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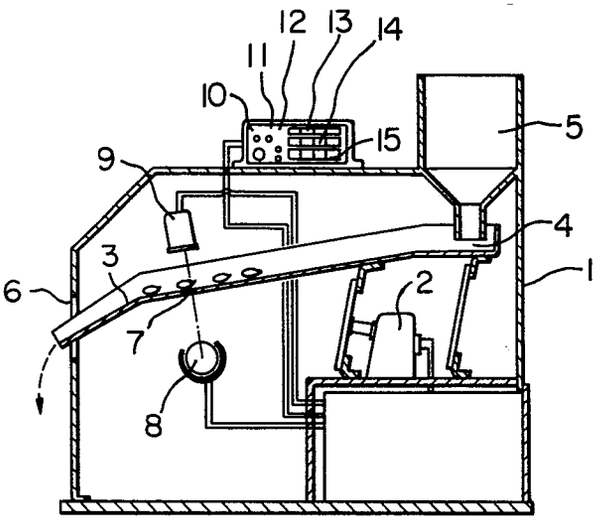
(54) Apparatus for detecting cracked grain of unhulled rice or hulled rice.

(57) An apparatus for detecting cracked grain of unhulled rice or hulled rice. The apparatus has a rice feeding trough (3) provided at its bottom with a light transmitting window (7) and disposed substantially horizontally or at a gentle gradient. A light quantity detecting device (10) has a light source (8) and a light receiving element (9) disposed to optically oppose each other across the light transmitting window (7) along which the rice grain flows. In operation, the rice grain flowing on the light transmitting window (7) is scanned by the light from the light source (8). If there is a crack in the grain particle, a change is caused in the quantity of light transmitted through the grain particle and received by the light receiving element (9), so that the presence of the crack and hence a cracked rice grain is detected at a high precision.



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APPARATUS FOR DETECTING CRACKED GRAIN OF UNHULLED RICE OR HULLED RICE

The present invention relates to an improvement in the apparatus for detecting cracked grains of unhulled and hulled rice.

Coping with the current demand for mechanization in the field of rice production, dryers have been put into practical use for drying the unhulled rice grain after the harvest. With this dryer, it is possible to conduct the drying of unhulled rice at a high efficiency under a constant condition without being affected by weather conditions. On the other hand, however, the use of the dryer imposes a problem of frequent generation of cracked grain particularly when the drying ratio of the unhulled rice becomes high.

This gives a rise to a demand for an apparatus capable of detecting the cracked grain efficiently.

Accordingly, an object of the invention is to provide an apparatus for detecting cracked grain of unhulled and hulled rice at a high precision.

To this end, according to one aspect of the invention, there is provided an apparatus for detecting cracked grain of unhulled rice or hulled rice comprising a rice feeding trough provided at its bottom with a light-transmitting window and arranged to extend substantially horizontally or at a gentle gradient along its length, and a device for detecting the quantity of

light having a light source and a light receiving element disposed to substantially oppose to each other across the light transmitting window, whereby the cracked grain is detected from the quantity of light received by the light quantity detecting device.

According to another aspect of the invention, there is provided an apparatus for detecting cracked grain of unhulled rice or hulled rice of the type mentioned above, characterized by comprising a grain number counter circuit adapted to detect, at each time the rice grain passes the light transmitting window, the time of passage and the reference darkness of light transmitted through the rice grain and to count the number of detections, and a cracked grain counter circuit adapted to detect the time of passage and the shadow of the grain of a predetermined darkness in the form of short shadow or a long continuous shadow, the cracked grain being detected as a plurality of short shadows, whereby the total number of grains which have passed the light transmitting window and the number of the cracked grain particles are detected.

By way of example only, an illustrative embodiment of the invention will now be described with reference to the accompanying drawings in which:

Fig. 1 is a sectional side elevational view of an apparatus in accordance with an embodiment of the invention;

Fig. 2 is an illustration of the principle of

operation of the apparatus shown in Fig. 1; and

Fig. 3 is an electric circuit diagram of an electric circuit suitable for use in the apparatus shown in Fig. 1.

