Office de la Propriété Intellectuelle du Canada
Un organisme d'Industrie Canada

Canadian Intellectual Property Office
An agency of Industry Canada

CA 2149363 C 2004/11/23

(11)(21) 2 149 363

(12) BREVET CANADIEN
CANADIAN PATENT

(13) C

(22) Date de dépôt/Filing Date: 1995/05/15

(41) Mise à la disp. pub./Open to Public Insp.: 1995/11/18

(45) Date de délivrance/Issue Date: 2004/11/23

(30) Priorité/Priority: 1994/05/17 (RM94A000306) IT

(51) Cl.Int.^{6}/Int.Cl.^{6} H01Q 21/00

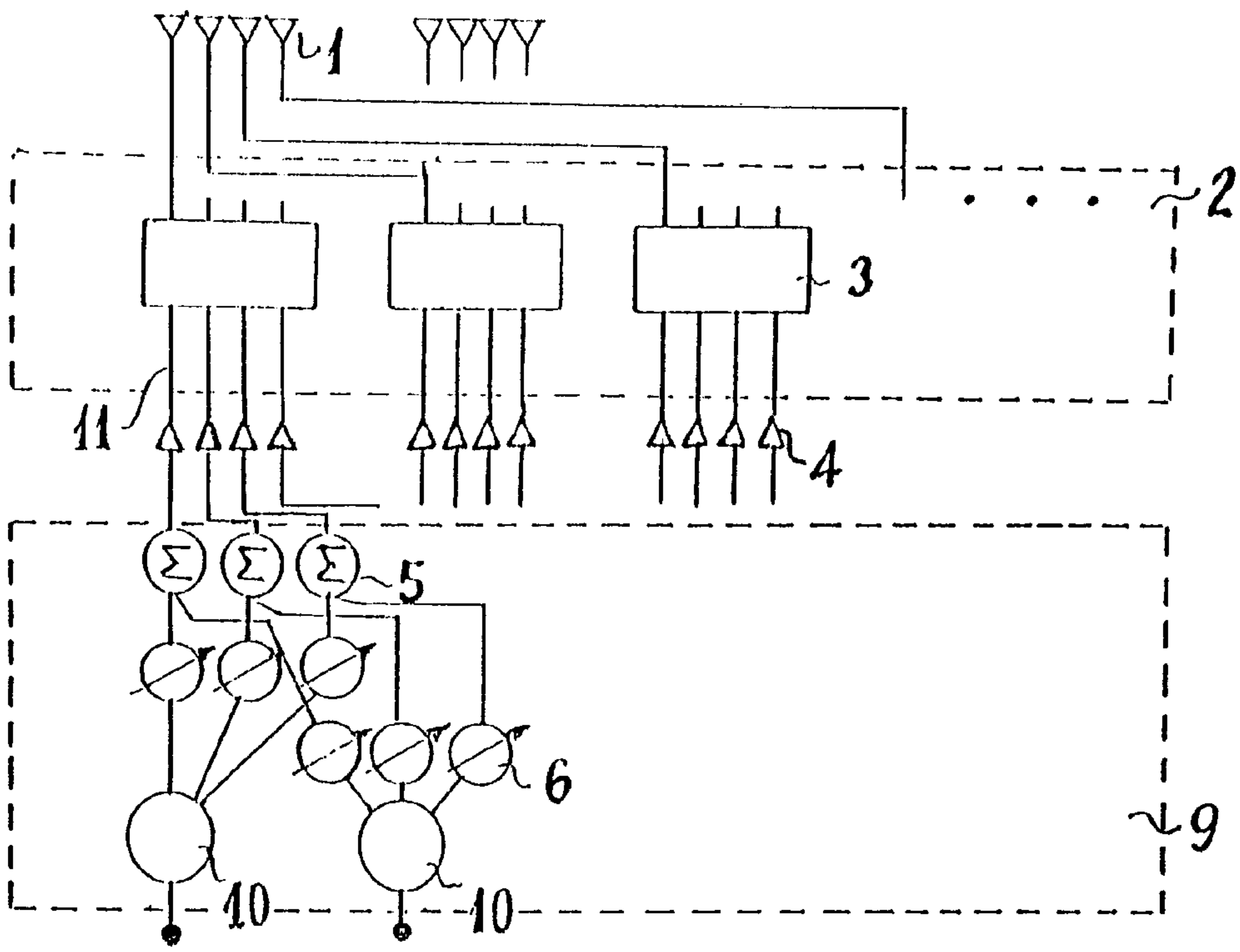
(72) Inventeurs/Inventors:
FORTI, RAIMONDO LO, IT;
LISI, MARCO, IT

