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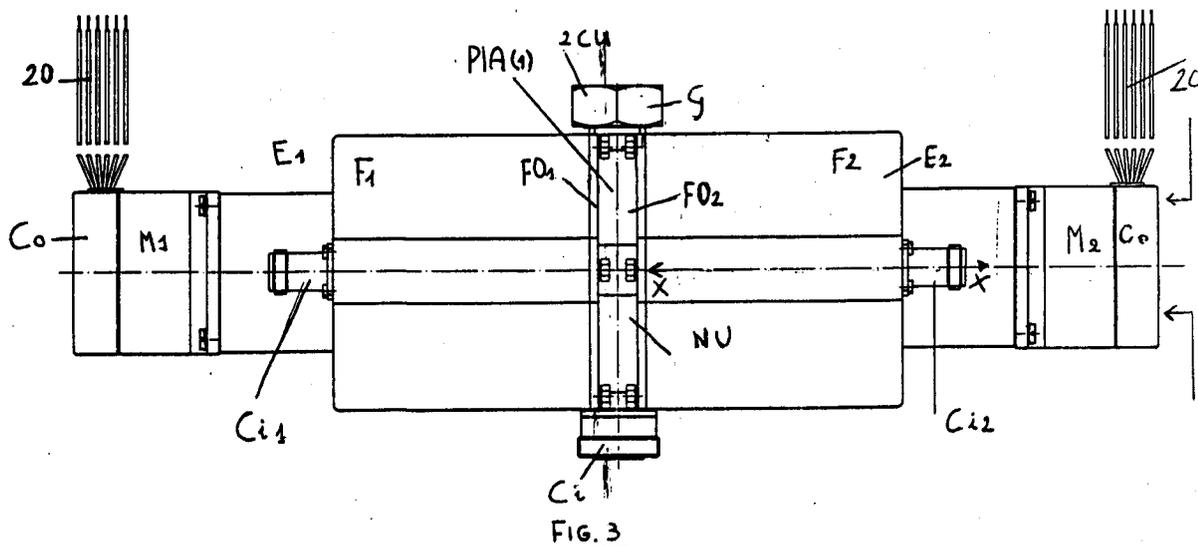
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System of "siamese" filter couples for microwave combination network.

In the system of band-pass filter pairs for networks combining microwave signals from N transmitters, each filter pair is now formed of two cavities which are each open on a wall thereof and are

disposed on the opposite sides of a central plate consisting of a nucleus and of two major walls each forming the missing cavity wall.



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The present invention relates to systems of couples of filters, f.i. band pass filters for networks of combination of radio frequency (microwave) signals, each filter of a couple consisting of a resonant cavity made of a box-like body having a polygonal form.

More particularly the invention refers to couples of microwave pass band filters so shaped to minimize the encumbrance of a combination network consisting of several couples of filters tuned on different frequencies.

Advantageously the filter couples are juxtaposed and interconnected at least two by two in a simple and efficient manner.

Prior Art

As known a combination network is intended to combine more signals generated f.i. from more transmitters working in the microwave field typically comprised between hundreds of Megahertz and some Gigahertz.

Just to refer to a recent embodiment of the basic stations for radio-mobile transmitter network the problem arises of combining on a single antenna the signals generated by a plurality of transmitters TX₁, TX₂...TX_N. The combination circuit must take minimum possible encumbrance.

In fig. 1 the equivalent scheme of a circuit utilizing conventional technics for the solution of the above problem is shown.

Filters F₁, F₂...F_N are coupled by mutual inductance M₁...M_n to a line L formed of N pieces S₁-S_n each having a length of $\lambda/2$, where corresponds to the central frequency of the working band. The line pieces S_i are a part of the filters F_i and are connected to each other by means of N-1 connectors C₁, C₂...C_{N-1}.

A suitable embodiment of the filter F₁ is described in the Applicant's Italian patent application No. 22559 filed on December 28, 1990 corresponding to Europ. Pat. Appln. 0492303.

In the scheme of fig. 1, the length of the connecting line amounts to the product of the wave half length $\lambda/2$ and the filter number i.e. $X/2 N \cdot \lambda/2$.

