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(54) **TRANSMISSION USING AN ANTENNA ARRAY IN A CDMA COMMUNICATION SYSTEM**

**ÜBERTRAGUNG IN EINEM CDMA-KOMMUNIKATIONSSYSTEM UNTER VERWENDUNG EINES
ANTENNEN-ARRAYS**

**TRANSMISSION AU MOYEN D'UN RESEAU D'ANTENNE DANS UN SYSTEME DE
COMMUNICATION AMDC**

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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates generally to signal transmission and reception in a wireless code division multiple access (CDMA) communication system. More specifically, the invention relates to a system and method of transmission using an antenna array to improve signal reception in a wireless CDMA communication system.

Description of the Prior Art

[0002] A prior art CDMA communication system is shown in **Figure 1**. The communication system has a plurality of base stations **20-32**. Each base station **20** communicates using spread spectrum CDMA with user equipment (UEs) **34-38** within its operating area. Communications from the base station **20** to each UE **34-38** are referred to as downlink communications and communications from each UE **34-38** to the base station **20** are referred to as uplink communications.

[0003] Shown in **Figure 2** is a simplified CDMA transmitter and receiver. A data signal having a given bandwidth is mixed by a mixer **40** with a pseudo random chip code sequence producing a digital spread spectrum signal for transmission by an antenna **42**. Upon reception at an antenna **44**, the data is reproduced after correlation at a mixer **46** with the same pseudo random chip code sequence used to transmit the data. By using different pseudo random chip code sequences, many data signals use the same channel bandwidth. In particular, a base station **20** will communicate signals to multiple UEs **34-38** over the same bandwidth.

[0004] For timing synchronization with a receiver, an unmodulated pilot signal is used. The pilot signal allows respective receivers to synchronize with a given transmitter allowing despreading of a data signal at the receiver. In a typical CDMA system, each base station **20** sends a unique pilot signal received by all UEs **34-38** within communicating range to synchronize forward link transmissions. Conversely, in some CDMA systems, for example in the B-CDMA™ air interface, each UE **34-38** transmits a unique assigned pilot signal to synchronize reverse link transmissions.

[0005] When a UE **34-36** or a base station **20-32** is receiving a specific signal, all the other signals within the same bandwidth are noise-like in relation to the specific signal. Increasing the power level of one signal degrades all other signals within the same bandwidth. However, reducing the power level too far results in an undesirable received signal quality. One indicator used to measure the received signal quality is the signal to noise ratio (SNR). At the receiver, the magnitude of the desired received signal is compared to the magnitude

of the received noise. The data within a transmitted signal received with a high SNR is readily recovered at the receiver. A low SNR leads to loss of data.

[0006] To maintain a desired signal to noise ratio at the minimum transmission power level, most CDMA systems utilize some form of adaptive power control. By minimizing the transmission power, the noise between signals within the same bandwidth is reduced. Accordingly, the maximum number of signals received at the desired signal to noise ratio within the same bandwidth is increased.

[0007] Although adaptive power control reduces interference between signals in the same bandwidth, interference still exists limiting the capacity of the system.

One technique for increasing the number of signals using the same radio frequency (RF) spectrum is to use sectorization. In sectorization, a base station uses directional antennas to divide the base station's operating area into a number of sectors. As a result, interference between signals in differing sectors is reduced. However, signals within the same bandwidth within the same sector interfere with one another. Additionally, sectorized base stations commonly assign different frequencies to adjoining sectors decreasing the spectral efficiency for a given frequency bandwidth.

[0008] U.S. Patent No. 5,652,764 discloses a transmitter array system. Each antenna of the array transmits a spread data signal. Each data signal is spread with a different orthogonal code. A receiver receives the transmitted spread data signals. The received signals are despread using the orthogonal codes by either match filters or correlators. The despread data signals are either combined or one despread signal is selected as the received data.

[0009] EPO 881 781 A2 discloses a transmission diversity scheme. An information signal is transmitted from a plurality of antennas using a different spreading code for each antenna.

[0010] U.S. Patent no. 5,812,542 discloses a soft handoff system for a CDMA system. Each of a plurality of base stations transmits a pilot signal and the same data signal. The mobile unit receives the pilot signals and despreads the same data signals using weighting information determined from the pilot signals. The despread same data signals are combined as an output data signal.

[0011] Accordingly, there exists a need for a system which further improves the signal quality of received signals without increasing transmitter power levels.

SUMMARY OF THE INVENTION

[0012] The invention provides for transmission and reception of a data signal using a plurality of transmitting antennas. Each antenna transmits a different pilot signal having a pseudo random chip code sequence. A receiver filters each transmitted pilot using that pilot's chip code. The filtered pilots are weighted and combined.

Each pilot signal's weight is adaptively adjusted in part on a signal quality of the combined signal. A data signal is transmitted such that different spread spectrum versions of the data signal are transmitted from each transmitting antenna. Each version having a different chip code identifier. Upon reception, each version is filtered with its associated chip code. The filtered versions are weighted in accordance with the adjusted weights associated with the pilot signal of the respective antenna.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013]

Figure 1 is a prior art wireless spread spectrum CDMA communication system.

Figure 2 is a prior art spread spectrum CDMA transmitter and receiver.

Figure 3 is the transmitter of the invention.

Figure 4 is the transmitter of the invention transmitting multiple data signals.

Figure 5 is the pilot signal receiving circuit of the invention.

Figure 6 is the data signal receiving circuit of the invention.

Figure 7 is an embodiment of the pilot signal receiving circuit.

Figure 8 is a least mean squared weighting circuit.

Figure 9 is the data signal receiving circuit used with the pilot signal receiving circuit of **Figure 7**.

Figure 10 is an embodiment of the pilot signal receiving circuit where the output of each RAKE is weighted.

Figure 11 is the data signal receiving circuit used with the pilot signal receiving circuit of **Figure 10**.

Figure 12 is an embodiment of the pilot signal receiving circuit where the antennas of the transmitting array are closely spaced.

Figure 13 is the data signal receiving circuit used with the pilot signal receiving circuit of **Figure 12**.

Figure 14 is an illustration of beam steering in a CDMA communication system.

Figure 15 is a beam steering transmitter.

Figure 16 is a beam steering transmitter transmitting multiple data signals.

Figure 17 is the data receiving circuit used with the transmitter of **Figure 14**.

Figure 18 is a pilot signal receiving circuit used when uplink and downlink signals use the same frequency.

Figure 19 is a transmitting circuit used with the pilot signal receiving circuit of **Figure 18**.

Figure 20 is a data signal receiving circuit used with the pilot signal receiving circuit of **Figure 18**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0014] The preferred embodiments will be described with reference to the drawing figures where like numerals represent like elements throughout. **Figure 3** is a transmitter of the invention. The transmitter has an array of antennas **48-52**, preferably 3 or 4 antennas. For use in distinguishing each antenna **48-52**, a different signal is associated with each antenna **56-60**. The preferred signal to associate with each antenna is a pilot signal as shown in **Figure 3**. Each spread pilot signal is generated by a pilot signal generator **56-60** using a different pseudo random chip code sequence and is combined by combiners **62-66** with the respective spread data signal. Each spread data signal is generated using data signal generator **54** by mixing at mixers **378-382** the generated data signal with a different pseudo random chip code sequence per antenna **48-52**, D_1-D_N . The combined signals are modulated to a desired carrier frequency and radiated through the antennas **48-52** of the array.

[0015] By using an antenna array, the transmitter utilizes spacial diversity. If spaced far enough apart, the signals radiated by each antenna **48-52** will experience different multipath distortion while traveling to a given receiver. Since each signal sent by an antenna **48-52** will follow multiple paths to a given receiver, each received signal will have many multipath components. These components create a virtual communication channel between each antenna **48-52** of the transmitter and the receiver. Effectively, when signals transmitted by one antenna **48-52** over a virtual channel to a given receiver are fading, signals from the other antennas **48-52** are used to maintain a high received SNR. This effect is achieved by the adaptive combining of the transmitted signals at the receiver.

[0016] **Figure 4** shows the transmitter as used in a base station **20** to send multiple data signals. Each spread data signal is generated by mixing at mixers **360-376** a corresponding data signal from generators **74-78** with differing pseudo random chip code sequences $D_{11}-D_{NM}$. Accordingly, each data signal is spread using a different pseudo random chip code sequence per antenna **48-52**, totaling $N \times M$ code sequences. N is the number of antennas and M is the number of data signals. Subsequently, each spread data signal is combined with the spread pilot signal associated with the antenna **48-52**. The combined signals are modulated and radiated by the antennas **48-52** of the array.

[0017] The pilot signal receiving circuit is shown in **Figure 5**. Each of the transmitted pilot signals is received by the antenna **80**. For each pilot signal, a despreading device, such as a RAKE **82-86** as shown in the **Figure 5** or a vector correlator, is used to despread each pilot signal using a replica of the corresponding pilot signal's pseudo random chip code sequence. The despreading device also compensates for multipath in the communication channel. Each of the recovered pilot

signals is weighted by a weighting device 88-92. Weight refers to both magnitude and phase of the signal. Although the weighting is shown as being coupled to a RAKE, the weighting device preferably also weights each finger of the RAKE. After weighting, all of the weighted recovered pilot signals are combined in a combiner 94. Using an error signal generator 98, an estimate of the pilot signal provided by the weighted combination is used to create an error signal. Based on the error signal, the weights of each weighting device 88-92 are adjusted to minimize the error signal using an adaptive algorithm, such as least mean squared (LMS) or recursive least squares (RLS). As a result, the signal quality of the combined signal is maximized.

[0018] Figure 6 depicts a data signal receiving circuit using the weights determined by the pilot signal recovery circuit. The transmitted data signal is recovered by the antenna 80. For each antenna 48-52 of the transmitting array, the weights from a corresponding despreading device, shown as a RAKE 82-86, are used to filter the data signal using a replica of the data signal's spreading code used for the corresponding transmitting antenna. Using the determined weights for each antenna's pilot signal, each weighting device 106-110 weights the RAKE's despread signal with the weight associated with the corresponding pilot. For instance, the weighting device 88 corresponds to the transmitting antenna 48 for pilot signal 1. The weight determined by the pilot RAKE 82 for pilot signal 1 is also applied at the weighting device 106 of Figure 6. Additionally, if the weights of the RAKE's fingers were adjusted for the corresponding pilots signal's RAKE 82-86, the same weights will be applied to the fingers of the data signal's RAKE 100-104. After weighting, the weighted signals are combined by the combiner 112 to recover the original data signal.

[0019] By using the same weights for the data signal as used with each antenna's pilot signal, each RAKE 82-86 compensates for the channel distortion experienced by each antenna's signals. As a result, the data signal receiving circuit optimizes the data signals reception over each virtual channel. By optimally combining each virtual channel's optimized signal, the received data signal's signal quality is increased.

[0020] Figure 7 shows an embodiment of the pilot signal recovery circuit. Each of the transmitted pilots are recovered by the receiver's antenna 80. To despread each of the pilots, each RAKE 82-86 utilizes a replica of the corresponding pilot's pseudo random chip code sequence, P_1-P_N . Delayed versions of each pilot signal are produced by delay devices 114-124. Each delayed version is mixed by a mixer 126-142 with the received signal. The mixed signals pass through sum and dump circuits 424-440 and are weighted using mixers 144-160 by an amount determined by the weight adjustment device 170. The weighted multipath components for each pilot are combined by a combiner 162-164. Each pilot's combined output is combined by a combiner 94. Since a pilot signal has no data, the combined pilot signal

should have a value of $1+j0$. The combined pilot signal is compared to the ideal value, $1+j0$, at a subtractor 168. Based on the deviation of the combined pilot signal from the ideal, the weight of the weighting devices 144-160 are adjusted using an adaptive algorithm by the weight adjustment device 170.

[0021] A LMS algorithm used for generating a weight is shown in Figure 8. The output of the subtractor 168 is multiplied using a mixer 172 with the corresponding despread delayed version of the pilot. The multiplied result is amplified by an amplifier 174 and integrated by an integrator 176. The integrated result is used to weight, W_{1M} , the RAKE finger.

[0022] The data receiving circuit used with the embodiment of Figure 7 is shown for a base station receiver in Figure 9. The received signal is sent to a set of RAKEs 100-104 respectively associated with each antenna 48-52 of the array. Each RAKE 100-104, produces delayed versions of the received signal using delay devices 178-188. The delayed versions are weighted using mixers 190-206 based on the weights determined for the corresponding antenna's pilot signal. The weighted data signals for a given RAKE 100-104 are combined by a combiner 208-212. One combiner 208-212 is associated with each of the N transmitting antennas 48-52. Each combined signal is despread M times by mixing at a mixer 214-230 the combined signal with a replica of the spreading codes used for producing the M spread data signals at the transmitter, $D_{11}-D_{NM}$. Each despread data signal passes through a sum and dump circuit 232-248. For each data signal, the results of the corresponding sum and dump circuits are combined by a combiner 250-254 to recover each data signal.

[0023] Another pilot signal receiving circuit is shown in Figure 10. The despreading circuits 82-86 of this receiving circuit are the same as Figure 7. The output of each RAKE 82-86 is weighted using a mixer 256-260 prior to combining the despread pilot signals. After combining, the combined pilot signal is compared to the ideal value and the result of the comparison is used to adjust the weight of each RAKE's output using an adaptive algorithm. To adjust the weights within each RAKE 82-86, the output of each RAKE 82-86 is compared to the ideal value using a subtractor 262-266. Based on the result of the comparison, the weight of each weighting device 144-160 is determined by the weight adjustment devices 268-272.

