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(72) HA, DONG IN, KR
(72) SEO, HO SOO, KR
(72) KIM, SEONG JOONG, KR
(72) GOUDELEV, ALEXANDRE, KR
(72) KRYLOV, KONSTANTIN, KR
(71) SAMSUNG ELECTRONICS CO., LTD., KR

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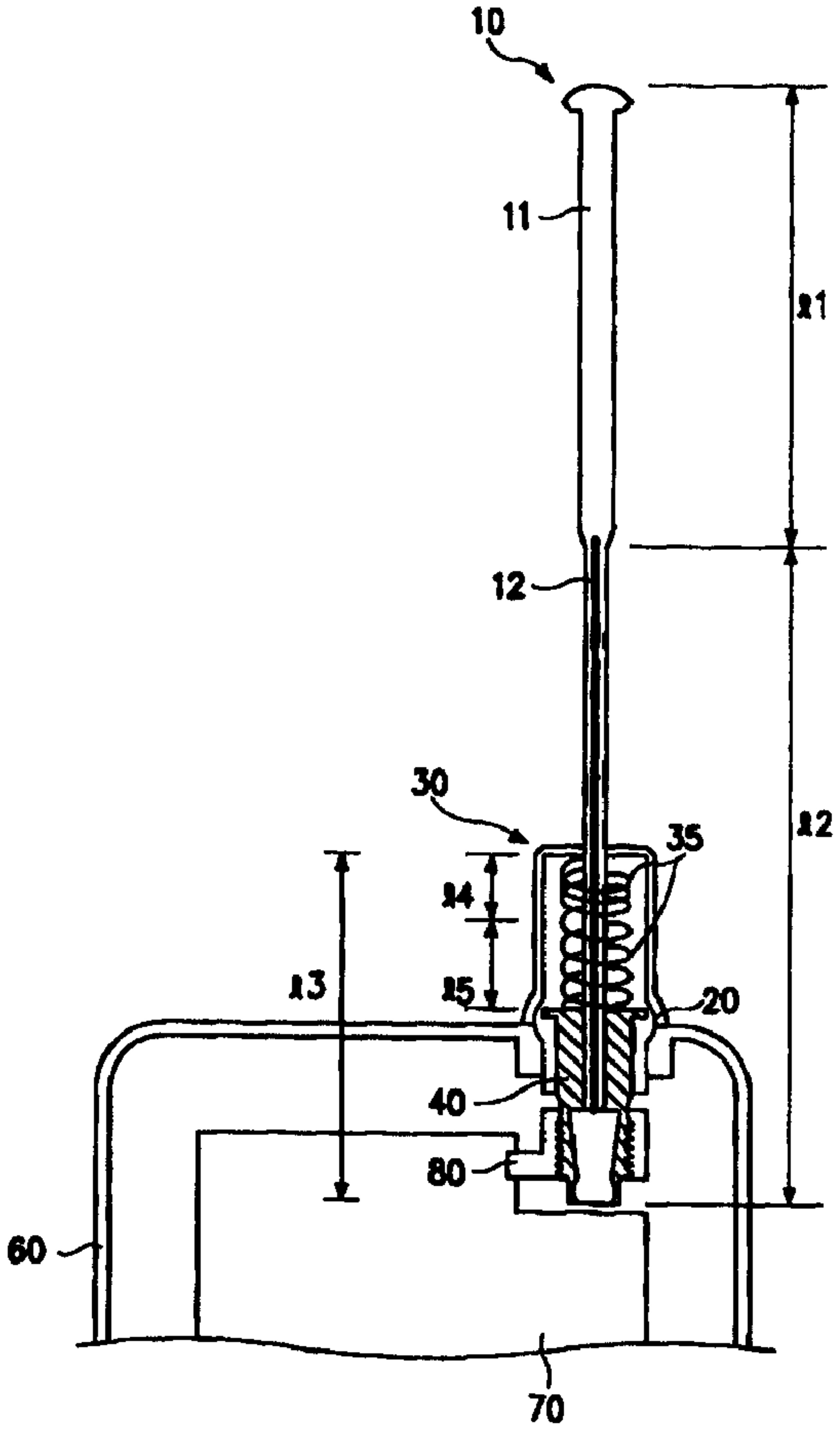
(54) ANTENNE DOUBLE BANDE POUR EQUIPEMENT RADIOELECTRIQUE TERMINAL

(54) DUAL BAND ANTENNA FOR RADIO TERMINAL



(57) Une antenne double bande pour équipement radioélectrique terminal consiste en une antenne-fouet (10) escamotable et en une antenne hélicoïdale (30) à pas irréguliers, l'antenne-fouet (10) étant indépendante de l'antenne hélicoïdale (30). L'antenne hélicoïdale (30) se

(57) A dual band antenna for a radio terminal consists of a retractable whip antenna (10) and a helical antenna (30) with irregular pitches, wherein the whip antenna (10) is independent of the helical antenna (30). The helical antenna (30) includes first and second helical portions

compose d'une première et d'une deuxième partie hélicoïdale (35), respectivement à premier et deuxième pas, lesdites parties pouvant fonctionner dans différentes bandes de fréquence, indépendamment. L'antenne-fouet (10) comprend une ligne centrale (12) conductrice, une substance conductrice (13) recouvrant une première partie de ladite ligne (12) afin de faire office de piège et un élément isolant s'étendant depuis une extrémité supérieure de la ligne centrale (12) conductrice, conçu pour remplir un espace situé entre la ligne conductrice centrale (12) et la substance conductrice (13). Ici, seule la première partie de la ligne centrale (12) conductrice peut fonctionner dans une première bande de fréquence et la ligne centrale conductrice dans sa totalité, peut fonctionner à une deuxième fréquence. Un élément de fixation (40) permet de fixer l'antenne hélicoïdale (30) et l'antenne-fouet (10) à l'équipement radioélectrique terminal (60). L'élément de fixation (40) présente une extrémité supérieure connectée à une extrémité inférieure de l'antenne hélicoïdale (30), et un orifice traversant par lequel l'antenne-fouet (10) est insérée à l'intérieur de l'équipement radioélectrique terminal (60).

(35) having first and second pitches, respectively and the first and second helical portions (35) are operable at different frequency bands independently. The whip antenna (10) includes a conductive core line (12), a conductive substance (13) covering a first portion of the conductive core line (12) to serve as a choke and an isolation element extending from an upper end of the conductive core line (12), for filling a gap between the conductive core line (12) and the conductive substance (13). Here, only the first portion of the conductive core line is operable at a first frequency band and the entire conductive core line (12) is operable at a second frequency. A fixing element (40) fixes the helical antenna (30) and the whip antenna (10) to the radio terminal (60). The fixing element (40) has an upper end connected to a lower end of the helical antenna (30) and a through hold via which the whip antenna (10) is inserted into an interior of the radio terminal (60).

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(71) Applicant: SAMSUNG ELECTRONICS CO., LTD. [KR/KR]; 416, Maetan-dong, Paldal-gu, Suwon-shi, Kyungki-do 442-370 (KR).

(72) Inventors: HA, Dong, In; 1030-6, Pangbae-dong, Socho-gu, Seoul 137-060 (KR). SEO, Ho, Soo; 177, Jungni-dong, Ichon-shi, Kyonggi-do 467-800 (KR). KIM, Seong, Joong; 298-1, Tonong-dong, Namyangju-shi, Kyonggi-do 472-100 (KR). GOUDELEV, Alexandre; Samsung 1-cha Apt. #5-1112, Maetan-dong, Paltal-gu, Suwon-shi, Kyonggi-do 442-370 (KR). KRYLOV, Konstantin; Samsung 1-cha Apt. #6-801, Maetan-dong, Paltal-gu, Suwon-shi, Kyonggi-do 442-370 (KR).

(74) Agent: LEE, Keon, Joo; Mihwa Building, 110-2, Myongryun-dong, 4-Ga, Chongro-gu, Seoul 110-524 (KR).

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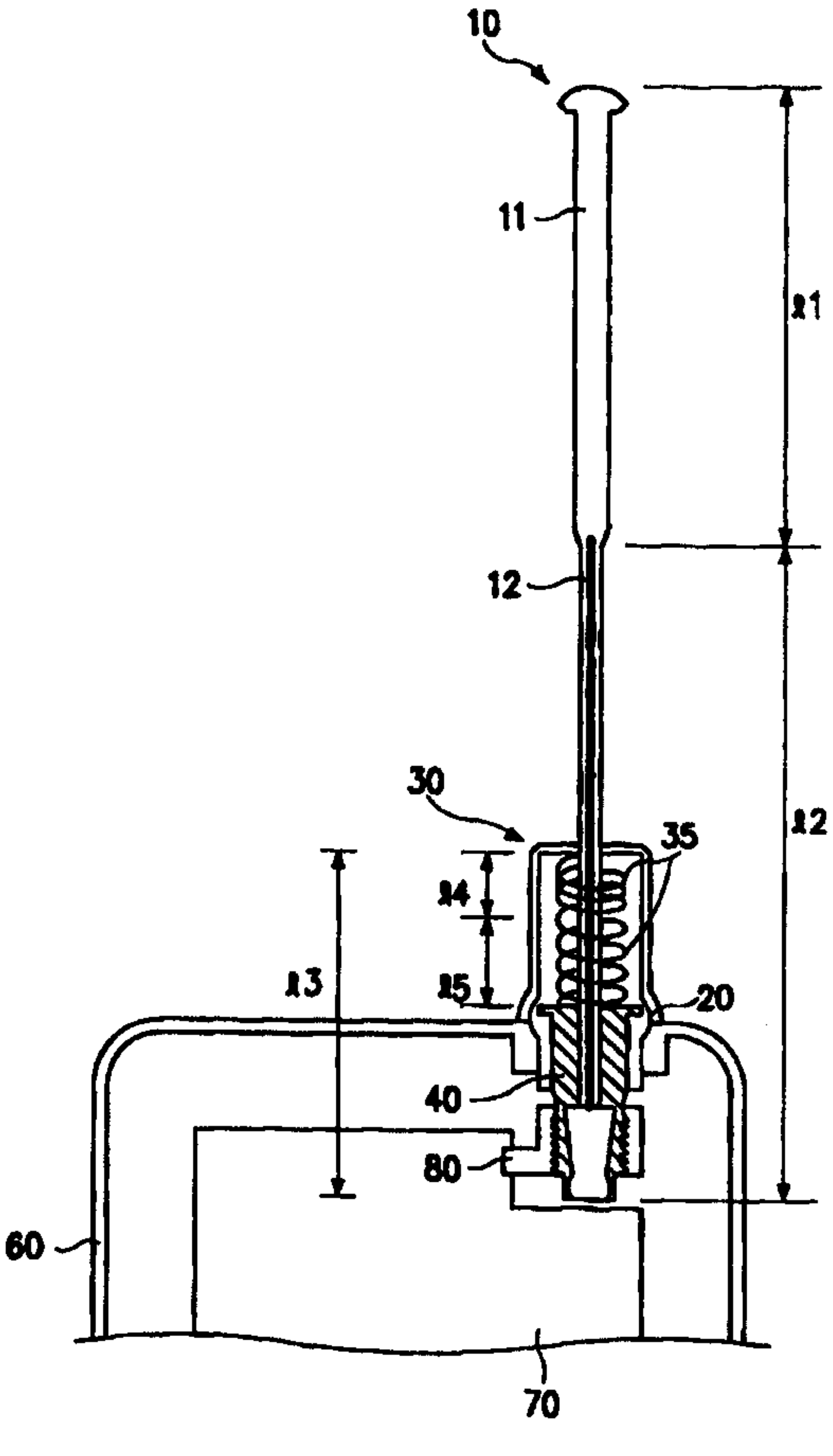
(57) Abstract

A dual band antenna for a radio terminal consists of a retractable whip antenna (10) and a helical antenna (30) with irregular pitches, wherein the whip antenna (10) is independent of the helical antenna (30). The helical antenna (30) includes first and second helical portions (35) having first and second pitches, respectively and the first and second helical portions (35) are operable at different frequency bands independently. The whip antenna (10) includes a conductive core line (12), a conductive substance (13) covering a first portion of the conductive core line (12) to serve as a choke and an isolation element extending from an upper end of the conductive core line (12), for filling a gap between the conductive core line (12) and the conductive substance (13). Here, only the first portion of the conductive core line is operable at a first frequency band and the entire conductive core line (12) is operable at a second frequency. A fixing element (40) fixes the helical antenna (30) and the whip antenna (10) to the radio terminal (60). The fixing element (40) has an upper end connected to a lower end of the helical antenna (30) and a through hold via which the whip antenna (10) is inserted into an interior of the radio terminal (60).



DUAL BAND ANTENNA FOR RADIO TERMINAL

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a dual band antenna for a radio terminal capable of efficient operation at two different frequency bands.

2. Description of the Related Art

In general, to implement a dual band antenna using a single antenna, an additional element such as a choke is required for enabling respective parts of the antenna to independently operate at different frequencies. U.S. Patent Nos. 3,139,620 and 4,509,056 disclose an antenna employing a choke, to permit operation at multiple frequencies.

U.S. Patent No. 4,509,056 (the '056 patent) discloses a multi-frequency antenna employing tuned sleeve chokes. FIG. 1 of the '056 patent illustrates a cross sectional view of a monopole antenna operating at dual frequencies. This antenna is suitable for a radio terminal in which the frequency is not isolated by harmonics and the frequency ratio is greater than 1.25. As illustrated, the antenna is composed of a common monopole antenna, a coaxial transmission line having an open end, a shorted end, and a ground plane.

In FIG. 1, a coaxial transmission line choke 12i is formed at the middle of the antenna and has an electrical length $\lambda/4$ at the higher frequency band of the dual frequency band. At the higher frequency band, the $\lambda/4$ sleeve choke 12i forms a very high impedance between the open end and an extension element 100 of the coaxial feed line, thereby preventing coupling therebetween. Accordingly, at the higher frequency band, only the portion represented by *l* illustrated in FIG.2 functions as the antenna. However, at the lower frequency band, the sleeve choke 12i does not serve as an isolation element so that the entire portion represented by P functions as a monopole antenna.

A drawback associated with the conventional dual band antenna employing a choke is that it is both complicated and large, as compared with a single band antenna. Further, the large antenna may be easily damaged by a trivial impact. In addition, the conventional fixed (i.e., irretractable) antenna may inconvenience a user in carrying the radio terminal.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a dual band antenna for a radio terminal, consisting of a retractable whip antenna and a helical antenna with irregular pitches, wherein the whip antenna is independent of the helical antenna.

To achieve the above object, there is provided a dual band antenna for a radio terminal, including a helical antenna having first and second helical portions having first and second pitches. The first and second helical portions being independently operable at different frequency bands. The dual band antenna further includes a whip antenna including a conductive core line, a conductive substance covering a first portion of the conductive core line to serve as a choke and an isolation element extending from an upper end of the conductive core line, for filling a gap between the conductive core line and the conductive substance, wherein only the first portion of the conductive core line is operable at a first frequency band and the entire conductive core line is operable at a second frequency; and a fixing element for fixing the helical antenna and the whip antenna to the radio terminal, wherein the fixing element has an upper end connected to a lower end of the helical antenna and a through hold via which the whip antenna is inserted into an interior of the radio terminal. Here, the first pitch of the first helical portion is narrower than the second pitch of the second helical portion.

A feature of the present invention is that when the whip antenna is retracted into the radio terminal, only the helical antenna is operable and the isolation element of the whip antenna is located in the through hole of the fixing element, so as to decouple the whip antenna from the helical antenna.

A ratio of the first frequency band to the second frequency band is controlled by adjusting the number of turns of a coil constituting the helical antenna, while the first and second pitches of the first and second helical portions are fixed to specified values.

