

Description

This application is a continuation-in-part of prior pending application Serial No. 07/118,672, filed November 9, 1987.

Substantial quantities of titanium dioxide pigment are produced commercially by reacting titanium tetrachloride with oxygen in the vapor phase. Immediately after such reaction, the titanium dioxide reaction mass is cooled by passing it through a conduit, i.e., flue, where growth of the titanium dioxide pigment particles takes place and agglomeration of such particles takes place.

It is desirable to cool the titanium dioxide rapidly because this will result in pigment having higher carbon black undertone ("CBU"). CBU is described in U.S. Patent 2,488,440, which is hereby incorporated by reference. However, when a smaller diameter flue is used to permit more rapid cooling, it has been found that while CBU is increased, turbulence can be increased, which increases agglomeration of the pigment particles and thereby decreases pigment gloss.

Also, it would be desirable to operate titanium dioxide processes at higher pressures to minimize equipment expenditures, but this can decrease CBU. Moreover, it is desirable to increase TiO_2 output, but higher product output can decrease CBU (due to the increased pressure) and decrease gloss (due to the increased turbulence).

The following information is disclosed which may be of interest to this invention.

U.S. Patent 3,273,589 discloses an internally finned condenser tube.

U.S. Patent 2,833,627 discloses a method for cooling TiO_2 by passing it through a water-cooled conduit.

U.S. Patent 4,462,979 discloses a method for cooling and producing TiO_2 having improved agglomerating properties, which comprises first increasing the cross-sectional area of the flue and then decreasing the cross-sectional area of the flue.

Summary of the Invention

A process for producing titanium dioxide by

(a) reacting titanium tetrachloride and oxygen in the vapor phase to produce titanium dioxide, and

(b) subsequently cooling the titanium dioxide in a flue,

comprising utilizing for all or a portion of the flue a conduit having a plurality of substantially longitudinal protuberances, depressions or both.

The invention also refers to an apparatus according to claim 13 for carrying out the above mentioned process.

It has been found that at a given production rate the process of this invention can improve gloss and CBU or either of such properties. Also, use of the process of this invention can permit operation at higher pressures (which can permit decreased equipment expenditures and increased titanium dioxide pigment output) while still maintaining satisfactory pigment gloss and CBU.

Detailed Description of the Invention

The process for producing titanium dioxide pigment by reacting oxygen and titanium tetrachloride in the vapor phase is disclosed, for example, in U.S. Patents 2,488,439, 2,488,440, 2,559,638, 2,833,627, 3,208,866, and 3,505,091. The disclosures of such patents are hereby incorporated by reference.

Such reaction usually takes place in a pipe or conduit, wherein oxygen and titanium tetrachloride are introduced at a suitable temperature and pressure for production of the titanium dioxide. In such reaction, a flame generally is produced.

Downstream from the flame, the titanium dioxide produced is fed through an additional length of conduit wherein cooling takes place. For the purposes herein, such conduit will be referred to as the flue. The flue should be as long as necessary to accomplish the desired cooling. Typically, the flue is water cooled and can be about 15-900 (50-3000), preferably about 30-450 (100-1500), and most preferably about 60-360 (200-1200) metres (feet) long.

The improved flue used in this invention can be any suitable shape which does not cause excessive turbulence. Preferably, the flue will be round, i.e., in the form of a pipe.

The improved flue used in this invention has substantially longitudinal internal protuberances, depressions or both. Examples of suitable protuberances include ridges and/or fins. Examples of depressions include grooves and/or cuts. Examples of both protuberances and depressions include a conduit having similar shaped protuberances and depressions such as a pipe having a corrugated surface. Preferred is a flue with protuberances; especially preferred is a flue with internal fins. Another preferred embodiment is a flue with internal, hollow fins.

Because the improved flue used in this invention can be more expensive than an ordinary flue, typically, only a portion of the flue will have protuberances, depressions or both. Also, because most of the cooling of the TiO_2 will take place in close proximity to the flame of the titanium dioxide reaction, preferably, the improved flue used in this invention will be used substantially immediately downstream of the reaction flame, and continue

thereafter until the point is reached where substantially all or most of the growth and/or agglomeration of the pigment particles ceases. Typically, the length of the improved flue used in this invention will be about 1.5-150 (5-500), more preferably about 1.5-90 (5-300), and most preferably about 1.5-30 (5-100) metres (feet). If desired, however, all or most of the flue can be the improved flue used in this invention; and, if so, this can decrease the required length because of the more efficient cooling it provides.

