector apparatus, not shown, so as to eject castings formed in the cavity when the dies 10, 11 are opened.

In describing the cover die 11, elements of the cover die structure that are similar to like parts of the ejector die 10 structure are given the same reference number as used in describing the ejector die except that the letter *a* follows that number. The cover die 11 includes a cover-holding block 13*a* that defines a cover nest or pocket 14*a* in the front face of block 13*a*, the pocket 14*a* and block 13*a* having substantially the same peripheral dimensions and geometry as pocket 14 and ejector-holding block 13. An impression block 15*a* and gate block 16*a* are abutted end to end at joint 19*a* in the pocket 14*a* in mirror relation to the impression block 15 and gate block 16 of the ejector die 10, see FIG. 1. The cover impression 15*a* and gate 16*a* blocks are of substantially the same outer peripheral dimensions and outer geometry as the ejector impression 15 and gate 16 blocks. Thus, fixed gaps 23*a*—25*a* substantially equal in dimension and configuration to fixed gaps 23—25 of the ejector die 10 are also established for the cover die 11 between sides 17*a*—17*a* and ends 21*a*, 22*a* of the cover block's pocket 14*a* and the sides of the impression block 15*a*—gate block 16*a* combination. The cover gate block 16*a* and holding block 13*a* are dissimilar from the ejector gate 16 and holding blocks 13 in that they cooperate to define a gate or molten metal inlet 33 for the die cavity 12. The inlet 33 receives the end 34 of a shot tube 35 passing through passageway 36 in the holding block 13*a* and gate block 16*a*. A flange 37 integral with the shot tube 35 is seated on the back of the holding block 13*a* to position the shot tube relative to the gate 33. The shot tube 35 is part of a diecasting machine, not completely shown.

The shot tube 35, being fixed, serves to maintain the gate block 16*a* in its preset position within pocket 14*a*. As with the ejector die 10, the cover impression block 15*a* is positioned within the pocket 14*a* by means of a rectangular key 27*a* located in keyways 28*a*, 29*a* cut in the bottom 18*a* of the pocket 14*a* and the bottom of the impression block 15*a*, respectively. The key 27*a* is fixed to holding block 13*a* in keyway 28*a* by bolts 31*a* in the same manner as for the ejector die 10.

As can be seen from the figures, when the two dies 10, 11 are closed into cavity 12 forming relation for receiving a charge of molten metal they meet at their front faces, that is, at die interface 41. The impression blocks 15, 15*a* cooperate to form the die cavity 12 which, in the figures, is illustrated as that of a standard test bar. The gate blocks 16, 16*a* cooperate to establish the gate or metal inlet 33 for the molten metal, the gate terminating in an end feeder area 42 that distributes the molten metal into the die cavity 12. Guide pins 38 are mounted to the cover-holding block 13*a* and are receivable in recesses 39 formed in the ejector-holding block 13 for centering or locating the holding blocks 13, 13*a* in register when they are closed into operable diecasting position. When the dies 10, 11 are opened to eject a casting and then again closed to form cavity 12, keys 27, 27*a* act to ensure that impression block 15, 15*a* will be in registry by maintaining the preset position of the impression blocks relative to their holding blocks 13, 13*a* even if expansion gaps or crevasses occur between the two blocks during the casting operation. Movement of the ejector impression block 15 relative to the cover impression block 15*a* only a few thousandths of an inch may, in complex casting configurations, so misalign those blocks 15, 15*a* when they are closed together that castings produced from them will be out of dimensional tolerance limits. Thus, keys 27, 27*a* play an important part in maintaining the position of impression blocks 15, 15*a* within their pockets 14, 14*a* and, in combination with guide pins 38 and recesses 39, maintain the registry of the impression blocks during repeated openings and closings of the die assembly even when expansion gaps between impression and holding blocks occur.