Referring first to Fig. 1, an apparatus for detecting cracked grain of unhulled or hulled rice, constructed in accordance with an embodiment of the invention, has a box-shaped frame 1 in which a rice feeding trough 3 provided with a vibrator 2 is mounted at a gentle gradient. A rice supply hopper 5 is disposed above the inlet portion 4 of the rice feeding trough 3, while the outlet end of the trough 3 is projected to the outside of the machine frame 1 through an opening 6 thereof. The rice feeding trough 3 is provided at its bottom with a light transmitting window 7. A light source 8 such as an incandescent lamp and a light receiving element 9 such as a photodiode are disposed to substantially oppose each other in the vertical direction across the light transmitting window 7. The light receiving element 9 is electrically and operatively connected to a cracked grain detector 10 mounted on an upper portion of the machine frame 1, so that the cracked grain is detected from the quantity of light transmitted through the grain passing over the window 7. The term "substantially oppose each other" in this specification is used to involve not only such an arrangement that the light source and the light receiving element are precisely confronting each other but also such a

case that the line interconnecting the light source and the light receiving element is arranged at a certain angle to the plane of the light transmitting window 7 and even such a case that, although the light source and the light receiving element are offset from each other, they oppose optically to each other along a curved path of light presented by an optical fiber or the like.

The cracked grain detector 10 includes a counter circuit 11 for counting the number of grain particles, a counter circuit 12 for counting the cracked grain particles, digital display devices 13, 14, 15 and so forth.

The construction of the cracked grain detecting device 10 will be explained hereinunder with reference to an electric circuit diagram shown in Fig. 3. The output of the light receiving element 9 is branched into two lines one of which is connected to the grain number counter circuit 11 while the other is connected to the cracked grain counter circuit 12. The grain number counter circuit 11 includes an amplifier 16 adapted to receive the output from the light receiving element 9 and to deliver an output to one of the inputs of a comparator 18. The counter circuit 11 further includes a setting device 19 for setting a reference darkness A for detecting the number of grain particles and connected to the other of two inputs to the comparator 18. The counter circuit 11 includes also a counter 20 connected to the output of the comparator 18, a reference clock

circuit 21 connected to the counter 20, and a grain number digital display device 13 connected to the output of the counter 20.

On the other hand, the cracked grain counter circuit 12 includes an amplifier 17 for receiving the output from the light receiving element 9, a comparator 23 to one input of which the amplifier 17 is connected, a setting device 24 for setting any desired darkness B for detecting the cracked grain and connected to the other input of the comparator 23, a counter 25 to which the output of the comparator 23 is connected, a reference clock circuit 26 connected to the counter 25 and a cracked grain digital display device 14 connected to the output of the counter 25.

A circuit shunting from the output of the comparator 23 is connected to a correction counter 27 to which is also connected a correcting clock circuit 28. The output of the correction counter 27 is connected to the cracked grain digital display device 14 to subtract the number counted by the counter 27 from the content of the display device 14. The grain number display device 13 and the cracked grain counter 14 are connected to a digital display device 15 adapted to display the ratio of the number of cracked grain particles to the total number of the grain particles.

Fig. 2 shows the principle of operation of the apparatus of the invention. Assume here that an hulled rice grain, regular unhulled rice grain, broken unhulled

rice grain, cracked unhulled rice grain, unripe unhulled rice grain or a dead unhulled rice grain are arrayed in the mentioned order. Light is applied to scan each grain from the upper side so that the shadow or quantity of light received by the light receiving element for each grain is obtained as shown by the full-line curve in Fig. 2.