Further, the fixing element has screwed teeth formed at a lower, outer wall for fixing the fixing element to the radio terminal.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present invention will become more apparent from the following detailed description when taken in conjunction with the accompanying drawings in which like reference numerals indicate like parts. In the drawings:

FIG. 1 is a cross sectional view illustrating a monopole antenna capable of operating at dual frequencies in accordance with the prior art;

FIG. 2 is a cross sectional view illustrating a dual band antenna consisting of a retractable whip antenna extended from a radio terminal and a helical antenna according to an embodiment of the present invention;

FIG. 3 is a cross sectional view illustrating the dual band antenna consisting of the retractable whip antenna retracted into a radio terminal and the helical antenna according to an embodiment of the present invention;

FIG. 4A is a diagram depicting a whip antenna to illustrate a periodic characteristic of the resonant frequency;

FIG. 4B is a diagram illustrating an impedance characteristic of the whip antenna in view of a frequency axis shown in FIG. 4A;

FIG. 5A is a diagram illustrating a common helical antenna with regular pitches in accordance with the prior art;

FIG. 5B is a Smith chart showing impedances at a frequency band including two resonant frequencies of the helical antenna shown in FIG. 5A;

FIG. 6A is a diagram illustrating a helical antenna with irregular pitches according to an embodiment of the present invention;

FIG. 6B is a Smith chart showing impedances at a frequency band including two resonant frequencies of the helical antenna shown in FIG. 6A;

FIG. 7 is a diagram illustrating the impedance characteristic of the helical antenna according to a change in the number of turns of a coil (35) at a first helical portion (*l*6) having a first pitch;

FIG. 8 is a diagram illustrating the impedance characteristic of the helical antenna according to a change in the number of turns of the coil at a second helical portion (*l*5) having a second pitch;

FIG. 9 is a diagram illustrating the impedance characteristic of the dual band antenna consisting of the whip antenna and the helical antenna;

FIG. 10 is a diagram illustrating a radiation characteristic of the dual band antenna at an AMPS (Advanced Mobile Phone Service) band according to one embodiment of the present invention;

FIG. 11 is a diagram illustrating the radiation characteristic of the dual band antenna at a US PCS (Personal Communication Service) band according to one embodiment of the present invention;

FIG. 12 is a cross sectional view illustrating a dual band antenna consisting of a retractable whip antenna and a helical antenna according to another embodiment of the present invention, wherein the whip antenna is extended from the radio terminal according to another embodiment of the present invention;

FIG. 13 is a diagram illustrating a VSWR (Voltage Standing Wave Ratio) of the whip antenna when the dual band antenna is not matched in an extended state according to another embodiment of the present invention;

FIG. 14 is a Smith chart showing a reflection coefficient of the whip antenna when the dual band antenna is not matched in the extended state according to another embodiment of the present invention;

FIG. 15 is a diagram illustrating a VSWR of the whip antenna when the dual band antenna is matched in the extended state;

FIG. 16 is a Smith chart showing a reflection coefficient of the whip antenna when the dual band antenna is matched in the extended state; and

FIG. 17 is a cross sectional view illustrating the dual band antenna consisting of the retractable whip antenna and the helical antenna according to another embodiment of the present invention, wherein the whip antenna is retracted into the radio terminal.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A preferred embodiment of the present invention will be described hereinbelow with reference to the accompanying drawings. In the following description, well known functions or constructions are not described in detail since they would obscure the invention in unnecessary detail.

A dual band antenna constructed in accordance with the present invention will be described comprising a whip antenna and a helical antenna, wherein the whip antenna is retractable into a radio terminal.

In a retracted state (See FIGs. 3 and 17), the whip antenna is completely retracted into the radio terminal and only the relatively short helical antenna is protruded on the radio terminal. In this state, only the helical antenna is operable. Therefore, in the retracted state, the overall length of the radio terminal becomes short, providing a good external appearance. Further, the whip antenna is protected from external impact. The whip antenna used in the present invention comprises two separate embodiments.

In a first embodiment, the whip antenna employs a choke structure which is widely used for dual band antennas. The choke structure of the whip antenna is comprised of a conductive substance covering a conductive core line (See FIG. 2). In a second embodiment, the whip antenna uses a simple matching circuit instead of the choke, to implement the dual band antenna (See FIG. 12).

With reference to the retracted state of the antenna, only the helical antenna portion of the dual-band antenna is operational. That is, the whip antenna is non-functional in the retracted state. Unlike the conventional dual band antenna, this helical antenna can operate independently at two different frequencies by simply adjusting the pitches of a helical coil without using an additional frequency isolation element. Such capability permits the dual band antenna of the present invention to be small in size and simple in structure.

FIG. 2 illustrates the dual band antenna assembled in a radio terminal (e.g., mobile telephone), wherein a retractable whip antenna 10 is extended from the radio terminal to extend an effective electrical length of the antenna, thereby improving a radiation characteristic. The whip antenna 10 is composed of a conductive core line 12, a conductive substance 13 covering a first portion of the conductive core line 12 to serve as a choke, and an isolation element 11 for filling a gap between the conductive core line 12 and the conductive substance 13. The isolation element 11 extends from an upper end of the conductive core line 12 to a specified extent. In the whip antenna 10, only the first portion of the conductive core line 12 serves as the antenna at one frequency band and the entire conductive core line 12 serves as the antenna at another frequency band.

A helical antenna 30 is composed of first and second helical portions *l4* and *l5* having different pitches, formed by winding a coil 35, and an isolation tube 20 for protecting the first and second helical portions *l4* and *l5*. With this structure, the helical antenna 30 can operate at two independent frequency bands by simply adjusting the pitches of the coil 35 instead of using the additional frequency isolation element, with a conventional dual band antenna. A metal fixing element 40 fixes the whip antenna 10 and the helical antenna 30 to a chassis 60 of the radio terminal. A lower end of the coil 35 constituting the helical antenna 30 is connected to an upper end of the metal fixing element 40. The fixing element 40 has a through hole so that the whip antenna 10 may be inserted into the interior of the radio terminal via the through hole. Further, a lower end of the fixing element 40 is connected to a printed circuit board (PCB) 70 via a feed point 80 for connecting the antenna to a signal source. In addition, the fixing element 40 has screwed teeth formed at a lower, outer wall thereof. Herein, the screwed teeth functions as combining a lower end of the helical antenna 30 with the body of the radio terminal.

In FIG. 2, reference *l1* denotes a length of a portion of the isolation element 11, in which the conductive core line 12 does not exist. Reference *l3* denotes a physical length of the helical antenna 30 including the fixing element 40. Reference *l7* denotes a length of the whip antenna 10, which serves as the antenna at the higher frequency band of the dual frequency bands. Reference *l2* denotes a length of the conductive core line 12 of the whip antenna 10. References *l5* and *l4* denote physical lengths of the second and first helical portions of the helical antenna 30 having different pitches, respectively, wherein the first helical portion *l4* has the narrower pitch than that of the second helical portion *l5*. Reference *l6* denotes a length of a portion of the conductive core line 12, which is not covered with the conductive substance 13. Reference *l8* denotes a length of the first portion of the conductive core line 12, which is covered with the conductive substance 13 to form the choke on the whip antenna 10 and has a length $\lambda/4$ at the higher frequency.

FIG. 3 illustrates the dual band antenna assembled in the radio terminal, wherein the whip antenna 10 is retracted into the radio terminal. The whip antenna 10 is shown completely retracted into the chassis 60 of the radio terminal, while the helical antenna 30 protrudes from the chassis 60. The helical antenna 30 fixed to the chassis 60 is much shorter than the whip antenna 10. When the whip antenna 10 is retracted, only the helical antenna 30 is operable.

FIG. 4A illustrates a simplified whip antenna to illustrate a periodic characteristic of the resonant frequency, and FIG. 4B illustrates an impedance characteristic of the whip antenna in view of a frequency axis shown in FIG. 4A.

In FIG. 4B, a frequency ratio f_A/f_B at points A and B having the lowest resonant frequencies is 3:1. If the radio terminal operates at an exact frequency ratio f_A/f_B of 3:1, it is possible to easily implement the dual band antenna using the characteristic shown in FIG. 4B. However, it is very rare that the dual band antenna will operate exactly at the correct frequency ratio f_A/f_B of 3:1. Therefore, it is impossible to apply this characteristic to the dual band antenna having an unspecified frequency ratio. In the prior art embodiment, illustrated in FIG. 1, a choke is formed at a specified position of the antenna in order to construct an antenna having a resonant characteristic at a desired frequency ratio. To prevent a lowering of the radiation efficiency, the frequency ratio of the two resonant frequencies of the dual band antenna may be adjusted using the choke formed at the middle of the antenna, as shown in FIG. 1. In accordance with the teachings of the present invention, the choke is not required. It is possible to obtain a desired frequency ratio without using the choke by only adjusting the pitch and/or the number of turns of the coil 35 constituting the helical antenna 30.

In the dual band antenna shown in FIGs. 2 and 3, the whip antenna 10 is retractable and independent of the helical antenna 30. Now, a detailed description will be provided wherein in an extended state of the antenna only the whip antenna 10 is operable, and in a retracted state of the antenna only the helical antenna 30 is operable.

Extended State of Whip Antenna

Referring again to FIG. 2, the whip antenna 10 is completely extended from the chassis 60 of the radio terminal. In this case, the fixing element 40 is connected to both the whip antenna 10 and the helical antenna 30. However, since the helical antenna 30 is relatively much shorter in physical length than the whip antenna 10 and is in contact with the whip antenna 10, actually, the whip antenna 10 is just operated. This equivalence is disclosed in U.S. Patent No. 5,479,178. Therefore, it is apparent that the dual band antenna is approximately equivalent to the whip antenna 10 when the whip antenna is in the extended state.

Since the helical antenna 30 portion is negligible, the whip antenna 10 and the fixing element 40 are only considered in the extended state of the antenna. Here, the whip antenna 10 can be divided into the conductive core line 12 serving as a radiation substance, the conductive substance 13 and the isolation element 11.

In the preferred embodiment, the choke for the higher frequency band is implemented using a $\lambda/4$ sleeve. The choke is implemented at the portion $l8$ where the conductive core line 12 is covered with the conductive substance 13. Owing to the choke, at the higher frequency band, the portion $l6$ of the whip antenna 10 is not operable and only the portion $l7$ functions as the antenna. In FIG. 2, an impedance seen at a junction 14 of $l7$ and $l6$ towards the feed point 80 is defined as

$$Z_{choke} = jZ_0\tan(2\pi/\lambda_H \times l8) \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$\text{where } Z_0 = 60/\sqrt{\varepsilon_r} \times \mathrm{Ln}(b/a) \ldots\ldots\ldots\ldots\ldots (2)$$

where Z_{choke} is a choke impedance,

λ_H is a wavelength of the higher frequency out of the dual frequencies,

Z_0 is a characteristic impedance of the coaxial line,

$l8$ is the length of conductive substance 13 serving as the choke,

ε_r is a dielectric constant of the dielectric substance used for the coaxial line, a is a diameter of the conductive core line 12 and

b is a diameter of the conductive substance 13.

It is understood from equations (1) and (2) that the choke impedance Z_{choke} is approximately infinite at the higher frequency band, (i.e., when the length *l8* is $\lambda/4$). In this case, the portion *l6* of the whip antenna 10 is decoupled from the portion *l8* so that only the portion *l7* may serve as the antenna at the higher frequency band. On the other hand, at the lower frequency band, the choke impedance Z_{choke} is not high enough to function as an isolation element so that the entire portion *l2* of the whip antenna 10 may serve as the antenna.

Retracted State of Whip Antenna

Referring to FIG. 3, when the whip antenna 10 is completely retracted into the chassis 60 of the radio terminal, the isolation element 11 of the whip antenna 10 is positioned in the helical antenna 30 and the upper end of the conductive core line 12 is located below a lower end of the fixing element 40, so that the fixing element 40 is decoupled from the conductive core line 12 of the whip antenna 10. As a result, only the helical antenna 30 can serve as the antenna. In this case, it can be considered that the antenna of the radio terminal consists of the helical antenna 30 and the fixing element 40 for fixing the helical antenna 30.

FIG. 5A illustrates a prior art helical antenna composed of a coil with a regular pitch, and FIG. 5B is a Smith chart showing the impedances at a frequency band including the two resonant frequency bands of the helical antenna of FIG. 5A. Here, the resonant frequency ratio is about 3:1 and the impedances at the two resonant frequencies are different from each other.

FIG. 6A illustrates the novel helical antenna 30 composed of the coil 35 with irregular pitches, and FIG. 6B is a Smith chart showing the impedances at the two resonant frequency bands of the helical antenna 30 of FIG. 6A. Here, the resonant frequency ratio is approximately 2.2:1 and the impedances at the two resonant frequencies are approximately equal.

It is known that an inductance of the coil is inversely proportional to the pitch. The coil 35 constituting the helical antenna 30 has the first helical portion *l4* and the second helical portion *l5* wherein the pitch of the first helical portion *l4* is narrower than that of the second helical portion *l5*, so that the inductance at the first helical portion *l4* is higher than that of the second helical portion *l5*. Here, the overall inductance of the coil is obtained by $j2\pi fL$. If f and L are high, the overall inductance of the coil 35 increases. Generally, when the inductance increases, a current flowing to the coil decreases. Thus, at a high frequency band, the inductance of the first helical portion L4 is higher than the inductance of the second helical portion L5 and the current flowing to the first helical portion L4 is smaller than the current flowing to the second helical portion L5. Accordingly, at the high frequency band, actually, just the second helical portion L5 functions as an antenna.

Referring to FIG. 6B, the resonant frequencies of the antenna are 1972MHz and 904MHz, respectively. Thus, the resonant frequency ratio is approximately 2.2:1. As previously stated, the resonant frequency ratio of the antenna can be controlled by adjusting the pitches of the first and second helical portions *l4* and *l5*. Table 1 shows the two resonant frequencies f_H and f_L, and its ratio f_H/f_L as a function of the pitch of the first helical portion *l4*. Here, it is assumed that the second helical portion *l5* has the pitch 4.7mm and an inner diameter 3.8mm, and the coil 35 has a diameter 0.4mm.

TABLE 1

Pitch of First Helical Portion		0.6	1.45	1.9	2.5
Resonant Frequency	f_H(MHZ)	2575	2810	2918	2936
	f_L(MHZ)	1237	1211	1169	1124
f_H/f_L		2.08	2.32	2.50	2.61

FIG. 7 illustrates the impedance characteristic of the helical antenna 30 according to a change in the number of turns of the coil 35 at the first helical portion *14* having the first pitch.

Table 2 shows the two resonant frequencies f_H and f_L, and their ratio f_H/f_L as a function of the pitch of the second helical portion *15*. Here, it is assumed that the first helical portion *14* has the pitch 0.6mm and an inner diameter 3.8mm, and the coil 35 has a diameter 0.4mm.

TABLE 2

Pitch of the Second Helical Portion		4.7	5.7	7.6
Resonant Frequency	f_H(MHZ)	2575	2522	2436
	f_L(MHZ)	1237	1233	1201
f_H/f_L		2.080	2.045	2.028

FIG. 8 illustrates the impedance characteristic of the helical antenna according 30 to a change in the number of turns of the coil at the second helical portion *15* having the second pitch.

The resonant frequencies of the antenna, illustrated in Table 3, may also be changed by changing the number of turns of the coil 35 while fixing the pitch to a specified value.

Table 3 shows the two resonant frequencies f_H and f_L, and their ratio f_H/f_L according to the number of turns of the coil 35 at the second helical portion *l5*. Here, it is assumed that the first and second helical portions *l4* and *l5* have the pitches 1.3mm and 5.5mm, respectively and an inner diameter 3.8mm, and the coil 35 has a diameter 0.4mm.

TABLE 3

Turns of Coil at Second Helical Portion		2	2.5	3	5
Resonant Frequency	f_H(MHZ)	2624	2382	2190	1755
	f_L(MHZ)	1183	1134	1086	899
f_H/f_L		2.21	2.10	2.02	1.95

Table 4 shows the two resonant frequencies f_H and f_L, and their ratio f_H/f_L according to the number of turns of the coil 35 at the first helical portion *l4*. Here, it is assumed that the first and second helical portions *l4* and *l5* have the pitches 1.3mm and 5.5mm, respectively and an inner diameter 4.6mm, and the coil 35 has a diameter 0.4mm.

TABLE 4

Turns of Coil at First Helical Portion	4.5	5.5	6.5	9.5

Resonant Frequency	f_H(MHZ)	2624	2418	2233	1790
	f_L(MHZ)	1183	1046	939	729
f_H/f_L		2.21	2.31	2.38	2.46

It is to be appreciated from Tables 3 and 4 that the resonant frequency ratio decreases (i.e., approaches 1) with increasing number of turns at the second helical portion *15*. It is also observed that the resonant frequency increases with increasing number of turns at the first helical portion *14*.