Each impression block 15, 15*a*—gate block 16, 16*a* combination in each holding block's pocket 14, 14*a*, respectively, is maintained in that pocket during use of the die assembly by restraining means or chocks 43, 43*a* engageable with each die 10, 11 from the front face of that die. The chocks 43, 43*a* are preferably trapezodial or wedge shaped in cross-sectional configuration, each chock having parallel top 44, 44*a* and bottom 45, 45*a* sides, a tapered side 46, 46*a* and a vertical side 47, 47*a*, the inwardly tapered sides meeting the top sides at an acute angle α, see FIG. 3. The chocks 43, 43*a* are positioned within and sized to fit in the fixed gaps 23—25, 23*a*—25*a* created when the impression 15, 15*a*, gate 16, 16*a*, and holding 13, 13*a* blocks are assembled to substantially frame each block 15, 16 and 15*a*, 16*a* unit in its related pocket 14, 14*a*, see FIGS. 1 and 3. The impression blocks 15, 15*a* are provided with outwardly tapered sides 48, 48*a* in an abotuse angle β, see FIG. 3. The sum of the angles α and β equals 180°. Thus, the inwardly tapered sides 46, 46*a* of the chocks 43, 43*a* are angled to cooperate with outwardly tapered sides 48, 48*a* of the impression 15, 15*a* and gate 16, 16*a* blocks so as to restrain those blocks in their respective pockets 14, 14*a*.

In essence, each impression block—gate block unit is restrained and, thereby, retained, in its pocket because of the wedging action of the chocks 43, 43*a* between the impression 15, 15*a* and gate 16, 16*a* blocks and the holding blocks 13, 13*a*.

It is to be noted that the chocks 43, 43*a* are of a thickness T substantially less than the depth D of the pockets 14, 14*a* so they can be adjusted downward when required, as is more fully explained hereinafter. The top side 44, 44*a* width of each chock 43, 43*a* is preferably about equal to or a little less than the width at interface 41 of the fixed gaps 23—25, 23*a*—25*a* that the chock is to serve when the die is at room temperature. Thus, when the chocks 43, 43*a* are initially positioned in a room temperature holding block 13, 13*a* during makeup of the die the top sides 44, 44*a* of the chocks are substantially parallel with the front faces of the die halves 10, 11, see FIG. 3, and substantial clearance 49, 49*a* is established between the bottom side 45, 45*a* of the chocks and the bottom 18, 18*a* of the pockets 14, 14*a*.

The chocks 43, 43*a* are maintained in operating position, and are adjustably positionable within fixed gaps 23—25, 23*a*—25*a* during heat up, operation, and cool down of the die, by adjustment means in the form of threaded bolts 50, 50*a* spaced along their length in mirror relation for the ejector die 10 and the cover die 11; the bolts are available to an operator for adjustment from the front face of each die. The bolts 50, 50*a* are engageable with the holding blocks 13, 13*a* by threads 52, 52*a* that pass through, without threadedly engaging the chocks 43, 43*a*. Each bolthead 54, 54*a* cooperates with a recessed shoulder 53, 53*a* in each chock 43, 43*a* for forcing the chock down toward the bottom of its related pocket 14, 14*a* when the bolts 50, 50*a* are tightened into the holding blocks 13, 13*a*. Thus, by virtue of the wedging action performed by the chocks 43, 43*a* in the fixed gaps 23—25, 23*a*—25*a* between the tapered sides of the impression—gate block units and the sides 17, 17*a*, 22, 22*a* of the holding block pockets 14, 14*a* (the pressure of which can be varied or adjusted by bolts 50, 50*a*) the impression blocks 15, 15*a* and gate blocks 16, 16*a* are easily and simply assembled and, thereafter, can be maintained together in tight and safe assembly during casting operations even when expansion gaps tend to occur due to different block material expansion coefficients and high temperatures. Therefore, not only do the chocks 43, 43*a* maintain the impression blocks 15, 15*a* and gate blocks **16**, **16***a* in nested position with the holding blocks **13**, **13***a*, but the geometry of the chocks in cooperation with the impression blocks and holding blocks also precludes undesirable molten metal or flashing from filling any expansion gaps between sides of the blocks adjacent the faces of the blocks that might normally be caused by the difference in the blocks' coefficients of expansion because those expansion gaps are never allowed to open through operation of adjustment means **50**, **50***a* for the restraining means **43**, **43***a*. Thus, no molten metal flashing runs into expansion gaps.

