Innovation, Sciences et Développement économique Canada
Office de la Propriété Intellectuelle du Canada

Innovation, Science and Economic Development Canada
Canadian Intellectual Property Office

CA 2804497 C 2019/06/25

(11)(21) 2 804 497

(12) BREVET CANADIEN
CANADIAN PATENT

(13) C

(86) Date de dépôt PCT/PCT Filing Date: 2012/03/15
(87) Date publication PCT/PCT Publication Date: 2012/10/04
(45) Date de délivrance/Issue Date: 2019/06/25
(85) Entrée phase nationale/National Entry: 2013/01/04
(86) N° demande PCT/PCT Application No.: EP 2012/054576
(87) N° publication PCT/PCT Publication No.: 2012/130625
(30) Priorité/Priority: 2011/03/31 (DE10 2011 006 566.0)

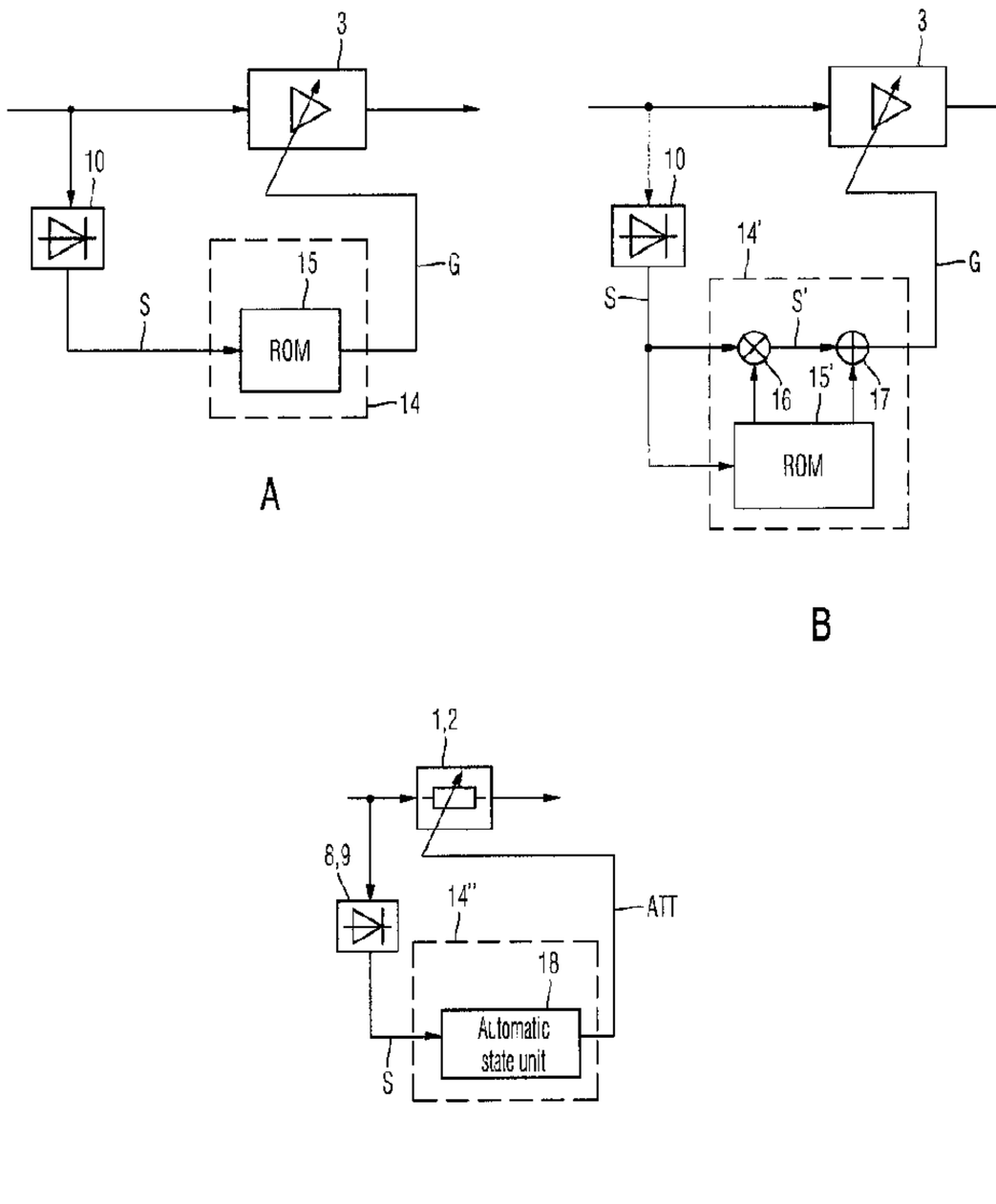
(51) Cl.Int./Int.Cl. *H03G 3/30* (2006.01)

(72) Inventeurs/Inventors:
KUHWALD, THOMAS, DE;
VALTEN, THOMAS, DE

(73) Propriétaire/Owner:
ROHDE & SCHWARZ GMBH & CO. KG, DE

(74) Agent: NELLIGAN O'BRIEN PAYNE LLP

(54) Titre : DISPOSITIF DE REGLAGE AUTOMATIQUE D'UN FACTEUR D'AMPLIFICATION OU D'ATTENUATION
(54) Title: DEVICES FOR THE AUTOMATIC ADJUSTMENT OF GAIN AND/OR ATTENUATION FACTOR



(57) Abrégé/Abstract:
A device for the automatic adjustment of a gain and/or attenuation factor (G;ATT) of several amplification or attenuation elements (1;2;3) connected in a cascade comprises respectively a detector (8;9;10) for measuring a signal level of a signal disposed at the input of the respective amplification or attenuation element (1;2;3) and respectively a downstream control unit (14;14';14'') for determining the gain and/or attenuation factor (G;ATT) respectively associated with each amplification or attenuation element (1;2;3). The control unit (14;14';14'') is a forward control unit for determining the gain and/or attenuation factor (G;ATT) respectively associated with each amplification or attenuation element (1;2;3) dependent exclusively upon the measured signal level of the signal disposed at the input of each amplification or attenuation element (1;2;3).

Abstract

A device for the automatic adjustment of a gain and/or attenuation factor (G;ATT) of several amplification or attenuation elements (1;2;3) connected in a cascade comprises respectively a detector (8;9;10) for measuring a signal level of a signal disposed at the input of the respective amplification or attenuation element (1;2;3) and respectively a downstream control unit (14;14';14'') for determining the gain and/or attenuation factor (G;ATT) respectively associated with each amplification or attenuation element (1;2;3). The control unit (14;14';14'') is a forward control unit for determining the gain and/or attenuation factor (G;ATT) respectively associated with each amplification or attenuation element (1;2;3) dependent exclusively upon the measured signal level of the signal disposed at the input of each amplification or attenuation element (1;2;3).

(Figure 3A,3B,4).

Translation

International Patent Application No. PCT/EP2012/054576

Devices for the automatic adjustment of a gain and/or attenuation factor

The invention relates to a device for the automatic adjustment of a gain and/or attenuation factor of cascaded amplification and/or attenuation elements.

The input unit of modern radio devices typically provides a very high input dynamic in order to receive radio signals over the widest possible radio range. This input dynamic of an input unit generally exceeds the dynamic range of signal processing units in radio devices, such as, filters or analog/digital converters. However, to achieve a high dynamic, automatic gain control circuits (automatic gain control, AGC) are used.

A signal-processing path with several cascaded amplifiers adjustable with regard to their gain factor, the gain factor being adjusted in each case by a control circuit based on a feedback structure (feed-back-structure), is known from JP 2004-080455 A.

An automatic gain control of this kind is only conditionally suitable for amplifiers arranged in the signal path of a radio device, because a feedback control structure is generally associated with poor settling behaviour and therefore provides a poorer time dynamic, and because modern radio devices are operated in a frequency-hop method with comparatively short time slots for message transmission. Moreover, the control structure can tend, dependent upon its structure, towards

unstable behaviour, which is not acceptable for secure message transmission, for example, in aeronautical radio technology.

