This invention relates to line stretchers and more particularly to non-contacting transducers for extremely fast responding line stretchers operating in the microwave and higher frequencies.

A line stretcher is a mechanical device for changing the physical length of a high frequency transmission line. While line stretchers may have many uses, one particular use is to steer the pattern of an antenna. Sometimes this pattern must be steered very quickly to follow a fast moving object. Therefore, the mechanical device must be quickly and easily adjustable.

One way of adding physical length to a high frequency transmission line involves telescoping tubes which lengthen or shorten wave guides included in the line. These tubes may be made in the form of a simple telescope; or, they may be folded to provide a trombone-type slide. Either way, the inner and outer slides must fit snugly to avoid high frequency losses. This snugness usually prevents rapid slide motion and causes excessive wear. Also, thermo-electric potentials develop across the contact between the slides to cause noise. Thus, a telescoping tube is totally unsuit for use where extremely fast response and low noise operation is required.

Another way of changing the physical length of a microwave transmission line involves the use of a movable short which is a quarter wave length open line followed by a quarter wave length shorted series line slidably positioned in a wave guide or other transmission line. If the shorted line is not used as a one port stub, but is used as a two port line stretcher (i.e. with input and output), two stubs must be used with a “perfect” quadrature hybrid network. In practice quadrature hybrid networks are far from perfect with multiple path lengths resulting.

Accordingly, an object of the invention is to provide new and improved line stretchers. A more particular object is to provide extremely fast moving, friction free line stretchers devoid of all electrical contacts. Also, an object is to provide for better impedance matching of the line stretcher—a two port device.

A further object is to provide line stretchers having greatly improved electrical characteristics. In this connection, an object is to reduce the voltage standing wave ratio (VSWR) of a line stretcher input to near unity with a minimum band width of 12% of a transmitted center frequency.

Yet another object is to reduce the cost of the mechanical structure of line stretchers. Here an object is to reduce to a minimum the use of precision milling, grinding, shaping, and other expensive manufacturing processes. In fact, an object is to substitute just as precise but much less expensive photoprocessing for the more expensive manufacturing processes. Moreover, an object is to accomplish these and other objectives with a minimum of friction and wear, with a fast responding mechanical movement, and with no physical contacts.

Still another object is to provide a two port line stretcher—as distinguished from a one port stub—which accomplishes all of the above mentioned objectives. And, an object is to do this without eliminating the possibility of using the line stretcher as a one port device.

In accordance with one aspect of this invention, a pair of radiant energy pickups and a printed circuit card are mounted in a cavity or cavities of a housing made of electrically conductive material. The pickups are stationarily positioned relative to the printed circuit card so that movement of the card relative to the pickups effectively increases or decreases the length of a conductive strip line printed on the card. For example, in one embodiment of the invention, a strip line of conductive material on the printed circuit card includes two spaced, parallel, straight sections joined at one end and open at the other to provide a generally U-shaped conductor. The pickups are positioned adjacent associated straight line sections of the U-shape. This way, the effective length of the strip line between the two pickups increases when the printed circuit card is moved in a direction causing the closed end of the U-shaped section to move toward the pickups. The effective length of the strip line between the pickups decreases when the closed end of the U-shaped section moves away from the pickups.

The above mentioned and other features and objects of this invention and the manner of obtaining them will become more apparent, and the invention itself will be best understood by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a perspective view (with a broken away section) of a preferred embodiment of the invention incorporating a printed circuit card slidably mounted for linear movement;

FIG. 2 is a perspective view of a second embodiment of the invention incorporating a printed circuit card mounted for rotary motion;

FIG. 3 is a perspective view of the cavity incorporated in the embodiment of FIG. 1;

FIG. 4 is a top view of the preferred embodiment taken along line 5—5 of FIG. 1;

FIG. 5 is a first cross sectional view of the embodiment taken along line 5—5 of FIG. 4;

FIG. 6 is a second cross sectional view of the preferred embodiment taken along line 6—6 of FIG. 4;

