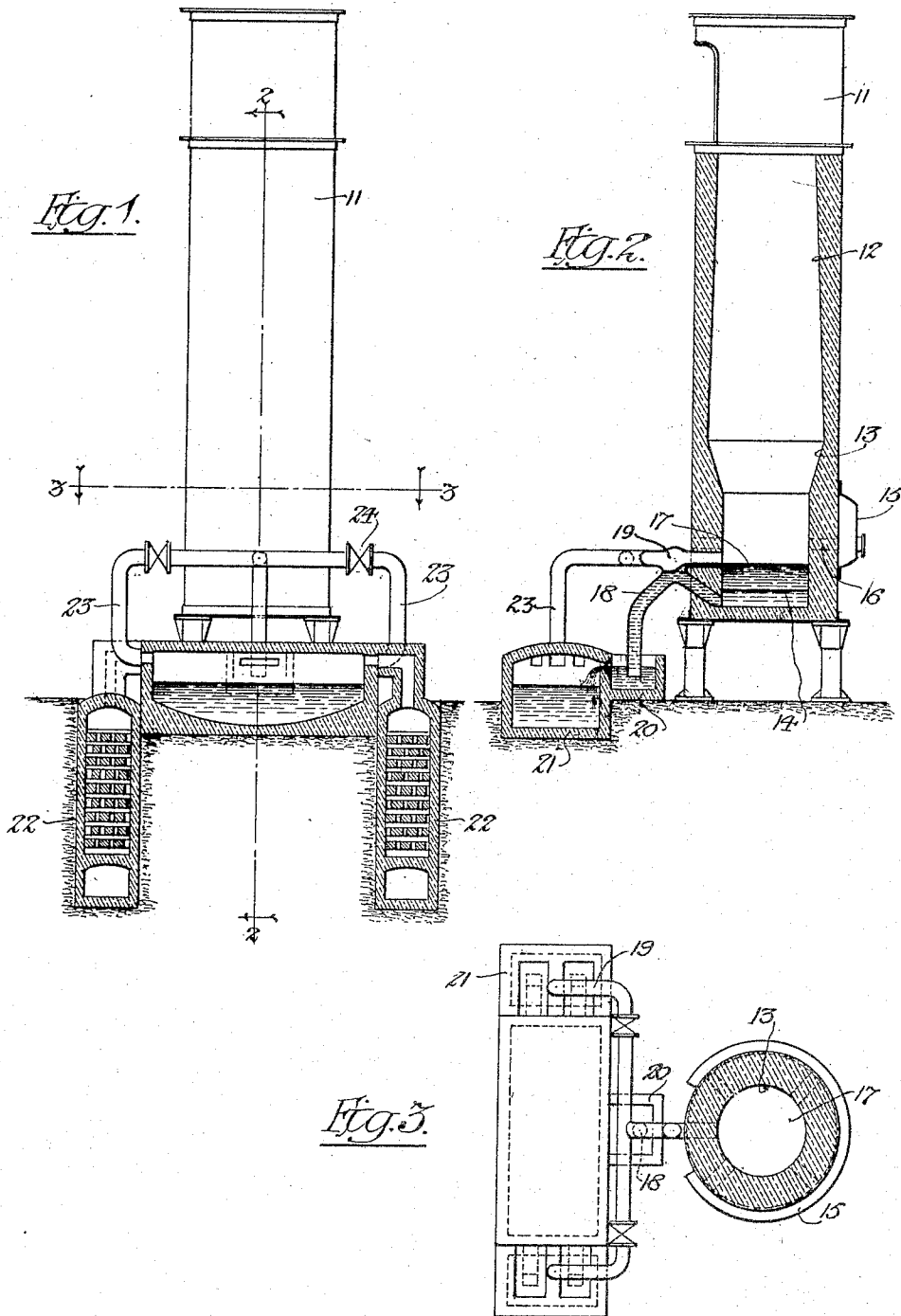


H. KOPPERS.
 CUPOLA TREATMENT OF METALS.
 APPLICATION FILED SEPT. 3, 1920.

1,357,780.

Patented Nov. 2, 1920.
 2 SHEETS—SHEET 1.



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Fig. 5.