The object of the invention is therefore to develop a device with automatic gain and/or attenuation control for amplification and/or attenuation elements disposed in the signal path of a radio device, which provides optimal time behaviour.

The object is achieved by a device for automatic adjustment of the gain and/or attenuation factor of several amplification and/or attenuation elements connected in a cascade with the features. Advantageous technical developments are exemplified herein.

The device for the automatic adjustment of the gain and/or attenuation factor of several amplification and/or attenuation elements connected in a cascade provides, in each case for every amplification and/or attenuation element, a detector for measuring the signal level at the input of the respective amplification and/or attenuation element, and in each case a downstream control unit for determining the gain and/or attenuation factor associated with each amplification and/or attenuation element. According to the invention, each control unit is realised as a forward control unit, which determines the gain and/or attenuation factor respectively associated with each amplification and/or attenuation element dependent upon the measured signal level of the signal disposed at the output of the respective amplification and/or attenuation element.

The transmission characteristic of the control unit associated with the amplification element can be determined from the transmission characteristic of the associated detector and the

transmission characteristic of the associated amplification element.

In a first preferred embodiment of a control unit associated with the amplification element, a buffer, of which the memory cells are each addressable dependent upon the abscissa value of the transmission characteristic of the control unit, that is to say, dependent upon the signal level from the detector disposed at the input of the respective amplification element and imaging in a linear scale, and of which the addressable memory-cell content, that is, the associated gain factor, can be read out at the output of the control unit, is provided in the control unit.

In a second preferred embodiment of a control unit associated with the amplification element, in each case, a multiplier for weighting the signal level measured by the detector at the input of the respective amplification element with a weighting factor which corresponds to the gradient of the transmission characteristic associated with the control unit, and, in each case, an adder for adding a signal level weighted in this manner with an offset value (offset value) which corresponds to the ordinate-axis value of the transmission characteristic associated with the respective control unit, are provided in the control unit.

The transmission characteristic of the control unit associated with an attenuation element can be determined preferably from the transmission characteristic of the associated detector, which converts a signal level of the signal disposed at the input of the respective attenuation element registered in the logarithmic scale into a signal present in the linear scale disposed at the output of the detector, and the individual

attenuation factors to be adjusted in the attenuation elements.

For this purpose, the control unit associated with the attenuation element preferably comprises an automatic state unit, which, in each case, provides one state for each attenuation factor realisable in the attenuation element. The automatic state unit waits in the respective state for as long as the signal disposed at the output of the detector is disposed within a signal-level range associated with that state. If the signal level present at the output of the detector leaves the signal-level range associated with the respective state, a switchover into one of the two adjacent states is implemented. The transitions between the individual states of the automatic state unit are preferably implemented by means of a hysteresis characteristic.

The device according to the invention for the automatic adjustment of the gain and/or attenuation factor of cascaded amplification and/or attenuation elements is explained in detail below with reference to the drawings. The drawings are as follows:

Figure 1 shows a block-circuit diagram of a receiver-end signal path of a radio device, in which the invention is used;

Figure 2A, 2B shows an exemplary diagram with the transmission characteristic of a detector and the transmission characteristic of an amplification element;

Figure 3A, 3B shows an exemplary block-circuit diagram of a first and second embodiment of a control unit

according to the invention associated with an amplification element;

Figure 4 shows an exemplary block-circuit diagram of a control unit according to the invention associated with an attenuation element;

Figure 5 shows an exemplary state diagram for determining an attenuation factor for an attenuation element in a control unit associated with an attenuation element; and

Figure 6A, 6B shows an exemplary diagram with the transmission characteristic of a control unit associated with the amplification element and a control unit associated with the attenuation element.

Switchable attenuation elements 1 and 2 and/or adjustable amplifiers 3, which ensure that the signal from the radio signal received from an antenna can be processed in the radio device within the existing dynamic range of the individual signal-processing units, comprising, for example, the high-frequency selection filter 5, the intermediate-frequency selection filter 6, the analog/digital converter 7, are inserted in the signal path of a radio device from the antenna to the analog/digital converter, as shown in Figure 1. The adjustment of the gain and/or attenuation factor of the individual amplification and/or attenuation units 1, 2 and 3 is implemented after a measurement of the signal level at the input of the respective amplification and/or attenuation unit 1, 2 and 3 by means of an associated detector 8, 9 and 10 in an associated automatic gain control (Automatic Gain Control (AGC)) 11, 12 and 13.

In a first embodiment according to Figure 3A, the control unit 14 according to the invention for determining a gain factor for an amplification element 3, that is to say, for an amplifier adjustable with regard to its gain factor G, comprises a buffer 15, which is preferably embodied as a read-only memory (Read Only Memory (ROM)). The values of the gain factor G for the amplification element 13 embodied in an equidistant matrix are stored in the individual memory cells of the buffer 15. The individual memory cells of the buffer 15 are addressable dependent upon the signal level of the signal disposed at the output of the detector 10. In this manner, the first embodiment of the control unit 14 according to the invention realised by the buffer 15 provides a transmission characteristic between the signal level of the signal S present in the linear scale at the output of the detector 10 and the gain factor G adjusted in the amplification element 3 in the logarithmic scale, as shown in Figure 6A.

The control unit 14' according to the invention for determining a gain factor G for an amplification element 3, as shown in Figure 3B, comprises a series circuit of a preferably digital multiplier 16 and a preferably digital adder 17. In the multiplier 16, the signal S present in the linear scale at the output of the detector 10 is weighted with a weighting factor stored in a buffer 15', preferably a ROM memory, which corresponds to the gradient of the transmission characteristic of the control unit 14 and/or 14', as shown in Figure 6A. The signal S' weighted with the weighting factor is added in the adjacent adder 17 to an offset value (offset value) stored in the buffer 15', which corresponds to the ordinate-axis value of the transmission characteristic of the control unit 14 and/or 14', as shown in Figure 6A. The memory cells of the buffer 15' storing the respective weighting-factor and offset

value are addressed via the signal level of the signal disposed at the output of the detector 10. Accordingly, with the second embodiment of a control unit 14' according to the invention, a transmission characteristic is realised between the signal level of the signal S present in the linear scale at the output of the detector 10 and the gain factor G adjusted in the logarithmic scale in the amplification element 3, as shown in Figure 6A.

The gain-factor values stored for the first embodiment of a control unit 14 according to the invention in the memory cells of the buffer 15 and also the weighting factors and offset values stored for the second embodiment of a control unit 14' according to the invention in the memory cells of the buffer 15' are determined, in each case, in advance by measuring the transmission characteristic of the detector 10 between the signal measured at the input of the amplification element 3 in the logarithmic scale and the signal level of the signal present in the linear scale disposed at the output of the detector 10, as shown in Figure 2A, and the transmission characteristic of the amplification element 3 between the signal level of the signal disposed at the input of the amplification element 3 measured in the logarithmic scale and the gain factor G adjusted in the amplification element 3 in the logarithmic scale, as shown in Figure 6A.

The control unit 14'' according to the invention for determining an attenuation factor ATT for an attenuation element 1 and/or 2 preferably comprises an automatic state unit 18, as shown in Figure 4. The automatic state unit 18 provides a number of states corresponding to the number of attenuation-factor values realised in the attenuation element 1 and/or 2. For example, the automatic state unit associated with the state diagram in Figure 5 provides 5 states with the

respectively associated attenuation-factor values (ATT_1, ATT_2, ATT_3, ATT_4, ATT_5). A larger number of states in the automatic state unit 18 can also be realised in order to achieve a finer screening of the attenuation factors adjustable in each case in the attenuation element 1 and/or 2.