The following additional considerations should be taken into account in designing the improved flue used in this invention:

- o To enhance cooling, there generally should be as many protuberances and/or depressions as possible, provided, however, that (1) there are not too many which would cause close spacing and consequently adherence between them of pigment or the particles of any material which are injected to scour the flue, and (2) the protuberances are not so thin that they substantially erode or corrode. Preferably, the spacings between the protuberances and/or depressions will be equal.
- o Generally, the protuberances and/or depressions should be substantially longitudinal, i.e., located along the length of the flue. By the term "substantially longitudinal" is meant that the protuberances and/or depressions should be substantially parallel (i.e., parallel to the axis of the conduit) or somewhat angled, (i.e., similar to the grooves in a rifle barrel). Preferably, the protuberances and/or depressions will be substantially parallel.
- o In regard to the height of the protuberances, they preferably should be as high as possible to enhance cooling, but not so high that they seriously erode (due to a high tip temperature) or cause increased turbulence.
- o The composition of the improved flue used in this invention should be any material which is chlorine resistant and has good heat transfer properties; preferred is nickel or a nickel alloy such as alloys commercially available as Nickel 200 or Nickel 201. Nickel 200 is commercially pure wrought nickel having a minimum of 99% nickel. Nickel 201 is the low carbon version of Nickel 200.
- o Preferably, the tips of the protuberances should be thinner than the base of the protuberances; preferred are protuberances of a trapezoidal shape where the spaces between the protuberances are depressions which are rounded.
- o Preferably, the protuberances are tapered, i.e., the inlet and outlet portions of the flue will have a protuberance height less than that

at the highest point of the protuberances; especially preferred are protuberances which are tapered and flush with the interior of the flue at its inlet and outlet.

- o The interior diameter of the improved flue of this invention should be that which does not in itself cause substantial turbulence with the velocity and other conditions for the TiO_2 and other materials in the flue. Typical interior diameters are about 5-130cm (2-50 inches), preferably about 13-76cm (5-30 inches), and most preferably about 15-51cm (6-20 inches). Preferably, the improved flue of this invention will have a conduit interior diameter which is greater than that of the ordinary flue which is located upstream from the improved flue of this invention. In the foregoing and as elsewhere used herein, (a) "interior diameter" means the distance between the two lowest points in the flue which are opposite each other, and (b) "upstream" or "downstream" are in reference to the flow of titanium dioxide pigment through the flue. Preferably, the diameter of the improved flue of this invention, when measured from tip to tip of protuberances which are opposite each other, will be greater than or approximately equal to the diameter of the ordinary flue which is located upstream from the improved flue of this invention.
- o If it is desired to optimize the gloss properties of the TiO_2 pigment, the protuberances and/or depressions should be designed to reduce turbulence without reducing the cooling rate. Conversely, if it is desired to optimize the CBU of the TiO_2 pigment, the cooling rate should be improved without increasing turbulence.
- o Preferably, the interior diameter of the ordinary flue which is located downstream from the improved flue of this invention will be greater than that of the improved flue of this invention.

The following example illustrates this invention:

Example

A 10m (32-foot) section of conduit pipe, comprised of Nickel 200, was inserted approximately 4m (12 feet) from the flame base which oxidizes TiCl_4 to TiO_2 in a continuous TiO_2 reactor. The conduit had an interior diameter of 31.1cm (11.5 inches) and had 30 trapezoidal-shaped protuberances which were approximately 2.5cm (1 inch) high. The base of the protuberances were 1.96cm (.77 inch) across, and the tips of the protuberances were 0.48cm (.19 inch) across. The spaces between the protuberances were depressed and

rounded. The protuberances were tapered so that at the inlet and outlet of the conduit they were flush with the interior surface of the conduit. An ordinary flue with a smooth interior surface was attached to the downstream end of the conduit and had an interior diameter of 29.2cm (11.5 inches) which tapered to 31.1cm (12.25 inches) interior diameter.

The 10m (32-foot) section of conduit pipe was comprised of two identical 5m (16-foot) sections of conduit which were bolted together. One of the 5m (16-foot) sections is illustrated in Figures 1 and 2. Figure 1 is an end view of such 5m (16-foot) section of conduit and Figure 2 is a section taken on line 2-2 of Figure 1. In the drawings, item 1 shows the trapezoidal-shaped protuberances, item 2 shows the taper of the protuberances, and item 3 shows the flanges which are used to bolt the conduits together.