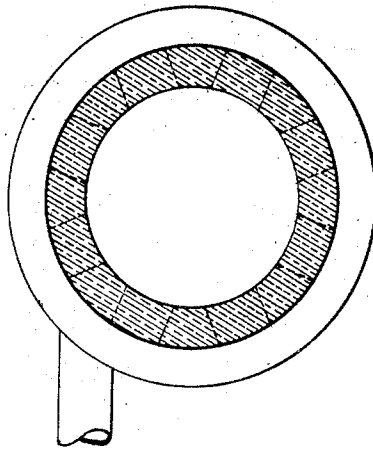
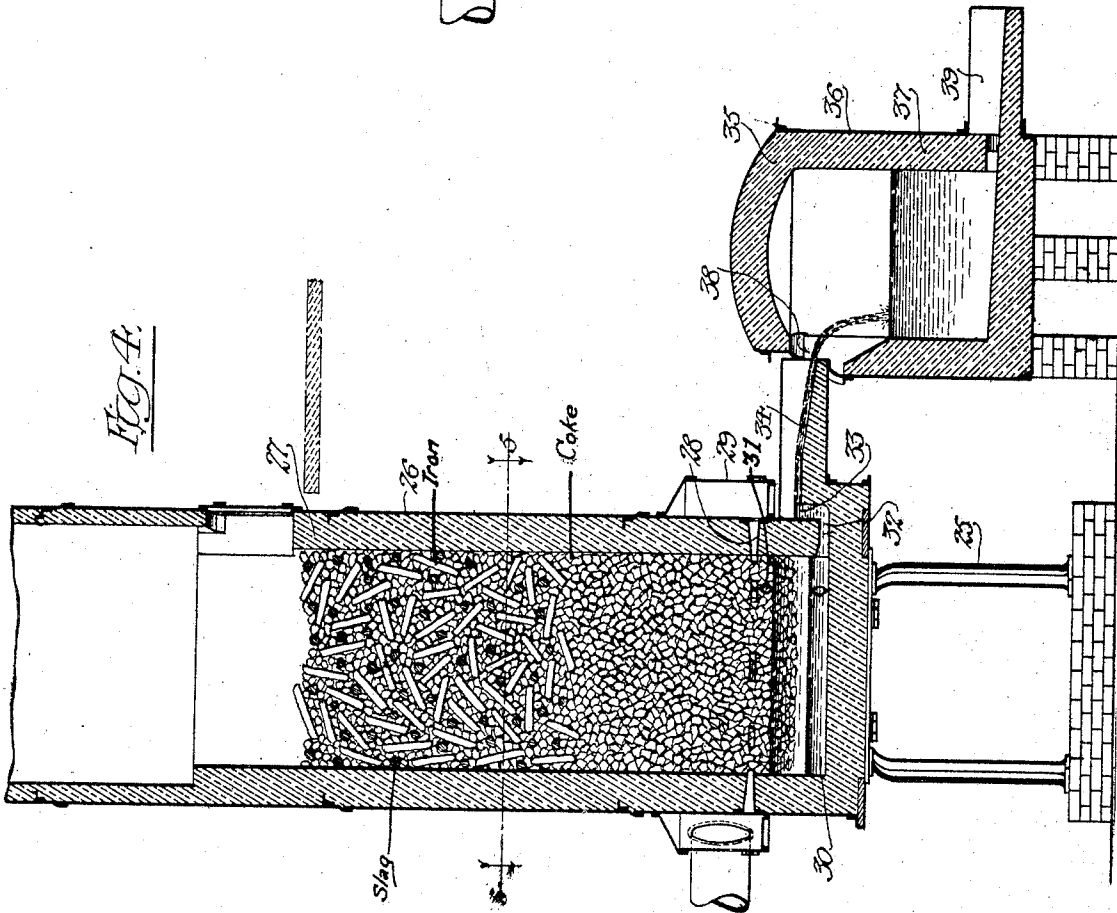


Fig. 4.



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 his *Attys.*

UNITED STATES PATENT OFFICE.

HEINRICH KOPPERS, OF ESSEN-ON-THE-RUHR, GERMANY, ASSIGNOR TO THE KOPPERS DEVELOPMENT CORPORATION, A CORPORATION OF PENNSYLVANIA.