Referring to FIG. 6B, the impedance cycles at the two resonant frequencies are approximately equal to each other. Accordingly, in the helical antenna 30, it is possible to adjust the impedances at the two frequency bands to an approximately identical value without a separate matching circuit, even though the ratio of the two frequencies are not exactly 3:1. As a result, it is possible to obtain a desired dual band antenna by adjusting the pitch and the number of turns of the coil 35.

In the embodiment, the helical antenna 30 has the same impedance characteristic as that of the whip antenna 10. That is, if the whip antenna 10 has the impedance characteristic shown in FIG. 7, the helical antenna 30 should also have the same impedance by adjusting the pitch and the number of turns of the coil 35. In this case, the helical antenna 30 is also matched to a matching circuit used for the whip antenna 10.

In the meantime, a helical antenna having a single pitch has a periodic resonant characteristic. However, since this helical antenna has different impedances at the respective frequencies, it is impossible for the helical antenna to have the same impedance as that of the whip antenna.

FIG. 9 illustrates the impedance characteristics of the dual band antenna mounted on the radio terminal in both the extended state and the retracted state. It is noted that the dual band antenna shows the good matching characteristics at the AMPS (824-894MHz) band and the US PCS (1850-1990MHz) band.

FIG. 10 illustrates a radiation characteristic of the dual band antenna at the AMPS band, and FIG. 11 illustrates the radiation characteristic of the dual band antenna at the US PCS band according to one embodiment of the present invention.

FIG. 12 illustrates a dual band antenna consisting of the retractable whip antenna 10 and the helical antenna 30 according to another embodiment of the present invention, wherein the whip antenna is extended from the radio terminal. As illustrated, the whip antenna 10 is in the form of a wire. In this embodiment, the dual band antenna is implemented using a periodic resonant characteristic of the whip antenna 10, without using the choke. Unlike the whip antenna shown in FIG. 2, the entire portion of the chokeless whip antenna operates at both the higher and lower frequency bands.

The whip antenna 10 is composed of a conductive core line 12 and an isolation element 1 extending from an upper end of the conductive core line 12. The helical antenna 30 has the same structure as that of FIG. 12.

In FIG. 12, reference *l1* denotes a length of a portion of the isolation element 11, in which the conductive core line 12 does not exist. Reference *l2* denotes a length of the conductive core line 12 of the whip antenna 10. Reference *l3* denotes a physical length of the helical antenna 30 including the fixing element 40. References *l4* and *l5* denote physical lengths of the first and second helical portions of the helical antenna 30 having different pitches, respectively, wherein the first helical portion *l4* has the narrower pitch than that of the second helical portion *l5*.

In order to realize the chokeless whip antenna, the resonant frequencies and the length of the whip antenna should be considered. Referring again to FIG. 4A, since the whip antenna 10 has a periodic resonant characteristic at a frequency ratio of 3:1, the length of the whip antenna 10 is properly determined such that one of the resonant frequencies is identical to one of the dual frequencies. Then, the antenna will resonate even at a frequency which is higher or lower than 3 times the selected frequency. In this case, it is possible to shift the periodic resonant frequency to a desired frequency by using a matching circuit (not shown) at the prestage of the antenna. Further, the VSWR of the first selected resonant frequency is rarely affected. As described above, even though the frequency ratio of the dual band frequencies is not exactly 3;1, it is possible to use the whip antenna as a dual band antenna by using the matching circuit. The helical antenna 30 can also use the matching circuit prepared for the whip antenna 10 to implement the dual band antenna characteristic.

FIG. 13 illustrates a VSWR of the whip antenna 10 when the dual band antenna is not matched in an extended state. By way of example, FIG. 13 shows the VSWR pattern in the event that the length of the whip antenna 10 is set to about 3λ/4 of the PCS frequency band out of the AMPS/PCS dual bands.

FIG. 14 is a Smith chart showing a reflection coefficient of the whip antenna 10 when the dual band antenna is not matched in the extended state. FIG. 15 illustrates a VSWR of the whip antenna when the dual band antenna is matched in the extended state. FIG. 16 is a Smith chart showing a reflection coefficient of the whip antenna when the dual band antenna is matched in the extended state. It can be appreciated that the whip antenna 10 shows a desired resonant frequency characteristic at the PCS frequency band even without using a matching element, because it has the length such that resonation frequency is generated at a frequency lower than the AMPS frequency band. In the embodiment, by providing a highpass matching circuit, only the lower resonant frequency is shifted to the AMPS frequency band without affecting the antenna impedance at the PCS frequency band, as shown in FIGs. 15 and 16. In FIGs. 13 and 15, markers 1 and 2 represent the AMPS frequency bands and markers 3 and 4 represent the PCS frequency bands. Additionally, according to the present invention, as at the state of mounting the helical antenna and extending the whip antenna, an antenna impedance is presented, the parasitic elements of the helical antenna and the body are generated. However, it does not matter to the subject matter of the present invention.

FIG. 17 illustrates the dual band antenna consisting of the retractable whip antenna and the helical antenna according to another embodiment of the present invention, wherein the whip antenna is retracted into the radio terminal.

As described above, the dual band antenna is composed of a whip antenna and a helical antenna. The whip antenna is retractable when it is not in use, so that the radio terminal with the novel antenna is convenient to carry and not easily damaged by external impact. Further, it is possible to implement the dual band antenna by simply adjusting the pitch or the number of turns of the coil of the helical antenna, without using the separate matching circuit or the choke.

While the invention has been shown and described with reference to a certain preferred embodiment thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the appended claims.

CLAIMS

WHAT IS CLAIMED IS:

1. A dual band antenna for a radio terminal, comprising:

a helical antenna including first and second helical portions, having first and second pitches, respectively, the first and second helical portions being independently operable at different frequency bands;

a whip antenna including a conductive core line, a conductive substance covering a first portion of the conductive core line to serve as a choke and an isolation element extending from an upper end of the conductive core line, for filling a gap between the conductive core line and the conductive substance, wherein only the first portion of the conductive core line is operable at a first frequency band and the entire conductive core line is operable at a second frequency band; and

a fixing element for fixing the helical antenna and the whip antenna to a radio terminal.

2. The dual band antenna as claimed in claim 1, wherein the fixing element has an upper end connected to a lower end of the helical antenna and a through hole for inserting the whip antenna into an interior of the radio terminal.

3. The dual band antenna as claimed in claim 1, wherein the whip antenna is retractable and extendable with respect to the radio terminal, such that only the helical antenna is operable when the whip antenna is retracted into the radio terminal.

4. The dual band antenna as claimed in claim 1, wherein the first pitch of the first helical portion is narrower than the second pitch of the second helical portion.

5. The dual band antenna as claimed in claim 2, wherein the isolation element of the whip antenna is located in the through hole of the fixing element, when the whip antenna is retracted into the radio terminal, so as to decouple the whip antenna from the helical antenna.

6. The dual band antenna as claimed in claim 1, wherein a ratio of the first frequency band to the second frequency band is controlled by adjusting the number of turns of a coil comprising said first and second helical portions.

7. The dual band antenna as claimed in claim 6, wherein the first and second pitches of the first and second helical portions are adjusted to control the ratio of the first frequency band to the second frequency band.

8. The dual band antenna as claimed in claim 1, wherein the first and second pitches of the first and second helical portions are fixed to specified values.

9. The dual band antenna as claimed in claim 2, wherein the first frequency band is between 1850-1990MHz and the second frequency band is between 824-894MHz.

10. The dual band antenna as claimed in claim 1, wherein the fixing element has screwed teeth formed at a lower, outer wall for fixing the fixing element to the radio terminal.

11. A dual band antenna including a helical antenna for a radio terminal, comprising:

a whip antenna including a conductive core line, a conductive substance covering a first portion of the conductive core line to serve as a choke and an isolation element extending from an upper end of the conductive core line, for filling a gap between the conductive core line and the conductive substance, wherein only the first portion of the conductive core line is operable at a first frequency band and the entire conductive core line is operable at a second frequency band; and

a fixing element for fixing the helical antenna and the whip antenna to the radio terminal, wherein the fixing element has an upper end connected to a lower end of the helical antenna and a through hole for inserting the whip antenna into an interior of the radio terminal.

12. The dual band antenna as claimed in claim 11, wherein the isolation element of the whip antenna is located in the through hole of the fixing element, such that when the whip antenna is retracted into the radio terminal, the whip antenna is decoupled from the helical antenna.

13. The dual band antenna as claimed in claim 11, wherein the first frequency band is between 1850-1990MHz and the second frequency band is between 824-894MHz.

14. The dual band antenna as claimed in claim 11, wherein a length of the first portion of the whip antenna, covered with the conductive substance, is equal to a wavelength $\lambda/4$ at the first frequency band.

15. The dual band antenna as claimed in claim 11, wherein the fixing element has screwed teeth formed at a lower, outer wall for fixing the fixing element to the radio terminal.

16. A dual band antenna for a radio terminal, comprising:

a helical antenna including first and second helical portions having first and second pitches, respectively, the first and second helical portions being independently operable at different frequency bands; and

a fixing element for fixing the helical antenna to the radio terminal.

17. The dual band antenna as claimed in claim 16, wherein the first pitch is narrower than the second pitch.

18. The dual band antenna as claimed in claim 16, wherein the first helical portion is operable at a first frequency band between 1850-1990MHz and the second helical portion is operable at a second frequency band between 824-894MHz.

19. The dual band antenna as claimed in claim 18, wherein a ratio of the first frequency band to the second frequency band is controlled by adjusting the number of turns of a coil constituting the helical antenna.

20. The dual band antenna as claimed in claim 19, wherein the first and second pitches of the first and second helical portions may also be adjusted to control the ratio of the first and second frequency bands.

21. The dual band antenna as claimed in claim 16, wherein the first and second pitches of the first and second helical portions are fixed to specified values.

22. The dual band antenna as claimed in claim 16, further comprising an isolation tube for protecting the helical antenna.

23. The dual band antenna as claimed in claim 16, wherein the fixing element has screwed teeth formed at a lower, outer wall for fixing the fixing element to the radio

terminal.

24. A dual band antenna for a radio terminal, comprising:

a helical antenna including first and second helical portions having first and second pitches, respectively, the first and second helical portions being operable at different frequency bands;

a whip antenna including a conductive core line and an isolation element extending from an upper end of the conductive core line, wherein the whip antenna is operable at the two different frequency bands using a periodic resonant frequency thereof; and

a fixing element for fixing the helical antenna and the whip antenna to the radio terminal, wherein the fixing element has an upper end connected to a lower end of the helical antenna and a through hole via which the whip antenna is inserted into an interior of the radio terminal.

25. The dual band antenna as claimed in claim 24, wherein the whip antenna has a length determined such that one of resonant frequencies detected by the periodic resonant characteristic of the whip antenna is identical to one of the two frequency bands.

26. The dual band antenna as claimed in claim 24, further comprising a matching circuit for adjusting the resonant frequency of the whip antenna.

27. The dual band antenna as claimed in claim 24, wherein the whip antenna is retractable and extendable with respect to the radio terminal, such that only the helical antenna is operable when the whip antenna is retracted into the radio terminal.

28. The dual band antenna as claimed in claim 24, wherein the first pitch of the

first helical portion is narrower than the second pitch of the second helical portion.

29. The dual band antenna as claimed in claim 24, wherein the isolation element of the whip antenna is located in the through hole of the fixing element, when the whip antenna is retracted into the radio terminal so as to decouple the whip antenna from the helical antenna.

30. The dual band antenna as claimed in claim 24, wherein a ratio of a first frequency band to a second frequency band is controlled by adjusting the number of turns of a coil constituting the helical antenna, adjusting the first and second pitches of the first and second helical portions.

31. The dual band antenna as claimed in claim 24, wherein an impedance characteristic of the helical antenna is identical to an impedance characteristic of the whip antenna, so that the whip antenna can shore the matching circuit with the helical antenna.