From this derive poor electric characteristics due to the line length and a bad mechanical disposition of the filters which cannot be parts of a compact structure.

A more convenient solution is represented by a combining circuit of N filters formed of N/2 filter couples. The equivalent scheme is shown in fig. 2.

Each line L portion which also in this case is long half wave length of the central frequency of the working band, is subdivided in two semi-pieces SP₁-SP₂, SP₃-SP₄...SP_{n-1} SP_n which are in parallel to each other and show double characteristic impedance. A filter F_i is coupled to each one of

said semi-pieces, f.i. F₁ is coupled to SP₁ which is in parallel to SP₂ associated to filter F₂.

The total length of line L' which connects the filter couples F_{i-1}-F_i to the antenna is now halved with consequent improvement of the electric characteristics.

The filter number remains however equal to that of fig. 1 with the advantage that couples of filters (F₁, F₂, F₃, F₄ etc) face a common line tract.

Summary of the Invention

A first object of the present invention is a system of composite filters consisting of at least a couple of filters combined as "siamese twins", each composite filter being advantageously obtained by the simply juxtaposing at least two elementary filters which are substantially and specularly identical to each other and each coincident with a filter normally used alone.

An other object of the invention is a filter couple which allows to drastically reduce the encumbrance and to obtain optimal electric characteristics.

A further object of the invention is to provide a particularly compact and efficient whole or set of at least two filter couples.

These and other objects are obtained, according to the invention, with a system consisting of at least one pair or couple of filters (f.i. band pass) for networks combining signals coming from N transmitters (TX_i) each of which is coupled to a common line (L) directed to an antenna, each filter consisting of a resonant cavity formed of preferably polygonal walls and comprising input and output connectors and an electro-magnetic coupling organ, characterized in that each pair or couple is formed of two cavities which are open at least on one portion thereof and are disposed on one side and on the other side of a central plate consisting of a nucleus and of two major external faces, each face forming the cavity open wall, said nucleus housing internally the control means of said electro-magnetic coupling organ.

According to the more remarkable feature of the invention, to each pair or couple of open cavities is associated a single plate which closes the two cavities and inserts in each one of them at least a dielectric resonator element.

According to an other advantageous feature of the invention, the electro-magnetic coupling organ formed of a curved lamina is disposed externally to each major face at a distance which is regulated through screws placed within a niche or recess made in the nucleus.

The plate thickness is advantageously regulated in a way to contribute to the obtainment of a $\lambda/2$ distance between connectors.

Preferably the cavities have a trapezoidal shape, the walls of each cavity taken away and associated to the plate are the bottom walls to which are to be associated the supports and the dielectric elements penetrated by the controllable tuning dielectrics.

In a particularly simple and advantageous embodiment of the invention, the two filters of each couple are combined as "Siamese twins".

The different features and advantages of the invention will better appear from the following description of the preferred but not limitative embodiment shown in the accompanying drawings in which:

- figure 2 is the equivalent scheme of the simplest system of filters combined two by two;
- figure 3 is an overall top view of the couple of filters assembled on the coupling plate according to the invention;
- figure 4 is a schematic and partial cross-sectional view of fig.3 taken along line X-X;
- figures 5 and 6 are views from the front and rear side respectively of the core of the invention, i.e. the central plate, to the major faces of which are associated the stationary dielectric parts, said plate being extracted from the cavities of the two filters;
- figure 7 is a view of a partial cross-section taken along line A-A of fig. 5 and shows one major face of the plate;
- figure 8 is a view of the filter (F_1) end remote from the central coupling plate, the motor and relevant accessories being displaced, and
- figure 9 is a lateral view of an ensemble of superposed drawers in which at least two filter couples are just-apposed according to the invention.

For the sake of clarity in the description and drawing reference is made to the simplest case of two by two coupled filters, it is however obvious that the coupled filters can be more than two f.i. four. In fig. 2 $F_1, F_2 \dots F_N$ indicate again the filters, $TX_1 \dots TX_N$ the relevant transmitters, $C_1 \dots CN-1/2$ the connectors and $M_1 \dots M_N$ the coupling inductances of the filters F_1 to the line L' .