As is illustrated in FIGS. **1** and **3**, the chock **43**, **43***a* structure is substantially the same for the chocks used with both the ejector die **10** and the cover die **11**, except that the depth of the working shoulder **53** from the chock's top side **44** for the ejector die chocks **43** is substantially deeper than that depth for the cover die chocks **43***a*. It is preferred that shoulders **53***a* of the chocks **43***a* be recessed to a depth substantially less than the height of the boltheads **54***a*, and it is preferred that the shoulders **53** of the chocks **43** be of substantially greater depth than the height of the boltheads **54**. This for the reason that when the ejector **10** and cover **11** dies are mated in operating relation, and because of the symmetry and mirror relation of the die assembly, the heads **54***a* of the cover chock bolts **50***a* will be partially received within the deeper recesses of chock **43** where the bolts **50** are positioned, see FIGS. **1** and **3**. Such a relationship prevents molten metal from being forced or flashed into the area **55** between heads **54**, **54***a* of the adjusting bolts during a casting cycle. If metal flashing got into this area **55** it could fuse the boltheads **54**, **54***a* together and hinder separation of the die halves **10**, **11**. If, for example, Allen head bolts are used and metal fills the wrench recess on the Allen head, removal of the adjusting bolts **50**, **50***a* from the chocks **43**, **43***a* and holding blocks **13**, **13***a* also would be extremely difficult.

The chock **43**, **43***a* structure of this invention admits of a method of use which is unique and novel in that it easily and simply permits the impression block **15**, **15***a* to be changed with its related holding block **13**, **13***a*. That is, the necessity for a tight friction fit between the impression block **15**, **15***a* and holding block **13**, **13***a* has been eliminated by the method and structure of this invention, thereby lessening the practical problems that obtain when handling, for example, refractory metal impression blocks which are relatively brittle at room temperature. In use, the impression block **15**, **15***a* and gate block **16**, **16***a* are placed in the holding block's pocket **14**, **14***a* from the front face of the die **10**, **11**, those blocks and pocket being formed so as to create fixed gaps **23—25**, **23***a***—25***a* between the sides of the impression block **15**, **15***a* and the sides **17**, **17***a*, **22**, **22***a* of the holding block pocket **14**, **14***a*. The key **27**, **27***a* is positioned in the keyways **28—29**, **28***a***—29***a* provided in the bottom **18**, **18***a* of the pocket **14**, **14***a* and the bottom of the impression block **15**, **15***a*, thereby centering the impression block in the holding block's pocket. Because the impression block—gate block unit is formed with a peripheral length less than the peripheral length of the holding block's pocket **14**, **14***a* the impression block **15**, **15***a* can be easily and gently set down into the holding block's pocket. This is of substantial advantage for refractory metal impression blocks in that it lessens the chance of cracking through mishandling. Subsequently, the chocks **43**, **43***a* are positioned within those gaps **23—25**, **23***a***—25***a* from the front face of the die **10**, **11** in a wedging fashion so as to maintain the impression block **15**, **15***a* immobile relative to the holding block **13**, **13***a*. The chocks **43**, **43***a* are tightened in position from the front face of the die **10**, **11** by tightening the bolts **50**, **50***a* and, thus, the impression block **15**, **15***a* is tightly and safely restrained in operating assembly with the holding block **13**, **13***a*. Even if the chocks **43**, **43***a* are tightened with unequal pressure on either side of the impression block **15**, **15***a*, those blocks still maintain their preselected alignment because of the key **27**, **27***a* and keyways **28—29**, **28***a***—29***a*. Such a method and structure has been found to substantially reduce the amount of time required by an operator to change impression blocks in a holding block.