In Fig. 2, the broken line A-A shows the reference darkness A as obtained at a substantially central portion of the shadow of the transparent portion of the regular unhulled rice grain, while a broken line B-B represents any desired darkness B corresponding to the germ of the unhulled rice grain and white opaque portions of the unripe rice grain and dead rice grain. Also, the broken line C-C represents the level of any desired darkness of the shadow of the hulled rice grain. More specifically, a symbol X represents the shadow of the white opaque portion of the germ, Y represents the shadow of a cracked surface and Z represents the shadow of the white opaque portion such as unripe rice grain and dead rice grain. When there is a crack in the grain, the light transmitted through such grain is scattered at the cracking surface to generate a short dark shadow at the lower side of the cracked portion of the grain. Such dark shadow appears for each crack surface. The white opaque portion of the germ produces a short dark shadow, while the white opaque portion of the unripe rice grain or dead grain form a long dark shadow.

It is, therefore, possible to discriminate between these grains and to count the number of particles of each kind of grain by precisely scanning each grain particle one after another. It is to be noted here that, when there is a crack in a grain particle, two or more short dark shadows appear for each of such cracked grain particles.

The apparatus of this embodiment having the described construction operates in a manner explained hereinunder.

The reference darkness A is set in the setting device 19 connected to the comparator 18 of the grain number counter circuit 11, while any desired darkness B is set in the setting device 24 connected to the comparator 23 of the cracked grain counting circuit 12. Then, as the apparatus is started while supplying the rice grain into the supplying hopper 5, the rice grain flows down from the hopper 5 onto the rice feeding trough 3. The rice grain particles are arrayed in a line along the length of the rice feeding trough 3 by the application of vibration generated by the vibrator 2 and move over the transparent window 7 provided in the bottom of the rice feeding trough 3. Meanwhile, the light is applied by the light source 8 from the lower side of the light transmitting window 7 to the rice grain on the light transmitting window 7, so that a shadow of darkness and brightness corresponding to the nature of each grain particle is formed on the reverse side of each grain particle. This shadow is received by the light receiving

element 9 disposed above the light transmitting window 7, and the output from the light receiving element, corresponding to the shadow of each grain particle, is transmitted to both of the grain number counter circuit 11 and the cracked grain counter circuit 12. In the grain number counter circuit 11, the detection signal from the light receiving element 9 is amplified by the amplifier 16 and delivered to the comparator 18 so as to be compared in the latter with the set value A of the reference darkness derived from the setting device 19. The comparator 18 then produces a coincidence signal at each time coincidence is obtained between two signals and delivers this coincidence signal to the counter 20. The counter 20 counts the number of clock pulses coming from the reference clock circuit 21 while the counting signal is being issued. At each time the counter 20 counts a predetermined number of pulses corresponding to the length of a longitudinally disposed unbroken grain, the counter 20 delivers a signal representing the passage of a grain particle to the display device 13 so that the total number of rice grain particles having shadows of the reference darkness A and passed over the light transmitting window, i.e. the regular rice grain particles, cracked rice grain particles, unripe rice grain particles and dead rice grain particles, is displayed on the display device 13.

Meanwhile, in the cracked grain counter 12, the detection signal from the light receiving element 9

is amplified by the amplifier 17 and the amplified signal is delivered to the comparator 23. The comparator 23 compares this amplified signal with the signal of the predetermined level of darkness B set by the setting device 24, and delivers the coincidence signal to the counter 25. The counter 25 counts the number of clock pulses coming from the reference clock circuit 26 while the counting signal is being issued. The counter 25 delivers a signal to the display device 14 at each time it counts the aforementioned predetermined number of clock pulses, so that the display device 14 displays the number of rice grain particles having shadows of the predetermined darkness B, i.e. the regular rice grain, cracked rice grain, unripe rice grain and dead rice grain, which have passed the light transmitting window. The output shunting from the output side of the comparator 23 is delivered to the correcting counter 27 which counts the number of clock pulses from the correction reference clock circuit 28 while a counting signal is being issued, so that a discrimination is made as to whether the shadow is a single short shadow or a single long shadow by means of the counting time. The discrimination signal is delivered to the display device 14. In consequence, in the display device 14, the number of particles of the regular rice grain, unripe rice grain and the dead rice grain are subtracted from the total number of the grain particles of the predetermined shadow darkness B which has been counted by the counter 25,