[0024] The data signal receiving circuit used with the embodiment of Figure 10 is shown in Figure 11. This circuit is similar to the data signal receiving circuit of Figure 9 with the addition of mixers 274-290 for weighting the output of each sum and dump circuit 232-248. The output of each sum and dump circuit 232-248 is weighted by the same amount as the corresponding pilot's RAKE 82-86 was weighted. Alternatively, the output of each RAKE's combiner 208-212 may be weighted prior to mixing by the mixers 214-230 by the amount of the corresponding pilot's RAKE 82-86 in lieu of weighting

after mixing.

[0025] If the spacing of the antennas 48-52 in the transmitting array is small, each antenna's signals will experience a similar multipath environment. In such cases, the pilot receiving circuit of Figure 12 may be utilized. The weights for a selected one of the pilot signals are determined in the same manner as in Figure 10. However, since each pilot travels through the same virtual channel, to simplify the circuit, the same weights are used for despreading the other pilot signals. Delay devices 292-294 produce delayed versions of the received signal. Each delayed version is weighted by a mixer 296-300 by the same weight as the corresponding delayed version of the selected pilot signal was weighted. The outputs of the weighting devices are combined by a combiner 302. The combined signal is despread using replicas of the pilot signals' pseudo random chip code sequences, P_2 - P_n , by the mixers 304-306. The output of each pilot's mixer 304-306 is passed through a sum and dump circuit 308-310. In the same manner as Figure 10, each despread pilot is weighted and combined.

[0026] The data signal recovery circuit used with the embodiment of Figure 12 is shown in Figure 13. Delay devices 178-180 produce delayed versions of the received signal. Each delayed version is weighted using a mixer 190-194 by the same weight as used by the pilot signals in Figure 12. The outputs of the mixers are combined by a combiner 208. The output of the combiner 208 is inputted to each data signal despreaders of Figure 13.

[0027] The invention also provides a technique for adaptive beam steering as illustrated in Figure 14. Each signal sent by the antenna array will constructively and destructively interfere in a pattern based on the weights provided each antenna 48-52 of the array. As a result, by selecting the appropriate weights, the beam 312-316 of the antenna array is directed in a desired direction.

[0028] Figure 15 shows the beam steering transmitting circuit. The circuit is similar to the circuit of Figure 3 with the addition of weighting devices 318-322. A target receiver will receive the pilot signals transmitted by the array. Using the pilot signal receiving circuit of Figure 5, the target receiver determines the weights for adjusting the output of each pilot's RAKE. These weights are also sent to the transmitter, such as by using a signaling channel. These weights are applied to the spread data signal as shown in Figure 15. For each antenna, the spread data signal is given a weight by the weighting devices 318-322 corresponding to the weight used for adjusting the antenna's pilot signal at the target receiver providing spatial gain. As a result, the radiated data signal will be focused towards the target receiver. Figure 16 shows the beam steering transmitter as used in a base station sending multiple data signals to differing target receivers. The weights received by the target receiver are applied to the corresponding data signals by weighting devices 324-340.

[0029] Figure 17 depicts the data signal receiving circuit for the beam steering transmitter of Figures 15 and 16. Since the transmitted signal has already been weighted, the data signal receiving circuit does not require the weighting devices 106-110 of Figure 6.

[0030] The advantage of the invention's beam steering are two-fold. The transmitted data signal is focused toward the target receiver improving the signal quality of the received signal. Conversely, the signal is focused away from other receivers reducing interference to their signals. Due to both of these factors, the capacity of a system using the invention's beam steering is increased. Additionally, due to the adaptive algorithm used by the pilot signal receiving circuitry, the weights are dynamically adjusted. By adjusting the weights, a data signal's beam will dynamically respond to a moving receiver or transmitter as well as to changes in the multipath environment.

[0031] In a system using the same frequency for downlink and uplink signals, such as time division duplex (TDD), an alternate embodiment is used. Due to reciprocity, downlink signals experience the same multipath environment as uplink signals send over the same frequency. To take advantage of reciprocity, the weights determined by the base station's receiver are applied to the base station's transmitter. In such a system, the base station's receiving circuit of Figure 18 is co-located, such as within a base station, with the transmitting circuit of Figure 19.

[0032] In the receiving circuit of Figure 18, each antenna 48-52 receives a respective pilot signal sent by the UE. Each pilot is filtered by a RAKE 406-410 and weighted by a weighting device 412-416. The weighted and filtered pilot signals are combined by a combiner 418. Using the error signal generator 420 and the weight adjustment device 422, the weights associated with the weighting devices 412-416 are adjusted using an adaptive algorithm.

[0033] The transmitting circuit of Figure 19 has a data signal generator 342 to generate a data signal. The data signal is spread using mixer 384. The spread data signal is weighted by weighting devices 344-348 as were determined by the receiving circuit of Figure 19 for each virtual channel.

[0034] The circuit of Figure 20 is used as a data signal receiving circuit at the base station. The transmitted data signal is received by the multiple antennas 48-52. A data RAKE 392-396 is coupled to each antenna 48-52 to filter the data signal. The filtered data signals are weighted by weighting devices 398-402 by the weights determined for the corresponding antenna's received pilot and are combined at combiner 404 to recover the data signal. Since the transmitter circuit of Figure 19 transmits the data signal with the optimum weights, the recovered data signal at the UE will have a higher signal quality than provided by the prior art.

Claims

1. A method for use in a spread spectrum communication system having a plurality of transmitting antennas (48-52), the method comprising the steps of:

transmitting from each transmitting antenna (48-52), a pilot signal having a pseudo random chip code sequence uniquely associated with that antenna (48-52);
receiving at the receiver all of said transmitted pilot signals;
filtering each said transmitted pilot signal using that pilot signal's pseudo random chip code sequence;

characterized by:

weighting each said filtered pilot signal by a particular weight;
combining said weighted pilot signals as a combined signal;
adaptively adjusting each said pilot signal's particular weight based in part on a signal quality of the combined signal;
transmitting a data signal such that different spread spectrum versions of the data signal are transmitted from each antenna (48-52), each version having a different chip code identifier for the respective transmitting antenna (48-52); and
receiving the data signal via filtering each version with its associated chip code and combining the filtered versions, wherein the different data signal versions are weighted in accordance with the adjusted weights associated with the pilot signal of the respective antenna (48-52).

2. The method of claim 1 wherein the different data signal versions are weighted in accordance with the adjusted weights prior to transmission.
3. The method of claim 1 wherein the different data signal versions are weighted in accordance with the adjusted weights after reception.
4. The method of claim 1 wherein adaptively adjusting is by using a least mean squared algorithm.
5. The method of claim 1 wherein adaptively adjusting is by using a recursive least squares algorithm.
6. The method of claim 1 wherein adaptively adjusting is by comparing the combined signal with an ideal value to produce an error signal and adjusting each said pilot signal's particular weight based in part on the error signal.

7. The method of claim 6 wherein the ideal value is $1 + j0$.

8. The method of claim 1 wherein the steps of filtering and weighting occur concurrently.

9. The method of claim 1 wherein the filtering of each said transmitted pilot signal and of each said version of the data signal is performed by a RAKE (82-86, 100-104).

10. The method of claim 1 wherein the filtering of each said transmitted pilot signal and of each said version of the data signal is performed by a vector correlator.

11. The method of claim 9 wherein the weighting of each said pilot signal is by weighting each finger (144-148, 150-154, 156-160) of that pilot's RAKE (82-86) by a particular amount and the weighting of each finger (190-194, 196-200, 202-286, 274-290) of each said version of the data signal's RAKE is in accordance with the adjusted weights associated with the respective finger (144-148, 150-154, 156-160) of the pilot signal's RAKE (82-86) for the pilot signal of the respective antenna (48-52).

12. The method of claim 9 wherein the weighting of each said pilot signal is by weighting each finger (144-148, 150-154, 156-160) of that pilot's RAKE (82-86) and weighting an output of that pilot's RAKE (82-86) and the weighting of each said version of the data signal is by weighting each finger (190-194, 196-200, 202-206, 274-290) and an output of each said version of the data signal's RAKE (100-104) in accordance with the adjusted weights associated with the respective finger (144-148, 150-154, 156-160) and the output of the pilot signal's RAKE (82-86) for the pilot signal of the respective antenna (48-52).

13. A spread spectrum communication system comprising

a transmitter comprising:

a plurality of transmitting antennas (48-52);
means (56-60) for transmitting from each transmitting antenna (48-52), a pilot signal having a pseudo random chip code sequence uniquely associated with that antenna; and
means (378-382, 360-376) for transmitting a data signal such that different spread spectrum versions of the data signal are transmitted from each transmitting antenna, each version having a different chip code identifier for the respective transmitting antenna; and

a receiver comprising:

a receiving antenna (80);
means (82-86, 88-92) coupled to said receiving antenna for filtering each said transmitted pilot signal using that pilot signal's pseudo random chip code sequence and for weighting each said filtered pilot signal by a particular weight;

characterized by:

means (94) for combining said weighted pilot signals as a combined signal;
means (98) for adaptively adjusting each said pilot signal's particular weight based in part on a signal quality of the combined signal; and
means (100-104, 106-110, 112) for receiving the data signal via filtering each version with its associated chip code and combining the filtered versions, wherein the different data signal versions are weighted in accordance with the adjusted weights associated with the pilot signal of the respective antenna (48-52).

14. The system of claim 13 wherein the transmitter further comprises means for weighting the different data signal versions in accordance with the adjusted weights.

15. The system of claim 13 wherein the receiver further comprises means (82-86) for weighting the different data signal versions in accordance with the adjusted weights.

16. The system of claim 13 wherein the adaptively adjusting means (98) uses a least mean squared algorithm to adaptively adjust each said pilot signal's particular weight.

17. The system of claim 13 wherein the adaptively adjusting means (98) uses a recursive least squares algorithm to adaptively adjust said pilot signal's particular weight.

18. The system of claim 13 wherein said adaptively adjusting means (98) comprises means (168) for comparing the combined signal with an ideal value to produce an error signal and adaptively adjusting each said pilot signal's particular weight is based in part on the error signal.

19. The system of claim 18 wherein the ideal value is $1+j0$.

20. The system of claim 13 wherein the pilot signal filtering and weighting means (82-86, 88-92) comprises a plurality of RAKEs (82-86) for respectively filtering each said transmitted pilot signal and the data signal receiving means (100-104, 106-110, 112) comprises a plurality of RAKEs (100-104) for

respectively filtering each version of the data signal.

21. The system of claim 13 wherein the pilot signal filtering and weighting means (82-86, 88-92) comprises a plurality of vector correlators for respectively filtering each said transmitted pilot signal and the data signal receiving means (100-104, 106-110, 112) comprises a plurality of vector correlators for respectively filtering each version of the data signal.

22. The system of claim 20 wherein the pilot signal filtering and weighting means (82-86, 88-92) weights each said pilot signal by weighting each finger (144-148, 150-154, 156-160) of that pilot's RAKE (82-86) by a particular amount and the weighing of each finger (190-194, 196-200, 202-206, 274-290) of each said version of the data signal's RAKE (100-104) is in accordance with the adjusted weights associated with the respective finger (144-148, 150-154, 156-160) of the pilot signal's RAKE (82-86) for the pilot signal of the respective antenna (48-52).

23. The system of claim 20 wherein the pilot signal filtering and weighting means (82-86) weights each said pilot signal by weighing each finger (144-148, 150-154, 156-160) of that pilot's RAKE (82-86) and weighting an output of the pilot's RAKE (82-86) and the weighting of each said version of the data signal is by weighing each finger (190-194, 196-200, 202-206, 274-290) and an output of each said version of the data signal's RAKE (100-104) in accordance with the adjusted weights associated with the respective finger (144-148, 150-154, 156-160) and the output of the pilot signal's RAKE (82-86) for the pilot signal of the respective antenna (48-52).

Patentansprüche

1. Verfahren zur Verwendung bei einem Spreizspektrum-Kommunikationssystem mit einer Vielzahl von Sendeantennen (48-52), wobei das Verfahren folgende Schritte umfasst:

Senden eines Pilotsignals mit einer pseudozufälligen Chipcodesequenz, die ausschließlich dieser Antenne (48-52) zugeordnet ist, von jeder Sendeantenne (48-52);
Empfangen aller gesendeten Pilotsignale am Empfänger;
Filtern jedes gesendeten Pilotsignals unter Verwendung der pseudozufälligen Chipcodesequenz dieses Pilotsignals;

gekennzeichnet durch:

Gewichtung eines jeden gefilterten Pilotsignals

durch ein bestimmtes Gewicht;
 Kombinieren der gewichteten Pilotsignale zu
 einem kombinierten Signal;
 adaptives Einstellen des bestimmten Gewichts
 jedes Pilotsignals zum Teil auf der Grundlage
 einer Signalqualität des kombinierten Signals;
 Senden eines Datensignals, so dass unter-
 schiedliche Spreizspektrumversionen des Da-
 tensignals von jeder Antenne (48-52) gesendet
 werden, wobei jede Version eine unterschiedliche
 Chipcode-Identifizierung für die betreffende
 Sendeantenne (48-52) hat; sowie
 Empfangen des Datensignals über das Filtern
 jeder Version mit ihrem zugehörigen Chipcode
 und Kombinieren der gefilterten Versionen, wo-
 bei die unterschiedlichen Datensignalversionen
 gemäß den eingestellten Gewichten, die
 zu dem Pilotsignal der betreffenden Antenne
 (48-52) gehören, gewichtet werden.