The selection of the respective state of the automatic state unit 18 is implemented on the basis of the signal level of the signal S disposed at the output of the detector 8 and/or 9. For this purpose, a signal level range of the signal disposed at the output of the detector 8 and/or 9 is allocated to each individual state, as shown in Figure 5. If the signal level of the signal S disposed at the output of the detector 8 and/or 9 rises above the signal-level range for the current state, a transition to the adjacent state, of which the signal-level range is disposed above the signal-level range of the current state, takes place in the automatic state unit 18. If the signal level of the signal S disposed at the output of the detector 8 and/or 9 falls below the signal-level range of the current state, the automatic state unit 18 moves to the adjacent state, of which the signal-level range is disposed below the signal-level range of the current state.

In order to avoid a constant switching of the automatic state unit 18 between two adjacent states in the case of a noise-affected signal level of the signal S disposed at the output of the detector 8 and/or 9 within the signal-level range of a state transition, the transitions between the individual states of the automatic state unit 18 preferably provide a hysteresis characteristic, as illustrated in the state diagram in Figure 5.

In this manner, with the control unit 14'' according to the invention, a transmission characteristic is determined between

the signal level of the signal S present in the linear scale at the output of the detector 8 and/or 9 and the attenuation factor ATT adjusted in the attenuation element 1 and/or 2 according to Figure 6B.

The invention is not restricted to the embodiment illustrated. In particular, any combinations of the features illustrated in the drawings, described in the description and claimed in the claims are also covered by the invention.

Claims

1. A device for an automatic adjustment of a gain or attenuation factor, comprising:

a. a plurality of amplification or attenuation elements connected in a cascade,

b. a detector for measuring a signal level of a signal disposed at an input of the respective amplification or attenuation element; and

c. a downstream control unit for determining the gain or attenuation factor respectively associated with each amplification or attenuation element;

wherein the control unit is a forward control unit for determining the gain or attenuation factor respectively associated with each amplification or attenuation element exclusively dependent upon the measured signal level of the signal disposed at the input of each amplification or attenuation element, and

wherein a weighting factor for weighting the measured signal level of the signal at an output of the detector in a multiplier and an offset value for adding to the weighted signal level of the signal at an output of the multiplier in an adder are stored in memory cells of a buffer, which are addressed via the signal level of the signal at the output of the detector.

2. The device according to claim 1,

wherein a transmission characteristic of the control unit associated with an amplification element is determined dependent upon the transmission characteristic of the respective detector between the measured signal level of the signal disposed at the input of the respective amplification element and the signal level output at the output of the respective detector, and the transmission

characteristic of the respective amplification element between the signal level of the signal disposed at the input of the amplification element and the gain factor adjusted in the amplification element.

3. The device according to claim 2,
wherein a buffer, of which the memory cells can be addressed dependent upon an abscissa values of the transmission characteristic of the control unit, and from the memory cells of which the associated ordinate values of the transmission characteristic of the control unit can be read, is provided in the control unit associated with an amplification element.

4. The device according to claim 2,
wherein the weighting factor, which corresponds to a gradient of the transmission characteristic associated with the control unit, and an offset value, which corresponds to an ordinate-axis value of the transmission characteristic associated with the control unit, are present in the control unit associated with an amplification element.

5. The device according to claim 2,
wherein the transmission characteristic of the control unit associated with an attenuation element is determined dependent upon the transmission characteristic of the respective detector between the measured signal level of the signal disposed at the input of the respective attenuation element, and the signal level output at the output of the respective detector and an individual attenuation factors realisable by the attenuation element.

6. The device according to claim 5,

wherein the control unit associated with an attenuation element is realised as an automatic state unit, in which respectively one state, in which the automatic state unit waits for an associated range of the signal level output at the output of the respective detector, is provided for each attenuation factor realisable in the attenuation element.

7. The device according to claim 6,
wherein transitions between individual states of the automatic state unit provide a hysteresis characteristic.

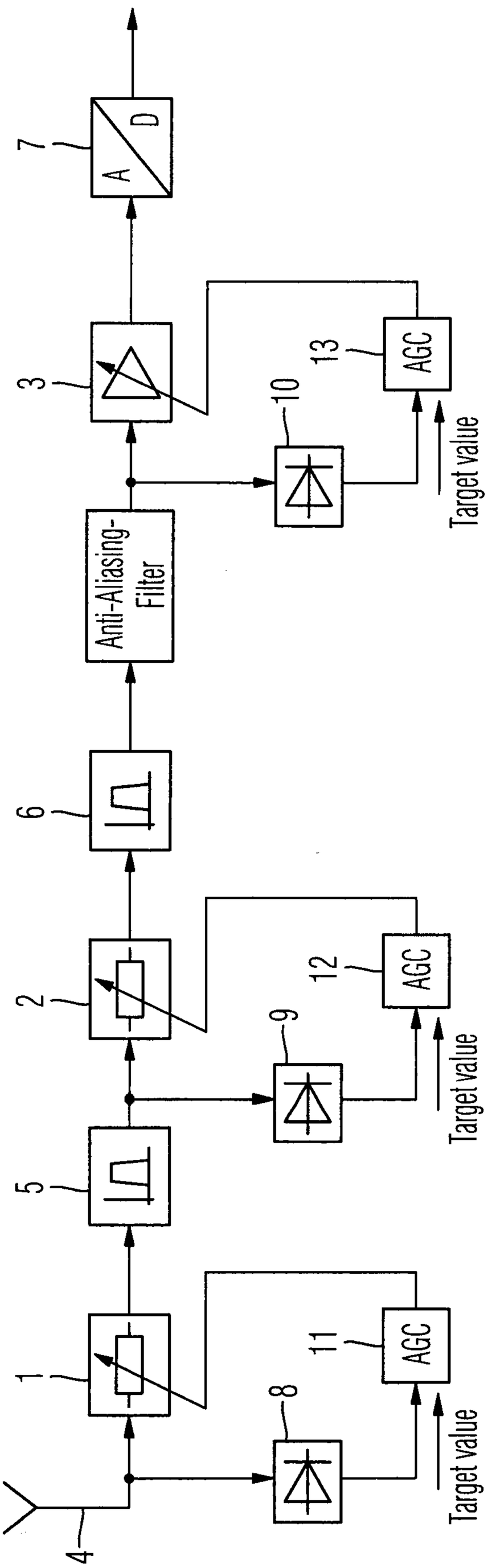

A/D
7
3
13
AGC
10
Target value
Anti-Aliasing-Filter
6
2
12
AGC
9
Target value
5
1
11
AGC
8
Target value
4