so that the display device 14 makes a display of only the number of cracked grain particles. The output from the display device 13 of the grain number counter circuit 11 and the output from the display device 14 of the cracked grain counter circuit 12 are delivered to a digital display device 15 where an arithmetic operation is made to display the ratio of the number of the cracked grain particles to the total number of grain particles.

This apparatus can easily be modified for the detection of cracked rice grain from the hulled rice grain simply by changing the set values (voltages) of the reference darkness A and the predetermined desired darkness B in the setting devices 19 and 24 of the grain number counter circuit 11 and the cracked grain counter circuit 12.

As has been described, in the cracked grain detecting apparatus of the invention, the surface of each rice grain particle is scanned one after another so that the time of passage of each grain particle and the quantity of light transmitted by the particle are detected to permit the counting of the total number of rice grain particles which have passed the light transmitting window. At the same time, the time of passage and the shadow of each grain particle in the form of a short shadow or long shadow are detected. In consequence, the cracked grain particle is detected directly or indirectly as having a shadow consisting of a plurality of short segments of dark shadow, thereby enabling counting of

number of the cracked grain particles. It is, therefore, possible to achieve a full automatic detection of cracked rice grain particles to remarkably save the labour in the detection work. Since the detection is made through the change in the quantity of light and shadow of each grain particle obtained by a precise scanning of each grain particle one after another, it is possible to calculate and display accurately and promptly the ratio of the number of cracked rice grain particles to the total number of grain particles.

CLAIMS:

1. An apparatus for detecting cracked grain of unhulled rice or hulled rice comprising: a rice feeding trough (3) provided at its bottom with a light-transmitting window (7) and arranged to extend substantially horizontally or at a gentle gradient along its length, and a device (10) for detecting the quantity of light having a light source (8) and a light receiving element (9) disposed to substantially oppose to each other across the light transmitting window (7), whereby the cracked grain particle is detected from the quantity of light received by said light quantity detecting device (10).

2. An apparatus for detecting cracked grain of unhulled rice or hulled rice as claimed in claim 1, characterized by comprising a grain number counter circuit (11) adapted to detect, at each time the rice grain particle passes said light-transmitting window (7), the time of passage and the light of a reference darkness (A) transmitted through said rice grain particle and to count the number of detections, and a cracked grain counter circuit (12) adapted to detect the time of passage and the shadow of the grain particles of a predetermined darkness (B) in the form of a short shadow or a long continuous shadow, the cracked grain particle being detected as having a plurality of short shadows, whereby the total number of grain particles which have passed said light-transmitting window and the number of cracked grain particles are detected.

