Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).
The invention comes within the scope of metallurgy of nonferrous metals and deals with the reactor construction that is intended for one-stage processing of titanium tetrachloride with use of natrium or magnesium.

There are a considerable number of various reactors and smelting furnaces destined for nonferrous metals production, whose construction depends on the type of ore being processed as well as on implemented technology and desired quality of the final product.

There are known the constructions of reactors described in patent specifications US 2004/0103791, GB 1202581 or GB 1429333 comprising a variety of reaction zones into which a reduction gas is introduced. These reactors produce titanium dioxide; however, they cannot be used to produce pure titanium. Specification GB 1260021 describes continual processing of titaniferous iron ore with use of hydrochloric acid in the equipment containing two or more arranged in cascades and mutually connected reactors which comprise mixing devices. The temperature in each of the reactor vessels is produced as a result of exothermic reactions of titanium chloride and is stabilized by regulation of flow of reagents passing through the equipment. Titanium dioxide is produced by hydrolysis after final solid suspension extraction is performed. This is to say that the reactor is destined for primary processing of titaniferous iron ore into TiCl₄ with subsequent TiO₂ production and does not refer to the production of pure titanium. Fabrication of pyrogenic TiO₂ with finely dispersed particles is described in patent specification GB 1187864, where the reaction of gaseous TiCl₄ with oxygen is used to produce a gas mixture containing TiO₂, which is consequently subjected to electrical field generated by electrodes and located in the reactor chamber at temperatures from 400 to 800°C. Said electrical field prevents accretion forming on the walls of reactor. After cooling the mixture down TiO₂ is separated either mechanically or with use of electrostatic dust extraction.

Construction of the reactor producing titanium is referred to in patent specification GB 814181, describing continual processing of TiCl₄ vapours in the presence of alkaline substances or alkaline earth metals, dissolved in a melt containing halides or other metals, the reaction vessel being designed so that its construction prevents unmelted reduction metal from coming into contact with TiO₂ vapours. Titanium formed in the reaction chamber settles down at the bottom and can be released as a suspension in a salt melt or can be pulled out as a cooled block of salt containing titanium. Weak point of this equipment is low manufacturing capacity and the fact that final product is not pure titanium but just a suspension in a salt melt or a cooled block of salt containing titanium.

Manufacturing of titanium from its halides is described in patent specification GB 717930, where TiCl₄ reacts with natrium in an inert atmosphere at temperature from 200°C up to melting temperature of NaCl, preferably from 480-620°C. During this process a non-sticky and non-coherent bed of reaction products is formed in the reactor and titanium is subsequently reduced. Prior to reaction the products can be heated up to more than 800°C in an inert atmosphere. NaCl can be precipitated with use of heating in the presence of water or 1% solution of H₂SO₄ or can vaporize in the inert atmosphere at temperatures exceeding melting temperature of titanium, which is subsequently casted. Weak point of this technical solution is that reactions of natrium and TiO₂ are carried out in a regime of laminar diffusion which results in low effectiveness and manufacturing productivity.

The weak points mentioned above are eliminated by construction of a reactor as defined in claim 1, intended for titanium production, comprising a body whose tubular jacket is cooled by a refrigerant and which is equipped with melting electrodes and comprises other systems designed to introduce gaseous medium containing titanium, to introduce liquid reduction agent and fluxing agents and to discharge by-pass products and to collect finished titanium. Subject matter of the invention consists in division of the interior of the reactor into two sections, namely reduction and melting ones, divided one from another with use of a barrier equipped with a by pass aperture, where the melting section comprises a melting chamber including main melting electrodes and a hopper for introducing fluxing agents; and where the reduction section comprises a reaction chamber into which reaction channels open being directed from mixing chambers; and comprises channels for delivering gaseous titanium-content medium being open into the reaction channels in their upper part and at the same time comprises a funnel chamber delivering the liquid reduction agent being connected with the reaction channels.

An embodiment of the invention is that reaction channels are introduced into the reaction chamber in an upward manner, at an angle and symmetrically one against another, and in a convenient version they decline at an angle of 30-60° with respect to horizontal plane and they have a rectangular section.
Subject matter of the invention is also the fact that the melting section is equipped with an outlet pipe designed for releasing vapour and a siphon outlet terminated with a melting pan designed to discharge condensed liquid portion and clinker as by-pass products of the productions.

In various modifications of the apparatus there can be hearth crystallizers arranged at the bottom part of the melting chamber which are equipped with drawing devices intended to catch and pull out cooled titanium ingots, or the melting section can be equipped with a discharging unit connected to the melting chamber through an outlet opening and a siphon outlet comprising auxiliary melting electrodes and opening into a discharging channel.