2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** die Gewichtung der unterschiedlichen Datensignalversionen gemäß den eingestellten Gewichten vor dem Senden erfolgt.
3. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** die Gewichtung der unterschiedlichen Datensignalversionen gemäß den eingestellten Gewichten nach dem Empfang erfolgt.
4. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** das adaptive Einstellen unter Verwendung eines Least-Mean-Squares- (LMS) Algorithmus erfolgt.
5. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** das adaptive Einstellen unter Verwendung eines Recursive-Least-Squares- (RSL) Algorithmus erfolgt.
6. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** das adaptive Einstellen durch Vergleichen des kombinierten Signals mit einem Idealwert zur Erzeugung eines Fehlersignals und Einstellen des bestimmten Gewichts jedes Pilotsignals zum Teil auf der Grundlage des Fehlersignals erfolgt.
7. Verfahren nach Anspruch 6, **dadurch gekennzeichnet, dass** der Idealwert $1 + j0$ beträgt.
8. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** die Schritte des Filterns und des Gewichtens zeitlich zusammenfallend erfolgen.
9. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** das Filtern jedes gesendeten Pilotsignals und jeder Version des Datensignals durch

einen RAKE (82-86, 100-104) erfolgt.

10. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** das Filtern jedes gesendeten Pilotsignals und jeder Version des Datensignals durch einen Vektorkorrelator erfolgt.
11. Verfahren nach Anspruch 9, **dadurch gekennzeichnet, dass** das Gewichten jedes Pilotsignals durch Gewichten jedes Fingers (144-148, 150-154, 156-160) des RAKE (82-86) dieses Pilotsignals um einen bestimmten Betrag erfolgt und das Gewichten jedes Fingers (190-194, 196-200, 202-286, 274-290) jeder Version des RAKE des Datensignals gemäß den eingestellten Gewichten, die zu dem betreffenden Finger (144-148, 150-154, 156-160) des RAKE (82-86) des Pilotsignals für das Pilotsignal der betreffenden Antenne (48-52) gehören, erfolgt.
12. Verfahren nach Anspruch 9, **dadurch gekennzeichnet, dass** das Gewichten jedes Pilotsignals durch Gewichten jedes Fingers (144-148, 150-154, 156-160) des RAKE (82-86) dieses Pilotsignals und durch Gewichten eines Ausgangs des RAKE (82-86) dieses Pilotsignals erfolgt, und das Gewichten jeder Version des Datensignals durch Gewichten jedes Fingers (190-194, 196-200, 202-206, 274-290) und eines Ausgangs jeder Version des RAKE (100-104) des Datensignals gemäß den eingestellten Gewichten, die zum betreffenden Finger (144-148, 150-154, 156-160) und dem Ausgang des RAKE (82-86) des Pilotsignals für das Pilotsignal der betreffenden Antenne (48-52) gehören, erfolgt.
13. Spreizspektrum-Kommunikationssystem, **gekennzeichnet durch:**

einen Sender, der folgendes umfasst:

eine Vielzahl von Sendeantennen (48-52);
 eine Vorrichtung (56-60) zum Senden eines Pilotsignals mit einer pseudozufälligen Chipcodesequenz, die ausschließlich dieser Antenne zugeordnet ist, von jeder Sendeantenne (48-52); sowie
 eine Vorrichtung (378-382, 360-376) zum Senden eines Datensignals, so dass unterschiedliche Spreizspektrumversionen des Datensignals von jeder Sendeantenne gesendet werden, wobei jede Version eine unterschiedliche Chipcode-Identifizierung für die betreffende Sendeantenne aufweist; sowie

einen Empfänger, der folgendes umfasst:

eine Empfangsantenne (80);
eine mit der Empfangsantenne gekoppelte
Vorrichtung (82-86, 88-92) zum Filtern je-
des gesendeten Pilotsignals unter Verwen-
dung der pseudozufälligen Chipcodese-
quenz dieses Pilotsignals und zum Ge-
wichten jedes gefilterten Pilotsignals um
ein bestimmtes Gewicht;

gekennzeichnet durch:

eine Vorrichtung (94) zum Kombinieren der ge-
wichteten Pilotsignale zu einem kombinierten
Signal;
eine Vorrichtung (98) zum adaptiven Einstellen
des bestimmten Gewichts jedes Pilotsignals
zum Teil auf der Grundlage einer Signalqualität
des kombinierten Signals; sowie
eine Vorrichtung (100-104, 106-110, 112) zum
Empfangen des Datensignals **durch** Filtern je-
der Version mit ihrem zugehörigen Chipcode
und Kombinieren der gefilterten Versionen, wo-
bei die Gewichtung der unterschiedlichen Ver-
sionen des Datensignals gemäß den einge-
stellten Gewichten, die zum Pilotsignal der be-
treffenden Antenne (48-52) gehören, erfolgt.

14. System nach Anspruch 13, **dadurch gekennzeichnet, dass** der Sender des weiteren eine Vorrichtung zum Gewichten der unterschiedlichen Datensignalversionen gemäß den eingestellten Gewichten umfasst.
15. System nach Anspruch 13, **dadurch gekennzeichnet, dass** der Empfänger des weiteren eine Vorrichtung (82-86) zum Gewichten der unterschiedlichen Versionen des Datensignals gemäß den eingestellten Gewichten umfasst.
16. System nach Anspruch 13, **dadurch gekennzeichnet, dass** die Vorrichtung (98) zum adaptiven Einstellen einen Least-Mean-Squares- (LMS) Algorithmus zum adaptiven Einstellen des bestimmten Gewichts jedes Pilotsignals verwendet.
17. System nach Anspruch 13, **dadurch gekennzeichnet, dass** die Vorrichtung (98) zum adaptiven Einstellen einen Recursive-Least-Squares (RSL) Algorithmus zum adaptiven Einstellen des bestimmten Gewichts des Pilotsignals verwendet.
18. System nach Anspruch 13, **dadurch gekennzeichnet, dass** die Vorrichtung (98) zum adaptiven Einstellen eine Vorrichtung (168) zum Vergleichen des kombinierten Signals mit einem Idealwert umfasst, um ein Fehlersignal zu erzeugen, und das adaptive Einstellen des bestimmten Gewichts jedes Pilotsignals zum Teil auf dem Fehlersignal basiert.
19. System nach Anspruch 18, **dadurch gekennzeichnet, dass** der Idealwert $1 + j0$ beträgt.
20. System nach Anspruch 13, **dadurch gekennzeichnet, dass** die Vorrichtung (82-86, 88-92) zum Filtern und Gewichten des Pilotsignals eine Vielzahl von RAKEs (82-86) zum jeweiligen Filtern jedes gesendeten Pilotsignals umfasst, und die Vorrichtung (100-104, 106-110, 112) zum Empfang des Datensignals eine Vielzahl von RAKEs (100-104) zum jeweiligen Filtern jeder Version des Datensignals umfasst.
21. System nach Anspruch 13, **dadurch gekennzeichnet, dass** die Vorrichtung (82-86, 88-92) zum Filtern und Gewichten des Pilotsignals eine Vielzahl von Vektorkorrelatoren zum jeweiligen Filtern jedes gesendeten Pilotsignals umfasst, und die Vorrichtung (100-104, 106-110, 112) zum Empfang des Datensignals eine Vielzahl von Vektorkorrelatoren zum jeweiligen Filtern jeder Version des Datensignals umfasst.
22. System nach Anspruch 20, **dadurch gekennzeichnet, dass** die Gewichtung jedes Pilotsignals durch die Vorrichtung (82-86, 88-92) zum Filtern und Gewichten des Pilotsignals durch Gewichten jedes Fingers (144-148, 150-154, 156-160) des RAKE (82-86) dieses Pilotsignals um einen bestimmten Betrag erfolgt, und dass die Gewichtung jedes Fingers (190-194, 196-200, 202-206, 274-290) jeder Version des RAKE (100-104) des Datensignals gemäß den eingestellten Gewichten, die zu dem betreffenden Finger (144-148, 150-154, 156-160) des RAKE (82-86) des Pilotsignals für das Pilotsignal der betreffenden Antenne (48-52) gehören, erfolgt.
23. System nach Anspruch 20, **dadurch gekennzeichnet, dass** die Gewichtung jedes Pilotsignals durch die Vorrichtung (82-86) zum Filtern und Gewichten des Pilotsignals durch Gewichtung jedes Fingers (144-148, 150-154, 156-160) des RAKE (82-86) dieses Pilotsignals und durch Gewichtung eines Ausgangs des RAKE (82-86) des Pilotsignals erfolgt, und dass die Gewichtung jeder Version des Datensignals durch Gewichten jedes Fingers (190-194, 196-200, 202-206, 274-290) und eines Ausgangs jeder Version des RAKE (100-104) des Datensignals gemäß den eingestellten Gewichten, die zu dem entsprechenden Finger (144-148, 150-154, 156-160) und dem Ausgang des RAKE (82-86) des Pilotsignals für das Pilotsignal der betreffenden Antenne (48-52) gehören, erfolgt.

Revendications

1. Procédé à utiliser dans un système de communica-

tion par étalement du spectre ayant plusieurs antennes d'émission (48-52), le procédé comprenant les étapes de :

émission de chaque antenne d'émission (48-52) d'un signal pilote ayant une séquence de code de brique pseudo-aléatoire associée de façon unique à cette antenne (48-52) ;
réception au récepteur de tous lesdits signaux pilotes émis ;
filtrage de chaque dit signal pilote émis en utilisant la séquence de code de brique pseudo-aléatoire de ce signal pilote ;

caractérisé par :

la pondération de chaque dit signal pilote filtré grâce à un poids particulier ;
la combinaison desdits signaux pilotes pondérés sous la forme d'un signal combiné ;
l'ajustement de manière adaptative du poids particulier de chaque dit signal pilote en se basant en partie sur une qualité de signal du signal combiné ;
l'émission d'un signal de données de telle sorte que différentes versions par étalement du spectre du signal de données soient émises à partir de chaque antenne (48-52), chaque version ayant un identifiant de code de brique différent pour l'antenne d'émission respective (48-52) ; et
la réception du signal de données par l'intermédiaire du filtrage de chaque version avec son code de brique associé et la combinaison des versions filtrées, où les différentes versions de signaux de données sont pondérées selon les poids ajustés associés au signal pilote de l'antenne correspondante (48-52).

2. Procédé selon la revendication 1, **caractérisé en ce que** les différentes versions du signal de données sont pondérées selon les poids ajustés avant émission. 40
3. Procédé selon la revendication 1, **caractérisé en ce que** les différentes versions du signal de données sont pondérées selon les poids ajustés après réception. 45
4. Procédé selon la revendication 1 **caractérisé en ce que** l'ajustement adaptatif se fait en utilisant un algorithme des moindres carrés moyens. 50
5. Procédé selon la revendication 1 **caractérisé en ce que** l'ajustement adaptatif se fait en utilisant un algorithme récursif des moindres carrés. 55
6. Procédé selon la revendication 1 **caractérisé en ce**

que l'ajustement adaptatif se fait en comparant le signal combiné à une valeur idéale pour produire un signal d'erreur et en ajustant le poids particulier de chaque dit signal pilote sur la base en partie du signal d'erreur.

7. Procédé selon la revendication 6 **caractérisé en ce que** la valeur idéale est $1 + j0$.
8. Procédé selon la revendication 1 **caractérisé en ce que** les étapes de filtrage et de pondération se produisent en même temps.
9. Procédé selon la revendication 1 **caractérisé en ce que** le filtrage de chaque dit signal pilote émis et de chaque dite version du signal de données est effectué par un peigne de mesure (RAKE) (82-86, 100-104).
10. Procédé selon la revendication 1 **caractérisé en ce que** le filtrage de chaque dit signal pilote émis et de chaque dite version du signal de données est effectué par un corrélateur de vecteur.
11. Procédé selon la revendication 9 **caractérisé en ce que** la pondération de chaque dit signal pilote se fait en pondérant chaque dent (144-148, 150-154, 156-160) du peigne de mesure (RAKE) de ce pilote (82-86) d'une valeur particulière et la pondération de chaque dent (190-194, 196-200, 202-206, 274-290) de chaque dite version du peigne de mesure (RAKE) du signal de données est conforme aux poids ajustés associés à la dent correspondante (144-148, 150-154, 156-160) du peigne de mesure (RAKE) du signal pilote (82-86) pour le signal pilote de l'antenne correspondante (48-52).
12. Procédé selon la revendication 9 **caractérisé en ce que** la pondération de chaque dit signal pilote se fait en pondérant chaque dent (144-148, 150-154, 156-160) du peigne de mesure (RAKE) de ce pilote (82-86) et en pondérant une sortie du peigne de mesure (RAKE) de ce pilote (82-86) et la pondération de chaque dite version du signal de données se fait en pondérant chaque dent (190-194, 196-200, 202-206, 274-290) et une sortie de chaque dite version du peigne de mesure (RAKE) du signal de données (100-104) selon les poids ajustés associés à la dent correspondante (144-148, 150-154, 156-160) et la sortie du peigne de mesure (RAKE) du signal pilote (82-86) pour le signal pilote de l'antenne correspondante (48-52).
13. Système de communication par étalement du spectre comprenant :

un émetteur comprenant
plusieurs antennes d'émission (48-52) ;

un moyen (56-60) pour émettre de chaque antenne d'émission (48-52) un signal pilote ayant une séquence de code de brique pseudo-aléatoire associée de façon unique à cette antenne ; et

un moyen (378-382, 360-376) pour émettre un signal de données de telle sorte que différentes versions d'étalement du spectre du signal de données soient émises de chaque antenne d'émission, chaque version ayant un identifiant différent de code de brique pour l'antenne d'émission correspondante ; et un récepteur comprenant :

une antenne de réception (80) ;

un moyen (82-86, 88-92) couplé à ladite antenne de réception pour filtrer chaque dit signal pilote émis en utilisant la séquence de code de brique pseudo-aléatoire de ce signal pilote et pour pondérer chaque dit signal pilote filtré d'un poids particulier ;

caractérisé par

un moyen (94) pour combiner lesdits signaux pilotes pondérés sous forme d'un signal combiné ;

un moyen (98) pour ajuster de façon adaptative le poids particulier de chaque dit signal pilote sur la base en partie d'une qualité de signal du signal combiné ; et

un moyen (100-104, 106-110, 112) pour recevoir le signal de données en filtrant chaque version avec son code de brique associé et en combinant les versions filtrées, où les différentes versions de signal de données sont pondérées en fonction des poids ajustés associés au signal pilote de l'antenne correspondante (48-52).