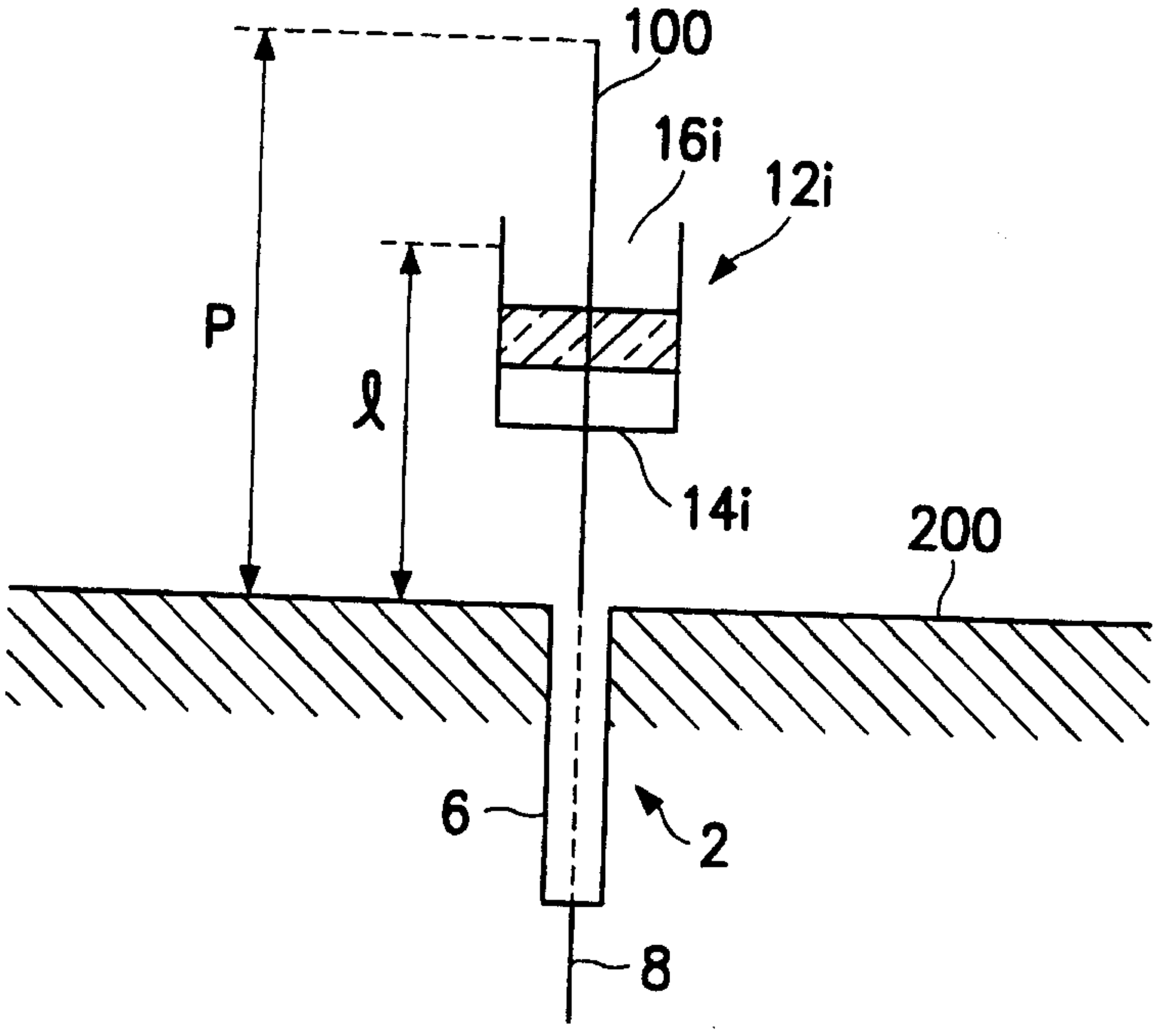


FIG. 1

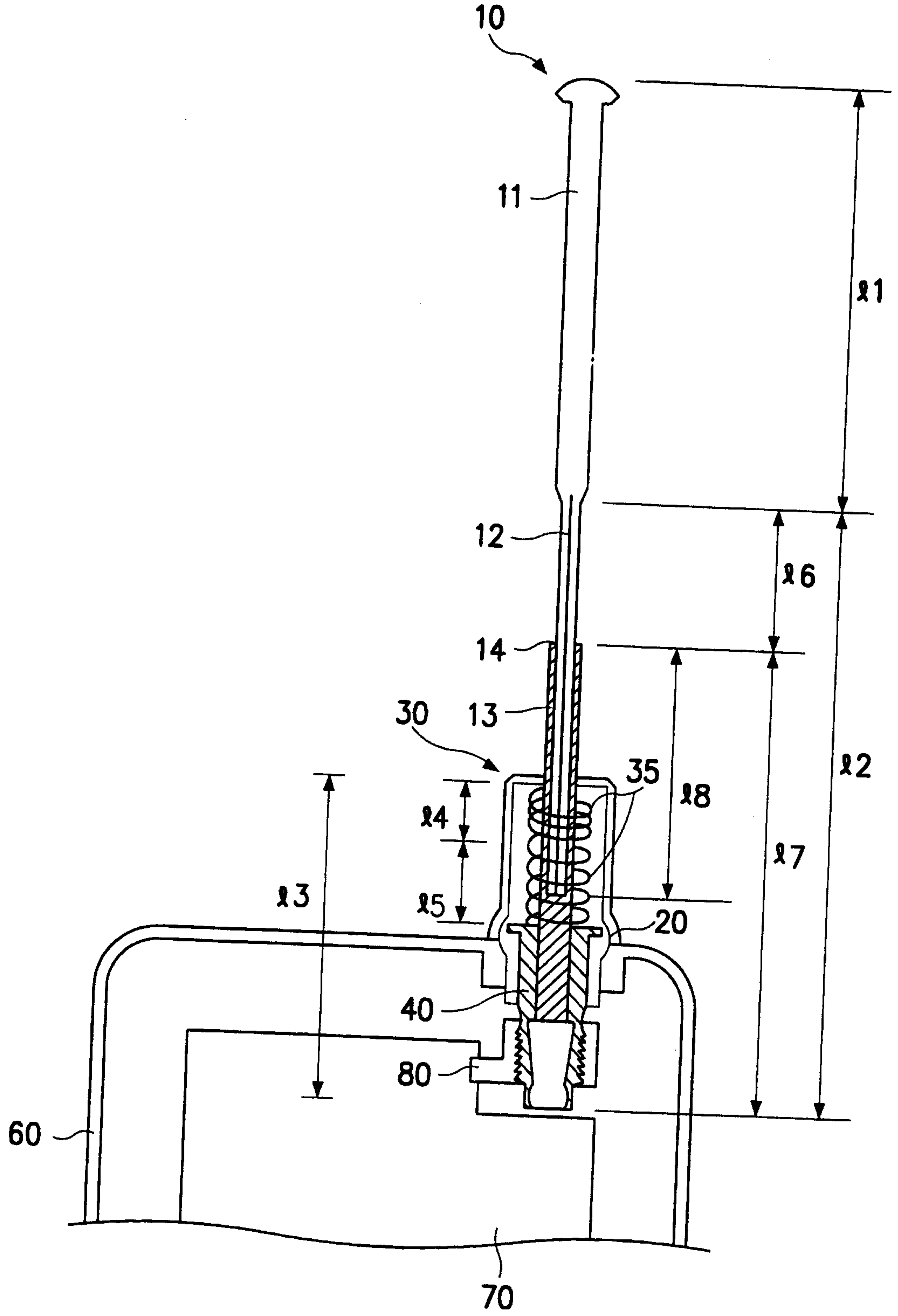


FIG. 2

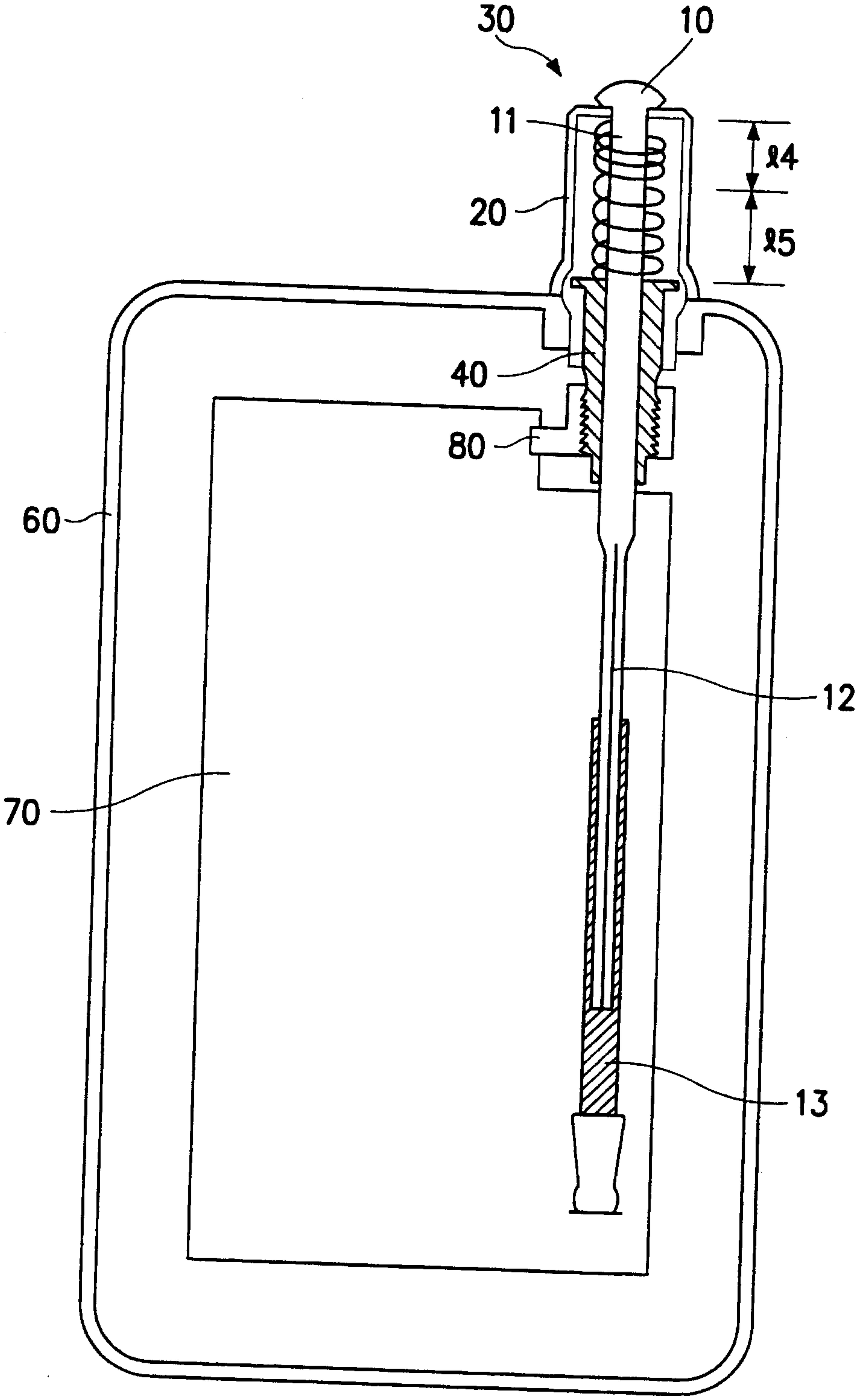


FIG. 3

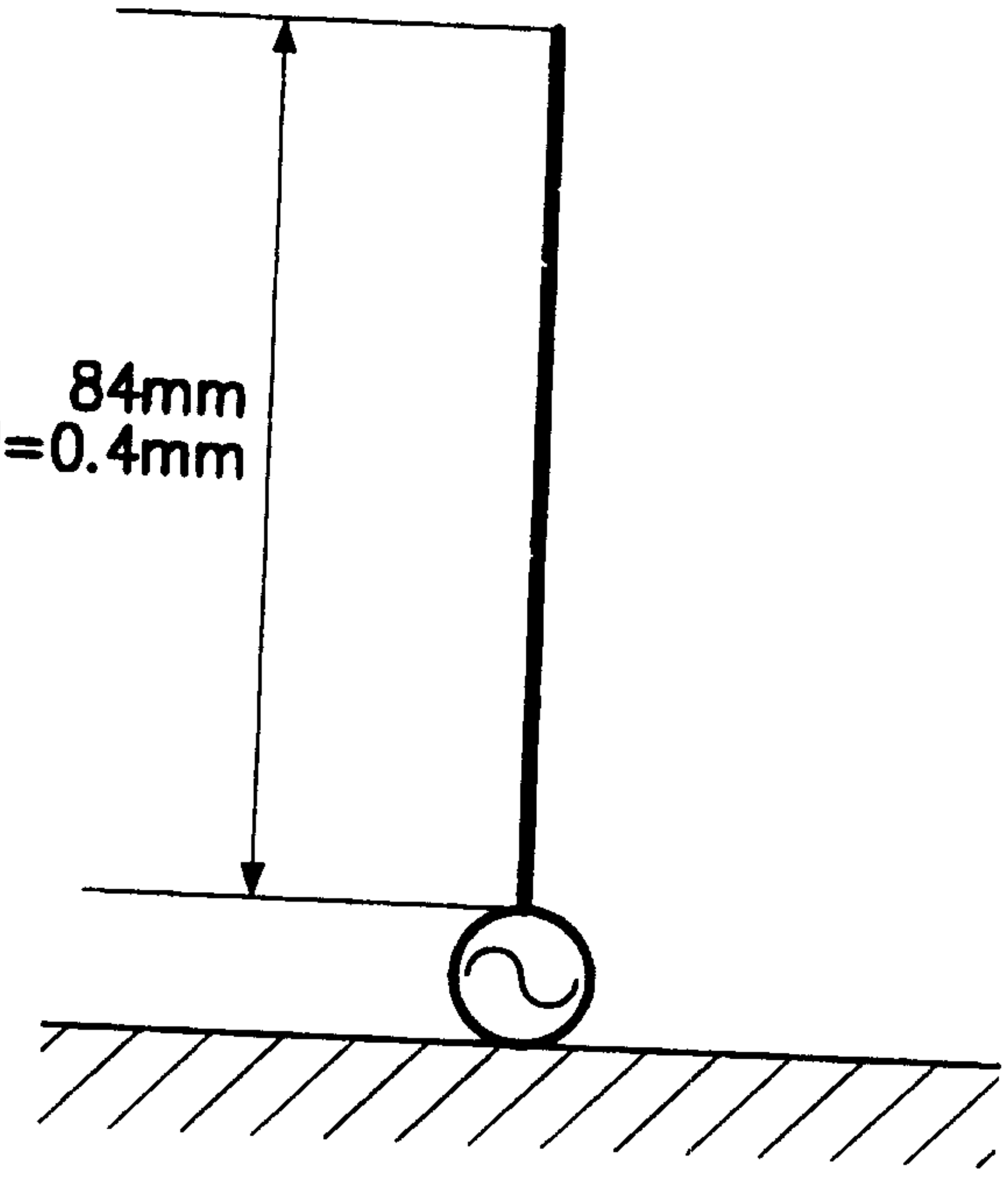


FIG. 4A

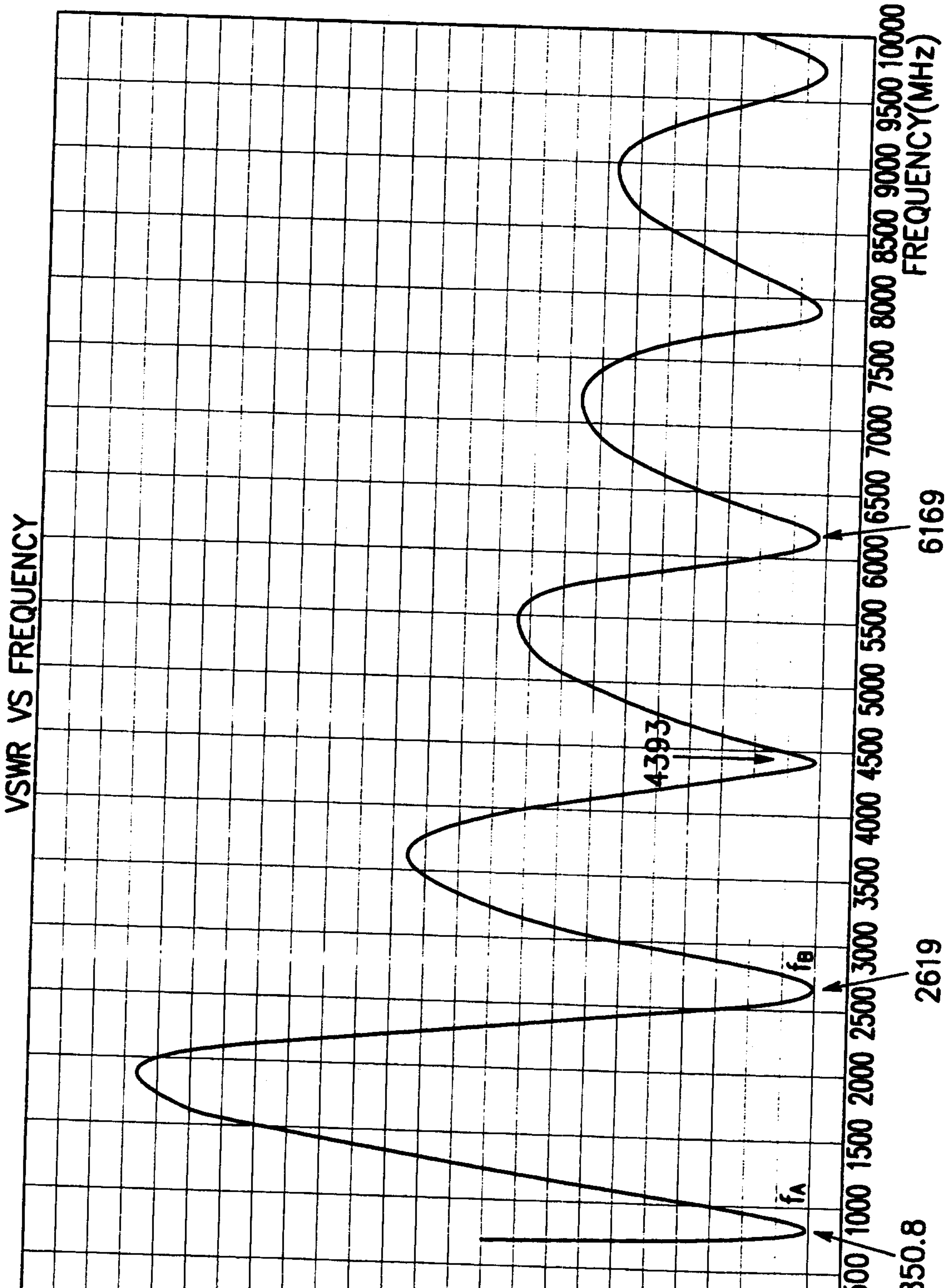

VSWR VS FREQUENCY
VSWR
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
7000
7500
8000
8500
9000
9500
10000
FREQUENCY(MHz)
f_A
850.8
f_B
2619
4393
6169