CUPOLA TREATMENT OF METALS.

1,357,780.

Specification of Letters Patent.

Patented Nov. 2, 1920.

Application filed September 3, 1920. Serial No. 408,080.

To all whom it may concern:

Be it known that I, HEINRICH KOPPERS, (assignor to The Koppers Development Corporation, of Pennsylvania,) a citizen of Germany, residing in Essen-on-the-Ruhr, Germany, have invented a new and useful Improvement in Cupola Treatment of Metals, of which the following is a specification.

This invention relates to the treatment of metals, such as iron and its alloys, in cupola furnaces and has for one of its objects to effect efficient desulfurization of the metal and to obtain a high grade product containing a minimum proportion of sulfur.

The presence of sulfur, especially in iron and its alloys, greatly impairs the quality of the metal, when occurring in other than extremely small proportions. When present in iron, sulfur makes the iron much more liable to rust; in fact the tendency of iron to deteriorate when exposed to atmospheric conditions is augmented by the presence of sulfur, which constitutes an important factor in promoting such deterioration. In the case of steel, the presence of sulfur not only makes the steel liable to rust, but imparts a brittle quality to the steel making it difficult to shape and impairing its strength. Consequently, it is of great importance in the metallurgical industries to restrict the quantity of sulfur in such metals as iron and steel to mere traces. This invention provides a novel and improved treatment of the metal in a cupola, or remelting furnace, by which treatment the sulfur contained in the product of the furnace is limited to mere traces, which do not appreciably impair the quality of the metal.

Another important object of the invention is to promote deoxidizing of the metal in the remelting furnace, such deoxidizing taking place as an incident to the desulfurization, thereby reducing the oxygen contained in the finished product and permitting a more extended remelting of rusty iron scrap in furnaces of this character, which otherwise would have to be charged into a blast furnace. The process further involves the reduction of slag compounds, of the nature of those derived from the iron, and in rejuvenating the iron with the elements recovered from such compounds.

The invention has for other objects such other improvements or advantages in operation and such other advantageous results as may be found to obtain in the improved

processes and apparatus hereinafter described as illustrative examples.

In the accompanying drawings, forming a part of this specification, and showing, for purposes of exemplification, a preferred manner in which the invention may be embodied and practised, but without limiting the claimed invention specifically to such illustrative instance or instances:

Figure 1 is a vertical sectional elevation of a diagrammatic representation of a cupola furnace for practising the improvements of the invention;

Fig. 2 is a vertical section on the line 2—2 of Fig. 1;

Fig. 3 is a horizontal section on the line 3—3 of Fig. 1;

Fig. 4 is a vertical sectional elevation of a modified form of cupola furnace apparatus; and

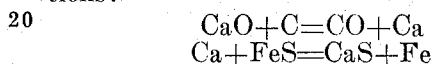
Fig. 5 is a horizontal section on the line 5—5 of Fig. 4.

The same characters of reference indicate the same parts throughout the several views.

One example of carrying out the invention is illustrated by the apparatus shown in Figs. 1, 2 and 3. This apparatus is intended for practising the invention in a cupola furnace having a fore-hearth. Referring to said Figs. 1, 2 and 3, the reference numeral 11 represents a cupola constituted of a stack 12 in the upper part, the bosh 13 in the intermediate part, and the hearth 14. Below the bosh 13 and above the hearth 14 is a bustle pipe 15 which supplies preheated air to the interior of the furnace through the series of tuyers 16. The charge to be treated in the furnace is introduced into the top of the stack 12 in the usual way and, when in the furnace consists of a mixture of pig iron, or scrap or burnt iron, coke and a basic material such as lime stone, for neutralizing the acidity of the ash and forming the slag which floats or stratifies on the top of the molten metal in the bottom of the hearth.