(73) Propriétaires/Owners:
SPACE ENGINEERING S.P.A., IT;
ALENIA SPAZIO S.P.A., IT

(74) Agent: RIDOUT & MAYBEE LLP

(54) Titre : ANTENNE A REFLECTEUR OU A LENTILLE A FAISCEAU CONFORME

(54) Title: SHAPED-BEAM OR SCANNED BEAMS REFLECTOR OR LENS ANTENNA



(57) Abrégé/Abstract:
Multiple shaped-beam or scanned beams reflector or lens antenna configured so as to have the radiating elements outside the focal plane (imaging) with improved characteristics in terms of gain and coverage area. Said antenna (Fig. 1) essentially consists of a reflector or a lens (1), a certain number of radiators (3) positioned outside the focal plane, a Beam Forming Network (BFN). It classifies in the technical field of multiple shaped-beam antennae and is applicable to radars, telecommunications in general and to space telecommunications in particular. Its most significant advantage consists in its use as transmitter antenna since in it the electric performance/complexity ratio is improved.

2149363

ABSTRACT

SHAPED-BEAM OR SCANNED BEAMS REFLECTOR OR LENS ANTENNA

Multiple shaped-beam or scanned beams reflector or lens antenna configured so as to have the radiating elements outside the focal plane (imaging) with improved characteristics in terms of gain and coverage area. Said antenna (Fig. 1) essentially consists of a reflector or a lens (1), a certain number of radiators (3) positioned outside the focal plane, a Beam Forming Network (BFN). It classifies in the technical field of multiple shaped-beam antennae and is applicable to radars, telecommunications in general and to space telecommunications in particular. Its most significant advantage consists in its use as transmitter antenna since in it the electric performance/complexity ratio is improved.

2149363

SHAPED-BEAM OR SCANNED BEAMS REFLECTOR OR LENS ANTENNA

Field of the invention.

This invention concerns a beam scan reflector or lens antenna which essentially has as novelty requisite the fact of being configured so as to have the radiating elements outside the focal plane, a characteristic known in the specific field of antennae as "imaging".

The invention may be categorized in the field of multiple shaped-beam antennae and is applicable to that of radars, telecommunications in general and to space telecommunications in particular, in marine, ground, civil and military applications.

The invention stems from the observation of previous solutions patented and owned by this same applicant. It may be considered a step forward with respect to these solutions and may be interpreted as the natural technological progress in the specific technique.

Prior art.

The previous solutions considered are:

[1] "Semiactive parabolic antenna capable of continuous beam scanning by varying the phase only" - Patent application No. RM91A000893.

[2] "Semiactive parabolic antenna capable of providing shaped beams, to be used preferrably in space" - Patent application No. RM91A000894.

[3] "Phased array shaped-beam multiple beam antenna" - Patent application No. RM94A000005.

As regards points [1] and [2], these are focalized type reflector antennae, but not of imaging type, namely the feeds are in the focal plane, unlike in the "imaging" optics which has the feeds outside the focal plane.

The use of imaging optics allows to make the BFN lighter and more compact.

Brief description of the invention.

The antenna of point [3] and the antenna subject of this application for patent have in common that they are semiactive antennae with distributed amplifiers, always using all of the amplifiers fed at the same level in order to create shaped beams. However, the substantial difference between the two lies in the fact that the new antenna is not a direct radiating one, but consists of an array of radiating elements placed in front of a reflector or lens. The result is an antenna with better general performance characteristics, namely better gain and coverage area values.

In particular, the peculiar characteristics of the invention consist in having introduced the optics in order to decrease the phased array antenna's complexity.

This compacting is obtained using the imaging technique, namely by positioning the radiating elements outside the focal plane.

The application of the single reflector imaging technique causes a deformation of the antenna beam, and consequently a degrading of the radioelectric performance: lower gain, higher sidelobes.

In order to recover the gain and the beam's integrity and to lower the sidelobes, a specifically sized BFN is added, thus preventing this imaging configuration from being degraded. In fact, the antenna's electrical performance is reintegrated by putting said BFN between the radiators and the amplifiers.

The antenna essentially consists of:

- a reflector
- a given number of radiators, positioned outside the focal plane
- a beam forming network (BFN).

The problem we intended to solve with this invention was to overcome the main problem of the imaging configuration, represented by the fact that, depending on the direction of the signal's origin, not all of the energy reflected by the reflector, or transmitted by the lens, was captured by the feeds since it shifted and therefore the feeds were not all fully illuminated. This implied a loss in terms of gain when one desired to maintain the amplifiers at the same power level.