14. Système selon la revendication 13 **caractérisé en ce que** l'émetteur comprend en outre un moyen de pondération des différentes versions du signal de données selon les poids ajustés.
15. Système selon la revendication 13 **caractérisé en ce que** le récepteur comprend en outre un moyen (82-86) pour pondérer les différentes versions de signal de données selon les poids ajustés.
16. Système selon la revendication 13 **caractérisé en ce que** le moyen de réglage adaptatif (98) utilise un algorithme des moindres carrés moyens pour ajuster de façon adaptative le poids particulier de chaque dit signal pilote.
17. Système selon la revendication 13 **caractérisé en ce que** le moyen de réglage adaptatif (98) utilise un algorithme récursif des moindres carrés pour ajuster de façon adaptative le poids particulier dudit signal pilote.

18. Système selon la revendication 13 **caractérisé en ce que** ledit moyen d'ajustement adaptatif (98) comprend un moyen (168) pour comparer le signal combiné à une valeur idéale pour produire un signal d'erreur et l'ajustement adaptatif du poids particulier de chaque dit signal pilote repose en partie sur le signal d'erreur.

19. Système selon la revendication 18 **caractérisé en ce que** la valeur idéale est $1 + j0$.

20. Système selon la revendication 13 **caractérisé en ce que** le moyen de filtrage et pondération du signal pilote (82-86, 88-92) comprend plusieurs peignes de mesure (RAKES) (82-86) pour filtrer respectivement chaque dit signal pilote émis et le moyen de réception du signal de données (100-104, 106-110, 112) comprend plusieurs peignes de mesure (RAKES) (100-104) pour filtrer respectivement chaque version du signal de données.

21. Système selon la revendication 13 **caractérisé en ce que** le moyen de filtrage et pondération du signal pilote (82-86, 88-92) comprend plusieurs corrélateurs de vecteur pour filtrer respectivement chaque dit signal pilote émis et le moyen de réception du signal de données (100-104, 106-110, 112) comprend plusieurs corrélateurs de vecteur pour filtrer respectivement chaque version du signal de données.

22. Système selon la revendication 20 **caractérisé en ce que** le moyen de filtrage et pondération du signal pilote (82-86, 88-92) pondère chaque dit signal pilote en pondérant chaque dent (144-148, 150-154, 156-160) du peigne de mesure (RAKE) de ce pilote (82-86) d'une valeur particulière et la pondération de chaque dent (190-194, 196-200, 202-206, 274-290) de chaque dite version du peigne de mesure (RAKE) du signal de données (100-104) est conforme aux poids ajustés associés à la dent correspondante (144-148, 150-154, 156-160) du peigne de mesure (RAKE) du signal pilote (82-86) pour le signal pilote de l'antenne correspondante (48-52).

23. Système selon la revendication 20 **caractérisé en ce que** le filtrage et la pondération du signal pilote (82-86) pondère chaque dit signal pilote en pondérant chaque dent (144-148, 150-154, 156-160) du peigne de mesure (RAKE) de ce pilote (82-86) et en pondérant une sortie du peigne de mesure (RAKE) du pilote (82-86) et la pondération de chaque dite version du signal de données se fait en pondérant chaque dent (190-194, 196-200, 202-206, 274-290) et une sortie de chaque dite version du peigne de mesure (RAKE) du signal de données (100-104) selon les poids ajustés associés à la dent

correspondante est conforme aux poids ajustés associés à la dent (144-148, 150-154, 156-160) et la sortie du peigne de mesure (RAKE) du signal pilote (82-86) pour le signal pilote de l'antenne correspondante (48-52).

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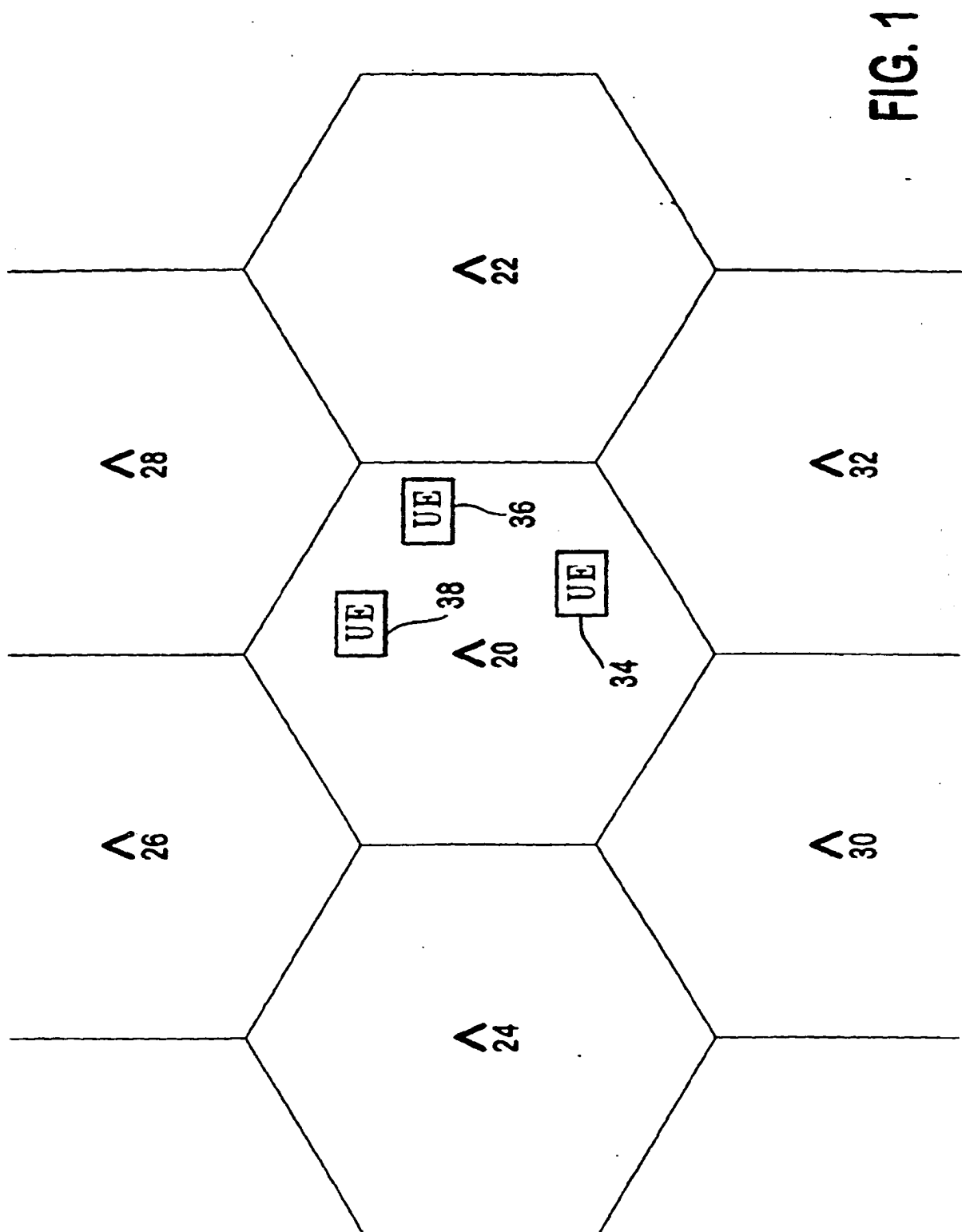
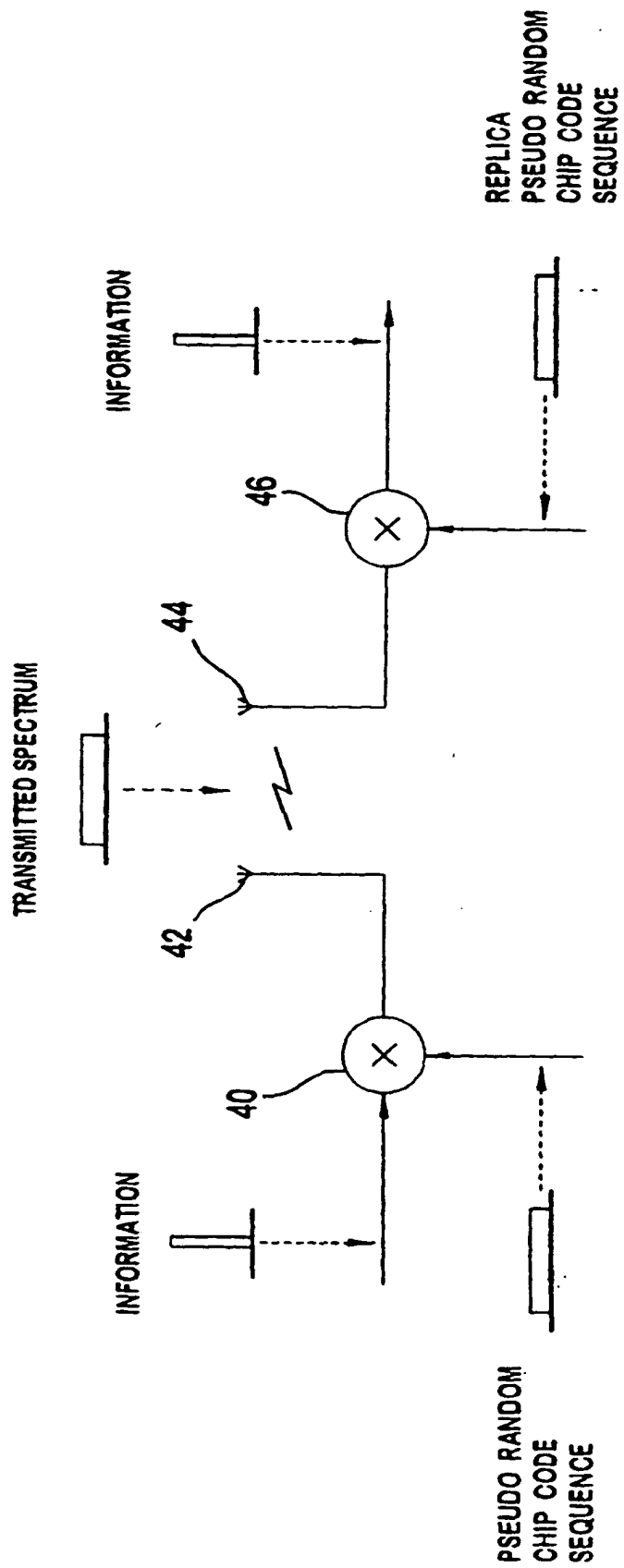