FIG. 4B

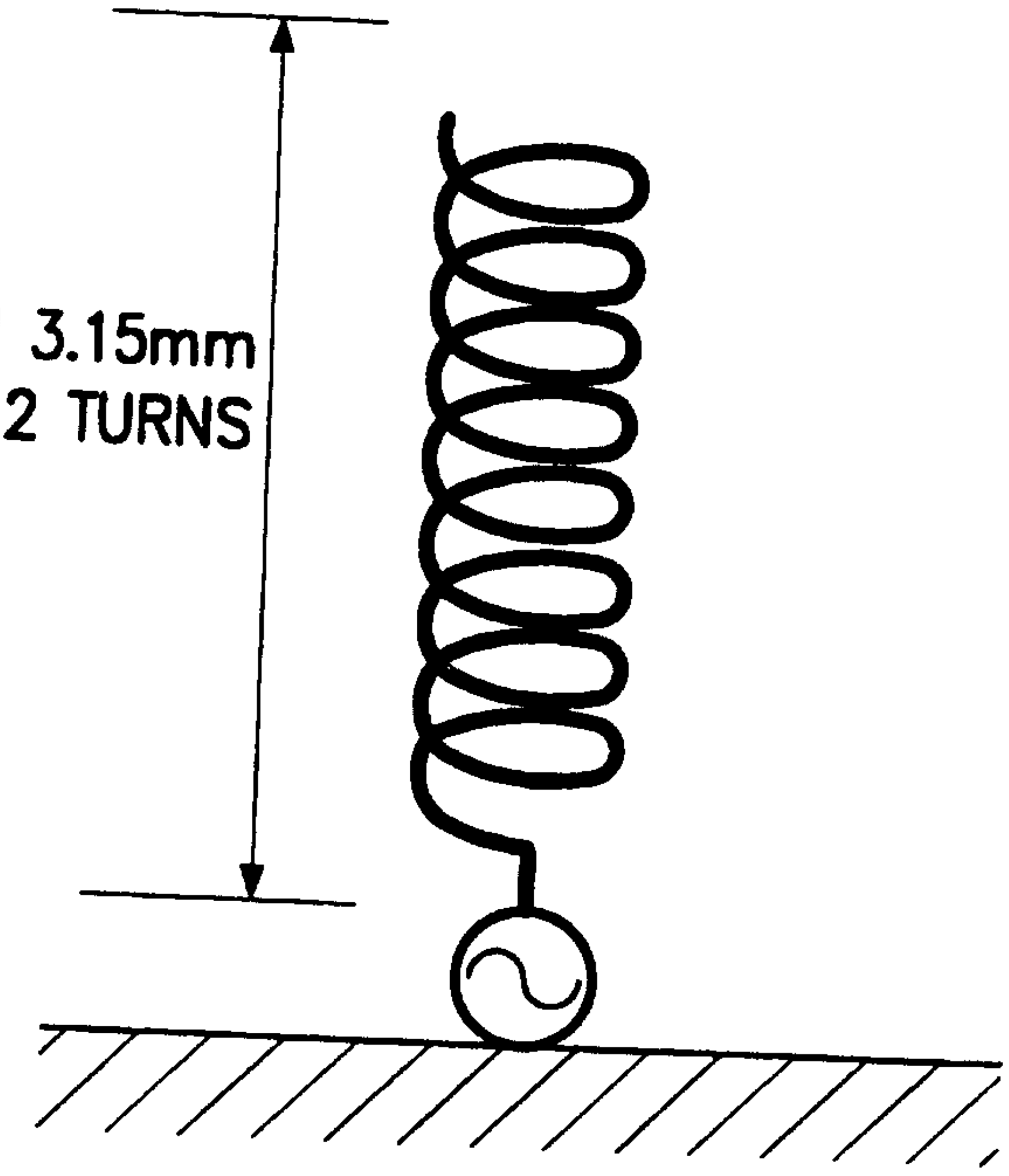


FIG. 5A

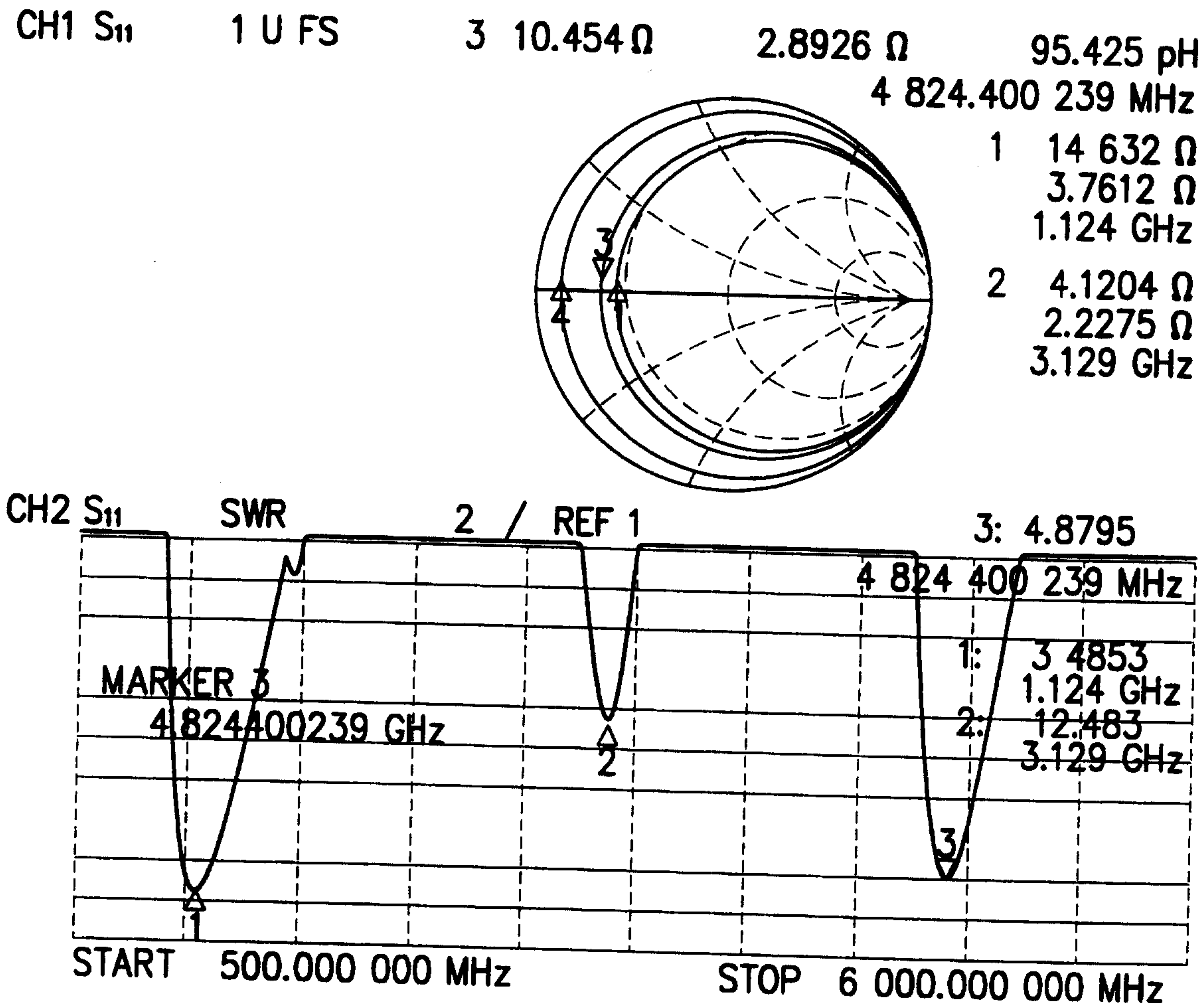

CH1 S11
1 U FS
3 10.454 Ω
2.8926 Ω
95.425 pH
4 824.400 239 MHz
1 14 632 Ω
3.7612 Ω
1.124 GHz
2 4.1204 Ω
2.2275 Ω
3.129 GHz
3
4
1
CH2 S11
SWR
2 / REF 1
3: 4.8795
4 824 400 239 MHz
1: 3 4853
1.124 GHz
2: 12.483
3.129 GHz
MARKER 3
4.824400239 GHz
1
2
3
START 500.000 000 MHz
STOP 6 000.000 000 MHz

FIG. 5B

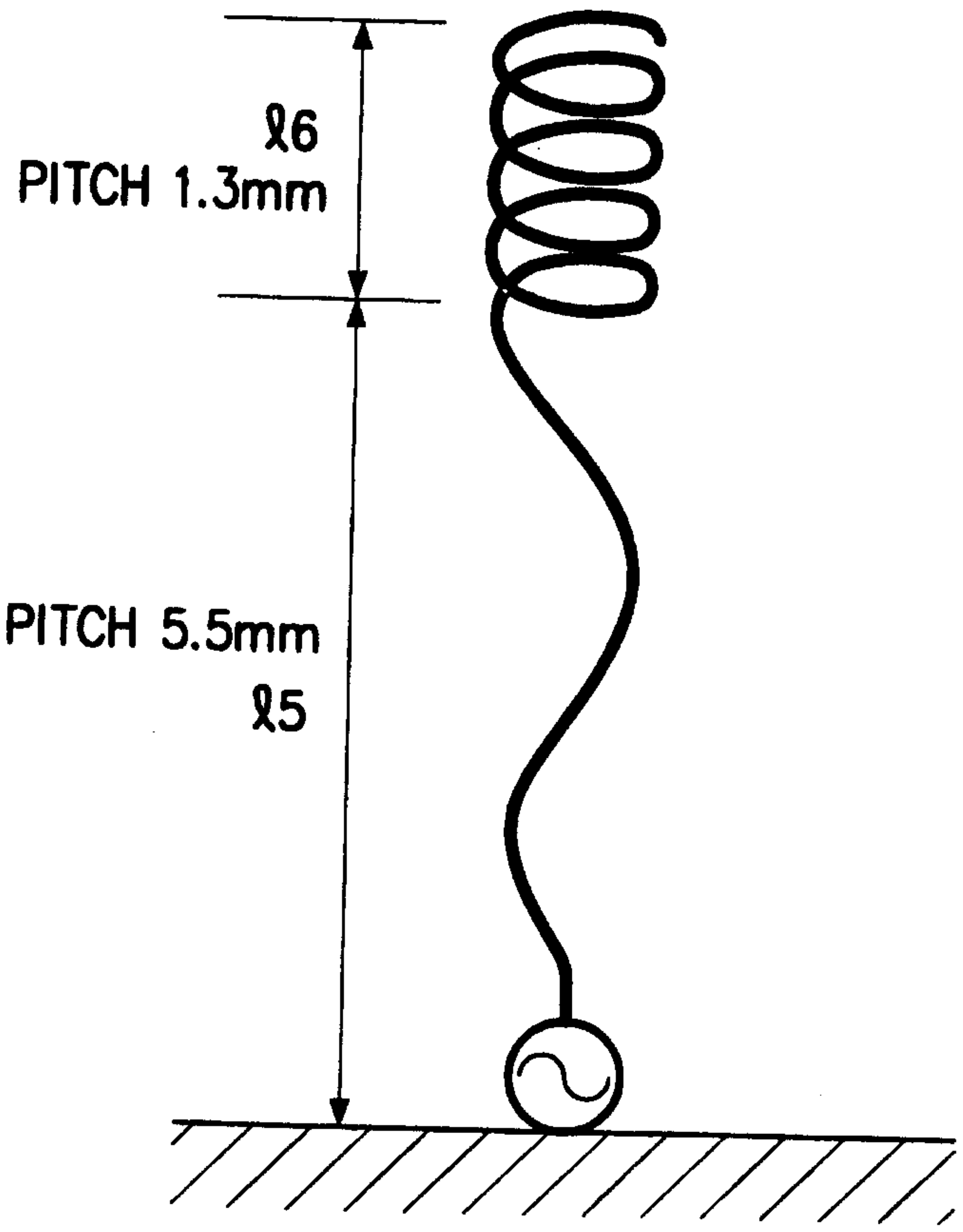


FIG. 6A

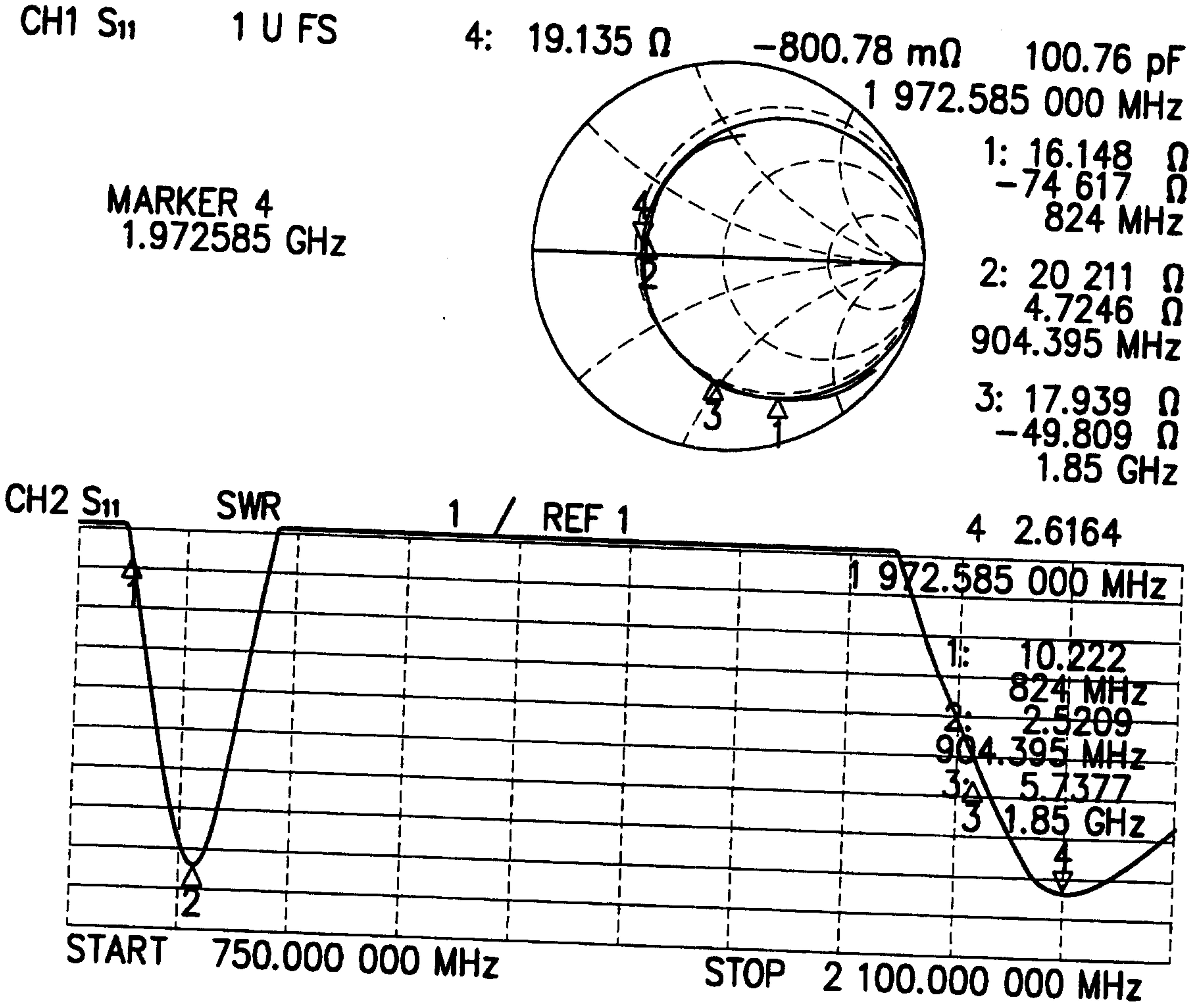

CH1 S11
1 U FS
4: 19.135 Ω
-800.78 mΩ
100.76 pF
1 972.585 000 MHz
MARKER 4
1.972585 GHz
1: 16.148 Ω
-74 617 Ω
824 MHz
2: 20 211 Ω
4.7246 Ω
904.395 MHz
3: 17.939 Ω
-49.809 Ω
1.85 GHz
1
2
3
4
CH2 S11
SWR
1 / REF 1
4 2.6164
1 972.585 000 MHz
1: 10.222
824 MHz
2: 2.5209
904.395 MHz
3: 5.7377
1.85 GHz
START 750.000 000 MHz
STOP 2 100.000 000 MHz