The problems that occur when using a refractory metal impression block **15**, **15***a* with a normal-grade steel-holding block **13**, **13***a* arise because of the difference in expansion coefficients between these materials, as heretofore explained. The refractory metals have a much lower coefficient of expansion than do steels, for example, a refractory metal alloy may have a coefficient of expansion only one-half to one-third that of a good grade steel. Hence, in the prior art, even though an impression block may have a tight friction fit with the holding block's pocket when it is first assembled in operating position with that pocket at room temperature, as the die assembly heats up to operating temperature the sides of the pocket of the steel-holding block tend to expand away from the sides of the refractory metal impression block. That is, the impression block does not expand as much as the holding block to maintain the tight friction fit; therefore, expansion gaps or crevasses on the order of thousandths of an inch or hundredths of an inch or more are formed during high-temperature operation between the impression block and the sides of the holding block's pocket when the prior art method of holding the two blocks in operating engagement is used. In solving these problem, the chock **43**, **43***a* structure of this invention is utilized by the method steps of periodically tightening the chocks **43**, **43***a* from the front face of the die **10**, **11** as the die heats up to operating temperature by means of adjusting bolts **50**, **50***a* to take up any expansion gaps or crevasses created, thereby maintaining the impression block in tight and safe operating assembly with the holding block **13**, **13***a* and preventing expansion gaps from opening in the first instance. This step drives the wedge-shaped chocks **43**, **43***a* deeper into the fixed gap **23—25**, **23***a***—25***a*, but the original clearance **49**, **49***a* between the bottom **18**, **18***a* of the pockets **14**, **14***a* and the bottom **45**, **45***a* of the chocks permits such limited movement to be achieved. Such tightening of bolts **50**, **50***a* also can be performed by an operator from the readily accessible front face of each die **10**, **11** when the die halves are momentarily parted for ejecting a casting at the end of one casting cycle during a casting run, that is, the die does not have to be dismounted from the casting machine or disassembled to make the required adjustments. After a casting run has been concluded, and as the die assembly is cooling down to room temperature for changing impression blocks **15**, **15***a* (thereby causing the expansion gap formed on heat up to contract), the chocks **43**, **43***a* are periodically loosened by unscrewing bolts **50**. This prevents any buildup of compressive forces between the holding block **13**, **13***a* and the impression block **15**, **15***a* that may cause the brittle impression block to crack. Thus, this method easily and simply permits takeup of any expansion gap or crevasse created during heat up and operation of the die assembly, thereby maintaining the impression block in tight operating assembly and registry with the holding block during a casting run without the necessity of periodically dismounting or disassembling the die, and thereby preventing expansion gaps from forming which precludes molten metal flashing from flowing into such gaps. Also, this method easily and simply permits that expansion gap to be recreated or opened as the die assembly is cooled down and the impression **15**, **15***a* and holding **13**, **13***a* blocks contract back to normal room temperature configuration, thereby preventing cracking of the impression block on cooling that may occur if intolerable pressures are created on the brittle refractory metal impression blocks.

When the impression block **15**, **15***a* is fabricated of, for example, a refractory metal and the holding block **13**, **13***a* is fabricated of, for example, a tool steel it is preferred that the chocks **43**, **43***a* be fabricated of that tool steel and the key **27**, **27***a* be fabricated of that refractory metal. In the case of the chocks **43**, **43***a*, they must usually be made of steel so they can withstand the stresses placed on them by tightening of the bolts **50**, **50***a*. In the case of the key **27**, **27***a*, it is desirably fabricated of the same material as the impression block **15**, **15***a* so that no slippage or gaps occur between the key and its related impression blocks because both expand and contract at equal rates. Even if small gaps occur between the key **27**, 27*a* and the holding block keyway 28, 28*a*, because the key is bolted to the holding block 13, 13*a* such gaps cannot adversely affect the centered position of the impression and holding blocks. Thus, in the very important phase of registry or block alignment it is by means of the key 27, 27*a*, keyways 28—29, 28*a*—29, and bolts 31, 31*a* fixing the keys to the holding blocks 13, 13*a* that the impression blocks 15, 15*a* are maintained in a centered position relative to the holding blocks' pockets 14, 14*a*. Over tightening on one of the chocks 43, 43*a* by an operator relative to another of the chocks may inadvertently move the impression block 15, 15*a* off center a substantial number of thousandths of an inch without the key—keyway structure; however, this structure prevents such a happenstance from occurring.