FIG. 1



PRIOR ART

FIG. 2

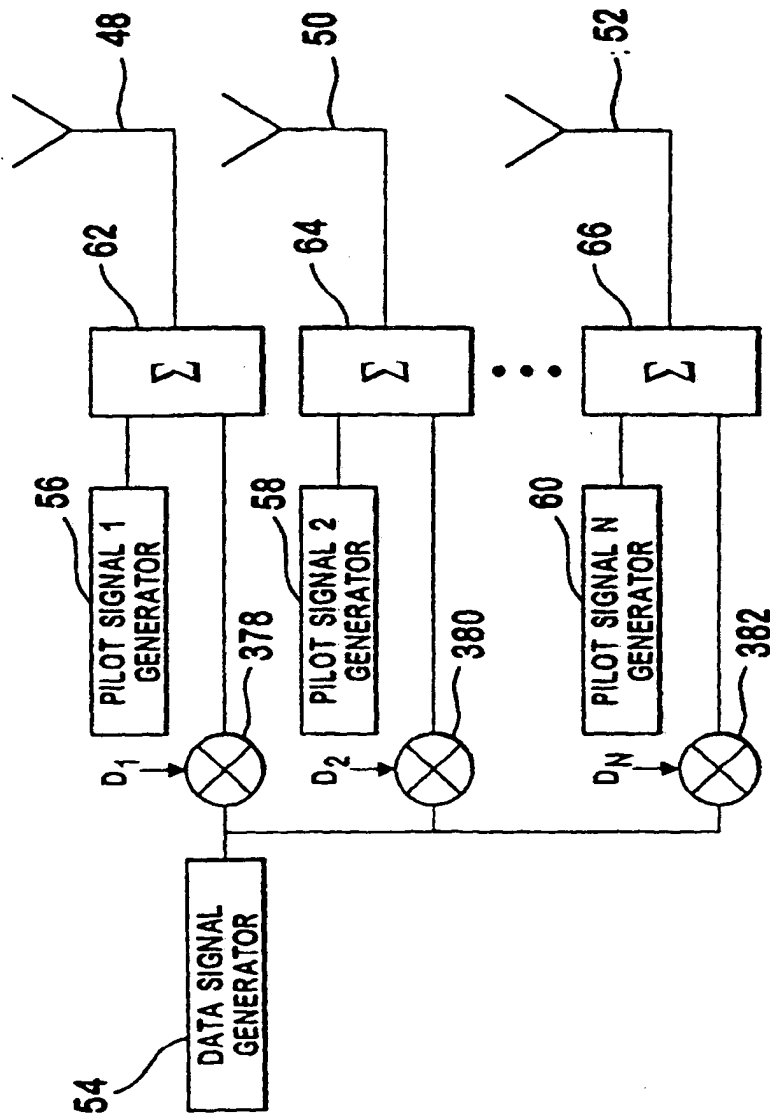


FIG. 3

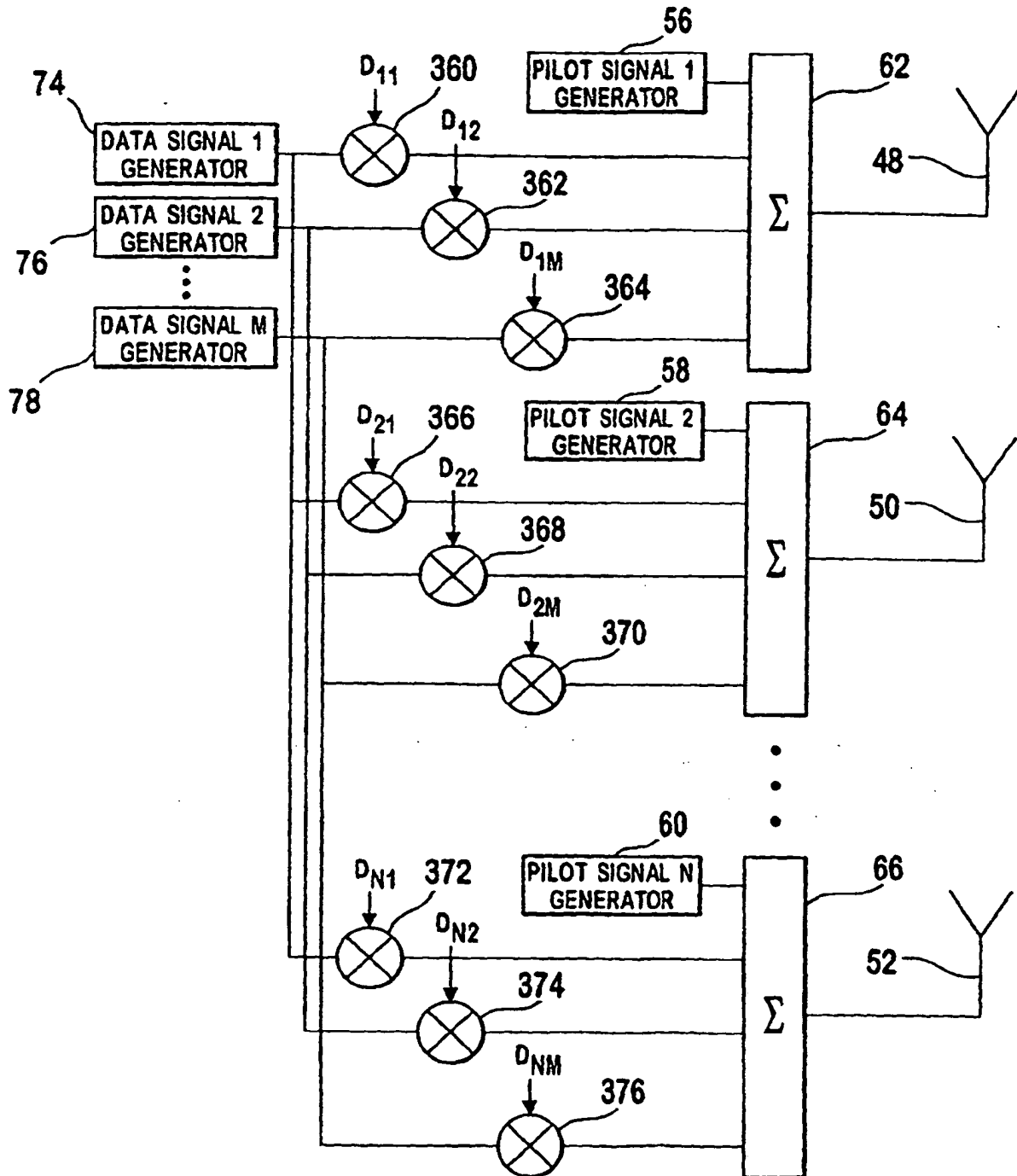


FIG. 4

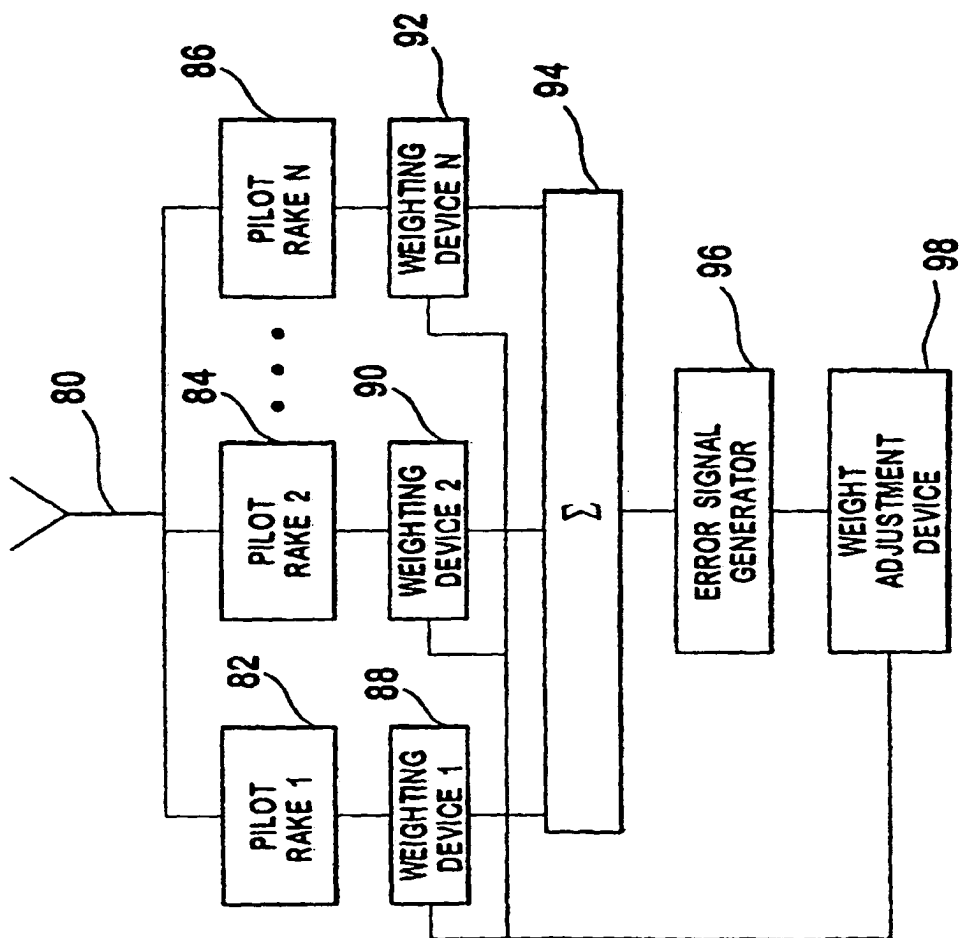


FIG. 5

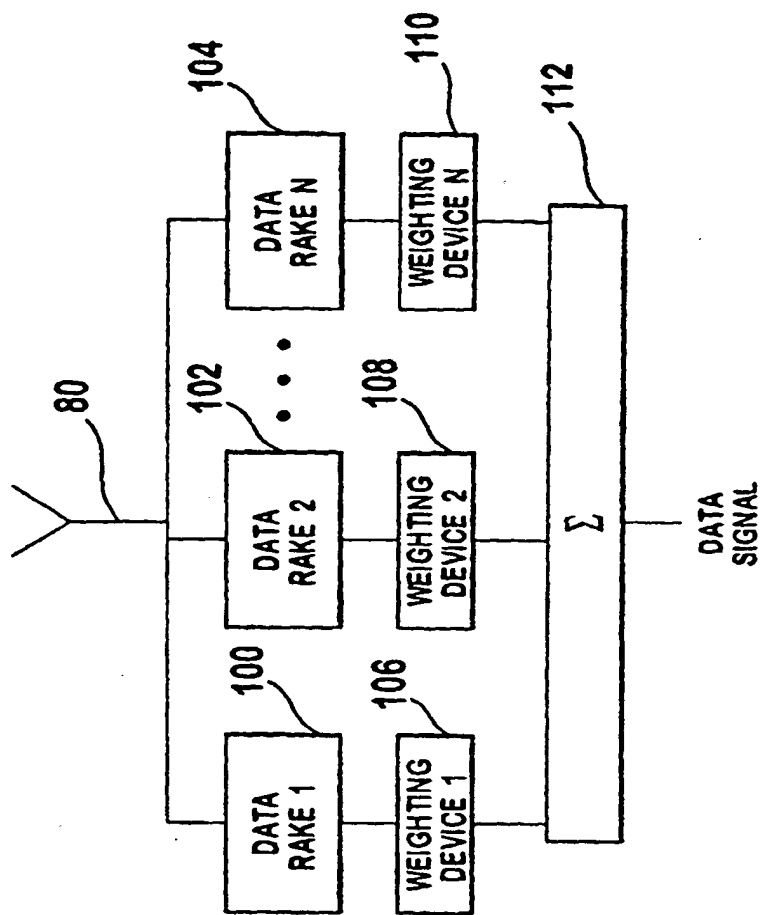


FIG. 6