Fig. 1

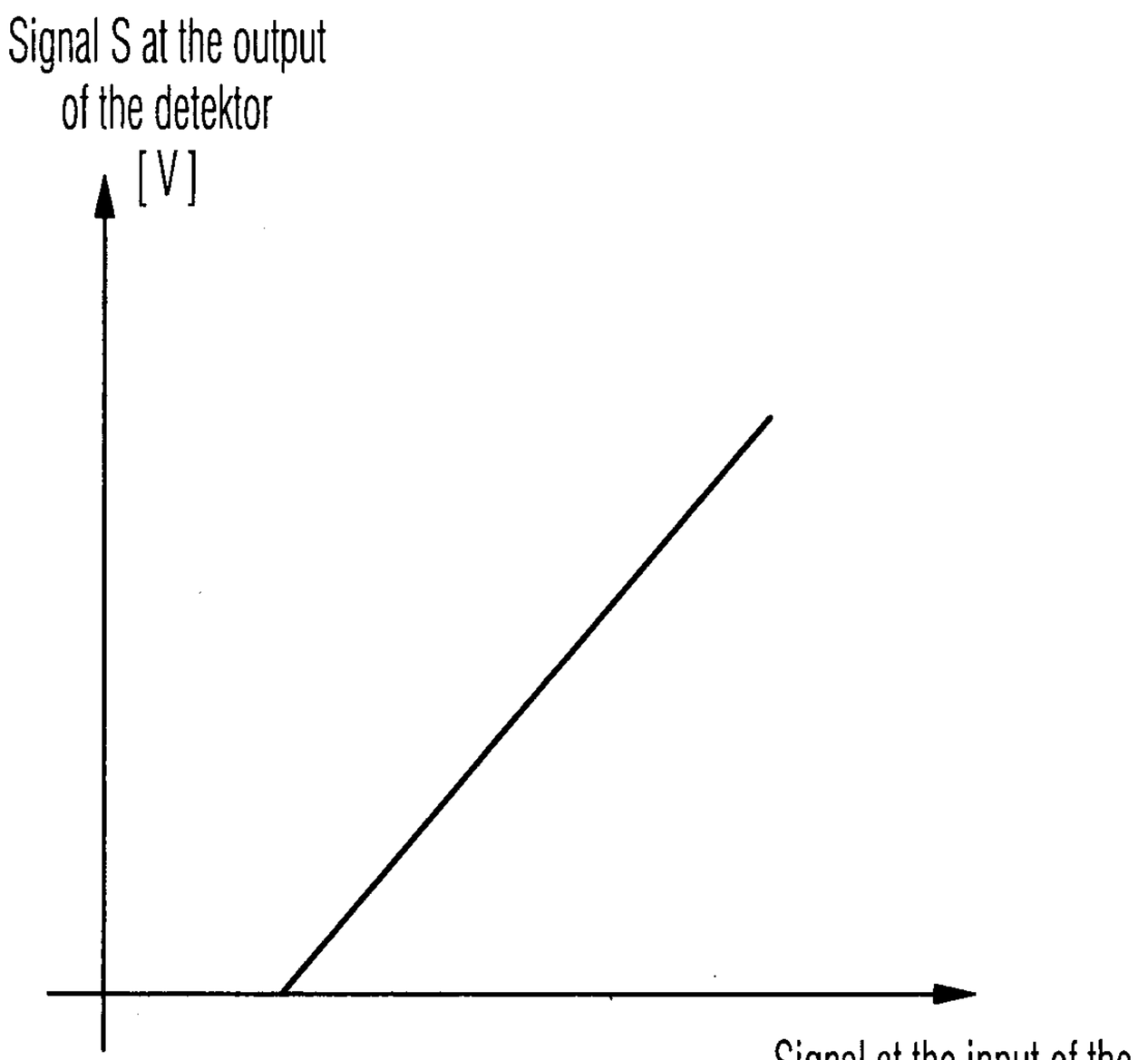

Signal S at the output
of the detektor
[V]
Signal at the input of the
amplification/ attenuation
element [dBm]

Fig. 2A

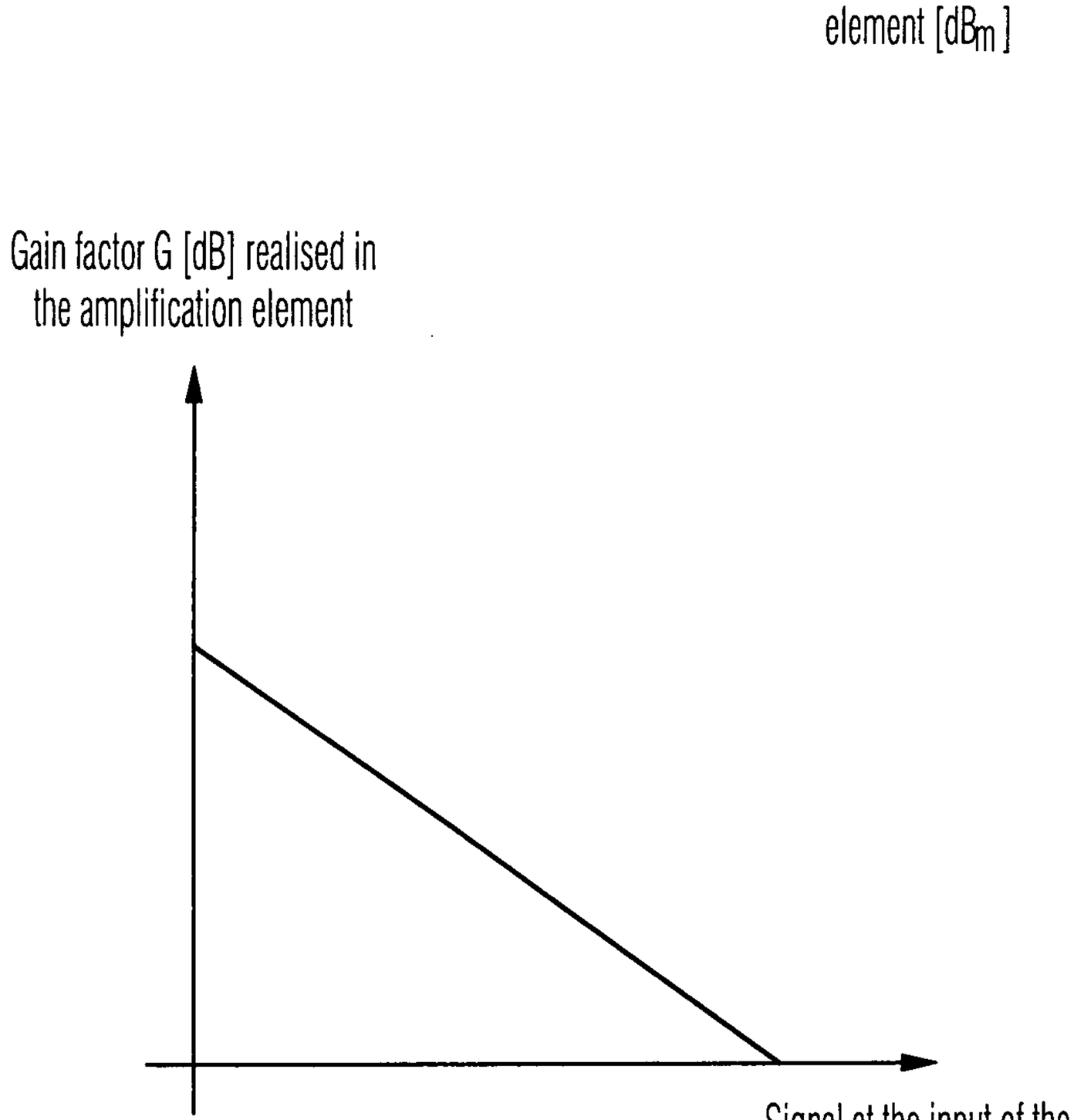

Gain factor G [dB] realised in
the amplification element
Signal at the input of the
amplification element [dB]