FIG. 6B

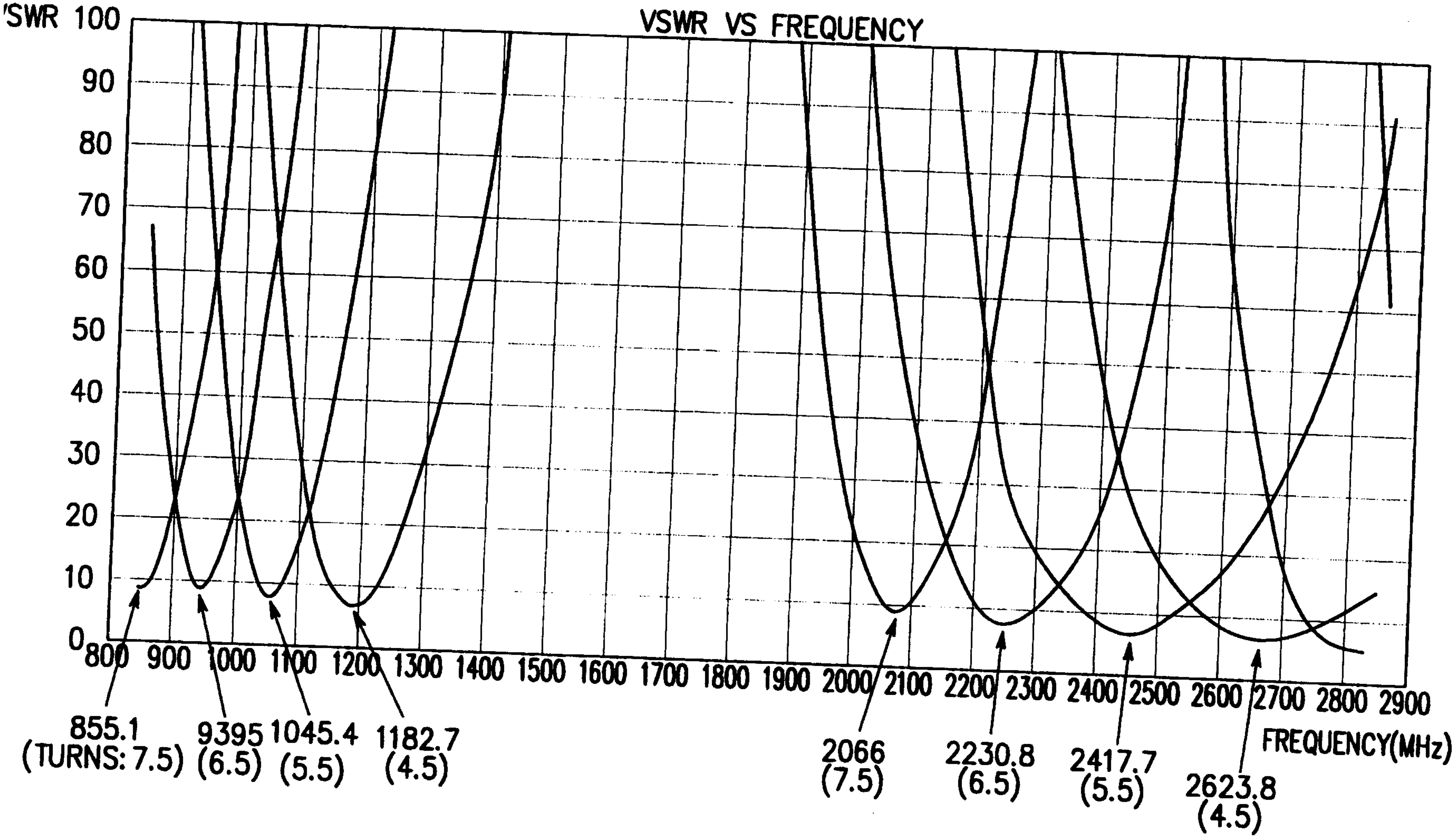

VSWR VS FREQUENCY
'SWR
100
90
80
70
60
50
40
30
20
10
0
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
2500
2600
2700
2800
2900
FREQUENCY(MHz)
855.1
(TURNS: 7.5)
9395
(6.5)
1045.4
(5.5)
1182.7
(4.5)
2066
(7.5)
2230.8
(6.5)
2417.7
(5.5)
2623.8
(4.5)

FIG. 7

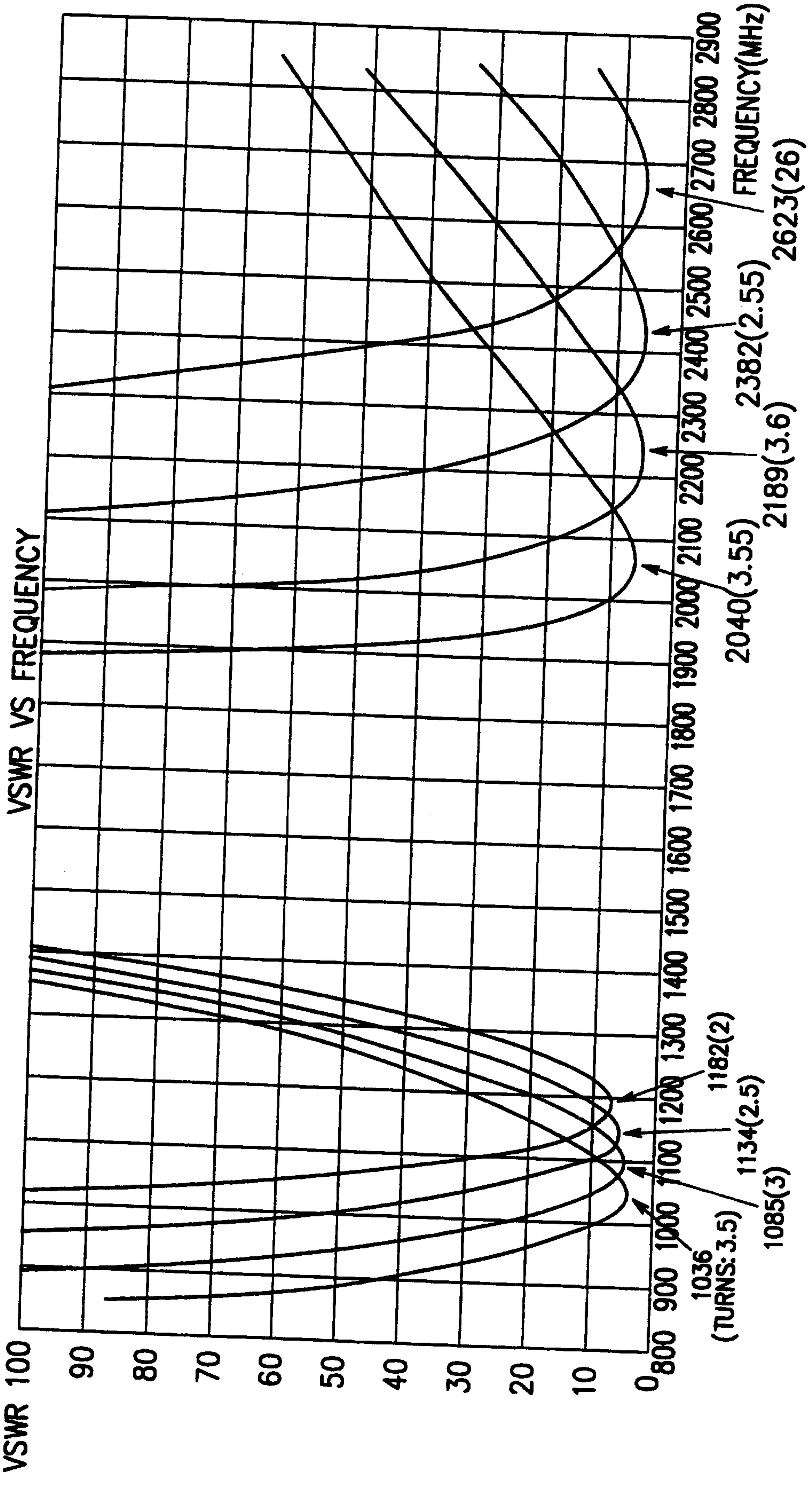

VSWR VS FREQUENCY
VSWR
100
90
80
70
60
50
40
30
20
10
0
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
2500
2600
2700
2800
2900
FREQUENCY(MHz)
1036
(TURNS: 3.5)
1085(3)
1134(2.5)
1182(2)
2040(3.55)
2189(3.6)
2382(2.55)
2623(26)

FIG. 8

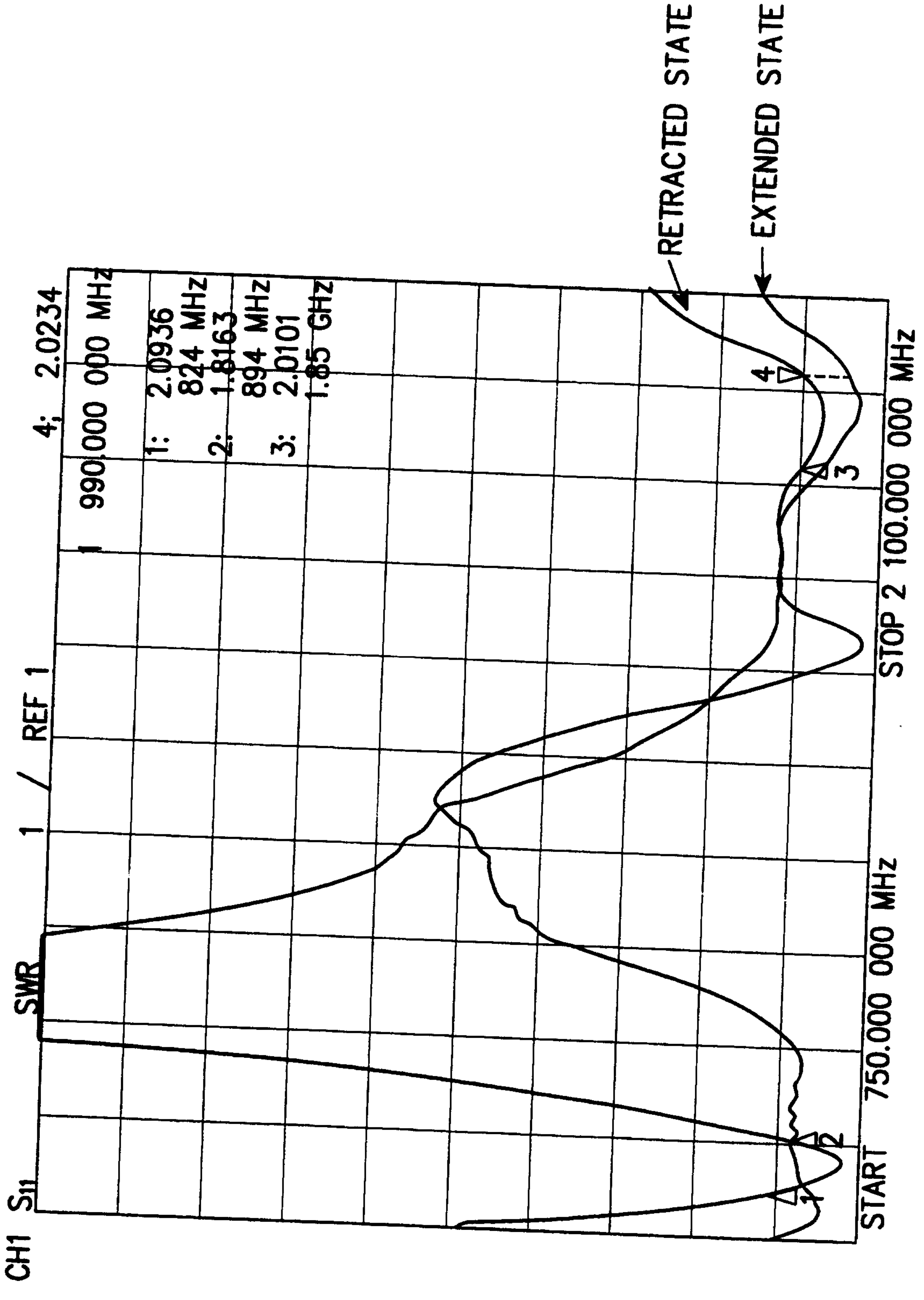

CH1 S11
SWR
1 / REF 1
4; 2.0234
1 990.000 000 MHz
1: 2.0936
824 MHz
2: 1.8163
894 MHz
3: 2.0101
1.85 GHz
RETRACTED STATE
EXTENDED STATE
1
2
3
4
START 750.000 000 MHz
STOP 2 100.000 000 MHz

FIG. 9

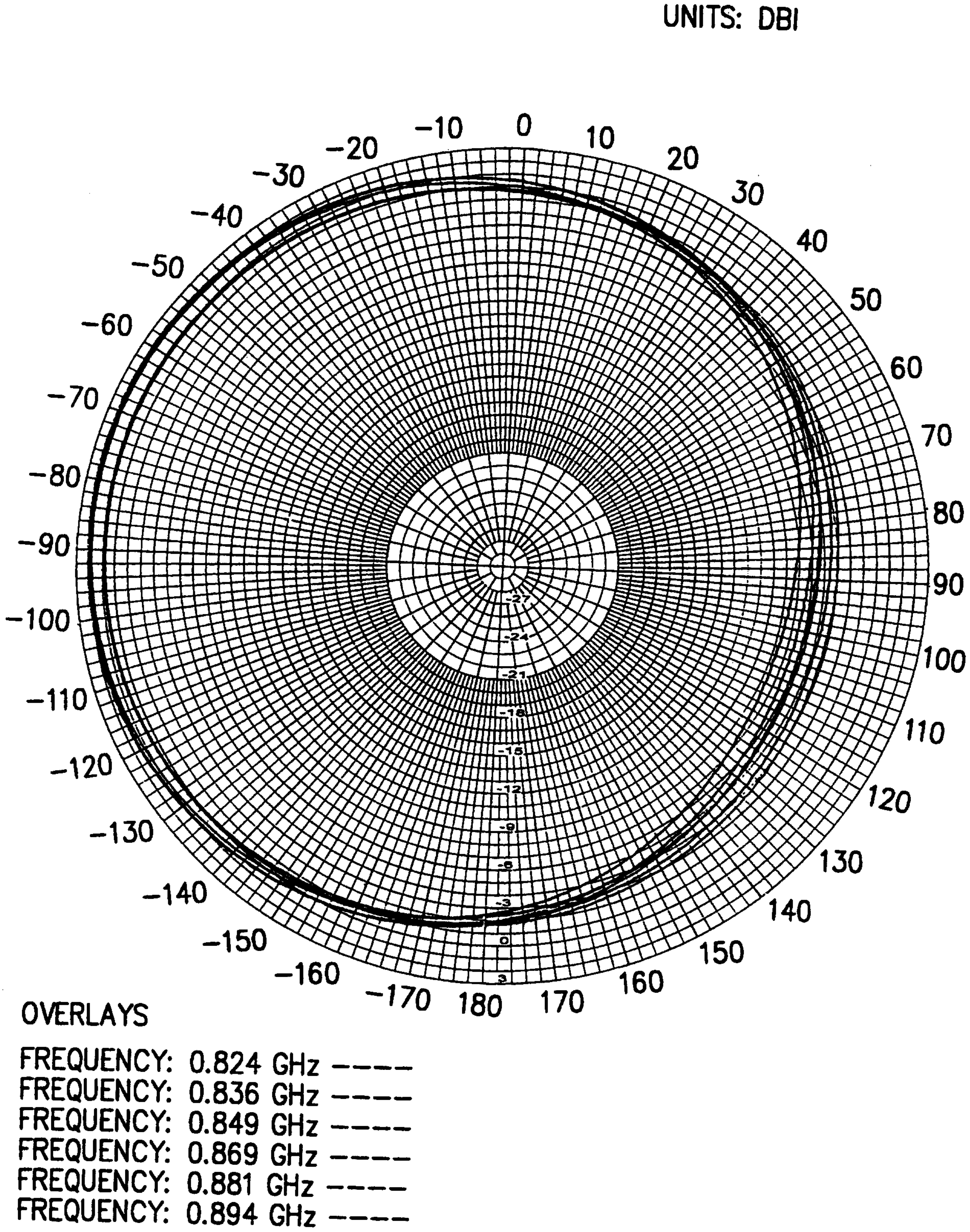

UNITS: DBI
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
-170
-160
-150
-140
-130
-120
-110
-100
-90
-80
-70
-60
-50
-40
-30
-20
-10
-27
-24
-21
-18
-15
-12
-9
-6
-3
0
3
OVERLAYS
FREQUENCY: 0.824 GHz ----
FREQUENCY: 0.836 GHz ----
FREQUENCY: 0.849 GHz ----
FREQUENCY: 0.869 GHz ----
FREQUENCY: 0.881 GHz ----
FREQUENCY: 0.894 GHz ----