The rate of TiO_2 production was about 18 tons per hour, the pressure was about 320kPag (47 psig), the TiCl_4 temperature was about 420°C , the O_2 temperature was about 1530°C , excess oxygen was about 7%, chlorine purge was about 1360kg (3000 pounds) per hour, and sodium chloride scrub of about 2.7kg (6 pounds) per 45.4kg (100 pounds) of TiO_2 was used to prevent TiO_2 buildup on the interior surface of the flue.

For the TiO_2 produced, the CBU was about 10 and the 30-J gloss was about 76. The 30-J gloss is a standard test which is performed by making an alkyd resin paint having about 16 percent TiO_2 pigment volume concentration (i.e., the volume of pigment occupied by the total volume of the dried paint film). The paint was sprayed on a smooth aluminum substrate, dried, and the gloss measured at a 20° angle by a gloss meter such as the Hunter Lab D-48 Glossmeter.

Claims

1. A process for producing titanium dioxide by:-
 - (a) reacting titanium tetrachloride and oxygen in the vapor phase to produce titanium dioxide, and
 - (b) subsequently cooling the titanium dioxide in a flue,

characterised by utilizing for all or a portion of the flue a conduit having a plurality of internal, substantially longitudinal protuberances, depressions or both.
2. A process according to claim 1 wherein the conduit is a pipe.
3. A process of claim 1 or 2 wherein the conduit has a plurality of substantially longitudinal protuberances having tips and bases, and wherein the tips of the protuberances are thinner than the bases of the protuberances.
4. A process according to claim 3 wherein the protuberances are trapezoidal in shape, there are spaces between the protuberances, and the spaces between such protuberances are rounded depressions.
5. A process according to any one of the preceding claims wherein the interior diameter of the conduit is about 5 to 127 cms (2-50 inches).
6. A process according to any one of the preceding claims wherein (a) the conduit has a plurality of substantially longitudinal protuberances, and (b) wherein one or more protuberances at the inlet and outlet portion of the conduit are tapered so that said protuberances are flush with the interior of the conduit at its inlet and outlet.
7. A process according to claim 1 wherein (a) a portion of the flue is said conduit, (b) the conduit has a plurality of substantially longitudinal protuberances, and (c) the interior diameter of the conduit is greater than that of the portion of the flue which is not said conduit and is located upstream from the conduit.
8. A process according to claim 7, wherein the diameter of the conduit, when measured from tip to tip of protuberances which are opposite each other, is greater than or approximately equal to the interior diameter of the flue which is not the conduit and is located upstream from the conduit.
9. A process according to claim 1 wherein (a) the conduit has a plurality of internal, substantially longitudinal protuberances having tips and bases, (b) the tips of the protuberances are thinner than the bases of the protuberances, and (c) one or more protuberances at the inlet and outlet portion of the conduit are tapered so that said protuberances are flush with the interior of the conduit at its inlet and outlet.
10. A process according to claim 9, wherein (a) a portion of the flue is said conduit, and (b) the interior diameter of the conduit is greater than that of the portion of the flue which is not the conduit and is located upstream from the conduit.
11. A process according to claim 9 wherein (a) a portion of the flue is said conduit, and (b) the diameter of the conduit, when measured from tip to tip of the protuberances which are op-



rounded. The protuberances were tapered so that at the inlet and outlet of the conduit they were flush with the interior surface of the conduit. An ordinary flue with a smooth interior surface was attached to the downstream end of the conduit and had an interior diameter of 29.2cm (11.5 inches) which tapered to 31.1cm (12.25 inches) interior diameter.

The 10m (32-foot) section of conduit pipe was comprised of two identical 5m (16-foot) sections of conduit which were bolted together. One of the 5m (16-foot) sections is illustrated in Figures 1 and 2. Figure 1 is an end view of such 5m (16-foot) section of conduit and Figure 2 is a section taken on line 2-2 of Figure 1. In the drawings, item 1 shows the trapezoidal-shaped protuberances, item 2 shows the taper of the protuberances, and item 3 shows the flanges which are used to bolt the conduits together.

The rate of TiO_2 production was about 18 tons per hour, the pressure was about 320kPag (47 psig), the TiCl_4 temperature was about 420°C , the O_2 temperature was about 1530°C , excess oxygen was about 7%, chlorine purge was about 1360kg (3000 pounds) per hour, and sodium chloride scrub of about 2.7kg (6 pounds) per 45.4kg (100 pounds) of TiO_2 was used to prevent TiO_2 buildup on the interior surface of the flue.