In calculating this antenna's efficiency the reciprocity theorem was applied and then reversed should the antenna be used as transmitter, as is exactly the case in this invention.

The problem is solved by using a beam forming network positioned between the radiating elements and the amplifiers, so as to maintain the same power level at the amplifiers even when the feeds are fed at different power levels.

The beam forming network consists of number n of hybrids, of high power phase-shifting elements and of low power phase-shifting elements.

The topology, the connections and the phase values must be studied in order to obtain maximum radioelectric performance.

Drawings.

The invention is now described, by way of illustration and in no way in a limiting manner, with reference to the version currently preferred by the Inventors and on the basis of the drawings attached hereto.

Fig. 1 - General drawing of the reflector (a) or lens (b) antenna system

Fig. 2 - Assembly drawing of the BFN at low power level (9)

Fig. 3 - Drawing of the beam forming network at high power level (2) and of the assembly of amplifiers and of radiating elements

Fig. 4 - Example of connections between BFN output gates and radiating elements

Fig. 5 - Envelope of the maximum gain values for all directions in UV space.

Embodiment of the invention.

With reference to these Figures, this invention basically comprises an optical system which can be a reflector (Fig. 1a) or a lens (Fig. 1b), of a set of radiating elements (feeds) (Fig. 1-2), of a high power BFN (Fig. 2-3), of a battery of amplifiers (Figs. 2 & 4), and of a low power BFN (Fig. 2-9).

The high power BFN consists of a set of fixed phase shifters and of a set of hybrids (Fig. 3-7), appropriately connected.

The high power BFN consists of a set of phase shifters (Fig. 2-6), a given number of dividers (Fig.2-10) and a given number of adders (Fig. 2-5), appropriately connected.

The values of the low power phase shifters are specifically chosen for each direction of beam pointing, in the case of scan antenna, and in order to obtain an effective beam shaping in case of shaped-beam antenna.

The main feature of both systems lies in their capability to compensate for the aberrations introduced by the optics, whatever type it may be, by optimizing the high and low power BFN's.

By "optimization" it is intended:

- the choice of feed size and their distance from the focal plane;
- the number and order of sub-BFN's composing as a whole the high power BFN (Fig. 2-2);
- the connection scheme between the high power BFN's outputs and the radiating elements (example in Fig. 4);
- the phase values of the phase shifters in the low power BFN (Fig. 2-9);
- the phase values of the phase shifters in the high power BFN (Fig. 3-8).

From all of the above one may infer that the specific scope of this invention consists in optimizing all those parameters in such a way that, once the optics' size and the number of radiating elements is determined, the directivity value and the size of the scan sector are increased (Fig. 5), while maintaining the same RF operating point for all power amplifiers. This allows the latter to obtain maximum efficiency possible. Moreover, should one desire to create shaped beams, this technique allows to maximize the minimum values in each beam.

CLAIMS:

1. A beam-type antenna system comprising:

an array of radiators defining an antenna beam;

antenna optics spaced from said array of radiators for focussing said beam and having a focal plane such that said array lies between said antenna optics and said focal plane and said array is outside said plane;

a passive main beam forming network connected to said array of radiators and comprising a plurality of beam forming subnetworks, each connected to a group of said radiators, each of said beam forming subnetworks being provided with pairs of input terminals, respective hybrids connected to said pairs of input terminals, respective phase shifters connected between said hybrids and respective output terminals, and further phase shifters connecting said hybrids of one pair of input terminals with hybrids of another pair of input terminals; and

respective power amplifiers connected to said input terminals.

2. The beam-type antenna system defined in claim 1 wherein a further network is connected to said passive main beam forming network and comprises: a plurality of dividers, respective phase shifters connected to said dividers and respective adders receiving inputs from phase shifters of different dividers and connected to said power amplifiers.