In addition to its neutralizing action on the acidity of the ash, the lime stone slag stratum indicated by the reference numeral 17 has an affinity for sulfur and such property of the slag to absorb sulfur, and also to promote deoxidizing of the molten iron is augmented by contact of incandescent carbon, which dips into the slag stratum. The molten metal flows in small drops, or

in the form of spray, downwardly through the solid portions of the charge in the melting zone, and dropping through the slag stratum on top of the mass of molten metal in the bottom of the hearth, the small drops of molten metal are subjected to the prolonged action of the slag which action is augmented by the submerged particles of incandescent carbon. In its passage through the slag stratum, a reaction is effected between the basic compounds present in the slag and the sulfur content in the metallic iron causing sulfur to be absorbed from the iron and retained by the slag, with which the sulfur combines to form principally the compound, calcium sulfid. The absorption of sulfur by the slag may be represented, for example, by the following two equations:



From these two equations it will be observed that the incandescent carbon induces the reaction resulting in the formation of calcium sulfid and pure iron. The calcium sulfid is soluble in and will be retained by the slag. The importance of the presence of incandescent carbon is illustrated by the first formula given above, inasmuch as the action of the carbon is first to reduce the calcium oxid to metallic calcium, thereby augmenting the affinity of the slag stratum for absorption of sulfur from the metal which passes through the slag. A further result of the contact of incandescent carbon with the slag stratum, is to promote deoxidizing of the metal as it drips through the slag, inasmuch as the incandescent carbon has a very high affinity for oxygen. Such incandescent carbon further promotes the reduction of manganese oxids present in the slag which originated in the iron charged in the cupola. There is thus effected a rejuvenation of the iron, by restoring thereto such essential elements as manganese and silicon, which elements are frequently lost in ordinary remelting processes. Other elements are also reduced, such for example as iron contained in the coke, and this iron may be recovered and added to the product of the remelting furnace. In ordinary cupola practice, it frequently happens that the metal discharged from the cupola contains more sulfur and oxygen and less manganese and silicon than that contained in the metal originally charged into the cupola, for the reason that, in the region of the twyers, the oxidizing effect of the air is not counteracted by the reducing effect of a slag mass, as the slag is discharged from the furnace as soon as it is formed. The present invention, by continuously maintaining a slag stratum in contact with incandescent carbon in the hearth of the

furnace, counteracts this oxidizing tendency, and has the opposite effect of obtaining a product having less oxygen and sulfur than the original charge, and without loss of manganese, or substantial loss of silicon. By the invention, it is possible to incorporate in the charge a large proportion of rusty iron scrap of poor quality and to effect complete rejuvenation, without resort to remelting in the blast furnace, as ordinary practice always requires. The rejuvenation of scrap or often remelted iron of poor quality is thus accomplished directly in the cupola, and blast furnace treatment, for this purpose, is avoided.

In accordance with the invention, the above described factors which augment desulfurization, deoxidation and rejuvenation of the iron are maintained continuously in their condition of maximum effect, during operation of the remelting furnace. In order to effect this result and to secure a maximum desulfurizing effect promoted by the action of the slag and immersed incandescent carbon, the invention provides for the maintenance of a continuous mass of slag in the hearth of the remelting furnace as contra-distinguished from ordinary practice in which the slag and metal are discharged from the furnace as soon as they form. By the invention, a mass of sulfur-absorbing slag is maintained at all times within the furnace, thereby producing a condition which results in maximum desulfurization and promotes the obtaining of a product of uniformly low sulfur content. In fact, the refined iron obtained, as a result of the practice of the invention, contains appreciably less sulfur and also appreciably less oxygen and more manganese than is present in iron refined by present processes, there being only small traces of sulfur present in the refined iron obtained by this invention. Accordingly, the invention may, if desired, be exploited for the purpose of producing refined iron having a specific maximum sulfur content, in which case it will be possible to utilize in the remelting furnace coke having a greater proportion of sulfur than could be used in present practice, to obtain refined iron of the required specifications. Consequently, coke produced from many coals, which has been heretofore rejected for metallurgical purposes, is made available for such purposes.