Instead of and in the place of each piece line S_i of fig. 1 a small plate $P_1 \dots P_N$ is inserted which has internally two semi-pieces $SP_1-SP_2 \dots SP_{N-1}-SP_N$ in parallel. The odd filters are disposed all together on one side of line L' and the even filters on the other side, a semi-piece SP_i of fig. 2 corresponding to a piece S_i of fig. 1. Each semi-piece has a length still equal to a half wave length (corresponding to the central frequency of the working band).

The invention concerns in particular a system to couple the pairs of filters $F_1-F_2 \dots FN-1-FN$ in such a way as to be possible to use elementary

filters identical to the filters currently used alone, and to bring about modules of pairs of filters assembled with particularly efficient means of tuning control.

In the figures from 3 to 8 the two filters f.i. F_1 and F_2 are united, on their (truncated or trapezoidal) bottoms $F0_1, F0_2$, to a central plate $PIA(1)$ at the ends of which the output connectors CU_1, CU_2 are disposed.

On the ends E_1, E_2 of filters F_1, F_2 remote from the plate PIA are placed the input connectors Ci_1, Ci_2 . In the figures, CU_2 is hidden by the ring nut G of the male connector. In the cross-section of fig. 4 (partial cross-section of fig.3 taken along line X-X) the numeral reference 1 designates the cavity or support of filter F_2 , in which penetrates the prolongation 19 of the input connector Ci_2 and is mounted the dielectric system placed on the base Ba .

This dielectric system comprises three elements, in particular the central female body DF in which enters the male dielectric body DM which can be moved (displaced) manually or preferably automatically by a motor M provided with a command box Co which is fed by the electric current to operate the motor and by the tuning regulating signals through the conductors 20. Accordingly the extension of the penetration of the male body into the female body can be controlled.

In prior patent Applications Applicant has described tuning systems with dielectric resonators as well systems to combine several high frequency signals.

In particular in the above mentioned Italian application No. 22559 A/90 (European Patent Application 91121336.1/0492303) a system is described to combine signals from filters having resonant cavities of tapered (trapezoidal or bottle-like) shape which allow a juxtaposition of minimum encumbrance because the tapered head (or bottle neck) of a filter is inserted between the wider portions of the preceding and successive filters.

Accordingly each filter pair is formed of two filters overturned of 180° and laterally approached, i.e. with the wall of one closed filter in contact with the lateral wall of the other filter.

Preferably the cavity houses a tuning dielectric system the coupling of which is regulated by means of an electric tele-controlled motor.

Advantageously the tuning dielectric system is that described in the Italian Patent Application No. 22557 A/90 (Europ. Pat. Appln. 0492304) while the system to select the motor control signal is that according to the Italian Pat. Appln. No. 22558 A/90 (Eur. Pat. Appln. 0492302).

The specifications of these two prior Applications can be considered as incorporated in this description.

Going back to fig. 3, the system according to the present invention comprises pairs of identical filters f.i. F_1 and F_2 , specularly disposed on one side and on the other side of the central plate PIA.

Characteristically the bottom walls F_{01} and F_{02} of the cavity forming envelope (f.i. 1 in fig. 4) of filters F_1 and F_2 are now absent; as, it can be seen from fig.4, the body or box-like chamber 1 of each filter F_1 , F_2 is open at the end opposite to the end E_1 , E_2 respectively where the motors M_1 , M_2 and input connectors C_{i1} , C_{i2} are disposed. Accordingly the most remarkable feature of this invention is to be seen in the fact that the central plate PIA (represented alone and on an enlarged scale in the front view of fig.6 and in the relevant partially cross-sectioned rear-end view of fig .5) comprises a central nucleus NU showing a niche (recess) N_c , and two major faces PM_1 , and PM_2 . At the ends of NU are disposed the male connector 2 (Cu) provided with ring nut G, and the female connector $3C_1$.

On each face PM_1 , PM_2 is disposed the organ of electro-magnetic coupling R_1 , R_2 between connectors 2 and 3; as it can be seen from fig.7, (a view partially cross-sectioned along line A-A on fig.3), said organ is preferably an arcuated lamina R_2 which has a length l_3 and is fixed on the two internal extensions PRO, PRO' of each connector.