3. The beam-type antenna system defined in claim 2 wherein said antenna optics is a reflector.

4. The beam-type antenna system defined in claim 2 wherein said optics is a lens.

RIDOUT & MAYBEE LLP
Toronto, Canada
Patent Agents

2149363

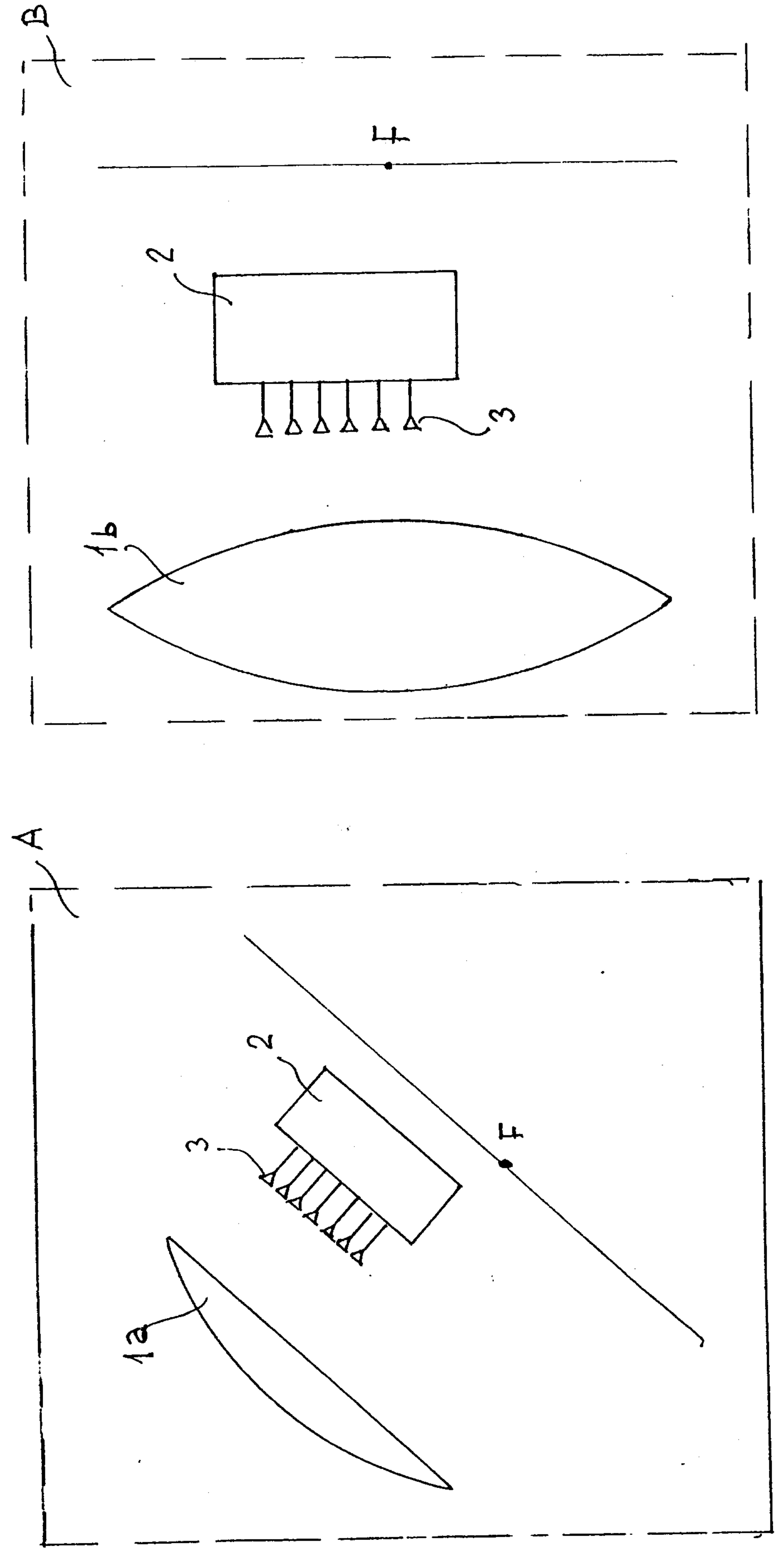


Fig. 1

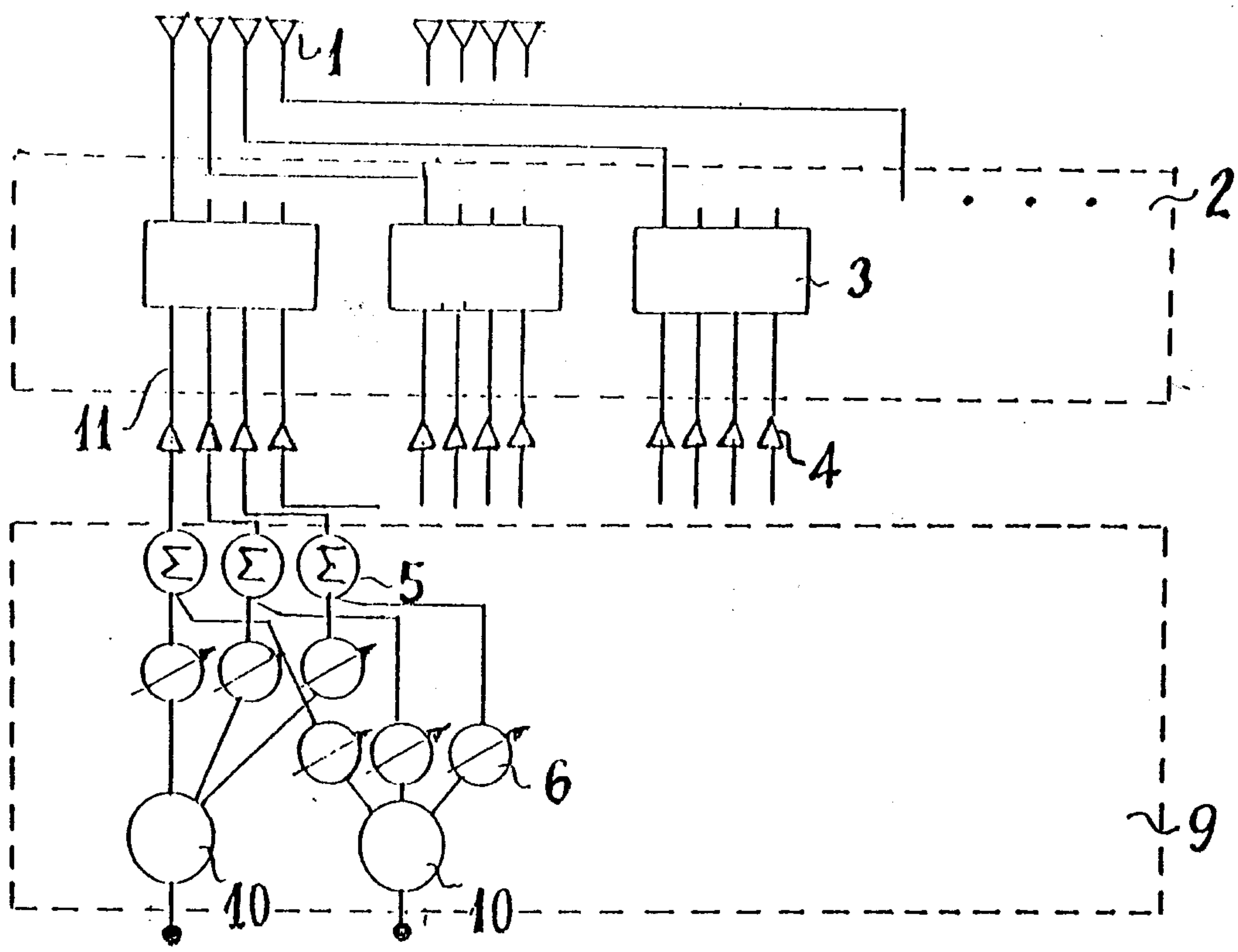