Fig. 2B

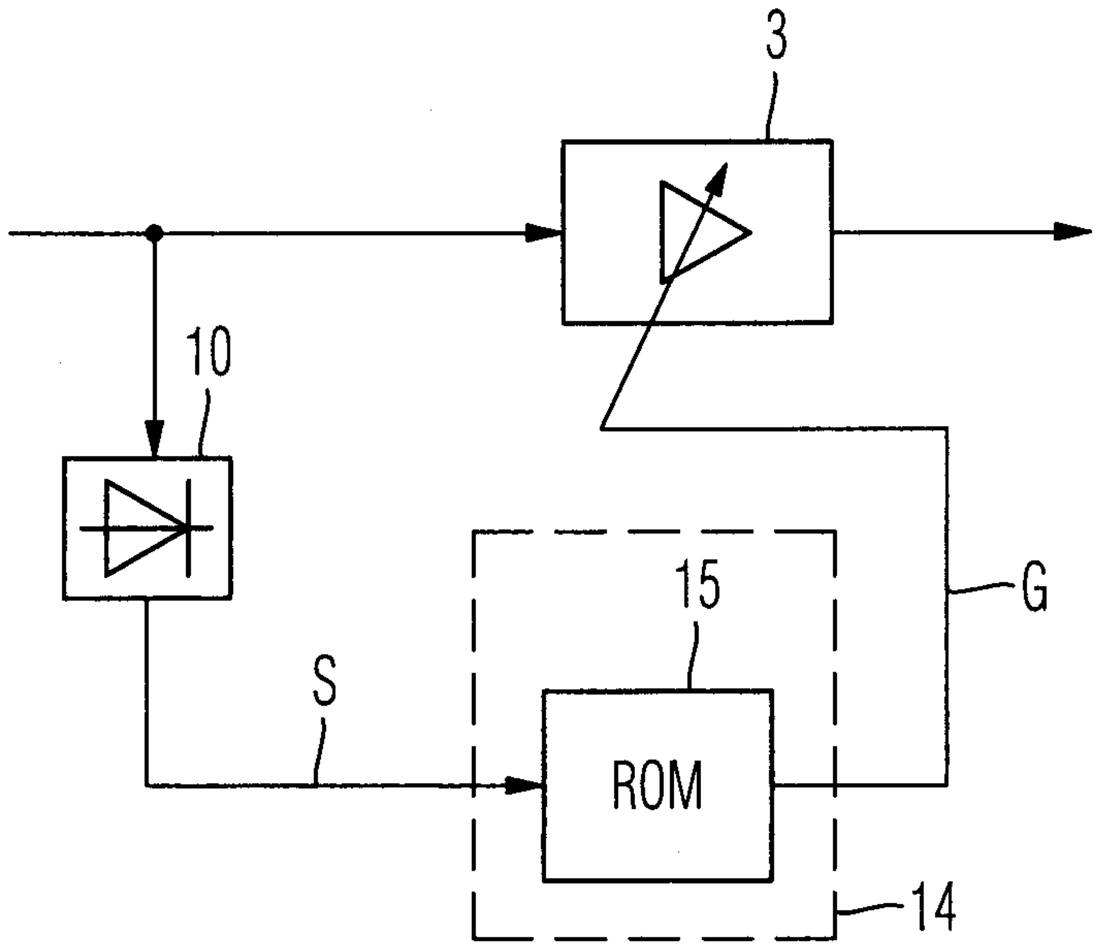


Fig. 3A

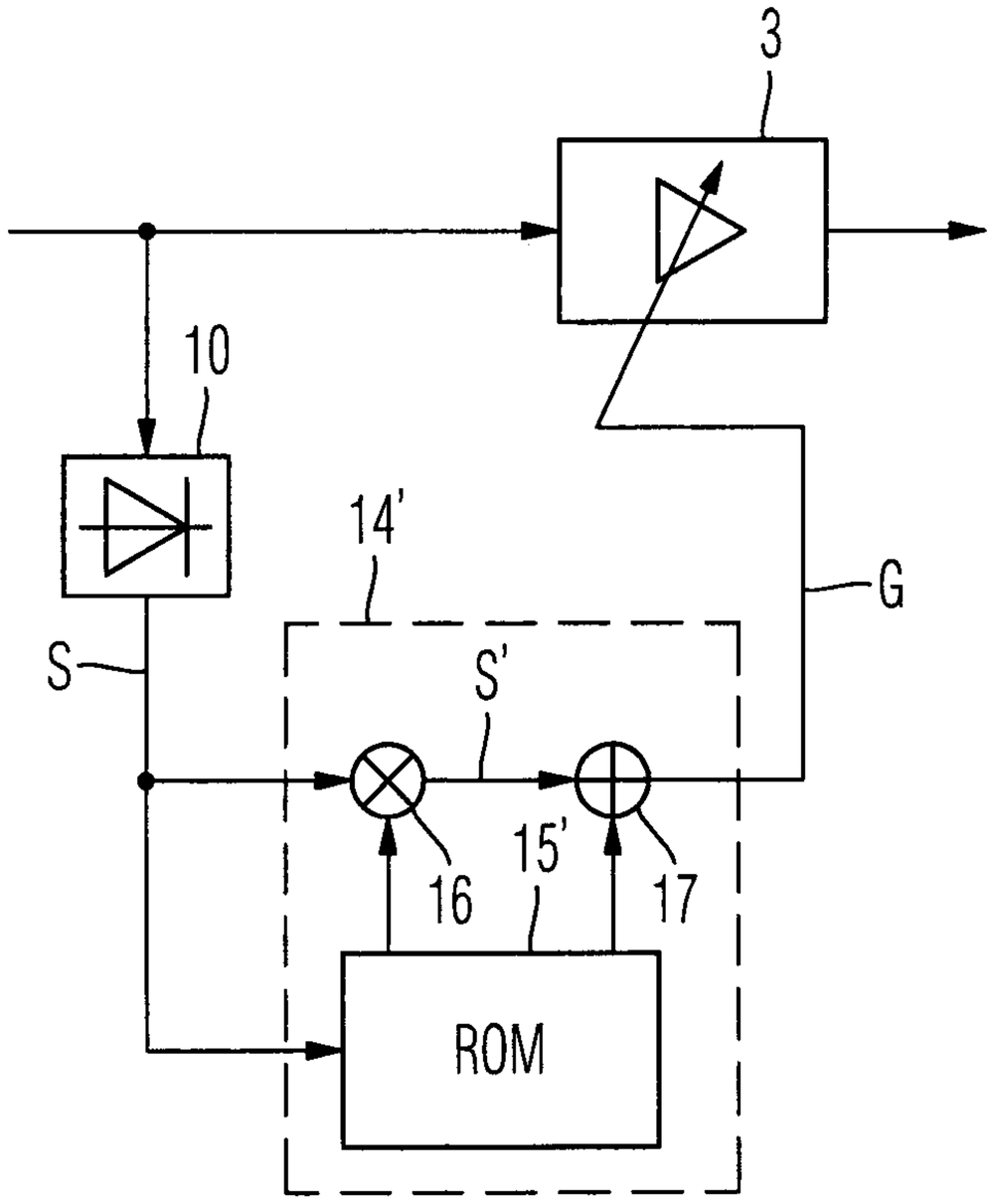


Fig. 3B

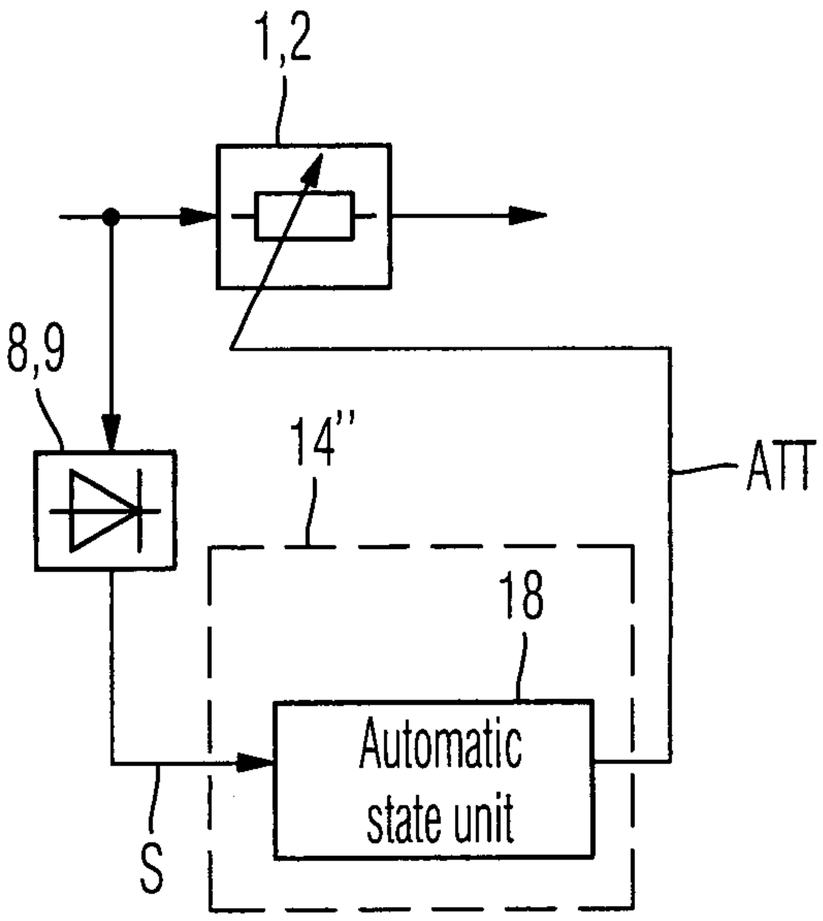


Fig. 4

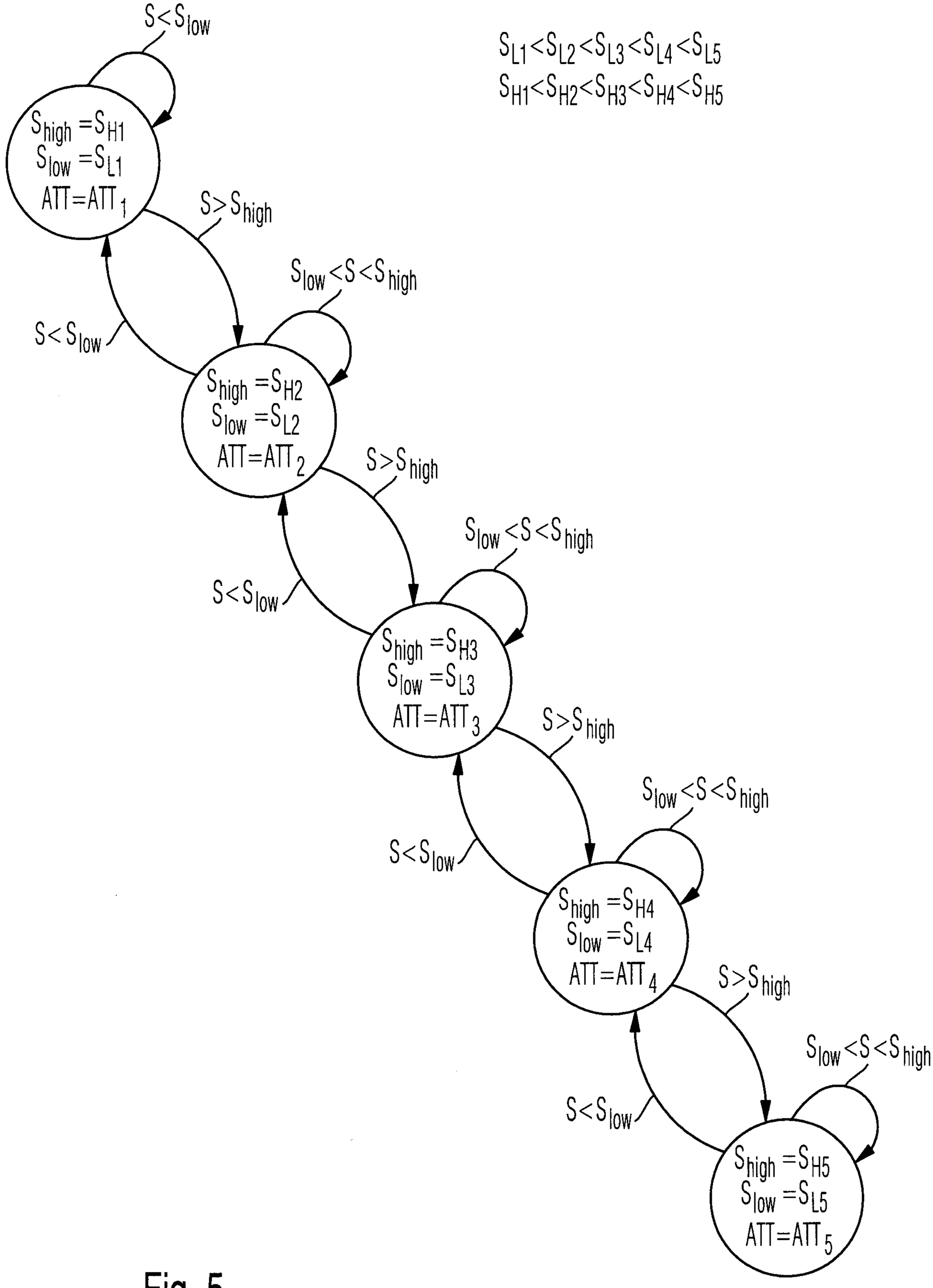

$S_{L1}<S_{L2}<S_{L3}<S_{L4}<S_{L5}$
$S_{H1}<S_{H2}<S_{H3}<S_{H4}<S_{H5}$
$S<S_{low}$
$S_{high}=S_{H1}$
$S_{low}=S_{L1}$
$ATT=ATT_1$
$S>S_{high}$
$S_{low}<S<S_{high}$
$S<S_{low}$
$S_{high}=S_{H2}$
$S_{low}=S_{L2}$
$ATT=ATT_2$
$S>S_{high}$
$S_{low}<S<S_{high}$
$S<S_{low}$
$S_{high}=S_{H3}$
$S_{low}=S_{L3}$
$ATT=ATT_3$
$S>S_{high}$
$S_{low}<S<S_{high}$
$S<S_{low}$
$S_{high}=S_{H4}$
$S_{low}=S_{L4}$
$ATT=ATT_4$
$S>S_{high}$
$S_{low}<S<S_{high}$
$S<S_{low}$
$S_{high}=S_{H5}$
$S_{low}=S_{L5}$
$ATT=ATT_5$