The distance or height "h" of each small lamina R_1 , R_2 from the relevant face PM_1 , PM_2 of the plate PIA is controlled with the aid of isolating screws 10 acting through the protrusion 100 on said lamina R_1 , R_2 which are secured (f.i. by means of screws) to spacers T6 connected on their turn, to the internal conductors PRO of the screw provided connectors 6.

Characteristically, as the distance between said connectors is determined by the length l_3 of R_1 , R_2 (fig.7), by the penetration l_1 , l'_1 of the internal conductor of each connector, and by the length l_2 , l'_2 of the T-shaped element T6 and must be equal to $l/2$, it is advantageously acted on the thickness of the plate PIA i.e. on the length l_2 of said element T6, so as to have the sum of $l_1 + l_2 + l_3$ be equal to $l/2$.

Since the figures 5,6 and 7 showing the plate PIA with the relevant dielectric female element DF carried by supports BA are to be imagined as exploded views of fig. 3, it can be understood that the filter pairs according to the invention are of the "Siamese twins" type.

Fig. 8 is a view of the internal part of a filter, f.i. F_2 , seen in the direction of arrow C of fig.3.

A further advantage of the filter ($F_1 + F_2$) pairs according to the invention is that said pairs beside being advantageous singularly i.e. when they are formed by two open cavities and by a single plate combined as single Siamese twins, they become

even more advantageous when same pairs are combined two by two with further encumbrance reduction and electric characteristics improvements.

Indeed the pairs formed by F_1 and F_2 through the plate PIA_1 , and F_3 , F_4 through f.i. the plate PIA_2 are perfectly justapposable and are connected to each other by means of the output connector C_u (1,2) of F_1 , F_2 which is engaged through the ring nut G, with unput connector C_i (3,4) of the pair or couple F_3, F_4 .

Further significant advantages of the filters combined as Siamese twins according to the invention are obtained in their combinations f.i. of four, six etc. pairs disposed in box-like drawers or sub-racks in an extremely efficient manner to the end of reducing encumbrances and losses and improving the electric characteristics. Fig.9 shows three drawers CAS_1 (the central one with two pairs F_1-F_2 , F_3-F_4 , on the central line leading to the antenna An filter and connector) and CAS_2 and CAS_3 each containing three pairs of filters (F_5-F_6 , F_7-F_8 , and F_9-F_{10} in CAS_2) and ($F_{11}-F_{12}$, $F_{13}-F_{14}$ and $F_{15}-F_{16}$ in CAS_3). The two drawers or sub-racks CAS_2 and CAS_3 each with three pairs are placed on one side and on the other side of the central drawer CAS_1 comprising only two pairs. The common outputs U_{5-10} of the filters in CAS_2 and U_{11-16} of the filters in CAS_3 are parallel connected to the common line of outputs U_{1-4} of CAS_1 .

The line groups 29, 21, 22 and 23 each consisting of three lines as well as the line groups 24,25 of two lines indicate schematically the inputs to the filters CAS_2 , CAS_3 while C_a indicate the open connectors.