One way of practising the invention is illustrated in Figs. 1, 2 and 3, and this consists in maintaining continuously during the operation of the furnace, constant levels respectively of the molten metal and superposed slag strata in the hearth of the furnace. This is accomplished by effecting withdrawal of the metal and slag separately from their respective strata, through overflow-ducts 18 and 19. The metal overflow-

duct 18 extends upwardly from the hearth of the furnace at a point below the level of the molten metal and thence downwardly to a sealed vessel 20. The slag overflow-duct 19 extends from the hearth of the furnace just below the level of the twyers 16 to the metal overflow-duct 18, through which the slag passes from the duct 19 to the vessel 20, from which it may be discharged separately from the metal. The fixed slag overflow pipe 19 determines the height of the slag level in the hearth of the furnace, whereas the fixed location of the crest of the metal overflow pipe 18 determines the height of the level of molten metal. In practice, the relation of these respective heights may be expressed as follows: The height of the crest of the metal overflow pipe above its junction point with the hearth of the furnace equals the height of the molten metal in the furnace above said junction point plus two-sevenths of the height of the slag stratum in the hearth of the furnace, assuming that the specific gravity of the slag be two and that of the iron be seven.

In this manner constant levels, both of slag and of molten metal, are maintained in the hearth of the furnace and this condition is combined with continuous discharge both of slag and of the refined metal from the furnace. Drawing off of the slag and metal, as soon as they are formed, is eliminated, and conditions which insure a maximum absorption of sulfur from the metal are maintained uninterruptedly in the furnace, with the result that the product contains but a minimum content of sulfur.

As shown in Figs. 1, 2 and 3, an open hearth furnace operation may be directly combined with the cupola operation, for further modifying the composition of the refined metal obtained from the cupola. Connected with the opposite ends of the fore-hearth or tub 21 are regenerators 22, said regenerators being alternately heated by the waste products from the hearth and giving up their heat to effect pre-heating of the air which enters the hearth to support combustion. The overflow-duct 19 is connected with the opposite ends of the hearth by gas ducts 23 the flow through which is respectively controlled by valves 24, thereby permitting the combustible gas from the cupola to be burned in conjunction with the air supplied by either regenerator. In this way the cupola gas, of high calorific value, is lead directly into an open hearth furnace and there utilized for open hearth treatment of the refined metal discharged from the cupola.

In Figs. 4 and 5, there is illustrated an application of the invention to a simple cupola furnace apparatus. The furnace illustrated in these figures is supported by pedestals 25 of any approved construction and consists

essentially of an outer cylindrical metallic shell 26 surrounding an inner cylindrical refractory lining 27. The twyers 28 are disposed in series around the furnace, and are connected at their outer ends with an air inlet pipe 29 which encircles the furnace and supplies the air for supporting combustion within the furnace. Just below the twyers and located in the hearth 30 of the cupola is an overflow-duct 31 for the slag. In the bottom of the hearth is a discharge duct 32 for the molten metal, such discharge duct 32 communicating at its outer end with an upwardly extending duct 33 through which the metal flows to and over an overflow-spout 34 which carries the refined metal to a closed receiver 35. The receiver 35 is constructed of an outer metallic shell 36 and an inner refractory lining 37, and is provided with an inlet 38 and with an outlet 39 through which the refined metal may be discharged as desired. The crest of the vertical duct 33 is related to the slag and molten metal levels within the hearth of the furnace, in the same manner as the crest of the duct 18 utilized in the form of the invention illustrated in Figs. 1, 2 and 3.

The invention as hereinabove set forth may be practised in various ways without departing from the scope of the claims herein-after made.

I claim:

1. In the cupola remelting treatment of iron and its alloys, the continuous maintenance, in the hearth of a cupola, of a pool of slag in the presence of incandescent carbon that has sunk below the level of the air blast and into said slag pool, combined with the passage of the remelted iron through said slag pool to effect absorption of sulfur from the iron; substantially as specified.

2. In the cupola remelting treatment of iron and its alloys, the continuous maintenance, in the hearth of a cupola, of a pool of slag in the presence of incandescent carbon that has sunk below the level of the air blast and into said slag pool, combined with the passage of the remelted iron in the form of a spray through said slag pool to effect absorption of sulfur from the iron; substantially as specified.

3. In the cupola remelting treatment of iron and its alloys, the continuous maintenance, in the hearth of a cupola, of a pool of basic slag in the presence of incandescent carbon that has sunk below the level of the air blast and into said slag pool, combined with the passage of the remelted iron through said slag pool to effect absorption of sulfur from the iron; substantially as specified.