Fig. 5

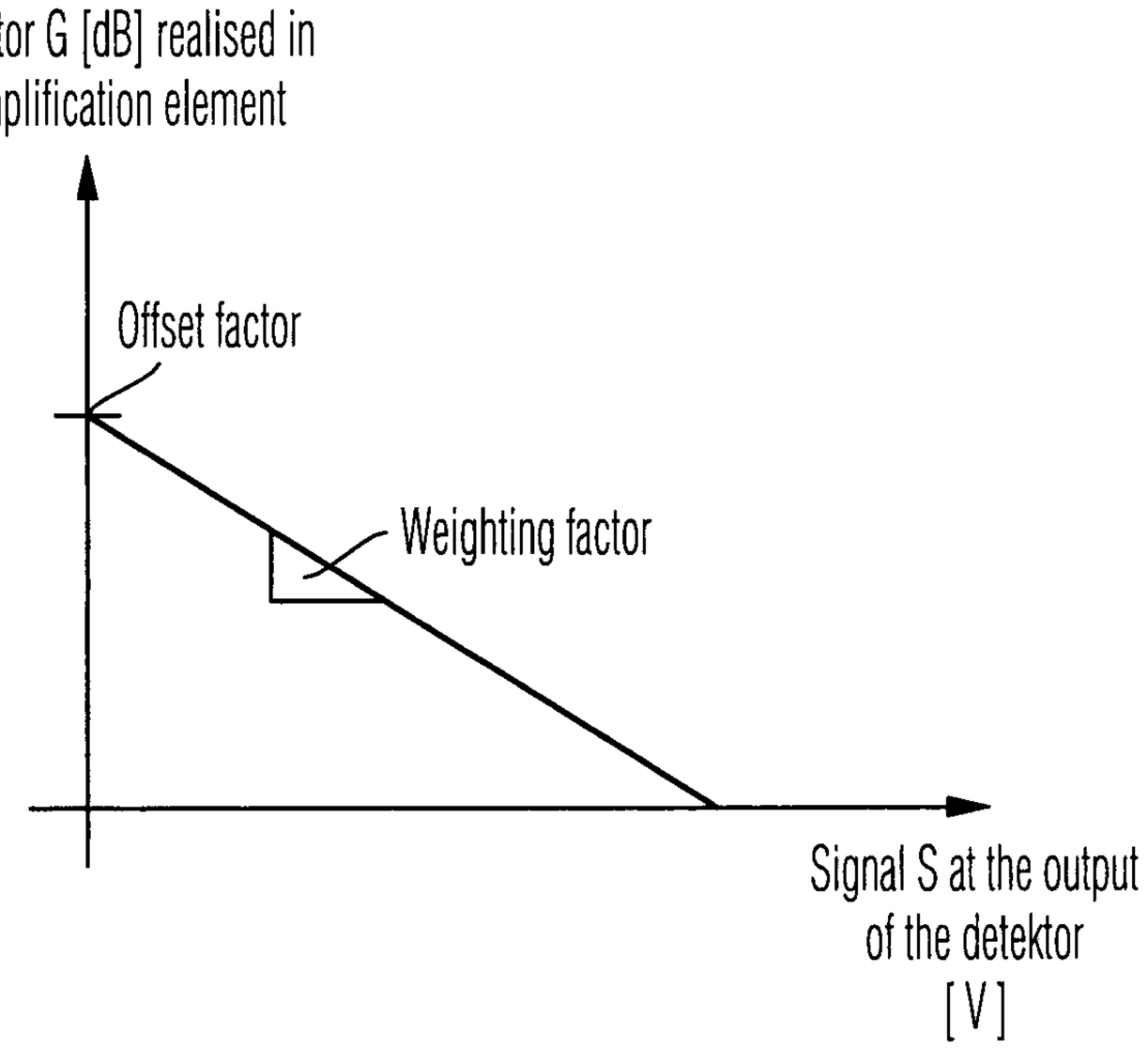

Gain factor G [dB] realised in
the amplification element
Offset factor
Weighting factor
Signal S at the output