FIG. 10

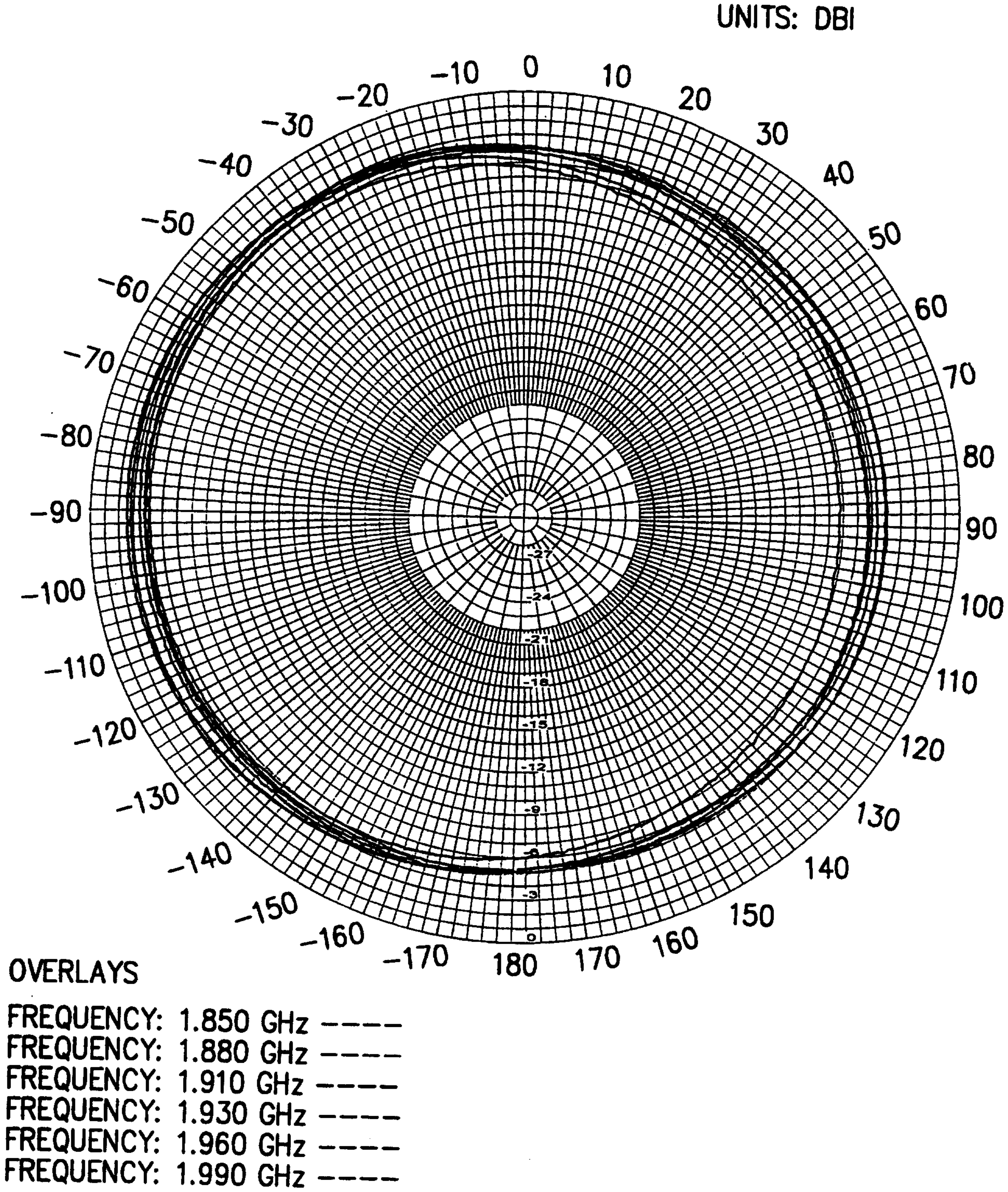

UNITS: DBI
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
-170
-160
-150
-140
-130
-120
-110
-100
-90
-80
-70
-60
-50
-40
-30
-20
-10
-27
-24
-21
-18
-15
-12
-9
-6
-3
0
OVERLAYS
FREQUENCY: 1.850 GHz ----
FREQUENCY: 1.880 GHz ----
FREQUENCY: 1.910 GHz ----
FREQUENCY: 1.930 GHz ----
FREQUENCY: 1.960 GHz ----
FREQUENCY: 1.990 GHz ----

FIG. 11

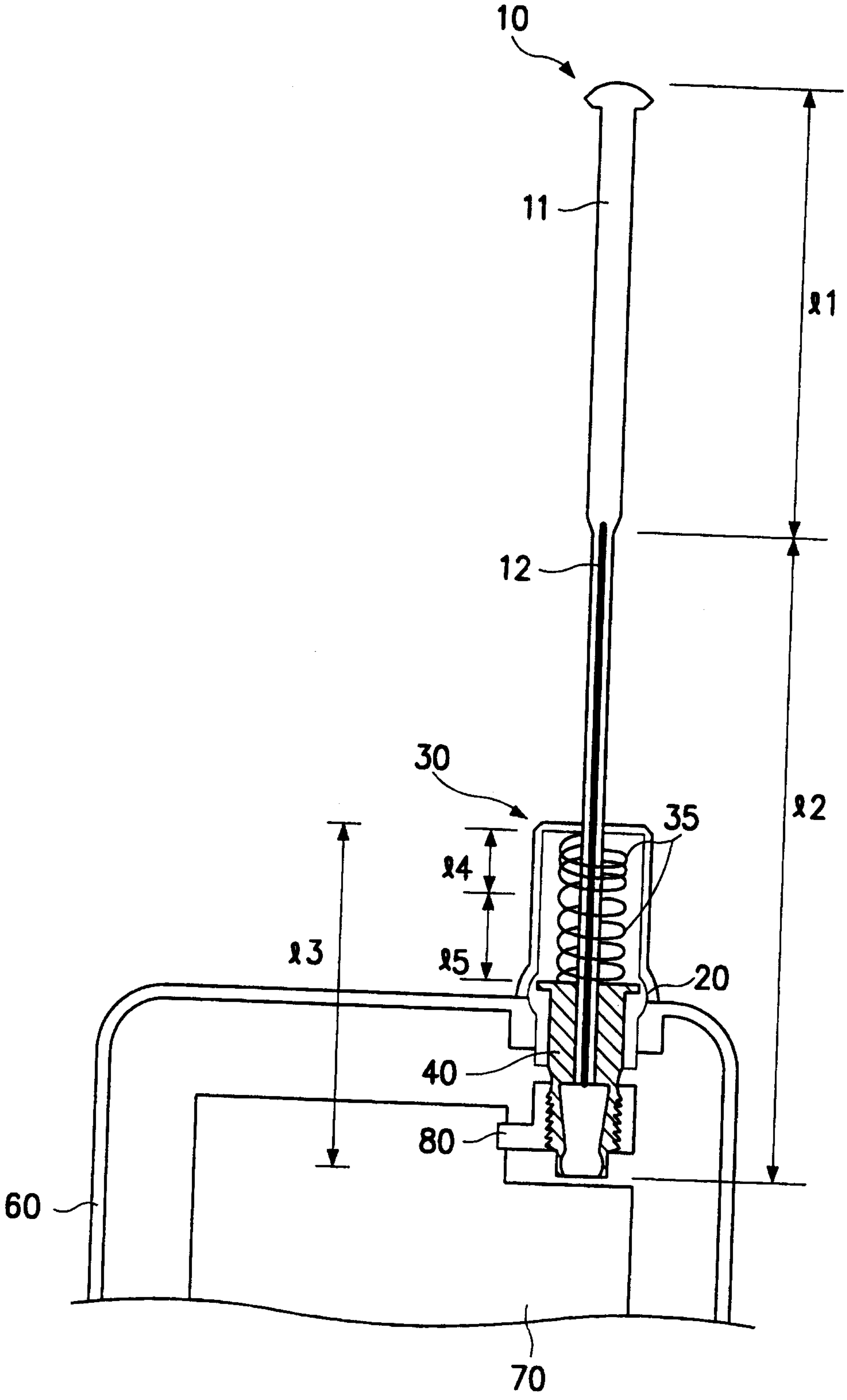


FIG. 12

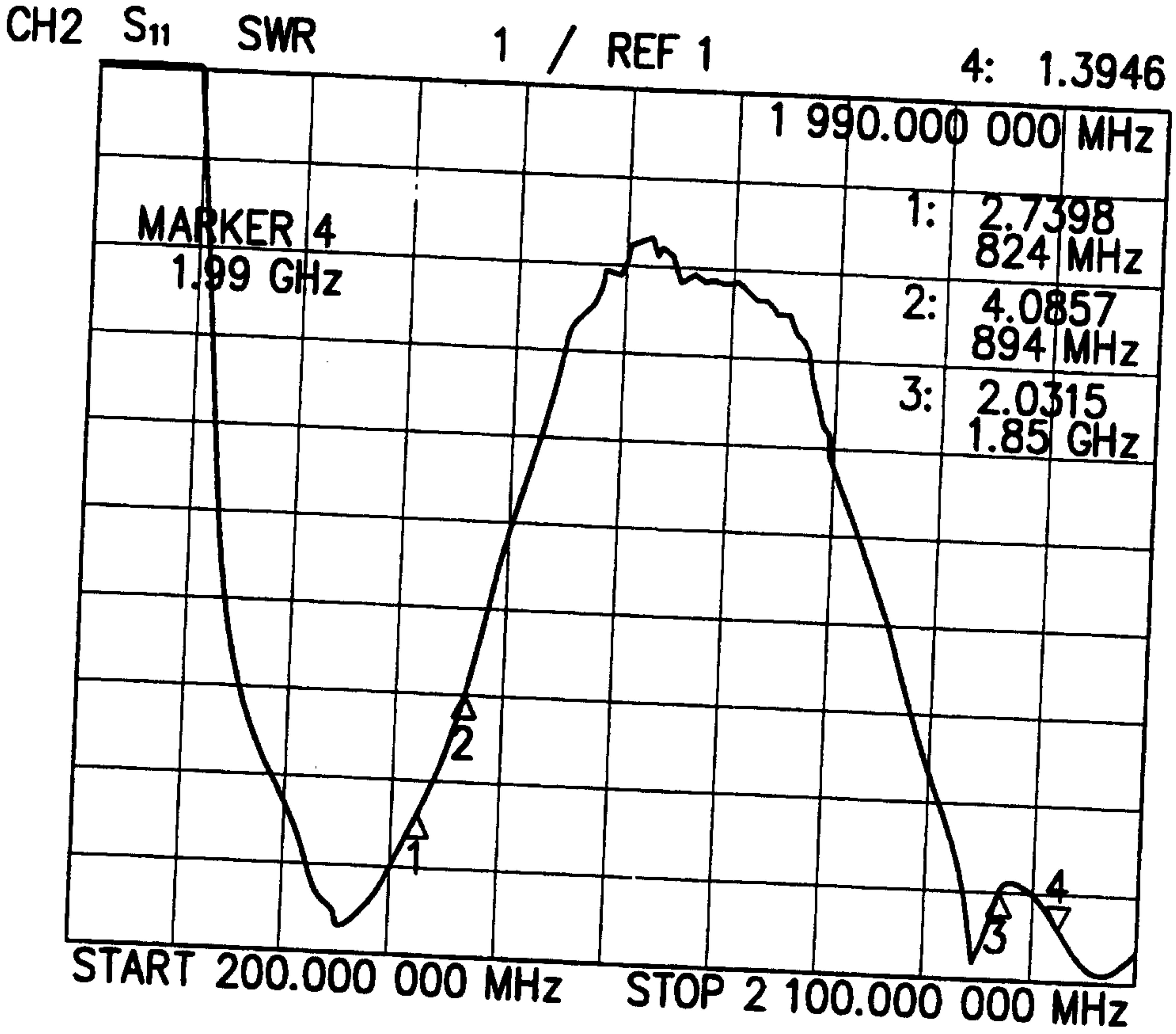

CH2 S11 SWR
1 / REF 1
4: 1.3946
1 990.000 000 MHz
MARKER 4
1.99 GHz
1: 2.7398
824 MHz
2: 4.0857
894 MHz
3: 2.0315
1.85 GHz
1
2
3
4
START 200.000 000 MHz
STOP 2 100.000 000 MHz

FIG. 13

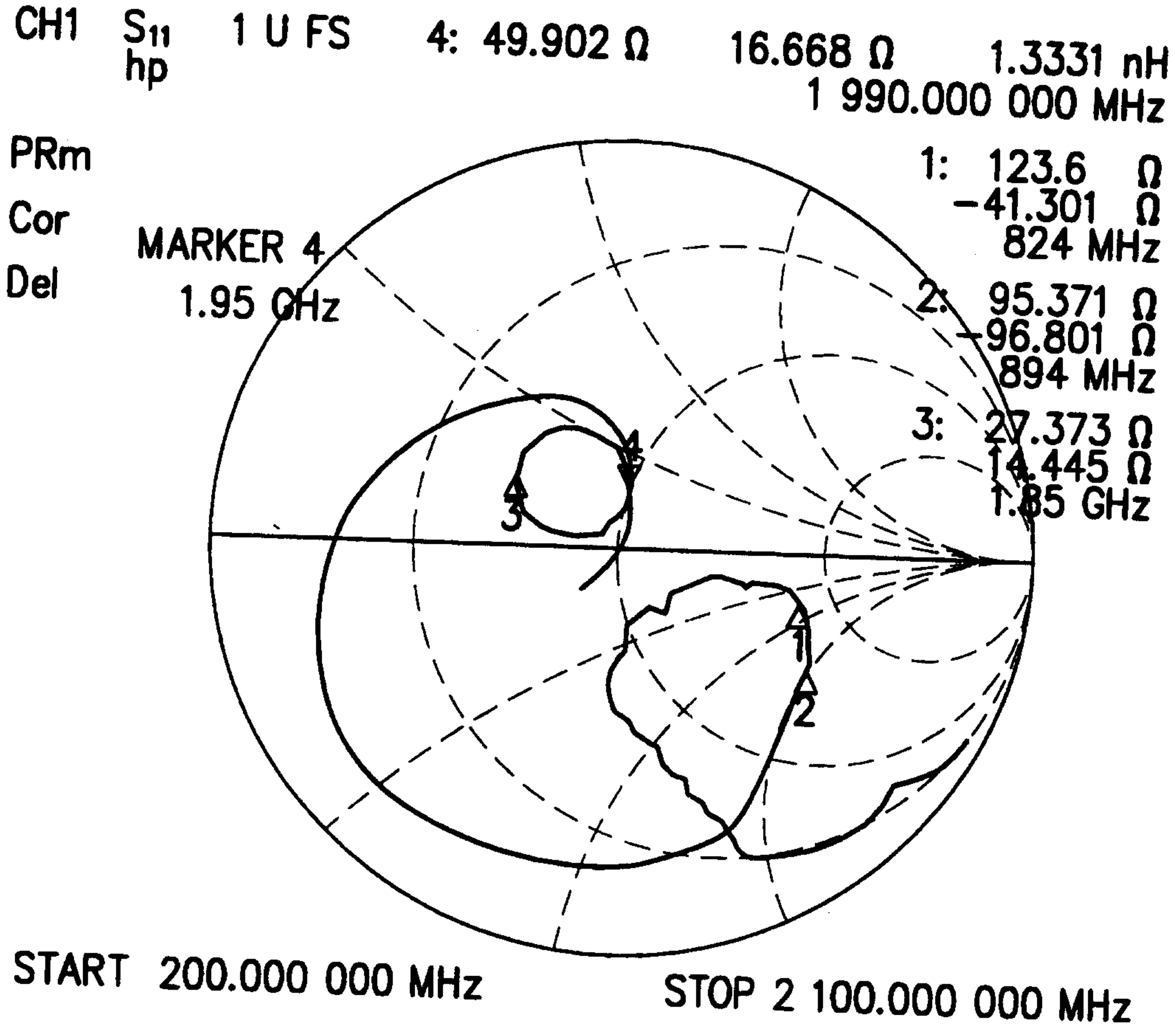

CH1 S11 1 U FS 4: 49.902 Ω 16.668 Ω 1.3331 nH
hp
1 990.000 000 MHz
PRm
Cor
Del
MARKER 4
1.95 GHz
1: 123.6 Ω
-41.301 Ω
824 MHz
2: 95.371 Ω
-96.801 Ω
894 MHz
3: 27.373 Ω
14.445 Ω
1.85 GHz
1
2
3
4
START 200.000 000 MHz
STOP 2 100.000 000 MHz