The impression blocks 15, 15*a* illustrated in FIGS. 1—3 have been shown as defining a single die cavity. However, an alternative embodiment for the impression block, as illustrated in FIG. 4, is one having one-half 61 of a first die cavity on its front face 62 and one-half 63 of a second die cavity on its back face 64. This alternative embodiment can be flipped over in a holding block's pocket when a casting configuration change is required. Such an impression block admits of substantial economy particularly when that block is formed of a high-cost material such as a refractory metal in that two castings, instead of just one, can be cast from it. As can be seen from FIG. 4, the cross-sectional angle β defined by each face 62, 64 with the tapered sides 65 of the impression block is an obtuse angle, thereby making such a block configuration useful with the expansion gap system of this invention.

An alternative embodiment of a die assembly incorporating the expansion gap compensating system of this invention is illustrated in FIGS. 5—8. The alternative embodiment of a die half 70 basically differs from the embodiment illustrated in FIGS. 1—3 in that (a) impression block 71 is inserted from the rear of holding block 72 instead of from the face of the holding block as with the preferred embodiment, and (b) the impression block 71 is automatically adjustable during use of the die assembly's alternative embodiment to compensate for expansion gaps that tend to open between sides of related impression and holding blocks at their face as the die assembly is heated up to operating temperature, as well as to compensate for contraction of the gaps as the die assembly cools after a casting run.

As illustrated in FIGS. 5—7 each die half 70 of the alternative embodiment is comprised of a holding block 72, an impression block 71, and a rear plate 73. The casting cavity 69 illustrated is that same type of test bar as illustrated in the preferred embodiment of FIGS. 1—3.

The holding block 72 is provided with a specially configured pocket 74 that extends completely through the holding block. The pocket 74 is configured to provide a seat 75 or recess in the rear surface 76 of the holding block 72, the seat being defined by vertical sidewalls 77 perpendicular to the rear surface and a bottom wall 78 substantially parallel to the rear surface of the holding block. The holding block's pocket 74 is further defined by angulated cam walls 79 which extend from the bottom wall 78 of the seat 75 to the face 81 of the holding block 72. The angulated walls 79 define a hole more or less in the shape of a truncated tetrahedron, the minor face of the tetrahedron being at the face 81 of the holding block and the major face of the tetrahedron being at the bottom wall 78 of the seat 75 in the holding block 72, that is, the periphery of the hole at the face of the holding block is substantially less than the periphery of the hole at the bottom wall of the seat in the holding block. This configuration, i.e., the cam walls 79, provides wedgelike surfaces for that portion of the pocket 74 adjacent the face 81 of the holding block 72.

The impression block 71 is especially configured to cooperate with the pocket 74 in the holding block 72. The impression block 71 is comprised of a base 84 which is of a width A and of a length B substantially less than the width A′ and length B′ of the seat 75 in the holding block 72, see FIG. 8. This configuration allows fixed gaps 85 to be established between the sides 86 and ends 87 of the base relative to the sidewalls 77 and bottom 78 of the seat 75 when the impression block 71 is operationally engaged with the holding block 72, see FIGS. 5 and 8. Further, the depth C of the impression block's base 84 is substantially less than the depth C′ of the seat 75 in the holding block 72.