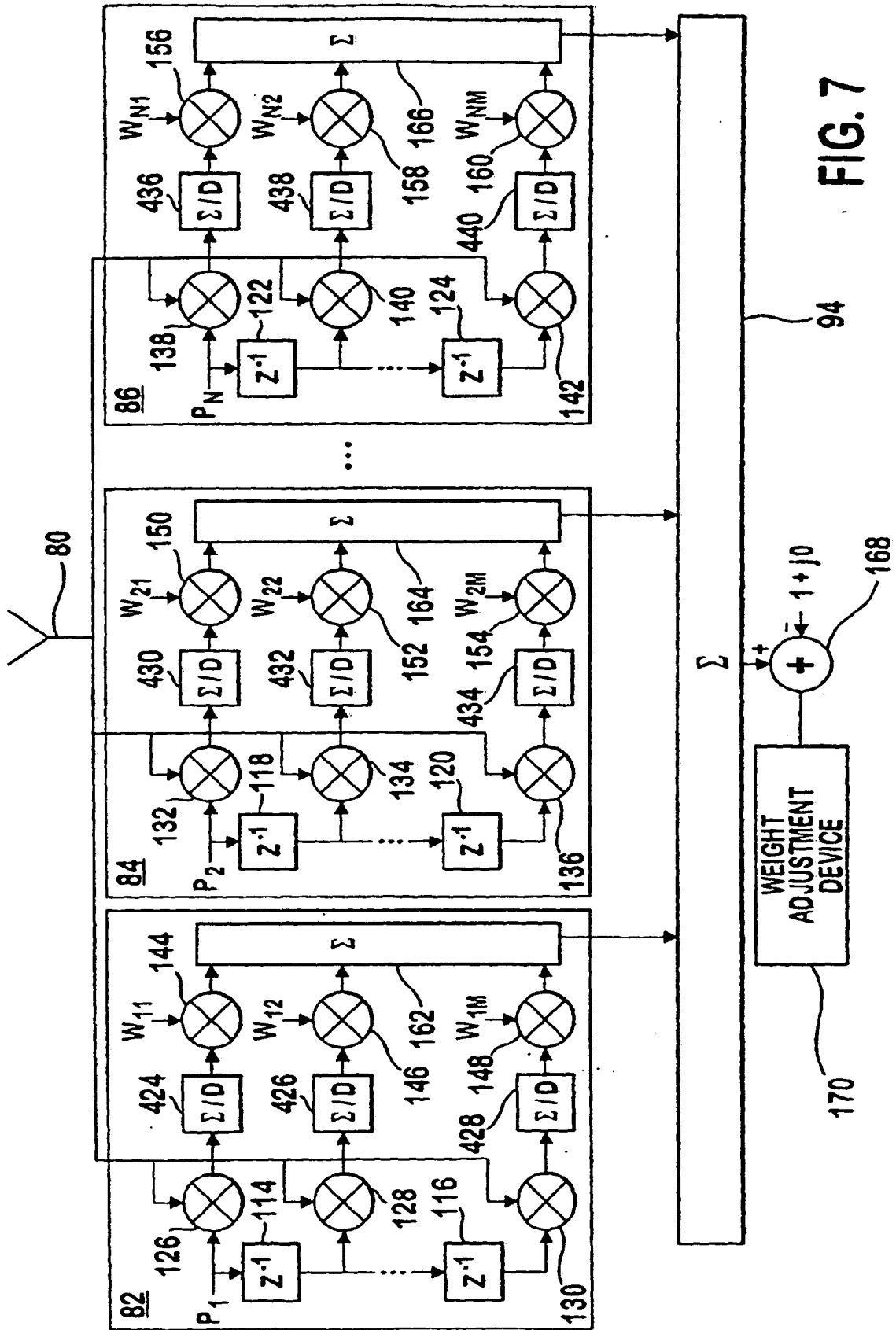


FIG. 7

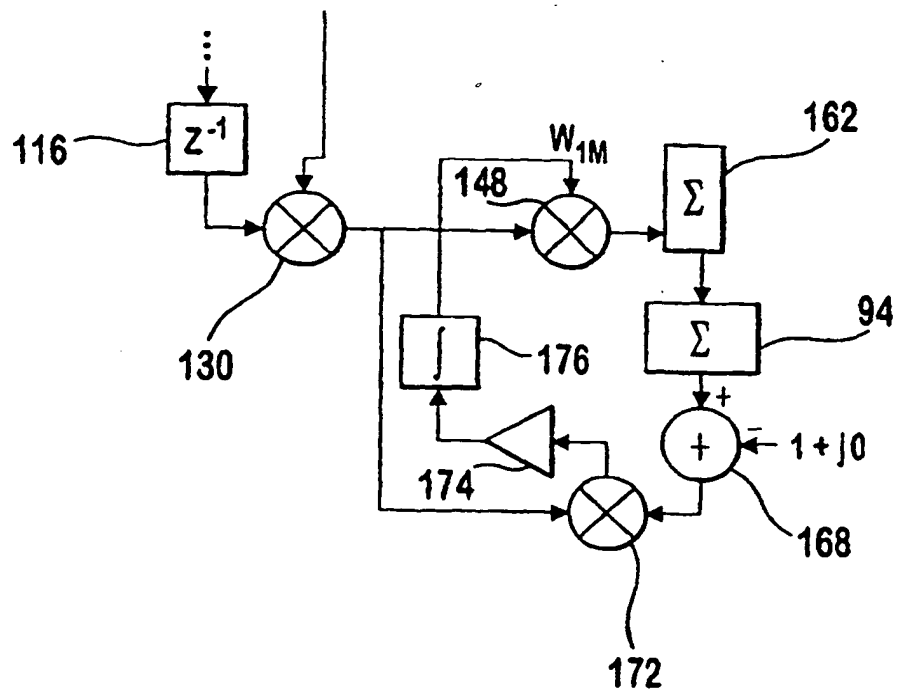


FIG. 8

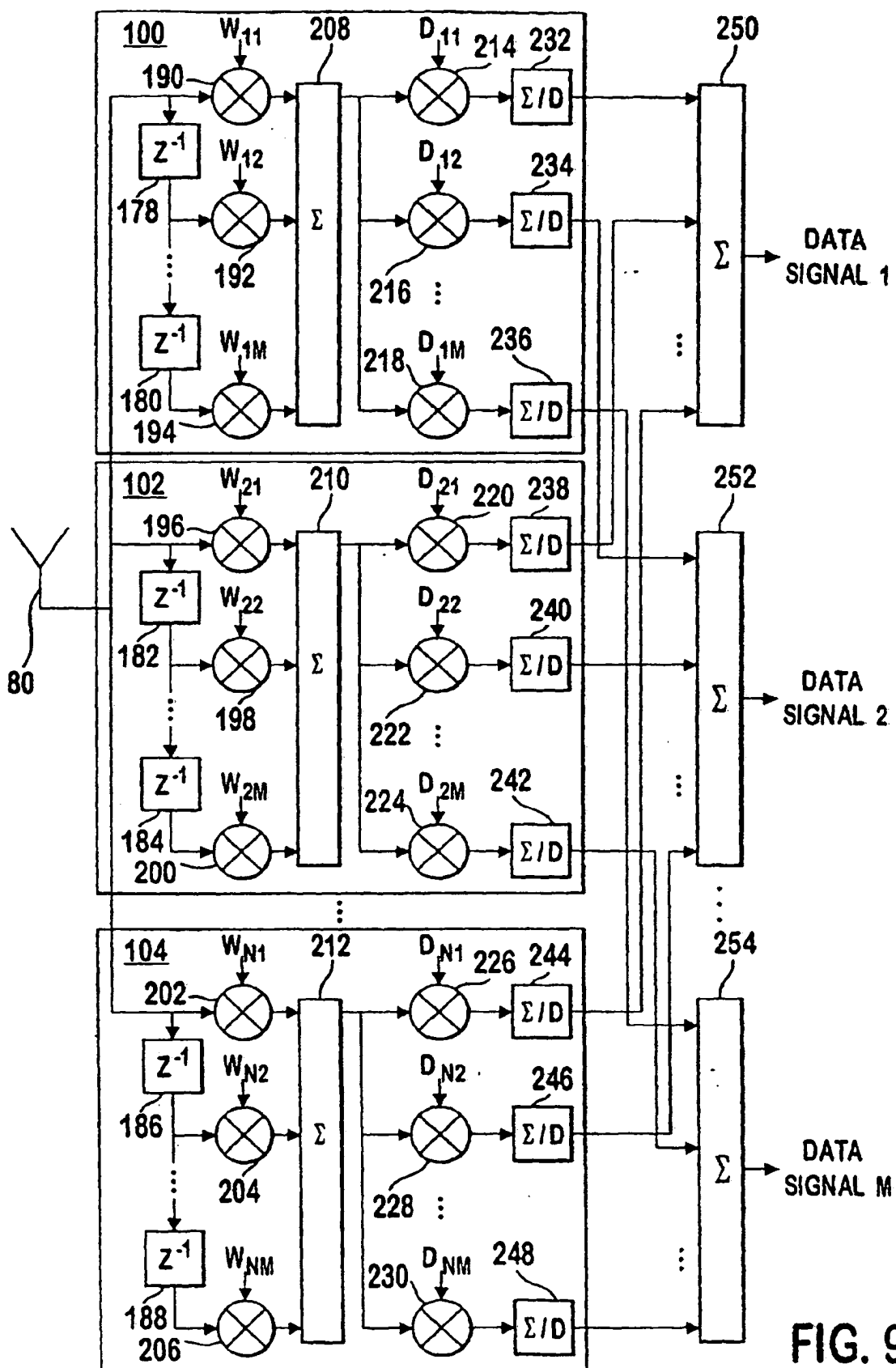


FIG. 9

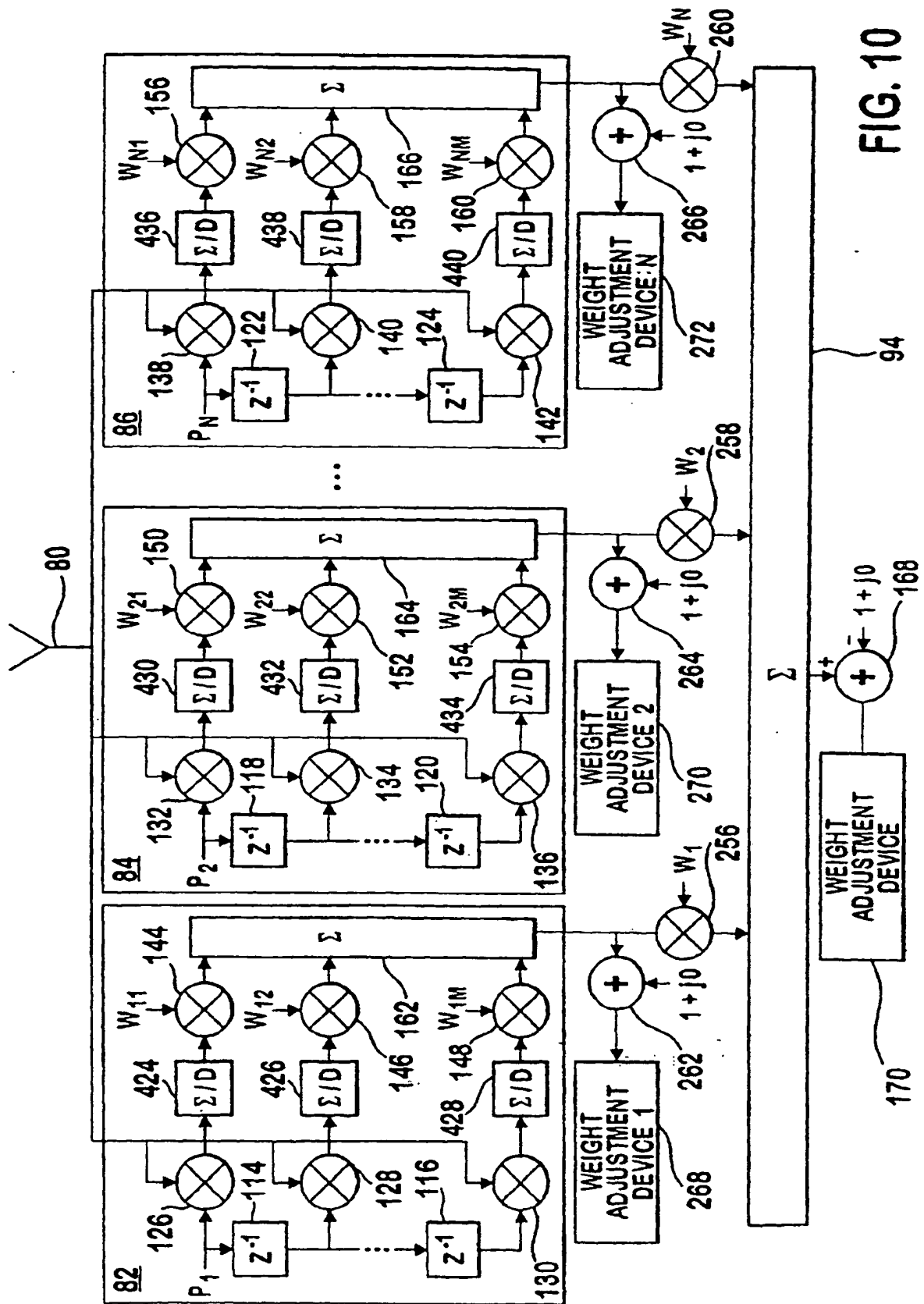
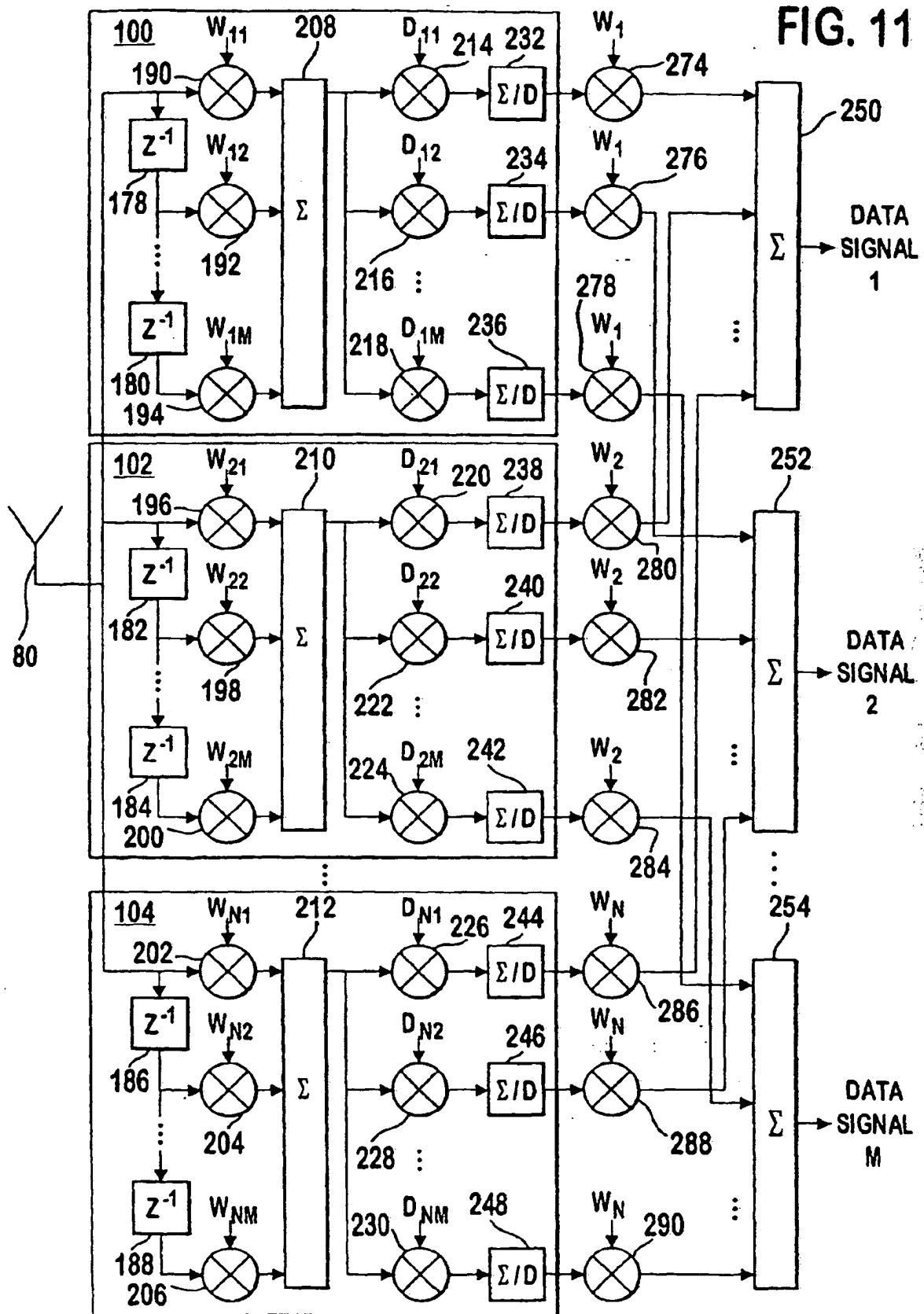