FIG. 7 is a third cross sectional view of the preferred embodiment taken along line 7—7 of FIG. 4;

FIG. 8 is a fourth cross sectional view of the preferred embodiment taken along line 8—8 of FIG. 4;

FIG. 9 is a fifth cross sectional view of the preferred embodiment taken along line 9—9 of FIG. 4;

FIG. 10 is a cross sectional view of a fragment of the printed circuit card showing a unique sandwich arrangement used to prevent wear;

FIG. 11 is an enlarged view of the section enclosed within the circle of FIG. 12 of FIG. 5 and shows how friction to linear motion is reduced to a minimum;

FIG. 12 is a plan view showing a laterally movable printed circuit card having a generally U-shaped strip line printed thereon and a pair of radiant energy pickups positioned adjacent thereto;

FIG. 13 is a plan view showing of a rotational printed circuit card having a pair of concentric arc strip lines printed thereon;

FIG. 14 is a side view taken along line 14—14 of FIG. 12 with a broken away portion of the housing; and

FIG. 15 shows the electrical equivalent of a cavity and a strip line.

As best shown in FIGS. 1, 2 the physical length of a transmission line (here coaxial cables 29, 30) may be increased or decreased through movement of a mechanically mounted device. The device includes a printed circuit card 31 which is movable in one direction to add or in another direction to remove an effective length of electrical conductive material deposited on the card.

While many motion imparting devices may be used in connection with the printed circuit card, FIG. 1 shows a rack and pinion arrangement. More particularly, one edge of the printed circuit card is shaped to form a rack
or a series of teeth 32. A pinion 33 is arranged so that any suitable source of power, such as a motor (not shown) may be driven in either of two opposite directions to give bidirectional linear motion to the printed circuit card 31. As shown in FIG. 2, the printed circuit card 31a is a disk-like device mounted on an axle 34 for rotary motion in either clockwise or counterclockwise directions. In the embodiments of both FIG. 1 and FIG. 5, the principle employed involves an application of a physiological motive force causing a printed circuit card motion equivalent to the motion of a conventional trombone slide type line stretcher. If the motion is in one direction, the effective trombone slide is extended to add length. If the motion is in an opposite direction, the effective trombone slide is retracted to subtract length from the conductor.

Next to be described is the construction details of the line stretcher. Since the embodiments of FIGS. 1, 2 are virtually identical except for the differences required to provide linear or rotary motion, this detailed description is restricted to FIG. 1. However, so that the embodiment of FIG. 2 may also be understood, the same reference numerals are used to identify similar parts in both figures with the suffix a added in FIG. 2 (see also FIG. 13).

The line stretcher of FIG. 1 is designed for use with a microwave transmission line such as coaxial cable 29, 30. The coaxial cable is attached to the line stretcher housing by conventional coaxial connectors 32, 33. The input electrical signal is transmitted into the line stretcher by coaxial cable 29 and the output electrical signal is taken from the line stretcher via coaxial cable 30, as indicated by the arrows A, B.

The line stretcher is housed within a pair of mating members 34, 35 made of a material having good electrical conducting characteristics, such as aluminum, for example. These two members 34, 35 are held together in any suitable means such as by bolt 36. Members 34, 35 form the system ground. Initially each of the members is a massive block of material. Then, by any suitable means (such as milling, for example) each block is shaped or formed to provide a plurality of cavities 37, of the type generally found in the wave guide art and particularly of the type providing for coaxial wave guide coupling. Also, each block is shaped to provide space for mounting the printed circuit cards. This particular card mounting space is sized and shaped to facilitate the desired card movement. That is, the card 31, for example, can be moved left or right in the card mounting space of FIG. 1. The card 31a can be rotated in the card mounting space of FIG. 2.

The relation between the cavity 37 and printed circuit card 31 may become more apparent from a study of FIG. 3. This figure shows the cavity 37 by solid lines and the printed circuit strip by dot-dashed lines. No effort is made to show the card supporting space; it extends leftward (as viewed in FIG. 2) from slot 38 and rightward from slot 39. The cavity 37 includes a principal coupling cavity 40, an impedance matching cavity 41, a non-contacting stub cavity 42, and an absorber cavity 43.