of the detektor
[V]

Fig. 6A

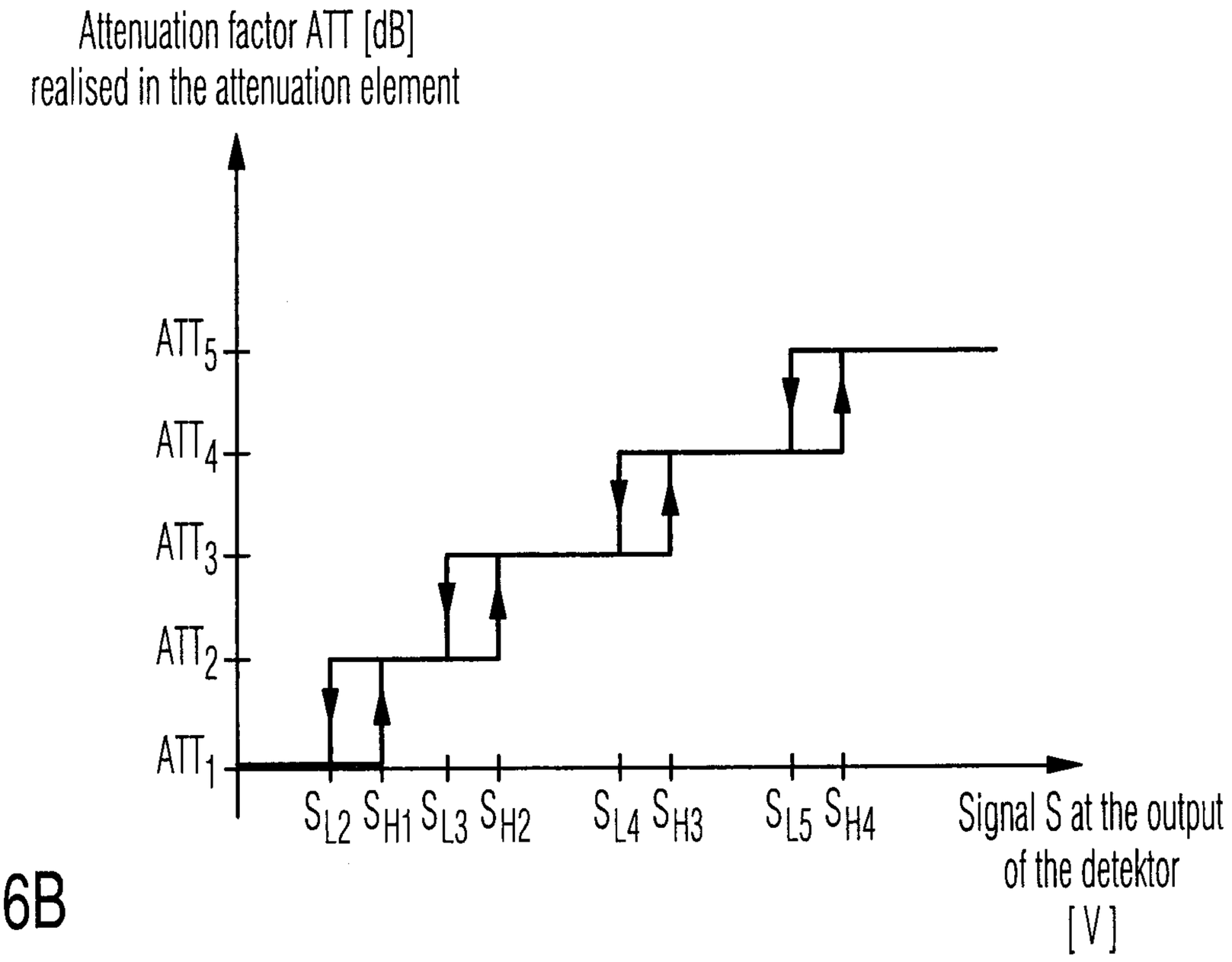
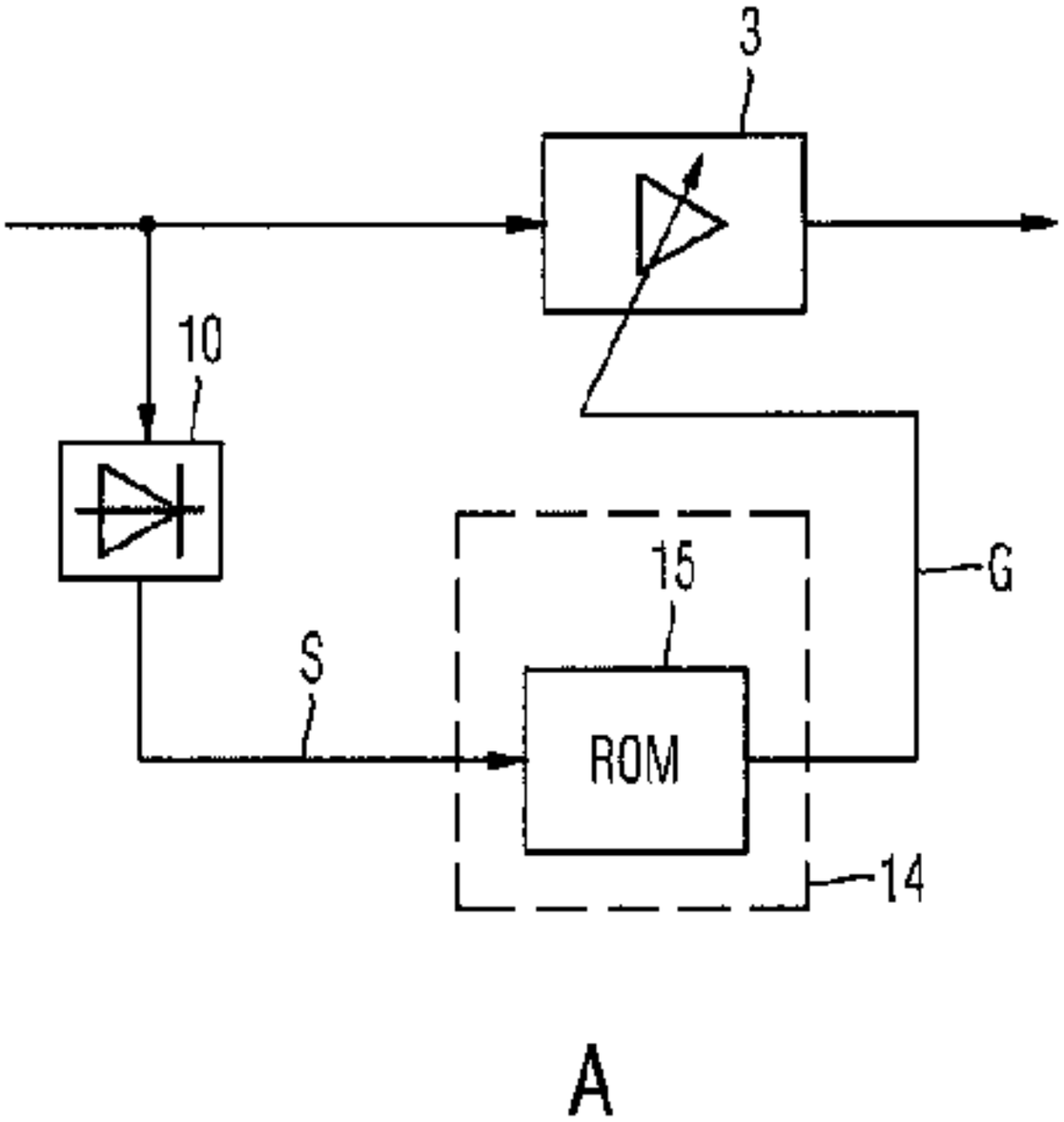
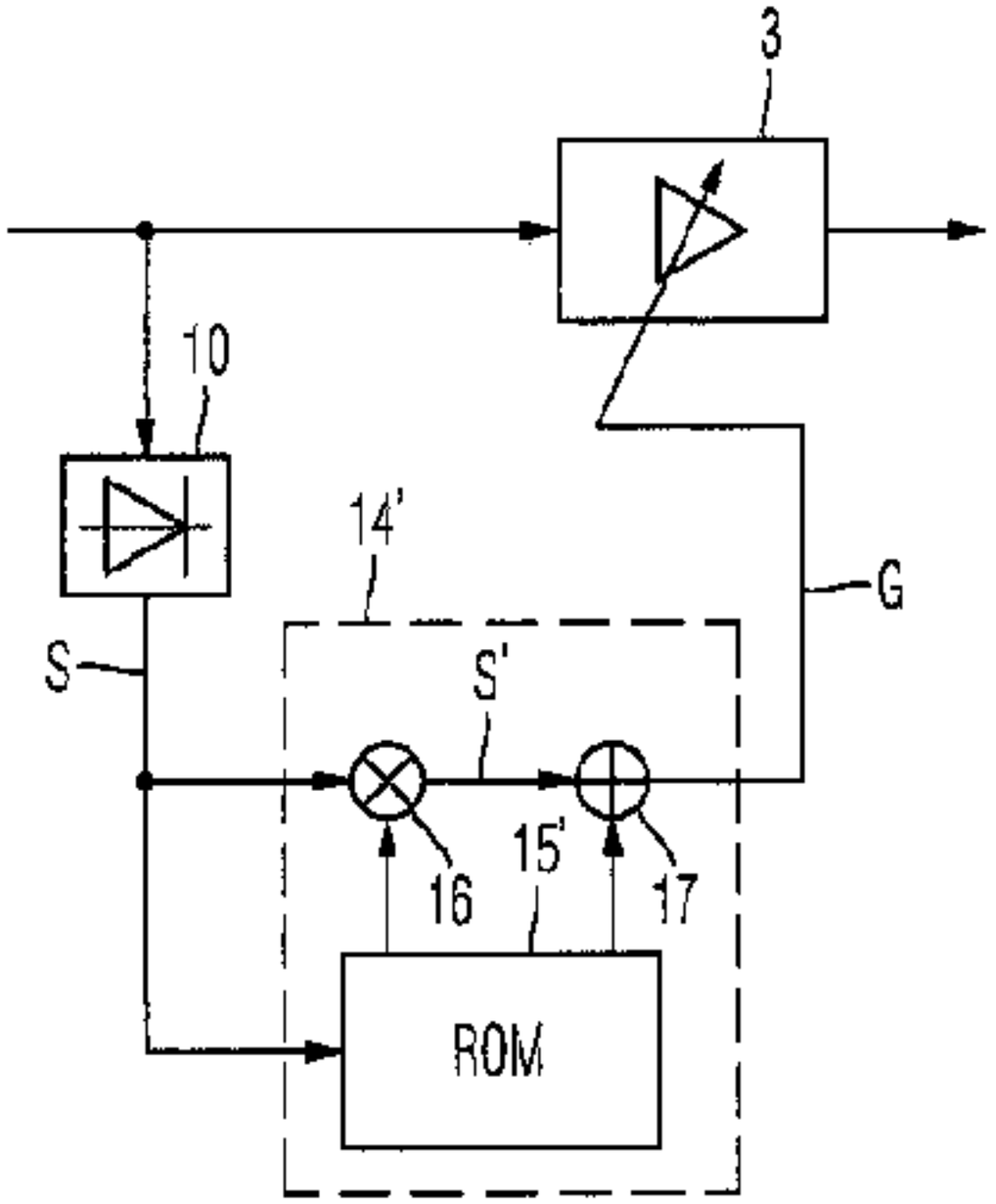