Fig. 2

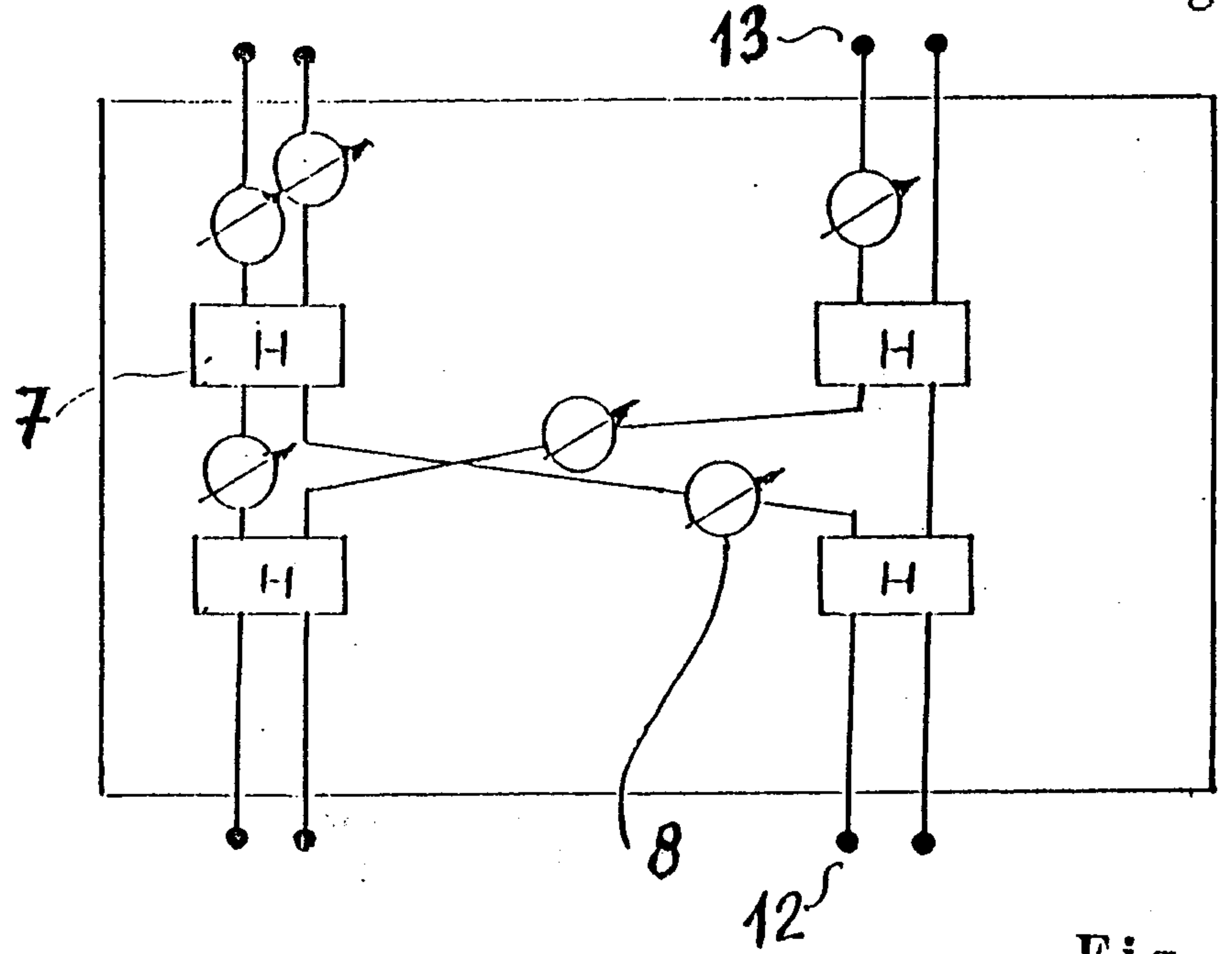


Fig. 3

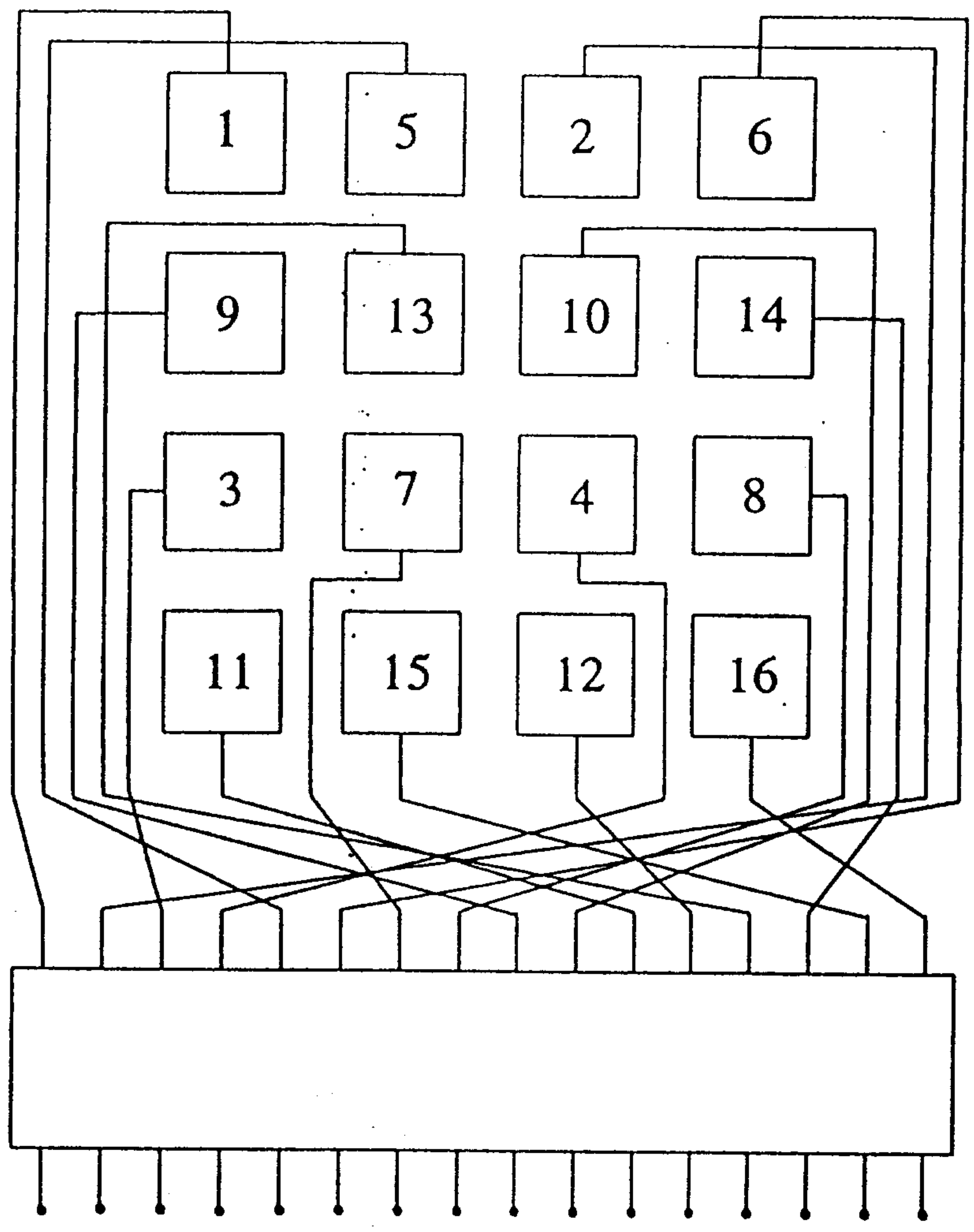


Fig. 4