The principal coupling cavity 40 was designed to achieve the largest tolerance in the location of a pickup 50 or a conductive strip 54. The characteristic impedances of the two transmission lines 50, 54 in this cavity were incorrect for resonating at the correct circuit Q's when terminated directly in the strip-line of FIGURE 5 and the coaxial line. Therefore, an impedance matching coaxial line section 56 is provided to transform the impedance of the coaxial line which will receive input from the pickup 50 into cavity 40 with the correct Q. Similarly, an impedance of the strip line 54 in cross section FIG. 5 to a value which will resonate strip 54 in cavity 40 with the correct Q. When both resonators in cavity 40 are resonated at the proper Q's an impedance match is achieved between coaxial line 29 and strip-line 54 in cross section FIG. 8.

To assure proper resonance of strip 54 in cavity 49, a non-contacting short circuit terminates the printed strip 54 at the same end of cavity 49 which is entered by coaxial line 29. The term "non-contacting" means that the card 31 does not physically touch the short or stub line. In greater detail, this device consists of a quarter wave length open line and a quarter wave length shorted line formed by a plug of conductive material such as beryllium copper inserted into an L-shaped section as shown at 44, 45. These plates are secured in the cavity 49 (in any suitable manner) to form the non-contacting short. The short circuit at points 46, 47 of the line formed by the cavity and plates reflects an open circuit at points 48, 49 which is in series with the impedance of the cavity 43. This short circuit at point 46, 47 transforms to the open circuit at points 48, 49.

The open line where the plates are parallel to the printed circuit card 31 transforms the open circuit at points 48, 49 into a short circuit at points 44, 45. Ideally, this shorted line or stub is one-quarter wave length long to further improve the impedance matching of the coaxial cable into the coupling cavity, by providing a perfect short circuit.

Means are provided in the principal coupling cavity for transferring energy between the coaxial cables and the printed circuit card. That is, the printed circuit card 31 is mounted in a cavity 50 which is positioned close to, but does not physically contact, the printed circuit card 31. The pickup is a flat plate of electrical conductive material (such as beryllium copper) having a lug or terminal at each end to facilitate an electrical connection. The coaxial cable 29, for example, connects to any lug 51 through coaxial cavity 55, and the system ground connects to the other lug 52. Preferably, the effective length (shown by the dashed center line 53) of the copper plate 50 is one quarter wave length of the desired center frequency. When the pickup is energized at radio and higher frequencies, energy is emitted into the cavity 37 in the form of electromagnetic waves.

An advantage of this arrangement is that no physical contact occurs between the pickup and the printed circuit card. Hence, contact noise does not develop and contact material does not erode.

The general configuration of the line stretcher and the manner in which the cross sectional geometry of the cavities changes along the length of the housing will be apparent from a study of FIGS. 4-9. That is, beginning at the left hand end FIG. 5, the space 38 is thicker than the printed circuit card 31, the thickness t being the width of the desired conductive impedance, such as 50 ohms. Moving along the housing to the right in FIG. 6, we find the impedance matching cavity 41 for printed circuit strip 54, and cavity 41 for strip 55. Moving still further to the right in FIG. 7, we come to the principal coupling cavities 40, 49 for giving entrance and exit to lines 29, 30 of the coaxial cable and housing the pickups 50, 51. The distance E between where the cables 29, 30 attach to the pickups 50, 50' is made as large as practical to minimize crosstalk. Between the coaxial line 29 and pickup 50, is located a coaxial impedance matching cavity 56. There is a similar cavity 57 for line 30. Continuing further to the right in FIG. 8, we come to the non-contacting short 44, 46 on the strip cavity 42 and the non-conducting short 44', 45' on the strip cavity 55. Moving still further to the right in FIG. 9, we find RF absorbing material 58, 59 for strip 54 and 60, 61 for strip 55. This material makes a low impedance back load that improves the electrical performance of the short 44, 45.