FIG. 1

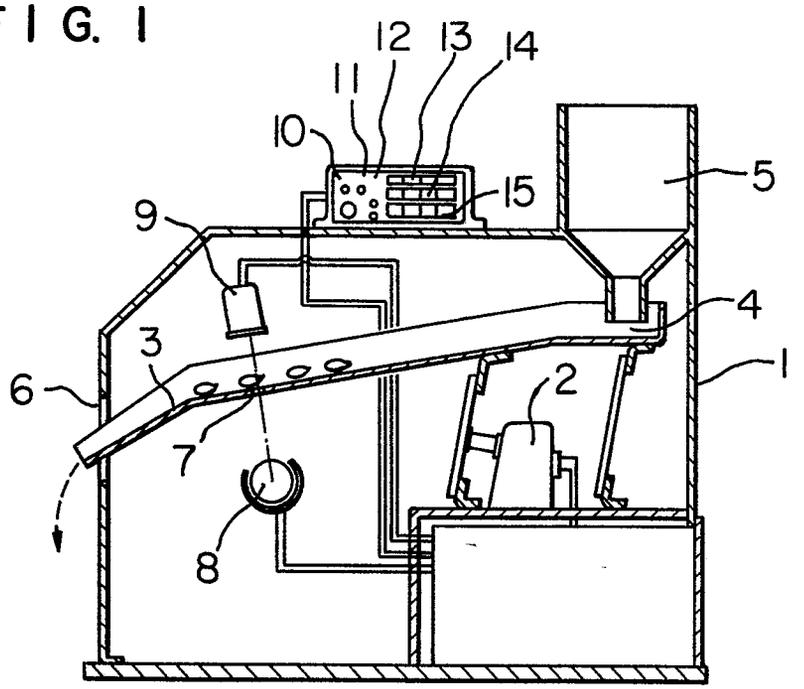
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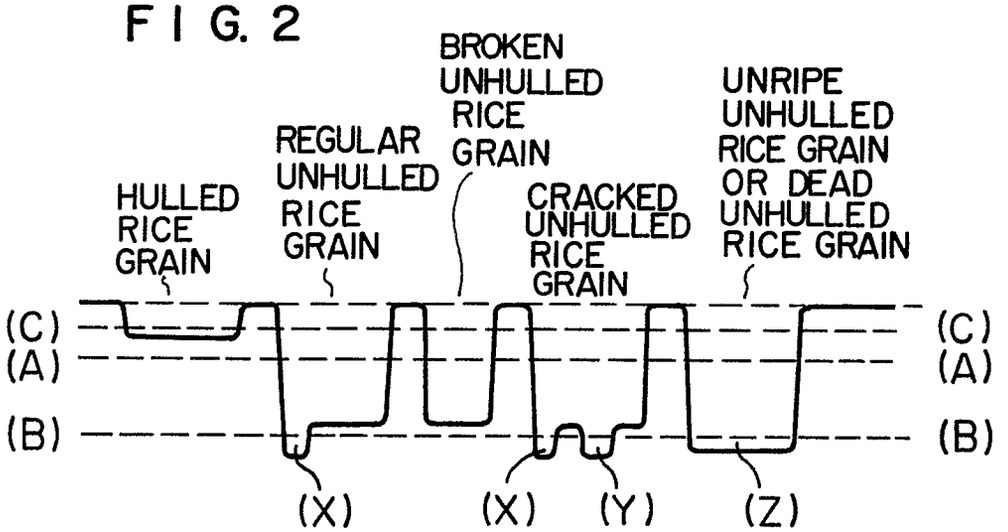
FIG. 2