For the TiO_2 produced, the CBU was about 10 and the 30-J gloss was about 76. The 30-J gloss is a standard test which is performed by making an alkyd resin paint having about 16 percent TiO_2 pigment volume concentration (i.e., the volume of pigment occupied by the total volume of the dried paint film). The paint was sprayed on a smooth aluminum substrate, dried, and the gloss measured at a 20° angle by a gloss meter such as the Hunter Lab D-48 Glossmeter.

Claims

1. A process for producing titanium dioxide by:-
 - (a) reacting titanium tetrachloride and oxygen in the vapor phase to produce titanium dioxide, and
 - (b) subsequently cooling the titanium dioxide in a flue,
 characterised by utilizing for all or a portion of the flue a conduit having a plurality of internal, substantially longitudinal protuberances, depressions or both.
2. A process according to claim 1 wherein the conduit is a pipe.
3. A process of claim 1 or 2 wherein the conduit has a plurality of substantially longitudinal protuberances having tips and bases, and wherein the tips of the protuberances are thinner than

the bases of the protuberances.

4. A process according to claim 3 wherein the protuberances are trapezoidal in shape, there are spaces between the protuberances, and the spaces between such protuberances are rounded depressions.
5. A process according to any one of the preceding claims wherein the interior diameter of the conduit is about 5 to 127 cms (2-50 inches).
6. A process according to any one of the preceding claims wherein (a) the conduit has a plurality of substantially longitudinal protuberances, and (b) wherein one or more protuberances at the inlet and outlet portion of the conduit are tapered so that said protuberances are flush with the interior of the conduit at its inlet and outlet.
7. A process according to claim 1 wherein (a) a portion of the flue is said conduit, (b) the conduit has a plurality of substantially longitudinal protuberances, and (c) the interior diameter of the conduit is greater than that of the portion of the flue which is not said conduit and is located upstream from the conduit.
8. A process according to claim 7, wherein the diameter of the conduit, when measured from tip to tip of protuberances which are opposite each other, is greater than or approximately equal to the interior diameter of the flue which is not the conduit and is located upstream from the conduit.
9. A process according to claim 1 wherein (a) the conduit has a plurality of internal, substantially longitudinal protuberances having tips and bases, (b) the tips of the protuberances are thinner than the bases of the protuberances, and (c) one or more protuberances at the inlet and outlet portion of the conduit are tapered so that said protuberances are flush with the interior of the conduit at its inlet and outlet.
10. A process according to claim 9, wherein (a) a portion of the flue is said conduit, and (b) the interior diameter of the conduit is greater than that of the portion of the flue which is not the conduit and is located upstream from the conduit.
11. A process according to claim 9 wherein (a) a portion of the flue is said conduit, and (b) the diameter of the conduit, when measured from tip to tip of the protuberances which are op-



posite each other, is greater than or approximately equal to the interior diameter of the flue which is not the conduit and is located upstream from the conduit.

12. A process according to any one of claims 1 to 11 wherein (a) a portion of the flue is said conduit, and (b) the portion of the flue which is not the conduit and is located downstream from the conduit has a diameter greater than or equal to said conduit.
13. Apparatus for producing titanium dioxide which comprises a reactor for reacting titanium tetrachloride and oxygen in the vapor phase and a flue connected to the reactor for cooling the titanium dioxide so formed, wherein the flue includes a conduit having a plurality of internal, substantially longitudinal protuberances (1) and/or depressions.
14. Apparatus according to claim 13 wherein said conduit comprises nickel or a nickel alloy.
15. Apparatus according to claim 13 or 14 wherein the protuberances are fins.
16. Apparatus according to claim 13 or 14 wherein the protuberances are hollow fins.

Patentansprüche

1. Verfahren zur Herstellung von Titandioxid durch:
 - (a) Umsetzen von Titantetrachlorid und Sauerstoff in der Dampfphase, um Titandioxid zu erzeugen und
 - (b) anschließendes Abkühlen des Titandioxids in einem Rauchabzug,
 dadurch gekennzeichnet, daß für den gesamten oder einen Teil des Rauchabzuges eine Leitung mit einer Vielzahl von internen, im wesentlichen in Längsrichtung angeordneten Ausbuchtungen, Einbuchtungen oder mit beidem verwendet wird.
2. Verfahren nach Anspruch 1, bei dem die Leitung ein Rohr ist.
3. Verfahren nach Anspruch 1 oder 2, bei dem die Leitung eine Vielzahl von im wesentlichen in Längsrichtung angeordneten Ausbuchtungen mit Spitzen und Senken aufweist und bei dem die Spitzen der Ausbuchtungen schmaler sind als die Senken der Ausbuchtungen.
4. Verfahren nach Anspruch 3, bei dem die Ausbuchtungen Trapezform besitzen, wobei zwi-

schen den Ausbuchtungen Abstände vorhanden sind und die Abstände zwischen solchen Ausbuchtungen gerundete Einbuchtungen aufweisen.