4. In the cupola remelting treatment of iron and its alloys, the continuous maintenance, in the hearth of a cupola, of a slag stratum at a substantially constant level and

in the presence of incandescent carbon that has sunk below the level of the air blast and into said slag stratum, combined with the passage of the remelted iron through said slag stratum to effect absorption of the sulfur from the iron; substantially as specified.

5 5. In the remelting of iron and its alloys with coke, the continuous maintenance of a mass of basic slag at a constant level above the bottom of the incandescent coke to effect desulfurization of the remelted metal during its passage through the slag and to maintain a reducing zone through which the remelted iron passes before being discharged, substantially as specified.

10 6. In the remelting of iron and its alloys with coke, the continuous maintenance of a mass of basic slag above the bottom of the incandescent coke to effect desulfurization of the remelted metal during its passage through the slag and to maintain a reducing zone through which the remelted iron passes before being discharged, substantially as specified.

25 7. A cupola furnace comprising: a remelting chamber, twyers, and means for controlling the molten metal in the hearth of said chamber in substantial proportion to the difference in specific gravities of said metal and the superimposed slag, to maintain substantial masses of the molten metal and superimposed slag respectively at constant levels in the lower portion of said remelting chamber and below the level of the blast from the twyers; substantially as specified.

35 8. A cupola furnace comprising: a remelting chamber, twyers, a slag overflow means below the level of the twyers, and a molten metal overflow means below said slag overflow means, said overflow means controlling the molten metal level in the hearth of said chamber in substantial proportion to the difference in specific gravities of said metal and the superimposed slag and operating to maintain constant levels of substantial masses of the molten metal and superimposed slag in the hearth of said remelting chamber below the level of the blast from the twyers; substantially as specified.

50 9. A cupola furnace comprising: a remelting chamber, twyers, a slag overflow means below the level of the twyers, and an overflow means for the molten metal below said slag overflow means, said means controlling the molten metal level in the hearth of said chamber in substantial proportion to the difference in specific gravities of said metal and superimposed slag; substantially as specified.

60 10. In the remelting treatment of iron and its alloys; passing the remelted iron through a mass of slag in the presence of incandescent carbon, to effect absorption of sulfur from the iron; withdrawing the desulfurized iron and gas; and burning such gas in

the presence of the withdrawn iron to effect further refining of the iron; substantially as specified.

11. A cupola furnace, comprising: a remelting chamber; twyers; a fore-hearth; means below the level of the twyers for permitting gas to pass into said fore-hearth; and a molten metal over-flow means also connected with said fore-hearth; substantially as specified.

75 12. A cupola furnace, comprising: a remelting chamber; twyers; a fore-hearth; regenerators for supplying preheated air to said fore-hearth; means below the level of the twyers for permitting gas to pass into said fore-hearth; and a molten metal over-flow means also connected with said fore-hearth; substantially as specified.

13. A cupola furnace comprising: a remelting chamber, twyers, and means for controlling the molten metal in the hearth of said chamber in substantial proportion to the difference in specific gravities of said metal and the superimposed slag, to maintain continuously, in the lower portion of said chamber and below the level of the blast from the twyers, levels of substantial masses of the molten metal and superimposed slag; substantially as specified.

14. In the cupola treatment of iron and its alloys, a process consisting in desulfurizing the iron and in reducing slag-compounds, of the nature of those derived from the iron, and in rejuvenating the iron with the alloying elements recovered from such compounds; substantially as specified.

15. In the cupola treatment of iron and its alloys, a process consisting in desulfurizing and deoxidizing the iron, and in reducing slag-compounds and conserving in the iron the manganese and silicon recovered from such compounds; substantially as specified.

16. In the cupola remelting treatment of iron and its alloys: a process which consists in subjecting the iron to the treatment of a blast of preheated air and in effecting a passage of the remelted iron through a pool of slag in the presence of incandescent carbon that has sunk below the level of said preheated blast and into said slag pool; substantially as specified.

17. A cupola furnace comprising: a remelting chamber, means for supplying a blast of preheated air to said remelting chamber, and means for controlling the molten metal in the hearth of said chamber in substantial proportion to the difference in specific gravities of said metal and superimposed slag, to maintain substantial masses of the molten metal and superimposed slag respectively at constant levels in the lower portion of said remelting chamber and below the level of the blast from the twyers; substantially as specified.

HEINRICH KOPPERS.