HULLED RICE GRAIN
REGULAR UNHULLED RICE GRAIN
BROKEN UNHULLED RICE GRAIN
CRACKED UNHULLED RICE GRAIN
UNRIPE UNHULLED RICE GRAIN OR DEAD UNHULLED RICE GRAIN
(C)
(A)
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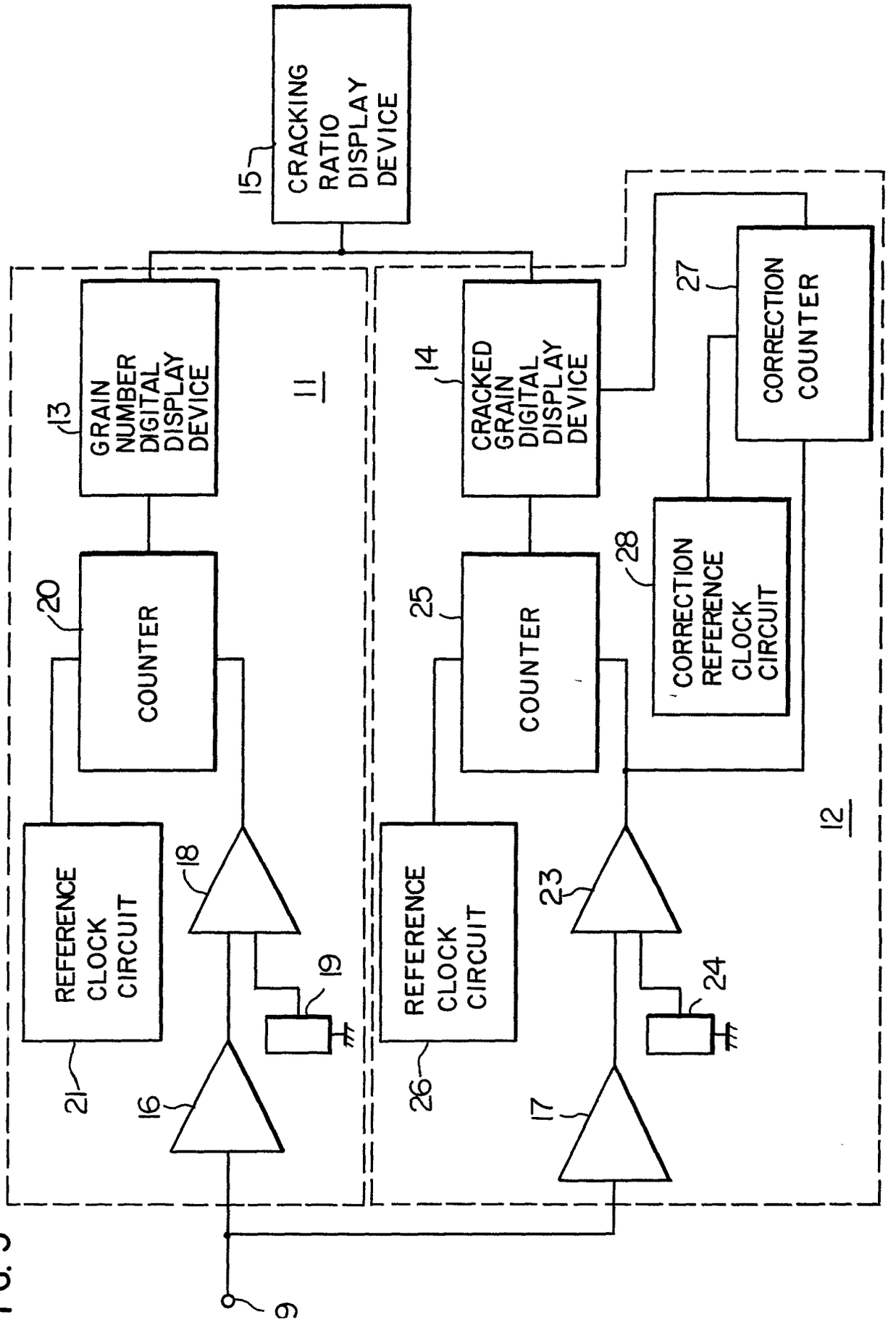

FIG. 3

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EUROPEAN SEARCH REPORT

0086289
Application number

EP 82 30 0724

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. ³)
A	US-A-3 880 289 (GRAY) * abstract; column 1, line 11 to column 2, line 20 *	1	B 07 C 5/342 G 06 M 7/04
A	DE-A-2 537 658 (ELMEG ELEKTRO-MECHANIK GmbH) * figures 1,2; pages 5 to 7; page 9 *	2	
A	US-A-4 279 346 (McCLURE) * figures 1-5; abstract; column 5, line 11 to column 6, line 17 *	1,2	
E	EP-A-0 060 493 (SATAKE ENGINEERING CO.) (priority 13-3-81; publ. 22-9-82) * figures 1,7; claims 1-6 *	1,2	

TECHNICAL FIELDS SEARCHED (Int. Cl. ³)

B 07 C 5/10
B 07 C 5/34
B 07 C 5/342
G 06 M 1/10
G 06 M 7/00
G 06 M 7/02
G 06 M 7/04

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	14-10-1982	PESCHEL W.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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