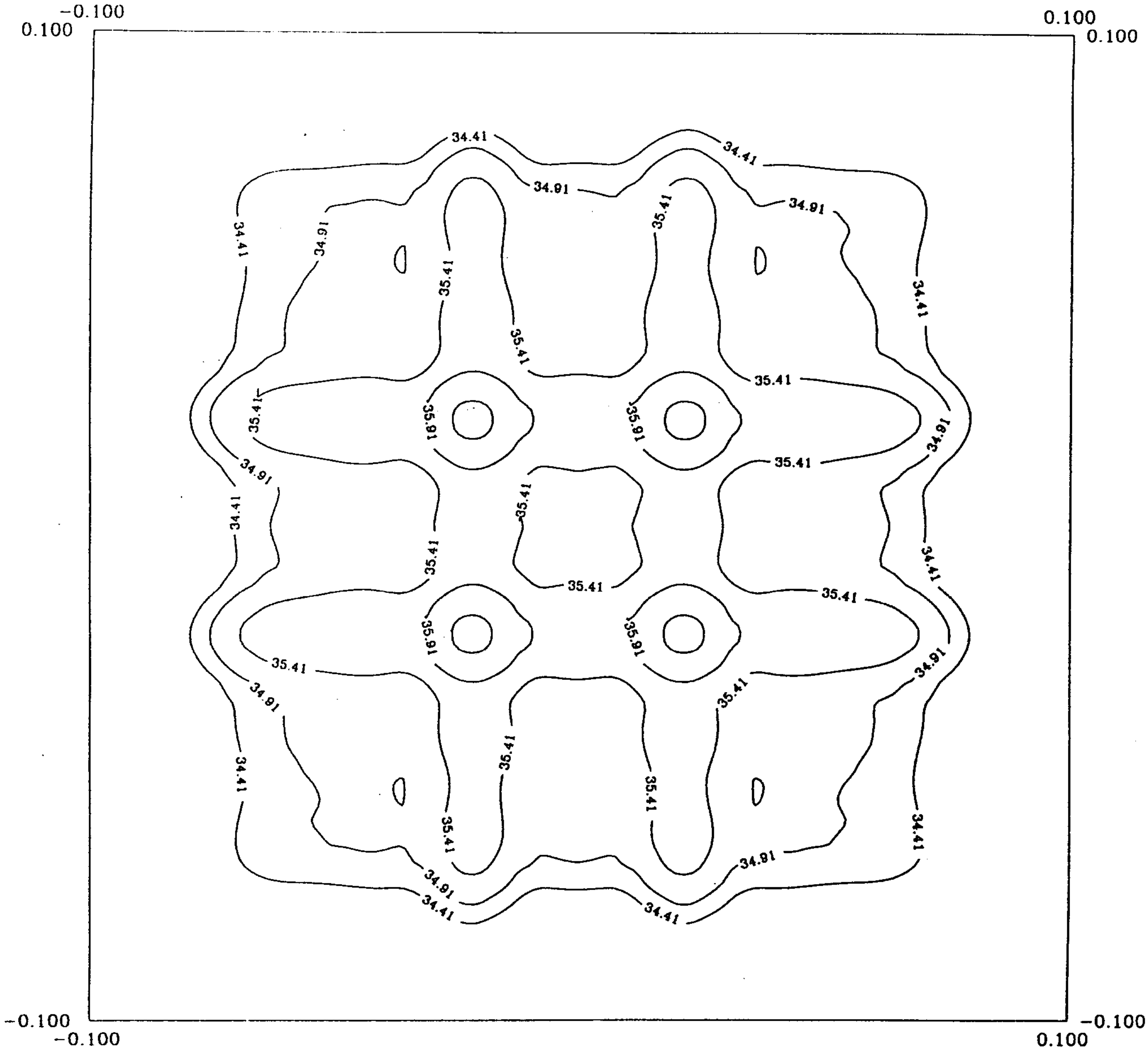
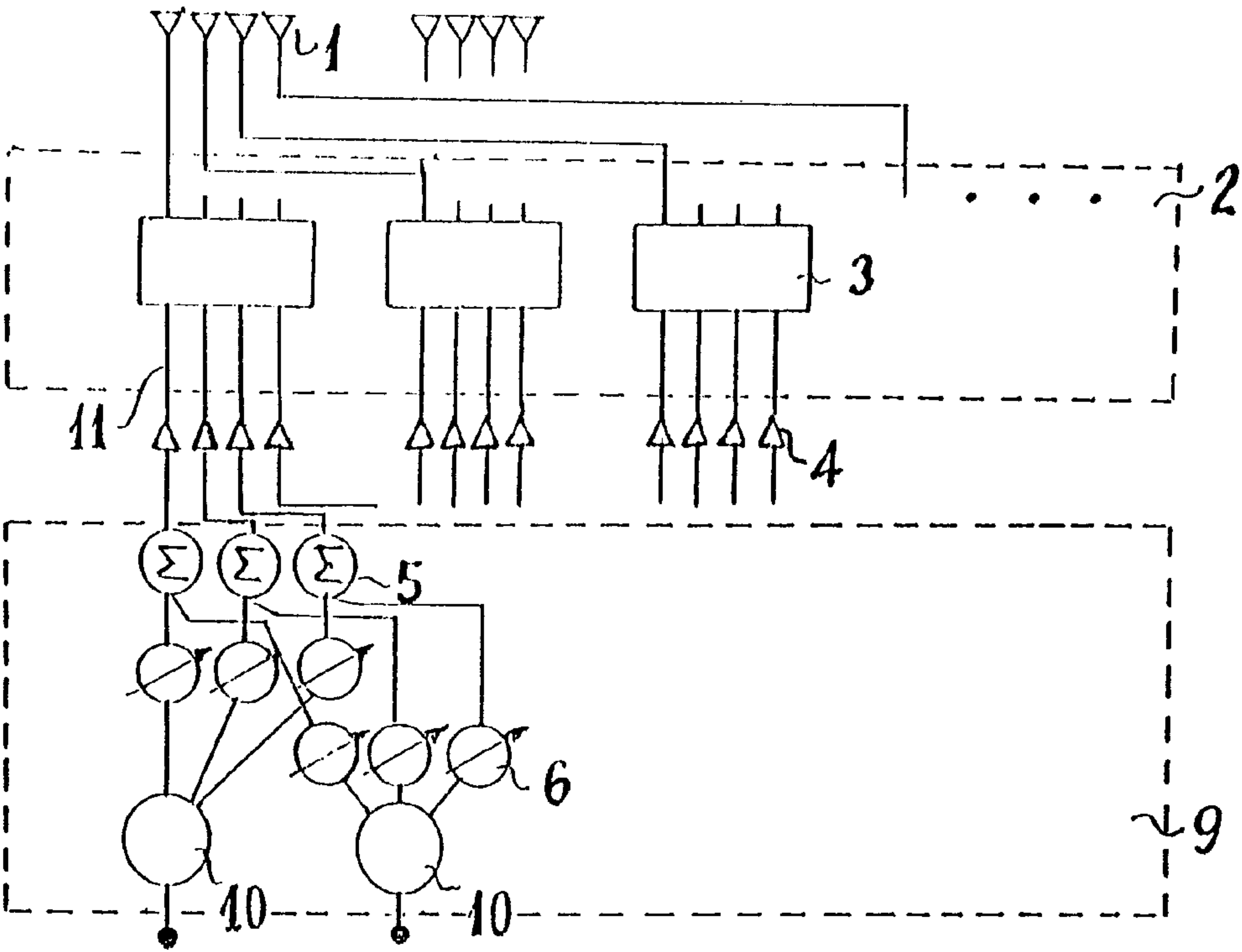


Fig. 5



1
2
3
4
5
6
9
10
10
11