The impression block's base 84 is formed integral with a truncated tetrahedron 91 which presents a face 92 having an outer periphery 93 that is substantially identical with the periphery 94 of the hole defined by cam walls 79 at the face 81 of the holding block 72 at room temperature. The truncated tetrahedron 91 is of the same cross-sectional configuration as is the hole defined by cam walls 79, but the depth D of the truncated tetrahedron is substantially greater than the depth D′ of the hole defined by cam walls 79 in the holding block 72. Thus, when the impression block 71 and holding block 72 are assembled, a fixed gap 96 between the bottom wall 78 of holding block's seat 75 and the ledge 97 of the impression block's base 84 is also created. Further, it will be noted that the overall depth $(C+D)$ of the impression block 71 is equal to the overall depth $(c'+D')$ of the pocket 74 in holding block 72.

Of course, the impression block 71 is made from a material having a different expansion coefficient than that of holding block 72, as in the case of the preferred embodiment, and it is preferred that the impression block be configured during manufacture so that, when assembled with the holding block at room temperature, the face 92 of the impression block is substantially flush or in the same horizontal plane with the face 81 of the holding block.

The impression block 71 is held in operative engagement with the holding block 72 by means of the backplate 73 which is fixed to the holding block by means of threaded bolts 102 (shown only in FIG. 5). The backplate 73 cooperates with the impression block 71 to maintain same in fixed or wedged engagement with the cam sides 79 of the holding block's hole pocket 74 at room temperature. The backplate 73 is preferably made of the same material as the holding block 72.

The backplate 73 is provided with a key 103 which cooperates with a keyway 104 in the impression block 71 to maintain same in exact position or registry during use of the die assembly. The key 103 is comprised of an elongated bar that is fixed by bolts 105 to the backplate 73, and the key is made of the same material as the impression block 71.

Because of the expansion gap phenomena explained in connection with the preferred embodiment of this invention, as the die assembly illustrated in FIGS. 5—8 is heated up during use expansion gaps or crevices will occur between the cam sidewalls 79 of the holding block and the cam sidewalls 106 of the impression block 71. So that such expansion gaps or crevices are not open at the face 92, 81 of the die half 70, restraining means in the form of a series of threaded bolts 108 each with a heavy spring washer 109 are spaced around the periphery of the pocket 74 at face 81 of the holding block 72 to assure that such expansion gaps do not form. One of the holding blocks 72 is provided with a series of recesses 110 of a depth substantially greater than the depth of the boltheads 111. Those recesses 110 are aligned relative to the periphery of pocket 74 so that a further hole 112 may be bored completely through ledge section 114 of the holding block 72 in alignment with a hole 113 through base section 84 of the impression block 71, the ledge section 114 and base section 84 overlapping as seen in cross section in FIG. 5. The diameter of holes 112, 113 is such that bolts 108 are not threadedly engaged therewith. The bolts 108 are inserted through the holes 112, 113 in the impression block 71 and holding block 72 and are each provided with heavy spring or disc washer 109 interposed between nut 116 and the rear 76 of the impression block. Seats 117 are provided in the baseplate 73 to receive the nutted end of the bolts 112. The springs 109 cooperate with the bolts 108 to continually pressure the cam sides 106 of the impression block 71 against, and to insure that the cam sides of the impression block are held in engagement with, the cam sidewalls **79** of the holding block's pocket **74** during a casting run, even when expansion gaps or crevices tend to occur. This prevents any expansion gaps from occurring at the face **92**, **81** of the die half **70** in which molten metal may freeze, and also holds the impression block **71** and holding block **72** in operable engagement once the temperature of the die half has increased to a point where the baseplate **73** no longer serves that purpose.

The holding block **72a** of the other mold half **70a** is provided with bolt holes **110a** of a depth substantially less than the height of the boltheads **111a**, and the holes **110a** are positioned in mirror relation to the boltholes **110** of the die half **70**. Thus, when the two die halves **70**, **70a** are in operable engagement (see FIG. 5) to define the casting cavity **69**, boltheads **111a** are received in recesses **110** in the holding block **70** so as to essentially seal off that space **121** between boltheads **111**, **111a** and prevent molten metal from freezing the bolts in position.