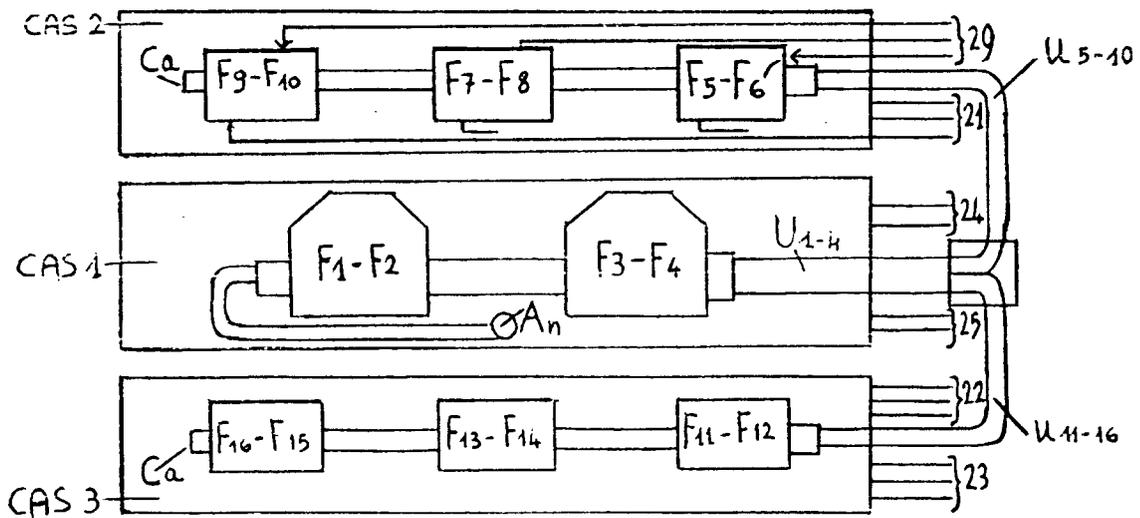
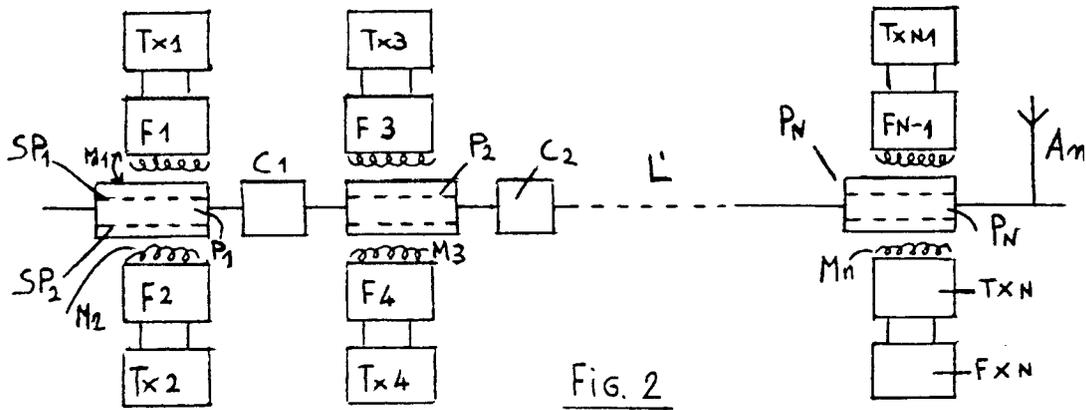
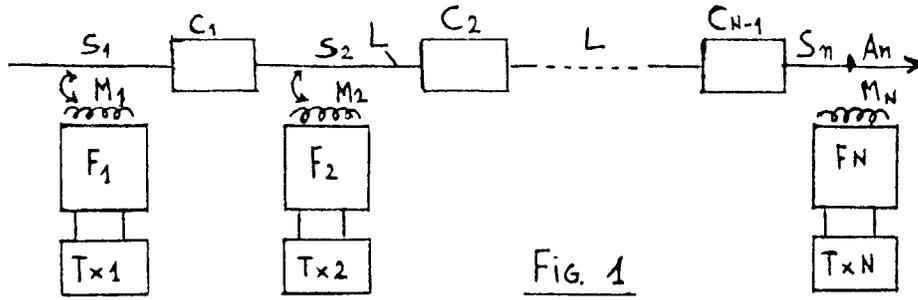
Summarizing the invention provides a system to form pairs (couples) of filters with two open cavities and only one plate which, being placed centrally to the two open cavities, shows two walls to close said cavities and at least one dielectric resonator element projecting from said closing walls. In other words, it is as if on a single central plate were transferred: one wall of each cavity filter and the stationary portion of the dielectric resonator of each filter. Since these two resonator elements project from one and the other side of the plate, after assembling, the plate forming a single integral body does not only close externally the two open cavities but moreover inserts therein the "viscera" (bowels) as Siamese twins.