FIG. 10

FIG. 11



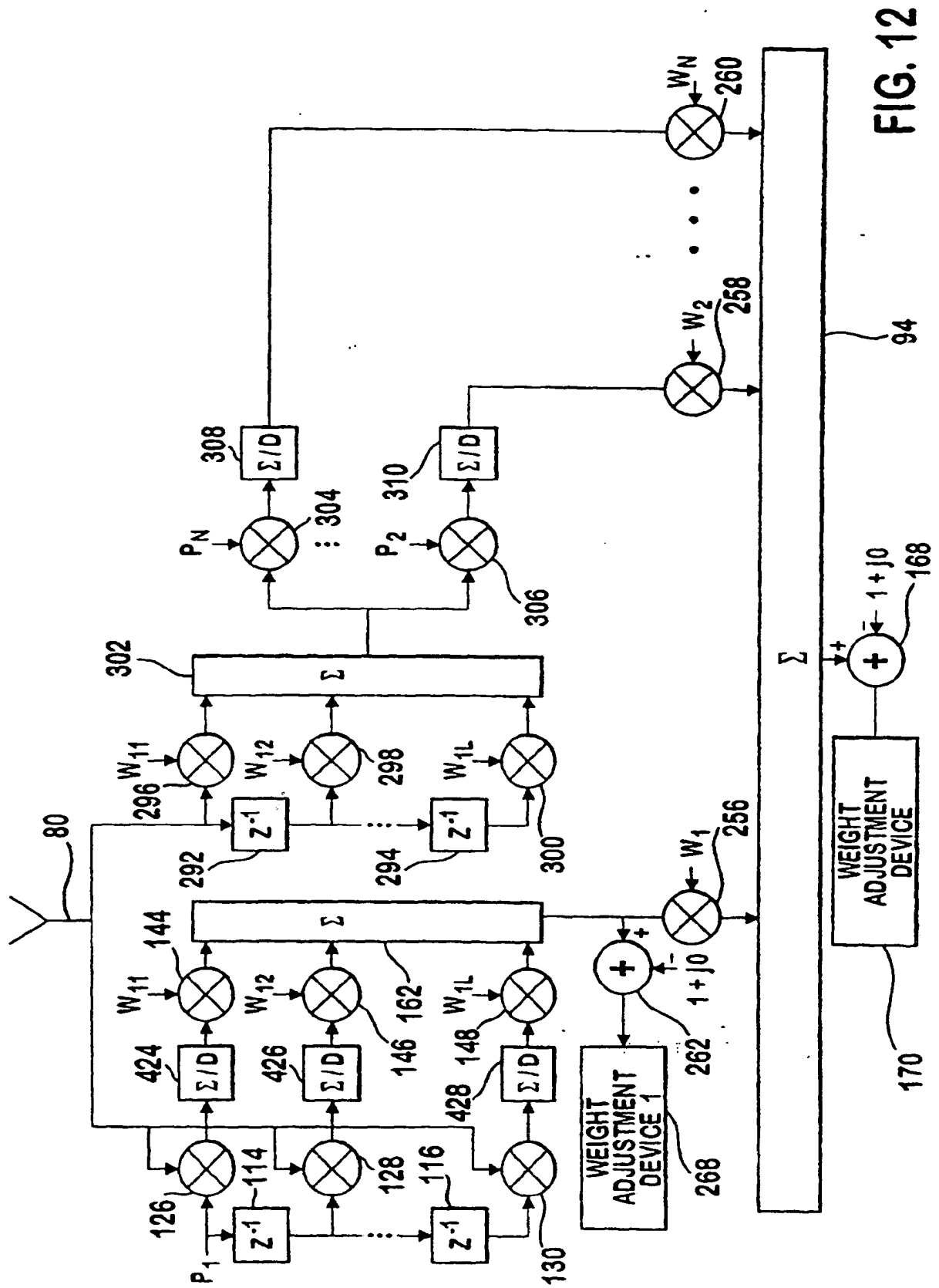
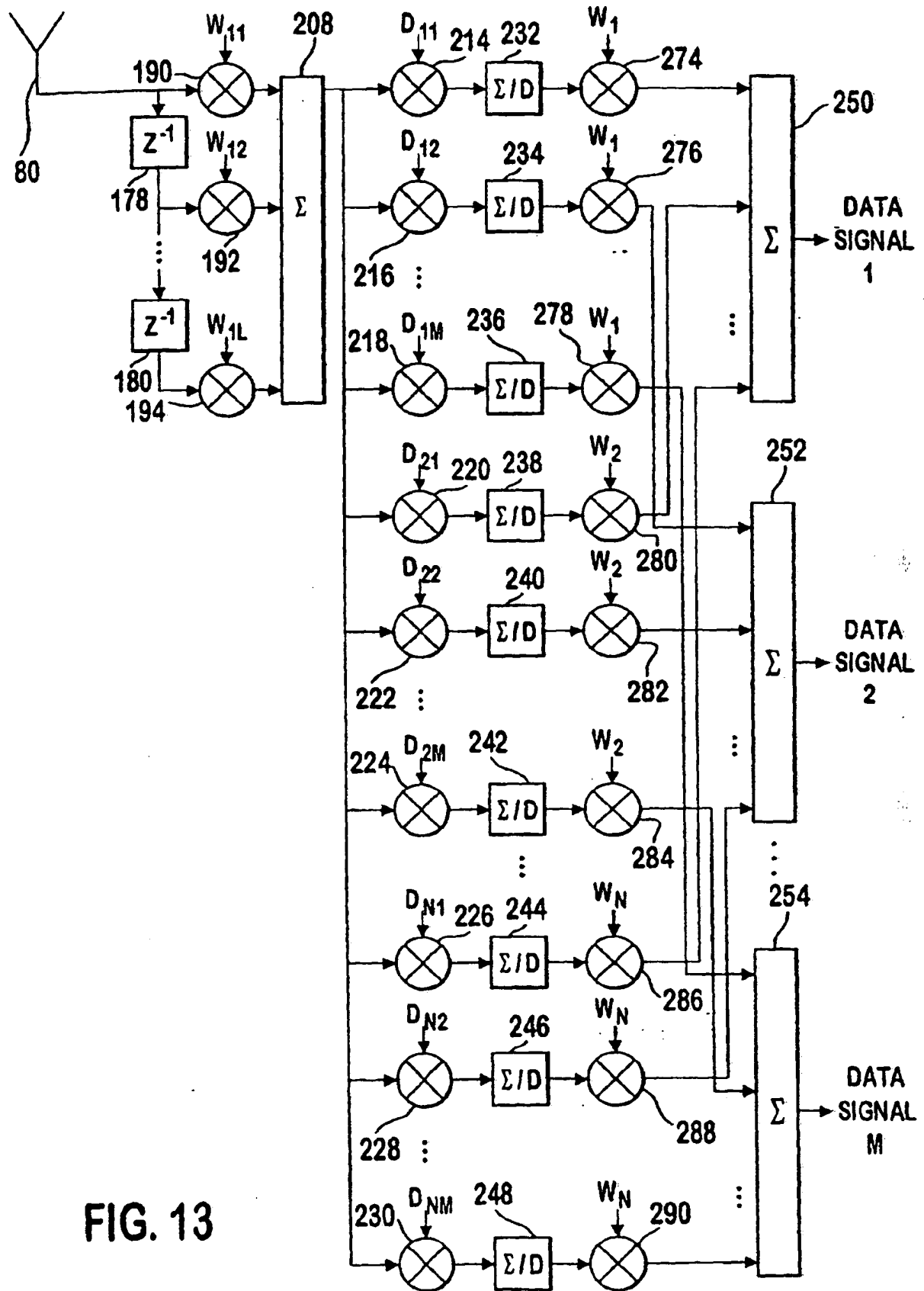