5. Verfahren nach einem der vorgenannten Ansprüche, bei dem der Innendurchmesser der Leitung etwa 5 bis 127 cm (2 bis 50 in.) beträgt.
6. Verfahren nach einem der vorgenannten Ansprüche, bei dem (a) die Leitung eine Vielzahl von im wesentlichen in Längsrichtung angeordneten Ausbuchtungen aufweist, und (b) eine oder mehrere Ausbuchtungen am Einlaß- oder Auslaßteil der Leitung schräg zulaufen, so daß die genannten Ausbuchtungen mit dem Inneren der Leitung am Einlaß und Auslaß bündig sind.
7. Verfahren nach Anspruch 1, bei dem (a) ein Teil des Rauchabzuges die genannte Leitung darstellt, (b) die Leitung eine Vielzahl von im wesentlichen in Längsrichtung angeordneten Ausbuchtungen aufweist und der Innendurchmesser der Leitung größer ist als derjenige des Teils des Rauchabzuges, der nicht die genannte Leitung darstellt und stromaufwärts von der Leitung angeordnet ist.
8. Verfahren nach Anspruch 7, bei dem der Durchmesser der Leitung, gemessen von Spitze zu Spitze der Ausbuchtungen, die sich gegenüberliegen, größer oder ungefähr gleich groß ist wie der Innendurchmesser des Rauchabzuges, der keine Leitung darstellt und stromaufwärts von der Leitung angeordnet ist.
9. Verfahren nach Anspruch 1, bei dem (a) die Leitung eine Vielzahl von internen im wesentlichen in Längsrichtung angeordneten Ausbuchtungen mit Spitzen und Senken aufweist, (b) die Spitzen der Ausbuchtungen schmaler sind als die Senken der Ausbuchtungen, und (c) eine oder mehrere Ausbuchtungen am Einlaß- und Auslaßteil der Leitung schräg zulaufen, so daß die genannten Ausbuchtungen mit dem Inneren des Rohrs am Einlaß und Auslaß bündig sind.
10. Verfahren nach Anspruch 9, bei dem (a) ein Teil des Rauchabzuges die genannte Leitung darstellt, und (b) der Innendurchmesser der Leitung größer ist als derjenige des Teils des Rauchabzuges, der keine Leitung darstellt und stromaufwärts von der Leitung angeordnet ist.



11. Verfahren nach Anspruch 9, bei dem (a) ein Teil des Rauchabzugs die genannte Leitung darstellt, und (b) der Durchmesser der Leitung, gemessen von Spitze zu Spitze der Ausbuchtungen, die einander gegenüberliegen, größer oder ungefähr gleich groß ist wie der Innendurchmesser des Rauchabzugs, der keine Leitung darstellt und stromaufwärts von der Leitung angeordnet ist.

12. Verfahren nach einem der Ansprüche 1 bis 11, bei dem (a) ein Teil des Rauchabzugs die genannte Leitung darstellt, und (b) der Teil des Rauchabzugs, der keine Leitung darstellt und stromabwärts von der Leitung angeordnet ist, einen Durchmesser besitzt, der größer oder gleich groß ist wie derjenige der genannten Leitung.

13. Apparatur zur Herstellung von Titandioxid, die einen Reaktor zur Umsetzung von Titan-tetrachlorid und Sauerstoff in der Dampfphase und einen Rauchabzug in Verbindung mit dem Reaktor zum Abkühlen des so gebildeten Titandioxids umfaßt, worin der Rauchabzug eine Leitung umfaßt, die eine Vielzahl von internen, im wesentlichen in Längsrichtung angeordneten Ausbuchtungen (1) oder Einbuchtungen umfaßt.