Claims

1. System of pairs (couples) of band-pass filters for networks combining radio-frequency (microwave) signals, in particular for networks combining signals from N transmitters (TXi) which, each through its own filter (Fi) is coup-

- led to a common line (L') directed to an antenna, each pair filter having a resonant cavity formed of polygonal walls and containing at least one dielectric resonator and comprising input and output connectors as well as an electro-magnetic coupling organ, characterized in that each pair or couple is formed of two cavities which are open at least on one portion thereof and are disposed on one side and on the other side of a central plate consisting of a nucleus and of two major walls, said nucleus housing internally the central means of said electro-magnetic coupling organ.
- 5 10
2. System according to claim 1, characterized in that a single plate forming an integral unique body carries dielectric resonator elements for two cavities. 15
3. System according to claim 2, characterized in that the plate having two major faces to close two open cavities and complementary dielectric resonators is inserted between and within said cavities as a common portion typical of Siamese twins. 20 25
4. System of filter pairs according to claim 1, characterized in that an electro-magnetic coupling organ formed of a curved lamina is disposed externally to each major face at a distance which is regulated through screws placed within a niche or recess made in the nucleus. 30
5. System of filter couples according to claim 1, 2 or 3, characterized in that the plate thickness is regulated and utilized to obtain a distance of $\lambda/2$ between the input connector and the output connector. 35 40
6. System of pair filter according to at least one of the preceding claims, characterized in that each cavity houses a dielectric resonator male element which is (tele)-controlled to assume a controllable penetration in a dielectric resonator female element, this last female element being secured to the plate major face through a dielectric support. 45
7. System of two filter pairs according to at least one of the preceding claims, characterized in that the pairs are approached in juxtaposition to each other, the male output connector of the plate of a pair engaging the female input connector placed on the plate of the other pair. 50 55
8. System of N pairs (N-2) of filters according to at least one of the preceding claims, consisting

of K drawers or sub-racks each comprising at least two filter pairs, K-1 drawers containing more than two filter couples and being connected to a common drawer containing beside at least a filter pair, also an antenna single filter.



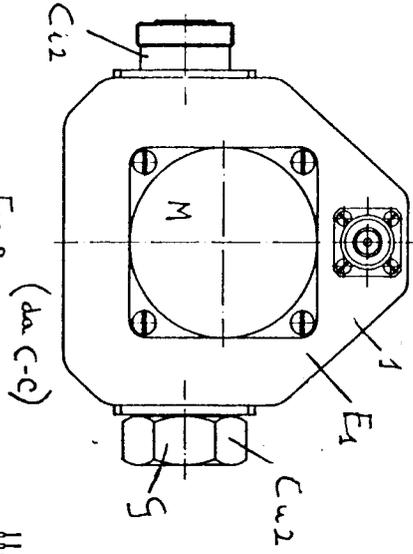


FIG. 8

(da C-C)