The nature of the printed circuit card construction will be apparent from a study of FIG. 10. That is, the printed circuit card includes a sandwich of two sheets of dielectric base material 62, 63 having good wear resistant qualities such as epoxy fiberglass, for example. Deposition of these sheets of fiberglass is a conductive material 54, such as copper, which is etched or eroded away through
any well known printed circuit card construction tech-
niques. Thus, the printed circuit card comprises a sand-
wich of dielectric supporting material separated by a printed image on the conductive strip. The construction are: wear resistance, elimination of accidental short circuits, and increased strength.

To reduce friction within the housing and facilitate movement of the printed circuit card, the upper and lower ends of the card supporting space 38 are rounded as shown in FIG. 11. These rounded ends provide guideways in which the printed card slides. Since the guide-
ways are rounded and the edges of the printed circuit card are squared, friction forces appear only at the relatively small working area indicated by the arrows F, G. Thus, it is apparent that the card movement causes a minimum of friction and allows a fast responding mechanical mechanism.

In keeping with one aspect of this invention, the printed circuit card includes a conductive strip having a geometry such that the effective length of the conductive strip increases when the card is moved to the right (as viewed in FIG. 12) and decreased when the card is moved to the left.

As shown in FIGS. 12, 14, the printed circuit card 31 has a strip line conductor 54, 55 deposited thereon. This strip line is shown in FIG. 12 (for lateral motion in the embodiment of FIG. 1) as including two spaced, parallel, straight sections joined at one end 65 to provide a gener-
ally U-shaped continuous strip line conductor. In the rotary embodiment of FIG. 2, the printed circuit card has a pair of concentric arcs 66, 67 shorted at one end 68, as shown in FIG. 13. In either embodiment, the pickups 50, 56, are positioned parallel to and spaced from the conductive strip. The major portion of the pickup should overlap and generally conform to that portion of the strip line which is immediately adjacent, or just beneath the pickup, as shown in FIG. 12.

Since the coaxial cable 29 and a ground potential must be connected to opposite ends of the pickup 50, it is convenient to provide lugs or terminals which give the pickup a somewhat arcuate shape. It may be desir-
able to rivet or swage the central conductor of a con-
ventional coaxial cable to the lug 51 on one end of the pickup 50. The other end 52 of the pickup may be secured to the housing 54 which is at ground potential.

The distance h between the pickup 50 and the strip line 54 represents a compromise between expense of manufacture and band width requirements. On the one hand, it is desirable to place the pickup as far as possible from the strip line so that the manufacturing tolerances will not be critical. On the other hand, it is desirable to place the pickup as near as possible to the strip line to pass a maximum bandwidth. In one particular de-
vice, a convenient compromise occurred when the pickup was secured .040" from the strip line 54.

By an inspection of FIG. 12 it will be apparent that the effective length of the strip line 54, 55 is approxi-
mately twice the length L. That is, the effective length is the length less the pickups. Thus, beginning at pickup 50, and continuing around the strip line to the pickup 50' there is a strip of conductive material about 2L. If the printed circuit card is moved to the left in the direction of the arrow C, obviously the effective line becomes shorter. If the card is moved to the right in the direction of the arrow D, obviously the effective line becomes longer. Hence, the coaxial cable 29, 30 is stretched or shortened by laterally moving the printed circuit card 31.