The new invention's efficiency is based on the fact that due to kinetic energy of the high-speed gasflow blown through the reaction channels and reaction chamber the regime of turbulent diffusion arises, which significantly favours practically immediate proceeding of pyrometallurgical reactions taking place at high rates and allowing material to melt quickly, thus the typical weak point of metallurgical equipment (converter, reflex furnaces) mutual interaction between final products and reagents is eliminated. The apparatus has quite a simple design and at the same time it exhibits unusually high manufacturing productivity; another advantage is that all magnesium introduced into the reduction section is almost restlessly utilized. The rate of reactions taking place at high temperatures is controlled through the transport speed regulation which means that speed of introducing reagents into reactor and speed of releasing products from the reaction zone influence the speed of reaction.

Enclosed drawings description

Actual examples of the present invention's versions are schematically displayed on the enclosed drawings, where

- Fig. 1 features a longitudinal section of the basic version of the reactor
- Fig. 2 features a horizontal projection of the reactor from fig.1
- Fig. 3 features a transversal section of the reactor from picture 1 in a section plane A-A
- Fig. 4 features a longitudinal section of the alternative modification of the reactor adjusted for releasing melted titanium

Examples of the invention's construction

According to the invention the reactor comprises a shaped body 1, whose tubular jacket consists of the reduction section 2 and the melting section 3, which are divided one from another with a barrier 4 equipped with a by pass aperture 41 creating a temperature divide between the two zones, when the temperature in the reduction section 2 amounts to about 650°C and the temperature in the melting section can range from 1500 to 1750°C. The tubular jacket of the body 1 is cooled by a cooling agent; for example a mixture of nitrates and nitrites KNO₃, NaNO₃ and NaNO₂, being introduced and drawn off through the cooling pipeline 101.

The reduction section 2 comprises a reaction chamber 21 into which reaction channels 22 open in an upward manner, at an angle and situated symmetrically one against another; the channels for delivering gaseous titanium-content medium 24, e.g. gaseous TiCl₄, being open into the reaction channels in their upper part and at the same time the funnel 25 delivering the liquid reduction agent, e.g. magnesium or natrium, equipped with funnel mouthing 26, being connected with the reaction channels. The reaction channels 22 have longitudinal, preferably rectangular section; they decline at an angle of 30-60° with respect to horizontal plane and they are designed so that optimum operating figures are as follows:

- velocity of gasflow in channels 50-300 m/s
- specific consumption of refining gas melt 0.5-3 kg/m

The melting section 3 comprises the melting chamber 31, where the sets of main melting electrodes 5 are situated, and which is at its upper part equipped with a charging hopper 32 designed to introduce fluxing agents, for example CaF₂, and also with purging nozzles 34 designed to introduce and release argon intended for establishing inert atmosphere during melting processes. At the bottom part of the melting chamber 31 hearth crystallizers 33 are arranged which are equipped with drawing devices 6 intended to catch and pull out the cooled titanium ingots. The melting section 3 is further equipped with an outlet pipeline 35 intended to discharge MgCl₂ vapours and sidewardly educed siphon outlet 36 terminated with a pan 37 designed to discharge condensed liquid portion of MgCl₂ and the clinker.

Prior to starting manufacturing process the whole reactor is purged with argon; the gas being introduced into the inner space of the reactor through the nozzles 34 until there is no atmosphere containing oxygen present within the reactor. The drawing devices 6 are pulled up into the upper position and the cold titanium ingots 7 are located into the hearth crystallizers 33 as a first charge in order to allow further continuous drawing the titanium ingots 7 out of the melting
A reactor primarily intended for titanium production, comprising a body (1) with a tubular jacket cooled by a cooling medium, the reactor being equipped with melting electrodes (5) and which is adjusted for introduction of gaseous medium including titanium, for introduction of liquid reducing agent and for charging of fluxing agents, and further adjusted for discharge of by-pass products and produced titanium, wherein the interior of the reactor is divided into a reduction section (2) and a melting section (3) divided by a barrier (4) with a by pass aperture (41), where the melting section (3) comprises a melting chamber (31) in which the sets of main melting electrodes (5) are located and which is in its upper part furnished with a hopper (32) designed for charging fluxing agents, and where the reduction section (2) comprises a reaction chamber (21) into which reaction channels (22) open being directed from the reaction chamber (21) through the by pass aperture (41) between the dividing barrier (4) and the jacket (1) to the melting section (3). Approximately half of the MgCl_2 vapour is continuously discharged from the melting chamber (31) through the siphon outlet (36) and the rest of MgCl_2 condensates and is discharged as a liquid, which means it is casted through the siphon outlet (36) with use of pan (37).