FIG. 12



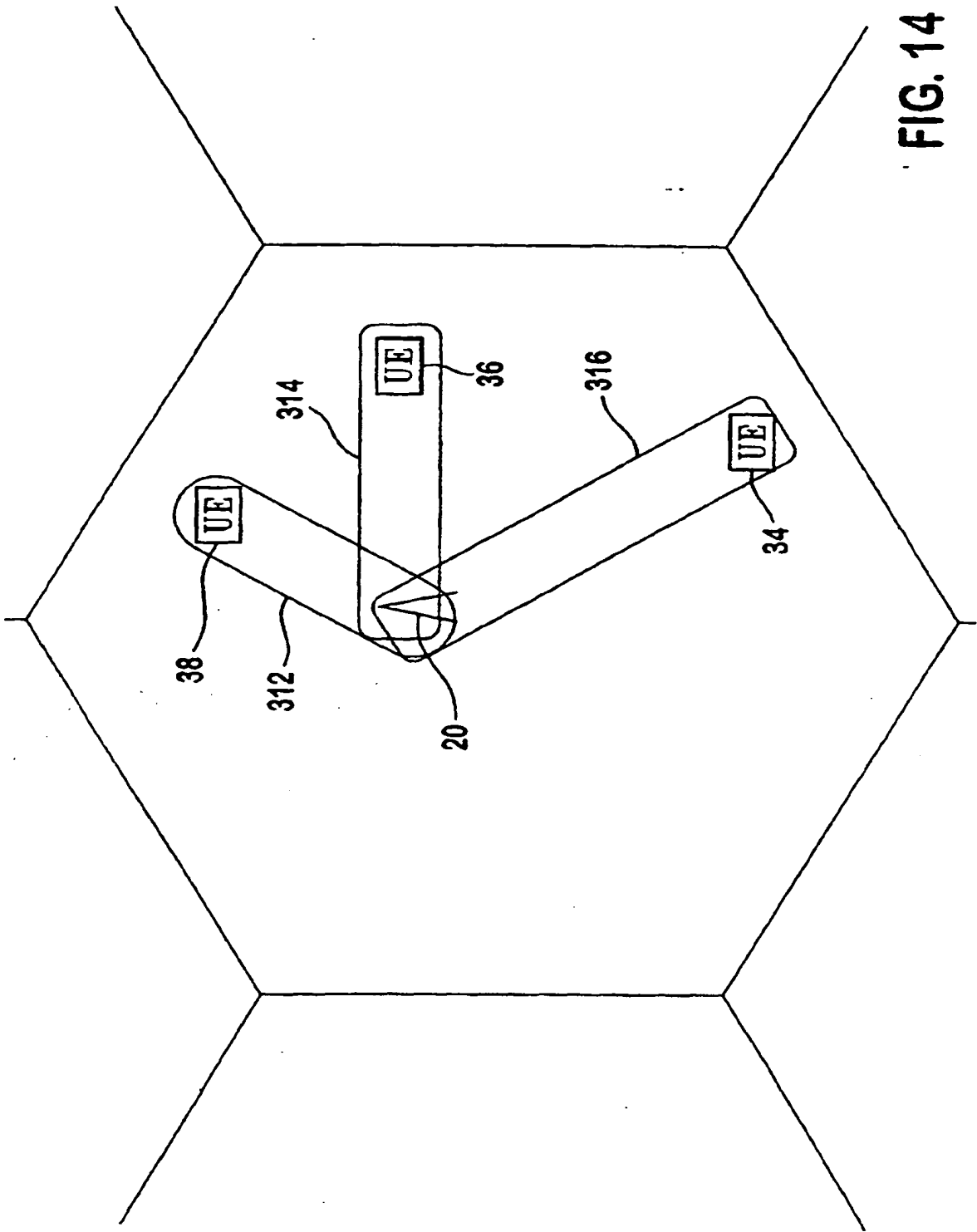


FIG. 14

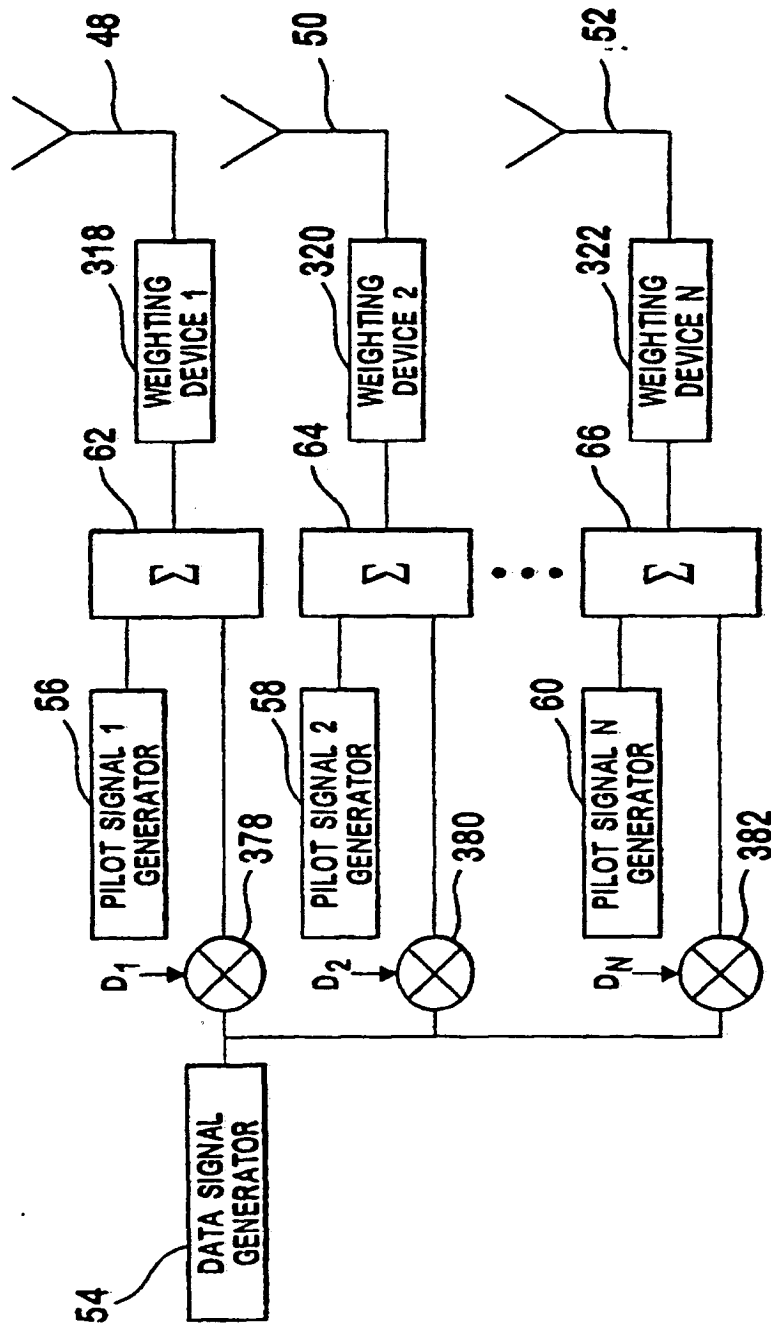


FIG. 15

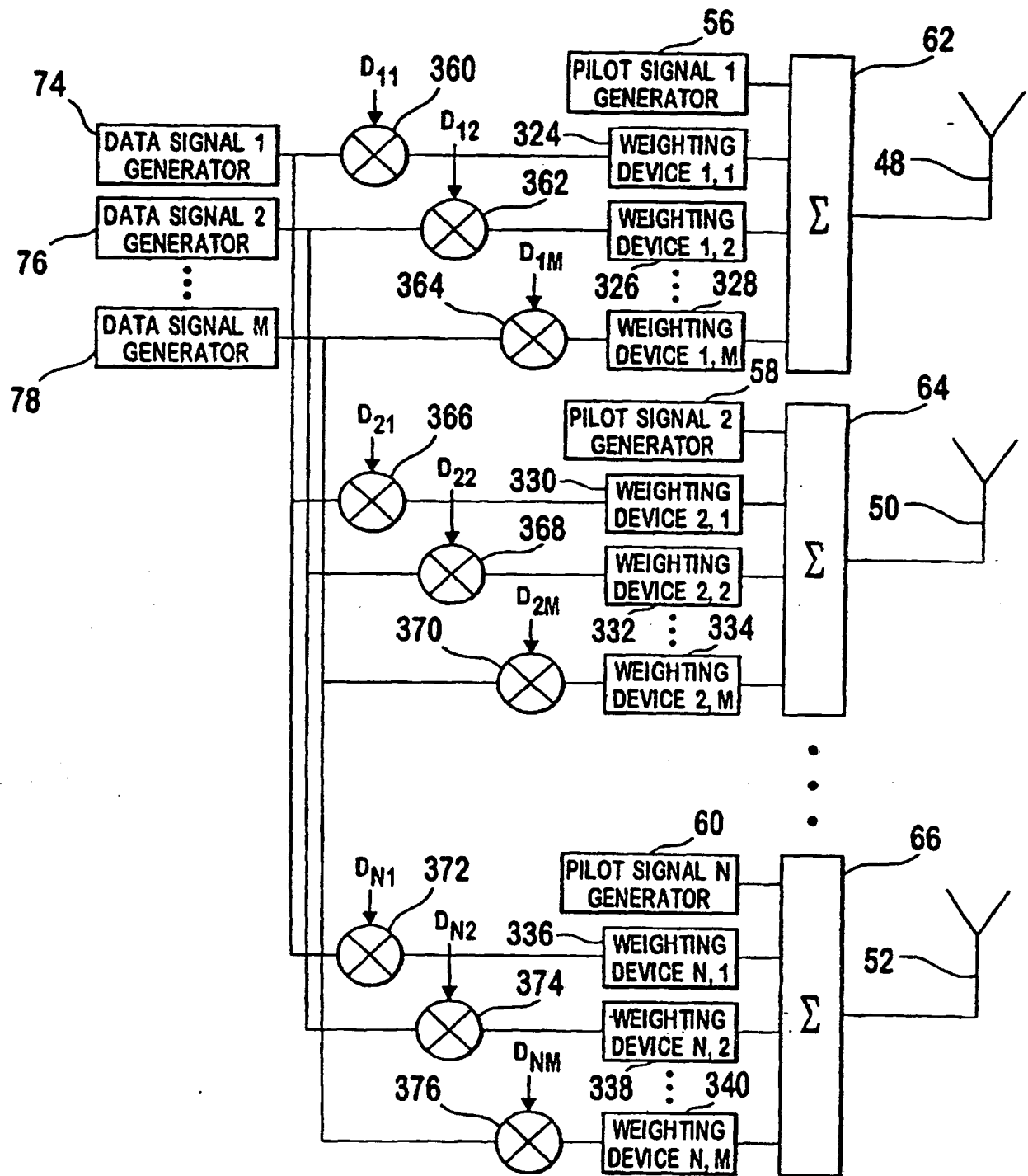


FIG. 16

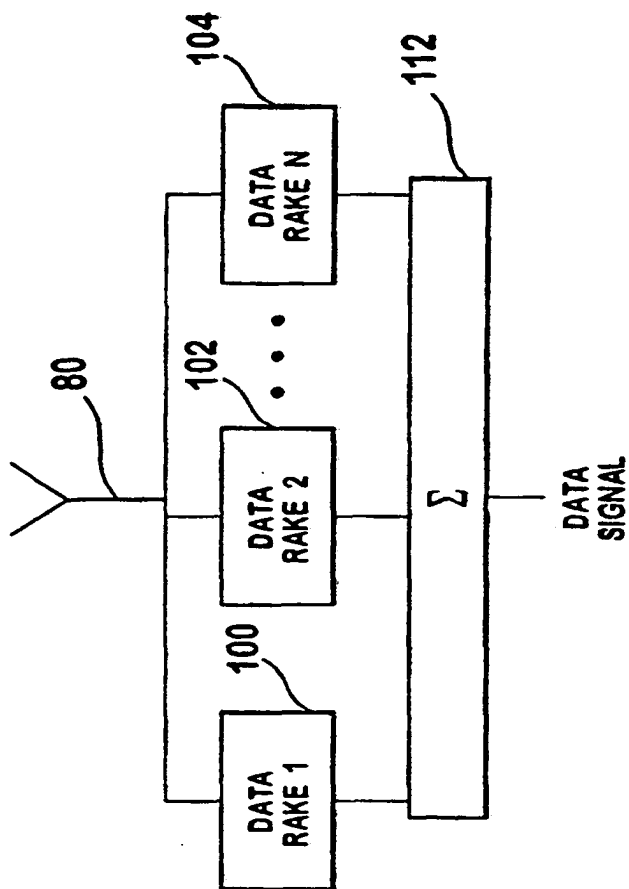


FIG. 17

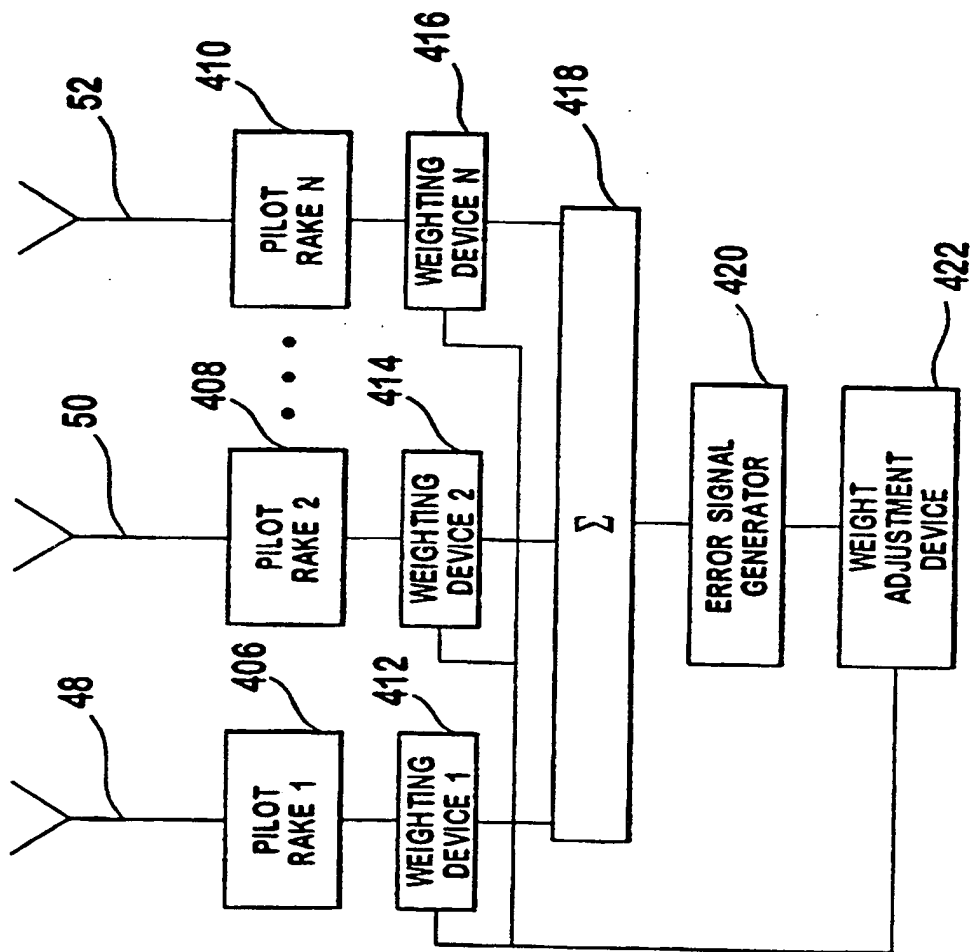


FIG. 18

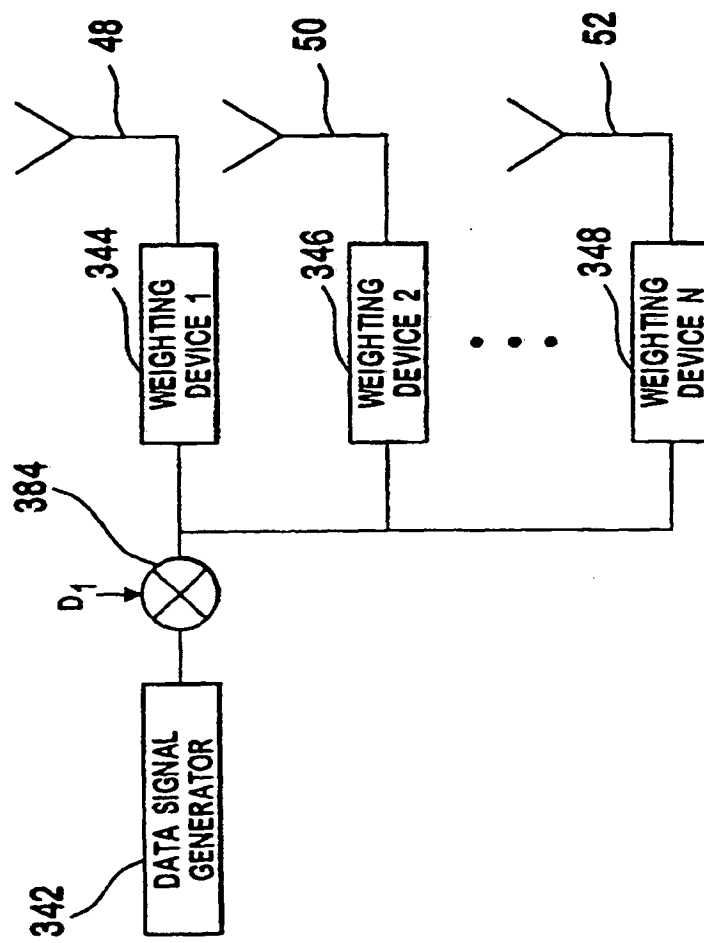


FIG. 19

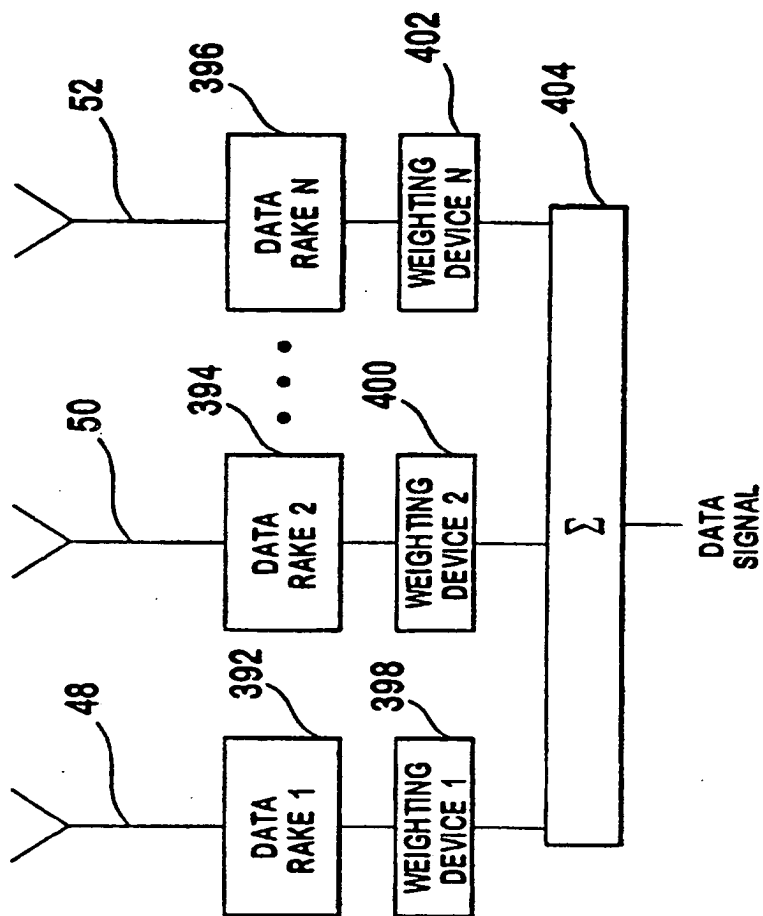


FIG. 20