The transfer of energy from the coaxial cable 29 to the strip line 54 or the transfer of energy from the strip line 55 to the coaxial cable 30 is via a radiant energy field set up between the two resonant strips 50, 54 in cavity 40 or 50', 55 in 40'. For an understanding of this feature, reference is made to FIG. 15 which shows the electrical equivalent of the resonant strip 54 in cavities 30, 41 and the coaxial cavity 55 and pickup 56 of cavity 40. In greater detail the coaxial cable is constructed to have a specified characteristic impedance. The strip transmission line 54 in cross section FIG. 5 is designed to have the same characteristic impedance as coaxial line 29. Strip 54 in cavity 40 has a different character-
istic impedance. Electrically interposed between the striplines of the cross section FIG. 5 and cavity 40 is the intermediate strip cavity 41 which transforms the im-
pedance of strip 54 in cross section FIG. 5 to a value 
which will cause strip 55 in cavity 40 to resonate with the required circuit Q. Similarly, cavity 56 is provided to transform the impedance of coaxial line 29 to a value which will resonate pickup strip 50 in cavity 40 with the correct Q. When the correct Q is achieved for the two circuits, an impedance match occurs between the coaxial line 29 and the strip transmission 54 of FIG. 5. Similar cavities are provided for cable 30. Each cavity is a quarter wavelength long at the desired center frequency. Since the two quarter wavelength sections 40, 41 of strip 54 are joined mechanically to provide a single resonator of a half wavelength in length, radiant energy in sections 40, 41 forms a standing wave 69 of one half-cycle of the center frequency of the transmitted band, FIG. 15. A similar half-wave 70 is shown for pickup 50 and cavity 56. This radiant energy wave transmits energy from the pickup 50 to the strip 54 in cavity 40 through electromagnetic coupling. The output signal is transmitted through cavities 40' containing pickup 50' in a similar manner. The input and output terminals can be reversed.

The relation between the two strip resonators 54, 50 in cavity 40 is such that the radiant energy in the input strip resonator 54 bears a relation to the radiant energy in the output pickup 56 which is described by the follow-

\[ K_{12} = \frac{A(Z_{50} - Z_{54})}{n\pi(Z_{50} + Z_{54})} \]

\[ Z_{50} = nZ_{50} \]

where:

\[ K_{12} = \text{the coupling coefficient between the strip 54, pickup 50 in cavity 40} \]

\[ Z_{50} = \text{even mode characteristic impedance of the strip 54 or pickup 50} \]

\[ Z_{50} = \text{odd mode characteristic impedance of the strip 54, pickup 50} \]

\( n \) is approximately 2 since total resonator 40-41 or 50-56 is two quarter wave lengths long; however, the characteristic impedances of the two sections in each resonator are not equal and the number \( n \) will not be exactly 2.

and:

\[ Z_{50} \text{ of the printed circuit strip 54 is made equal to } Z_{50} \text{ of the pickup 50} \]

\[ Z_{50} \text{ of the printed circuit strip 54 is made equal to } Z_{50} \text{ of the pickup 50} \]

Note: When \( Z_{50}/Z_{50} = .24 \) the manufacturing tolerances are best.

The circuit values should be selected to make \( K_{12} \) a maximum practical value while maintaining \( Z_{50}/Z_{50} \) close to 2.4. If the input figure of merit of a loaded circuit) of the input strip 54 and cavity 40, 41 equals \( Q \), and the "Q" of the output coaxial cable 29 and resonator 50, 55 equals \( Q_{50} \), the voltage standing wave ratio (VSWR) of the strip line to coaxial transducer is described by the following mathematical equation:

\[ \text{VSWR} = K_{12}Q_{50} \]

\[ Q = \text{energy stored in cavity} \]

\[ \text{energy dissipated in generator} \]
when:
transmission line is resonant

\[ Q = \frac{n \pi Z_0}{R_s} \frac{n \pi Z_0}{R_s} \]

where:
\( R_s \) = equivalent series resistance of generator referred to current maximum of resonator.

\[ R_s = \frac{n \pi Z_0}{R_s} \]

where:
\( R_s' \) = equivalent series resistance of load referred to current maximum of resonator.

\[ R_s' = \frac{n \pi Z_0}{R_s} \]

and with resonator No. 1 shorted at voltage maximum or open at current maximum.

The circuit values should be selected to make the VSWR = 1 for Butterworth response or slightly above 1 for Chebishev response.

Where
\( Q_1 = Q \) of combined 40, 41, strip 54
\( Q_2 = Q \) of combined 50, 56

and
\( Q_1 = Q \) for proper design.