Attenuation factor ATT [dB]
realised in the attenuation element
ATT5
ATT4
ATT3
ATT2
ATT1
SL2 SH1 SL3 SH2 SL4 SH3 SL5 SH4
Signal S at the output
of the detektor
[V]

Fig. 6B

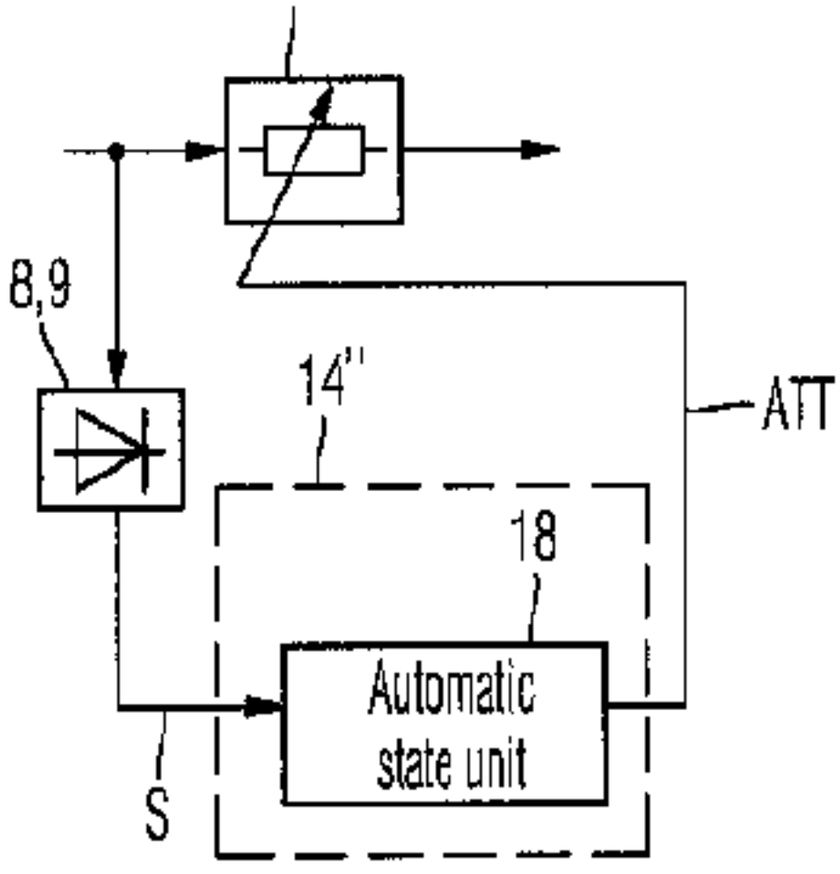

3
10
15
S
ROM
G
14

A


3
10
14'
G
S
S'
15'
16
17
ROM

B

1,2


8,9
14''
ATT
18
Automatic
state unit
S