Although I have described the preferred embodiment of my invention in complete detail it will be understood by those skilled in the art that variations and modifications may be established in the expansion gap system structure and method of this invention as described herein without departing from the spirit or scope of the appended claims. For example, even though the inventive concept of this application has been described primarily with reference to the art of diecasting, it will be understood that the inventive principles are also applicable to permanent molding, centrifugal molding, gravity molding and other related areas where a die is utilized comprised of a holding block and an impression block wherein the expansion coefficients of those block materials cause problem (s) such as are discussed above. Accordingly, having fully disclosed the preferred embodiment of my invention, what I desire to claim and protect by Letters Patent is:

1. A method of compensating for expansion gaps in a die wherein each die half is made up of a holding block and an impression block, and wherein the coefficient of expansion of said holding block is greater than the coefficient of expansion of said impression block, comprising the steps of

providing a pocket in said holding block

providing said impression block with an outer periphery configured such that said impression block can be established in nested position within said holding block's pocket, said impression block thereafter being nested in said holding block's pocket,

providing restraining means associated with said impression and holding blocks that maintains said impression block in nested position with said holding block, and that precludes undesirable molten material from filling any expansion gaps between sides of said blocks adjacent the face of said die half that might normally be caused by the difference in said blocks' coefficients of expansion, as the temperature of said die half rises during use thereof,

charging molten material into the cavity of said die half thereby increasing the temperature of said die half and promoting differential expansion between said impression block and said holding block, and

adjusting said restraining means to compensate for the differential expansion of said impression block and said holding block as the temperature of said die half rises, thereby alleviating the formation of expansion gaps between the sides of said impression and holding blocks adjacent the face of said die half during use thereof.

2. A method as set forth in claim **1** including the further steps of

returning the temperature of said die toward ambient temperature, and

adjusting said restraining means to compensate for the differential contraction of said impression block and said holding block as the temperature of said die half decreases, thereby permitting the contraction of the expansion gap formed between the sides of said impression and holding blocks as the temperature of said die half was rising without subjecting said impression block to undesirable compressive forces.

3. A method as set forth in claim **2** including the further step of

providing registration means associated with said holding and impression blocks for maintaining desired registry of each of said die half's impression blocks to each other during adjusting of said restraining means.

4. A method as set forth in claim **3** wherein said impression block is provided with an outer periphery substantially less than the periphery of said pocket, and said impression block is positioned in said pocket so a preformed gap is created between the sides of said impression block and said holding block, and including the further step of

inserting said restraining means within said preformed gap.

5. A method as set forth in claim **3** wherein the step of providing registering means includes

keying said impression block to said holding block.

6. A method as set forth in claim **4** wherein said restraining means is a chock and said chock is inserted in wedging fashion within said gap.

7. A method as set forth in claim **6** wherein said chock is inserted until the top side of said chock is substantially flush with the front face of said impression block at ambient temperature, said chock being so sized that a clearance is thereby established between the bottom of said chock and the bottom of said pocket at ambient temperature.

8. A method as set forth in claim **7** wherein said chock is adjusted by the manual tightening and loosening of bolts interconnecting said chock and said holding block.

9. A method as set forth in claim **8** wherein said impression block is positioned, said chock is inserted, and said bolts are adjusted all from the front face of said die half.

10. An expansion gap compensating system for a die assembly having two complimentary die halves, at least one die half comprising, in combination,

a holding block with a pocket defined therein,

an impression block established in nested position within said holding block's pocket, the impression block material having a lesser expansion coefficient than the holding block material,

restraining means associated with said impression and holding blocks, said restraining means maintaining said impression block in nested position with said holding block, and said restraining means cooperating with said blocks to preclude undesirable molten material from filling any expansion gap between the sides of said blocks adjacent the face of said die half that might normally be caused by the difference in said blocks' coefficients of expansion, as the temperature of said die half rises during use thereof, and

adjusting means associated with said impression and holding blocks for adjusting said restraining means as required to compensate for the differential expansion of said impression and holding blocks as the die half's temperature rises during use, thereby alleviating the formation of an expansion gap between the sides of said impression and holding blocks adjacent the face of said die half during the use thereof.