The reactor comprising constructional features presented in the invention can be used in metallurgy of non-ferrous metals for the purposes of titanium production.

Claims

1. A reactor primarily intended for titanium production, comprising a body (1) with a tubular jacket cooled by a cooling medium, the reactor being equipped with melting electrodes (5) and which is adjusted for introduction of gaseous medium including titanium, for introduction of liquid reducing agent and for charging of fluxing agents, and further adjusted for discharge of by-pass products and produced titanium, wherein the interior of the reactor is divided into a reduction section (2) and a melting section (3) divided by a barrier (4) with a by pass aperture (41), where the melting section (3) comprises a melting chamber (31) in which the sets of main melting electrodes (5) are located and which is in its upper part furnished with a hopper (32) designed for charging fluxing agents, and where the reduction section (2) comprises a reaction chamber (21) into which reaction channels (22) open being directed from mixing chambers (23); and comprises channels for delivering gaseous titanium-content medium (24) being open into reaction channels (22) in their upper part and at the same time comprises a funnel chamber (25) delivering a
liquid reduction agent being connected with the reaction channels.

2. The reactor as claimed in claim 1, wherein the reaction channels (22) open into the reaction chamber (21) in an upward manner and symmetrically situated one against another.

3. The reactor as claimed in claims 1 or 2, wherein the reaction channels (22) decline at an angle of 30-60° with respect to horizontal plane.

4. The reactor as claimed in any of claims 1, 2 and 3, wherein the reaction channels (22) have a longitudinal section.

5. The reactor as claimed in any of claims 1, 2, 3 and 4, wherein the melting section (3) is equipped with a discharge pipeline (35) designed to discharge vapours and with a siphon outlet (36) terminated with a pan (37) designed to discharge condensed liquid portion and clinker as by-pass products of the production.

6. The reactor as claimed in any of claims 1, 2, 3, 4 and 5 further comprising hearth crystallizers (33) arranged at the bottom part of the melting chamber (31), which are furnished with drawing devices (6) designed to catch and pull out cooled titanium ingots (7).

7. The reactor as claimed in any of claims 1, 2, 3, 4, 5 and 6, wherein the melting section (3) comprises a discharging section (8) connected to the melting chamber (31) through an outlet opening (38) and the melting section (3) comprising a siphon discharge (81) in which auxiliary melting electrodes (82) are located and which opens into a discharging channel (83).

Patentansprüche

1. Ein Reaktor, der primär für die Titan-Produktion vorgesehen ist, bestehend aus einem Korpus (1) mit einem Mantelrohr, das durch ein Kühlmedium gekühlt wird, der Reaktor ist mit Schmelzelektroden (5) ausgerüstet und angepasst für das Einführen von gasförmigen Medien, einschließlich Titan, für das Einführen von flüssigen Reduzierungsmitteln und für das Befüllen mit Flux-Reagenzien, und ist weiterhin für das Ablassen von Bypass-Produkten und produzier-tem Titan eingerichtet, der dadurch gekennzeichnet ist, dass der Innenbereich des Reaktors in einen Reduktionsbereich (2) und einen Schmelzbereich (3) unterteilt wird und der Schmelzbereich (3) eine Schmelzkammer (31) umfasst, in der die Sätze der hauptsächlichen Schmelzelektroden (5) positioniert sind und die in oberen Bereich mit einem Trichter (32) ausgestattet ist, durch den die Fluxmittel eingefüllt werden, und wobei der Reduktionsbereich (2) eine Reaktionskammer (21) umfasst, in die die Reaktionskanäle (22) öffnen, die von den Mischkammern (23) hergeleitet werden, und Kanäle für die Lieferung des gasförmigen, titanhaltigen Mediums (24) umfasst, die zu den Reaktionskanälen (22) am oberen Ende offen sind und gleichzeitig eine Trichterkammer (25) umfassen, die ein flüssiges Reduktionsmittel leitet und mit den Reaktionskanälen verbunden ist.

2. Der Reaktor, wie im Antrag 1 beansprucht, der dadurch gekennzeichnet ist, dass sich die Reaktionskanäle (22) nach oben verlaufend in die Reaktionskammer (21) öffnen und symmetrisch gegeneinander ausgerichtet sind.

3. Der Reaktor, wie im Antrag 1 oder 2 beansprucht, der dadurch gekennzeichnet ist, dass sich die Reaktionskanäle (22) in einem Winkel von 30-60° zur horizontalen Planfläche hin verjüngen.