14. Apparatur nach Anspruch 13, worin die genannte Leitung Nickel oder eine Nickellegierung umfaßt.

15. Apparatur nach Anspruch 13 oder 14, bei der die Ausbuchtungen Kühlrippen sind.

16. Apparatur nach Anspruch 13 oder 14, bei der die Ausbuchtungen hohle Kühlrippen sind.

Revendications

1. Un procédé de préparation de dioxyde de titane par les opérations consistant :
(a) à faire réagir du tétrachlorure de titane et de l'oxygène en phase vapeur pour obtenir du dioxyde de titane, et
(b) à refroidir ensuite le dioxyde de titane dans un tube cheminée,
caractérisé par l'utilisation pour tout ou partie du tube cheminée d'un conduit présentant une multiplicité de protubérances et/ou de dépressions internes sensiblement longitudinales.

2. Un procédé selon la revendication 1 dans lequel le conduit est un tuyau.

3. Un procédé selon la revendication 1 ou 2 dans lequel le conduit comporte une multiplicité de protubérances sensiblement longitudinales présentant des sommets et des bases, les sommets des protubérances étant plus minces que les bases des protubérances.

4. Un procédé selon la revendication 3 dans lequel les protubérances sont à profil trapézoïdal, des espaces sont ménagés entre les protubérances et les espaces ménagés entre les dites protubérances sont des dépressions arrondies.

5. Un procédé selon l'une quelconque des revendications précédentes dans lequel (a) le diamètre intérieur du conduit est d'environ 5 à 127 centimètres.

6. Un procédé selon l'une quelconque des revendications précédentes dans lequel (a) le conduit présente une multiplicité de protubérances sensiblement longitudinales, et (b) dans lequel une ou plusieurs protubérances dans les portions d'entrée et de sortie du conduit sont évasées de telle manière que lesdites protubérances se trouvent de niveau avec l'intérieur du conduit à son entrée et à sa sortie.

7. Un procédé selon la revendication 1 dans lequel (a) une portion du tube cheminée est ledit conduit, (b) le conduit porte une multiplicité de protubérances sensiblement longitudinales, et (c) le diamètre intérieur du conduit est supérieur à celui de la portion du tube cheminée qui n'est pas ledit conduit et est située en amont du conduit.

8. Un procédé selon la revendication 7, dans lequel le diamètre du conduit, lorsqu'il est mesuré entre sommets de protubérances se faisant mutuellement face, est supérieur ou approximativement égal au diamètre intérieur du tube cheminée qui n'est pas le conduit et est situé en amont du conduit.

9. Un procédé selon la revendication 1 dans lequel (a) le conduit porte une multiplicité de protubérances internes sensiblement longitudinales présentant des sommets et des bases, (b) les sommets des protubérances sont plus minces que les bases des protubérances, et (c) une ou plusieurs protubérances dans les portions d'entrée et de sortie du conduit sont évasées de telle manière que lesdites protubérances se trouvent de niveau avec l'intérieur du conduit à son entrée et à sa sortie.



10. Un procédé selon la revendication 9, dans lequel (a) une portion du tube cheminée est ledit conduit, et (b) le diamètre intérieur du conduit est supérieur à celui de la portion du tube cheminée qui n'est pas ledit conduit et est située en amont du conduit. 5
11. Un procédé selon la revendication 9 dans lequel (a) une portion du tube cheminée est ledit conduit, et (b) le diamètre du conduit, lorsqu'il est mesuré entre sommets des protubérances qui se font face, est supérieur ou approximativement égal au diamètre intérieur du tube cheminée qui n'est pas le conduit et est situé en amont du conduit. 10 15
12. Un procédé selon l'une quelconque des revendications 1 à 11 dans lequel (a) une portion du tube cheminée est ledit conduit, et (b) la portion du tube cheminée qui n'est pas le conduit et est située en aval du conduit présente un diamètre supérieur ou égal à celui dudit conduit. 20
13. Appareil pour la production de dioxyde de titane qui comprend un réacteur pour faire réagir du tétrachlorure de titane et de l'oxygène en phase vapeur et un tube cheminée relié au réacteur pour refroidir le dioxyde de titane ainsi formé, dans lequel le tube cheminée comporte un conduit portant une multiplicité de protubérances (1) et/ou de dépressions internes sensiblement longitudinales. 25 30
14. Appareil selon la revendication 13 dans lequel ledit conduit comprend du nickel ou un alliage de nickel. 35
15. Appareil selon la revendication 13 ou 14 dans lequel les protubérances sont des ailettes. 40
16. Appareil selon la revendication 13 ou 14 dans lequel les protubérances sont des ailettes creuses. 45

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