11. An expansion gap compensating system as set forth in claim **10** wherein said adjusting means also includes means adapted for adjusting said restraining means as required to compensate for the differential contraction of said impression and holding blocks as the temperature of said die half decreases, thereby permitting the contraction of the expansion gap formed between the sides of said impression and holding block as the temperature of said die half was rising without subjecting said impression block to undesirable compressive forces.

12. An expansion gap system as set forth in claim **11** including

registration means associated with said impression and holding blocks for maintaining desired registry of said impression block with a cooperating impression block of another die half during use of said adjustment means.

13. An expansion gap system as set forth in claim **12** wherein said registration means comprises key means.

14. An expansion gap compensating system as set forth in claim **12** wherein the periphery of said impression block is substantially less than the periphery of said holding block's pocket, said dissimilar peripheries resulting in a preformed gap between the sides of said blocks equal to at least about one-half the peripheral length of said impression block being disposed between the sides of said impression block and said holding block's pocket, and wherein said restraining means is positioned within said preformed gap.

15. An expansion gap compensating system as set forth in claim **14** wherein said restraining means comprises a chock positioned within said fixed gap.

16. An expansion gap compensating system as set forth in claim **15** wherein said chock is wedge shaped in cross-sectional configuration, and wherein said chock is fabricated of the same material as said holding block.

17. An expansion gap compensating system as set forth in claim **15** wherein the thickness of said chock is substantially less than the depth of said fixed gap so that a clearance is established between the bottom of said chock and the bottom of said pocket when said chock is positioned within said gap at ambient temperature, and wherein the top side of said chock is substantially flush with the front face of said impression block when said chock is positioned within said gap at ambient temperature.

18. An expansion gap compensating system as set forth in claim **14** wherein said registration means comprises key means engageable with said holding block and said impression block.

19. An expansion gap compensating system as set forth in claim **18** wherein said key means includes

a key, and

a keyway in at least one of said impression blocks and said pocket.

20. An expansion gap compensating system as set forth in claim **19** wherein said key is fixed to said holding block, a keyway is at least in said impression block, and said key is of the same material as said impression block.

21. An expansion gap compensating system as set forth in claim **17** wherein said adjusting means includes

a series of bolts interconnecting said chock and said holding block, said chock and said bolts being accessible from the front face of said die half.

22. An expansion gap compensating system as set forth in claim **16** wherein said impression block and chock are configured so that an obtuse angle is formed between the front face and side of said impression block and a mating acute angle is formed between the top and side of said chock, said angles totaling about 180°.

23. An expansion gap compensating system for a die assembly having two die halves comprising, in combination,

a first and a second holding block with pockets defined therein,

a first and a second impression block each receivable within one of said pockets, the impression blocks' material having a lesser expansion coefficient than the holding blocks' material and said impression blocks each having a substantially shorter peripheral length than its related pocket so that a fixed gap is created for each pair of blocks,

a chock positionable within each of said gaps, said gaps being in mirror relation one to the other when said die halves are positioned together in operable die assembly,

a first series of bolts adjustably interconnecting a first chock and said first holding block from the front face of said first die half, the first boltheads being substantially recessed below the top side of the first said chock, and

a second series of bolts adjustably interconnecting a second said chock and said second holding block, the second boltheads extending substantially above the top side of the second said chock and being positioned in mirror relation to said first bolts, and the heads of said second bolts being received in the deeper recesses formed for said first bolts after said die halves are positioned in operable die assembly,

both said series of bolts adapted to be turned to periodically adjust the position of the respective chocks within the respective fixed gaps to compensate for widening or narrowing of said fixed gap as the die temperature increases and decreases, respectively, from and to ambient temperature during use.