FIG. 14

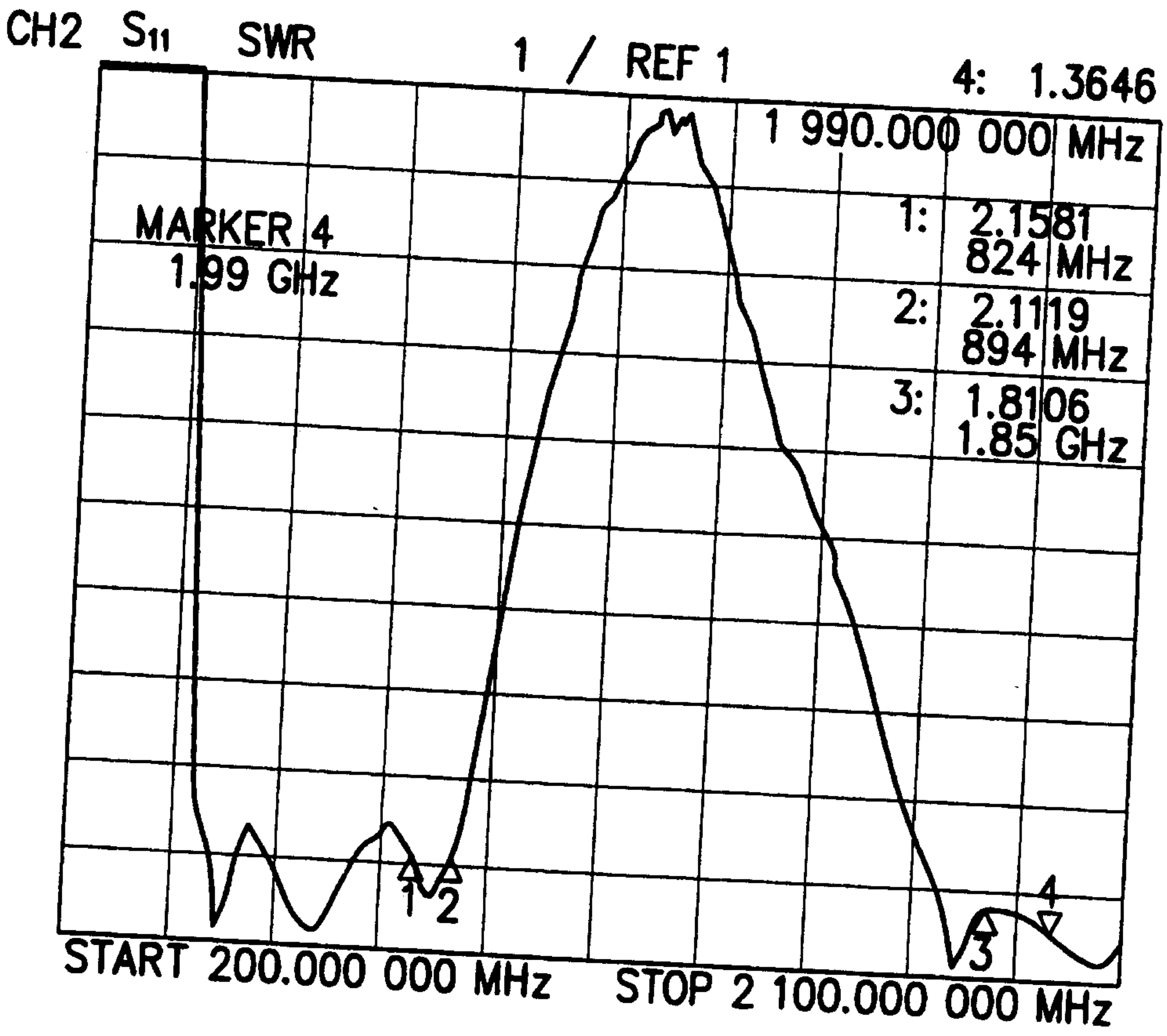

CH2 S11 SWR
1 / REF 1
4: 1.3646
1 990.000 000 MHz
MARKER 4
1.99 GHz
1: 2.1581
824 MHz
2: 2.1119
894 MHz
3: 1.8106
1.85 GHz
1
2
3
4
START 200.000 000 MHz
STOP 2 100.000 000 MHz

FIG. 15

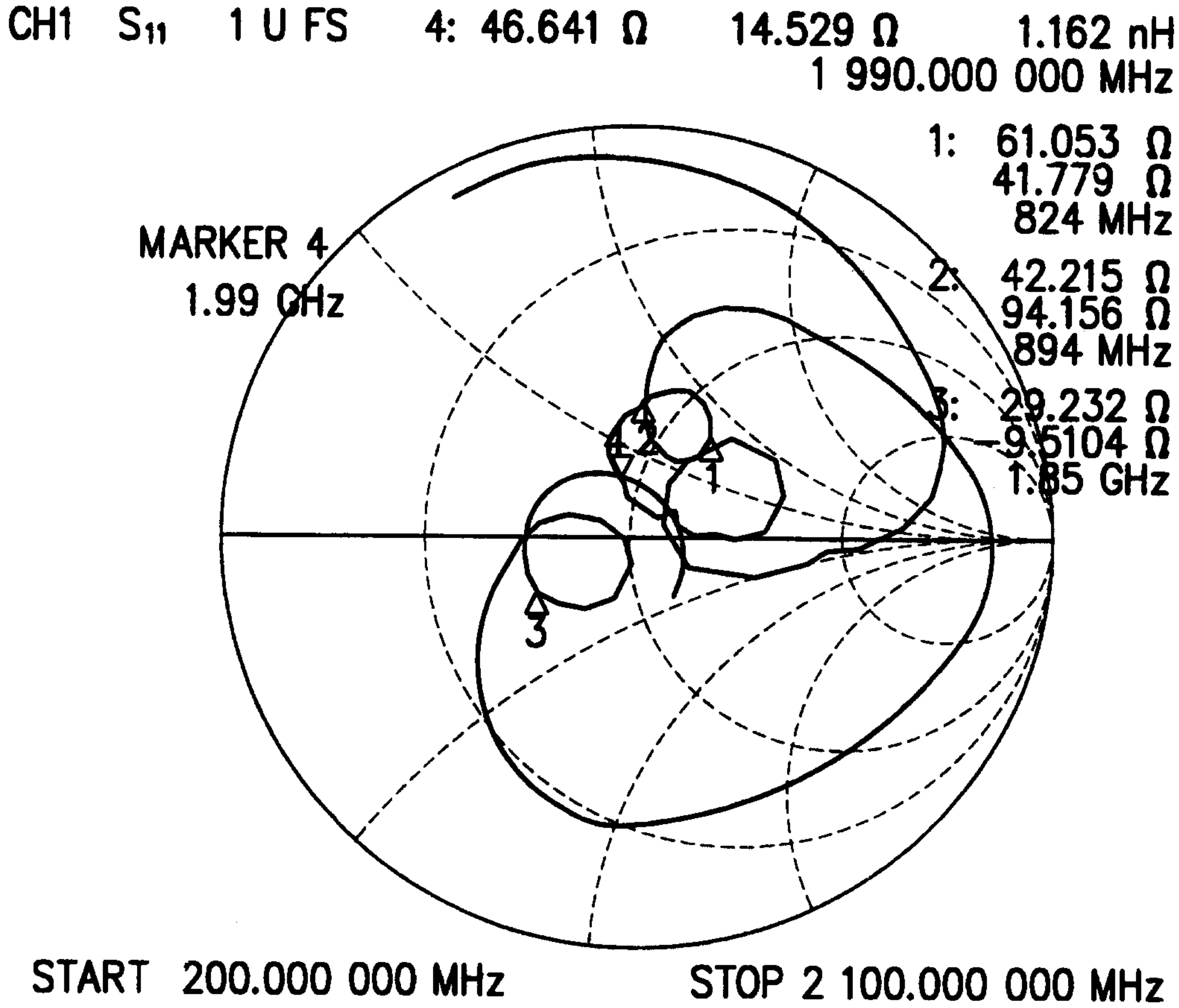

CH1 S11 1 U FS 4: 46.641 Ω 14.529 Ω 1.162 nH
1 990.000 000 MHz
1: 61.053 Ω
41.779 Ω
824 MHz
2: 42.215 Ω
94.156 Ω
894 MHz
3: 29.232 Ω
-9.5104 Ω
1.85 GHz
MARKER 4
1.99 GHz
1
2
3
4
START 200.000 000 MHz
STOP 2 100.000 000 MHz

FIG. 16

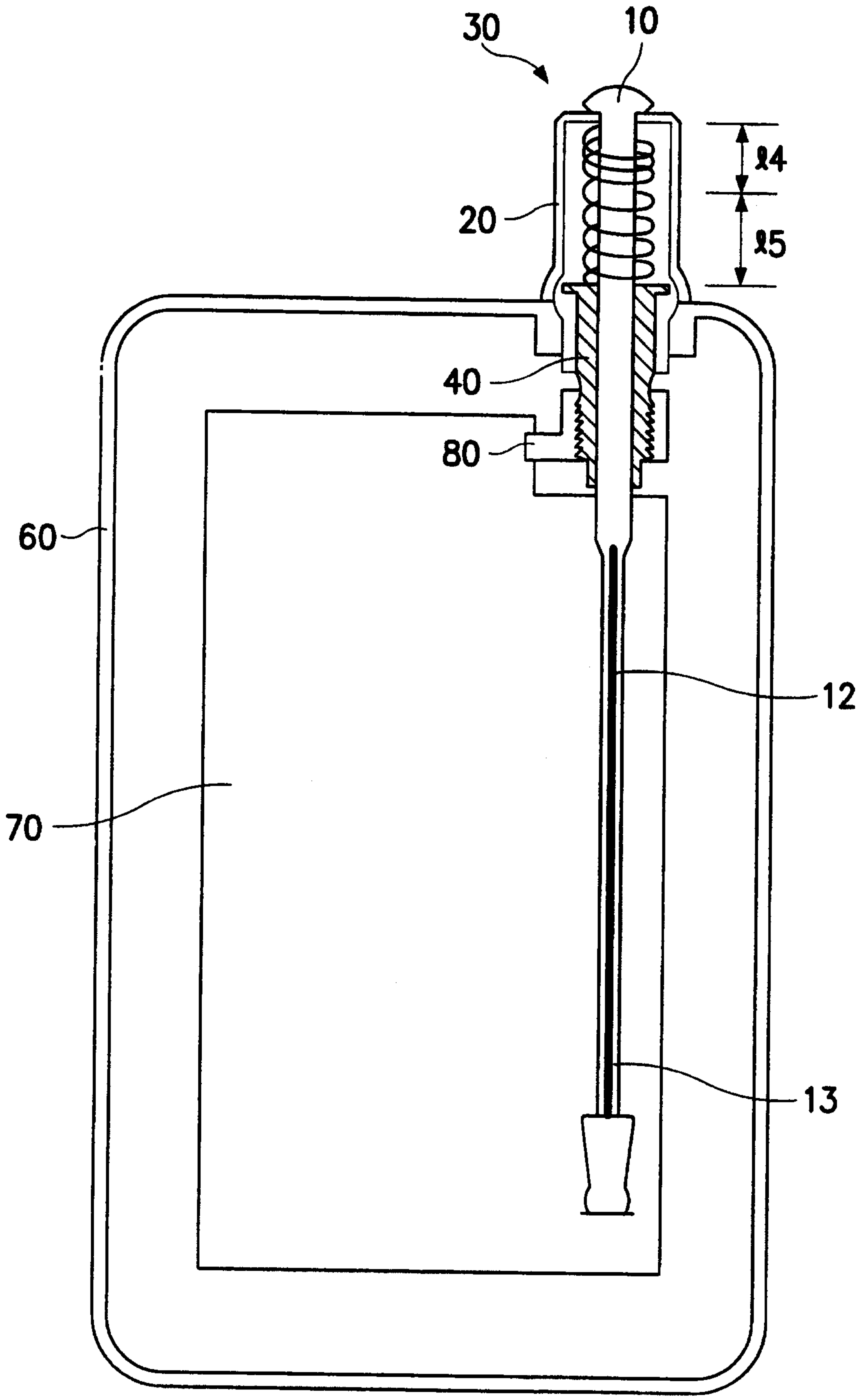
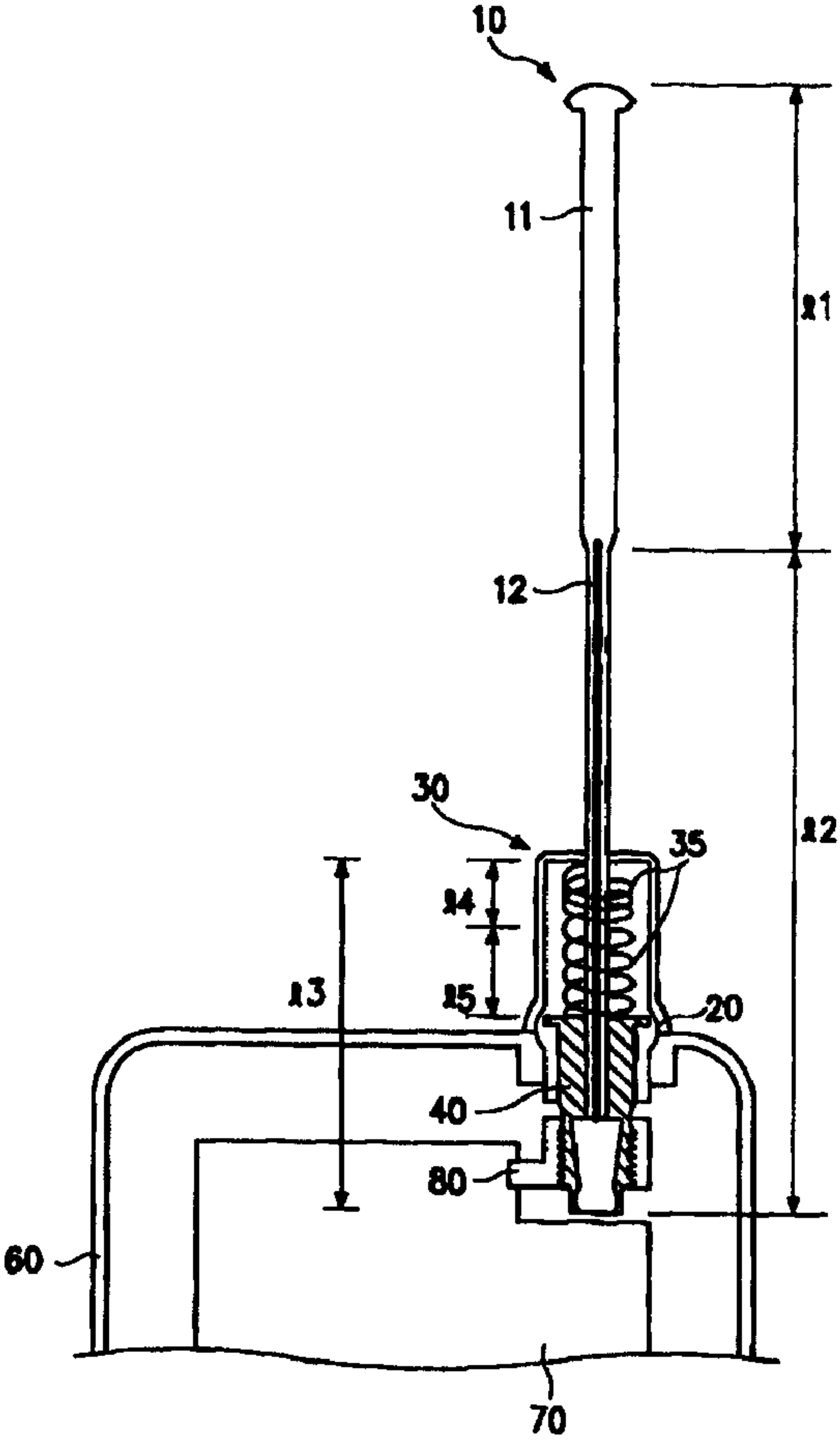


FIG. 17


10
11
ℓ1
12
ℓ2
30
35
ℓ4
ℓ3
ℓ5
20
40
80
60
70