4. Der Reaktor, wie in den Anträgen 1, 2 und 3 beansprucht, der dadurch gekennzeichnet ist, dass die Reaktionskanäle (22) einen Abschnitt in Längsrichtung aufweisen.

5. Der Reaktor, wie in den Anträgen 1, 2, 3 und 4 beansprucht, der dadurch gekennzeichnet ist, dass der Schmelzbereich (3) mit einer Ablaufleitung (35) ausgestattet ist, die zum Abführen von Dämpfen entwickelt wurde, und mit einem Siphon-Ausgang (36) mit Wanne (37) am Ende zum Ablauf von kondensierter Flüssigkeit und Klinker als Bypass-Produkt des Produktionsvorgangs.

6. Der Reaktor, wie in den Anträgen 1, 2, 3, 4 und 5 beantragt, der weiterhin mit Heizkristallisatoren (33) im unteren Bereich der Schmelzkammer (31) ausgestattet ist, die mit Tiefzieheinrichtungen (6) zum Auffangen und Herausziehen der gekühlten Titanblöcke (7) versehen ist.
Der Reaktor, wie in den Anträgen 1, 2, 3, 4, 5 und 6 beantragt, **der dadurch gekennzeichnet ist, dass** der Schmelzbereich (3) einen Ablassbereich (8) umfasst, der durch eine Auslassöffnung (38) an die Schmelzkammer (31) angeschlossen ist und der Schmelzbereich (3) einen Siphonablauf (81) enthält, in dem weitere Schmelzelektroden (82) vorhanden sind und der in einen Ablaufkanal (83) mündet.

**Revendications**

1. Un réacteur essentiellement projeté pour la production de titane, qui inclut les coquilles (1) avec une double enveloppe tubulaire refroidie à l'aide d'un moyen de refroidissement, le réacteur étant équipé avec des électrodes enrobées (5) et qui est ajusté pour l'introduction d'un moyen gazeux, y compris le titane, pour l'introduction d'un agent réducteur liquide et pour le chargement des agents fondants, et ensuite ajusté pour le refoulement de demi-produits et titane fabriqué, **caractérisé par le suivant** : l'intérieur du réacteur est divisé en une partie de réduction (2) et une partie de fusion (3) divisée par une barrière (4) avec un hublot (41), où la partie de fusion (3) comprend une chambre de fusion (31) dans laquelle sont localisées les séries des principaux électrodes enrobées (5) et qui, dans sa partie supérieure, est fournie d'une trémie (32) désignée pour le chargement des agents fondants, et dans laquelle la partie de réduction (2) comprend une chambre de réaction (21) où des canaux de réaction (22) ouvrent lorsqu'ils sont dirigés des chambres de mélange (23) ; et elle comprend des canaux pour la distribution d'un moyen avec contenu du titane gazeux (24) qui ouvre sur les canaux de réaction (22) dans leur partie supérieure et elle comprend également une chambre filtrante (25) qui fournit l'agent de réduction liquide connecté aux canaux de réaction.

2. Le réacteur considéré dans la demande 1, **caractérisé par le suivant** : les canaux de réaction (22) ouvrent sur la chambre de réaction (21) vers le haut et placés de façon asymétrique l'un contre l'autre.

3. Le réacteur considéré dans les demandes 1 ou 2, **caractérisé par le suivant** : les canaux de réaction (22) déclinent à un angle de 30-60° par rapport au plan horizontal.

4. Le réacteur considéré dans les demandes 1, 2 et 3, **caractérisé par le suivant** : les canaux de réaction (22) ont une section longitudinale.

5. Le réacteur considéré dans les demandes 1, 2, 3 et 4, **caractérisé par le suivant** : la partie de fusion (3) est munie d'une conduite de refoulement (35) désignée à évacuer les vapeurs et d'une vanne de fond (36) de cuve (37) désignée à évacuer une partie de liquide condensé et mâchefer comme demi-produits de la production.

6. Le réacteur considéré dans les demandes 1, 2, 3, 4 et 5 qui comprend des cristallisoirs du foyer (33) disposés dans la partie inférieure de la chambre de fusion (31), qui sont munis des dispositifs de dessin (6) désignés de recueillir et d'extraire les lingots refroidis de titane (7).

7. Le réacteur considéré dans les demandes 1, 2, 3, 4, 5 et 6, **caractérisé par le suivant** : la partie de fusion (3) comprend un tapis d'évacuation (8) connecté à la chambre de fusion (31) à travers une soupape (38) et à la partie de fusion (3) qui comprend une vanne de fond (81) dans laquelle des électrodes enrobées supplémentaires (82) sont placées et qui ouvre sur un canal d'évacuation (83).
REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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