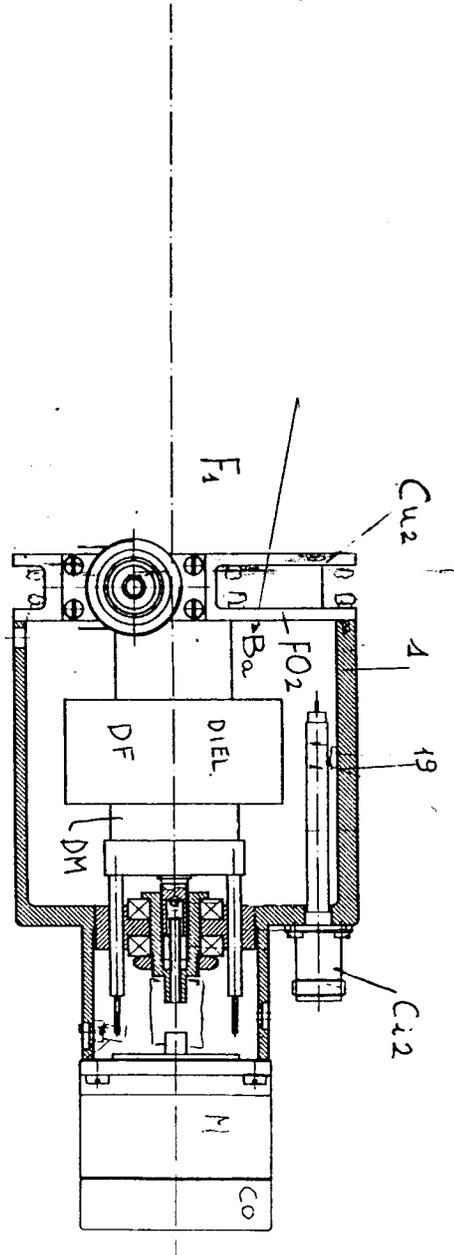


FIG. 4

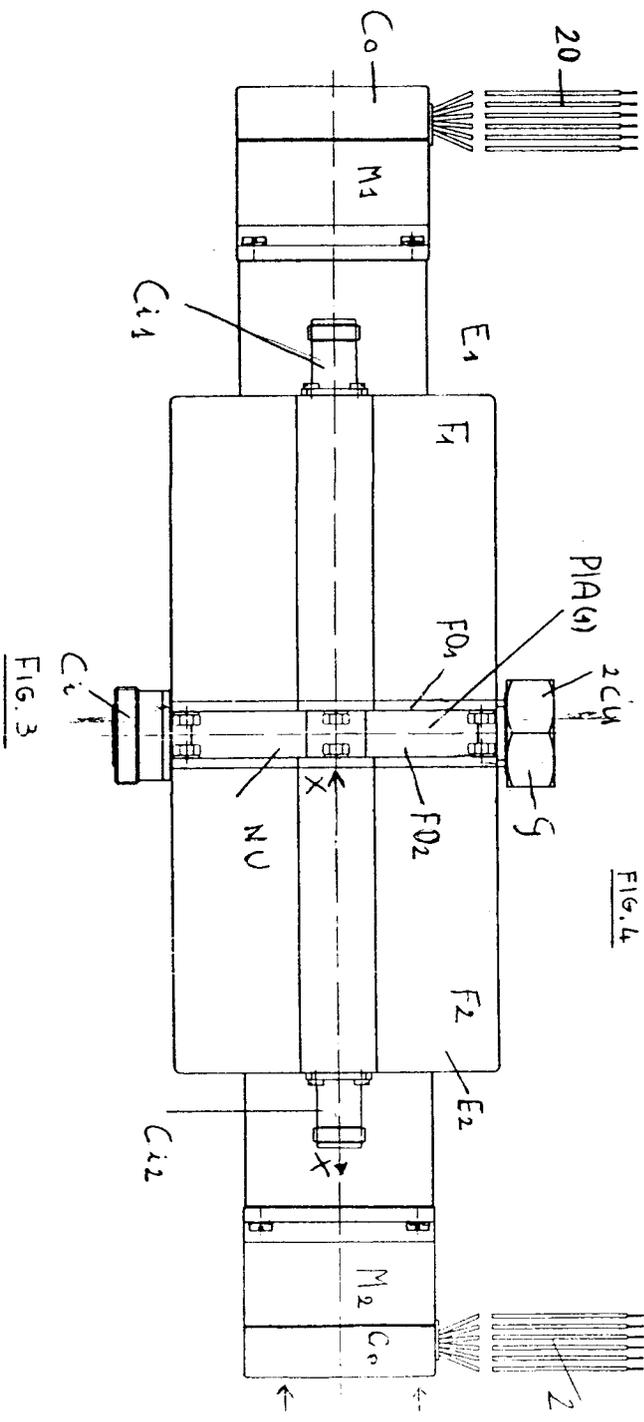


FIG. 3

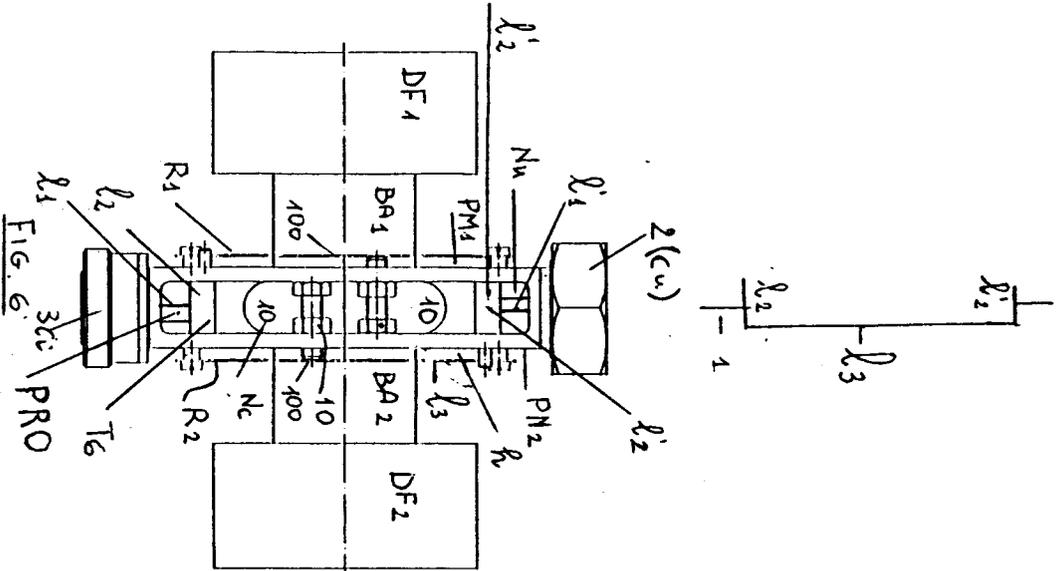


FIG. 7

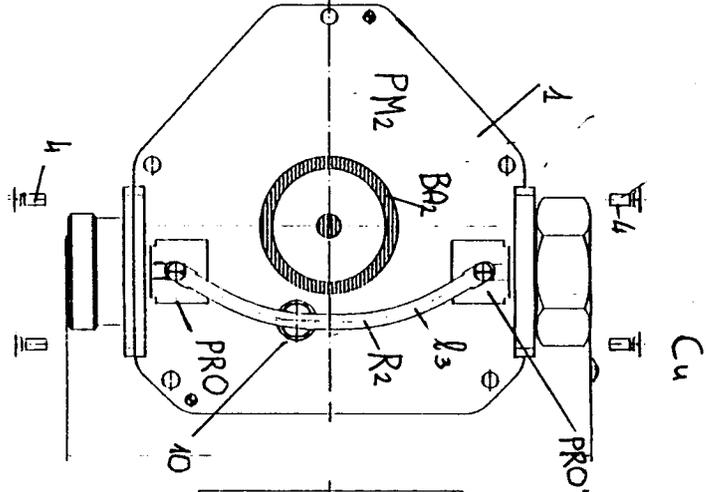
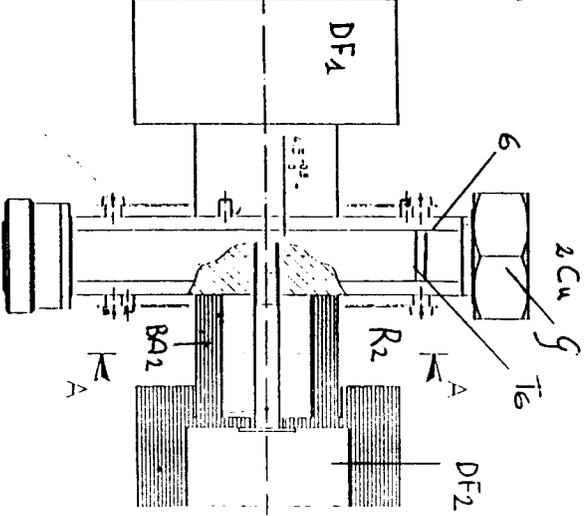


FIG. 5





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.5)
A	WO-A-8 803 711 (HUGHES AIRCRAFT COMP.) * page 9, line 14 - line 28; figure 7 * ---	1	H01P1/213
A	GB-A-2 203 898 (MURATA MANUFACTURING CO LTD) * page 5, line 14 - page 7, line 19; figure 1 * ---	1	
A	FR-A-995 560 (COMPAGNIE GÉNÉRALE DE TÉLÉGRAPHIE SANS FIL) * the whole document * ---	1	
A	US-A-3 425 006 (WOLF) * column 5, line 28 - line 55; figure 1 * -----	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			H01P
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 22 MARCH 1993	Examiner DEN OTTER A.M.
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			