To design the coaxial to stripline transducer of the line stretcher to have a Chebishev response, the following procedure may be followed:

1. Compute \( Z_{m0} \) and \( Z_{m0} \) of an assumed configuration
2. Assume a maximum voltage standing wave ratio over the band of \( r = 1.02 \)
3. Required resonator \( Q \)

\[ Q_1 = Q_2 = \frac{n \pi Z_0}{R_s} \sqrt{r} \]

4. Definition of \( Q \)

\[ Q = \frac{n \pi Z_0}{R_s} \frac{Z_0}{Z_0} \]

Where

\( Z_0 = \sqrt{Z_{m0} Z_{m0}} \)

\( R_s \) = mathematical equivalent series resistance of generator or load

5. Characteristic impedance of impedance matching sections 41, 56

\[ Z_{em} = Z_0 \sqrt{Z_{m0} R_s} \]

Where \( Z_{m0} \) is the characteristic impedance of the strip 54 to compute 41 or of coaxial line 39 to compute 55

6. Mode number \( n \)

\[ n = 1 + \frac{Z_0}{Z_{m0}} \]

7. Computation of \( Q_1 \) from Equation 4

\[ Q_1 = \frac{n \pi Z_0}{R_s} \]

8. Computation of band width over which the value assumed in step 2.

\[ B = F_s \sqrt{2(n-1)} \]

Where \( F_s \) = center frequency

9. If the band width calculated above is quite different

10. If the above voltage standing wave ratio \( r \) is too high, it is necessary to change the configuration of the strip and cavities associated with 40 to obtain a higher value of \( K_p \).

11. Those skilled in the art will readily perceive many advantages resulting from use of the invention. However, it may be helpful here to review a few of these advantages. More specifically, the line stretcher provides an extremely fast moving, friction free device devoid of all electrical contact. Therefore, through the use of suitable servo or feedback mechanisms, the line stretcher may be adjusted almost instantaneously to changing electrical needs of associated equipment. Additionally, the line stretcher provides greatly improved electrical characteristics because there are no contacts across which thermal potential differences appear as noise. Moreover, the highly efficient coupling virtually eliminates any standing wave reflections between the strip line and the coaxial cable. For example, with one particular device, it was found that the VSWR = 1.09 when the band width was 12% of the transmitted center frequency (for one transducer only). Also, the extremely simple mechanical structure reduces to a minimum the need for precision milling, grinding, shaping and other expensive processes required heretofore. Much of this expensive processing has been replaced by equally precise, but quite inexpensive, photoprocesing. Finally, the line stretcher provides a two port structure without sacrificing any of the many advantages provided by one port non-contacting structures. In fact, by elimination of one pickup, the device may be used as a one port stub.

While the principles of the invention have been described above in connection with specific apparatus and applications, it is to be understood that this description is made only by way of example and not as a limitation on the scope of the invention.

I claim:

1. A line stretcher for use with a microwave transmission line comprising a shielding housing having at least one pickup cavity formed therein, a printed circuit card having a conductive strip line printed thereon, at least one non-contacting pickup connected to said transmission line and mounted in said cavity, and means for selectively moving said printed circuit card to a desired position relative to said pickup, said conductive strip having a geometry which increases or decreases the effective length of said transmission line as a function of the position of said card relative to said pickup.

2. The line stretcher of claim 1 wherein said pickup cavity provides an impedance match between the coaxial line and the impedance of said strip transmission line.

3. The line stretcher of claim 2 wherein said printed circuit card comprises a sandwich of dielectric supporting material separated by a printed conductive strip.

4. The line stretcher of claim 3 wherein the geometry of said strip is generally U-shape, there being two of said pickups, each of said pickups being positioned adjacent an individually corresponding one of the straight sections of said U-shape, whereby movement of said printed circuit card which causes the closed end of said U-shape to advance toward said pickups effectively shortens the length of the conductive strip material positioned between said pickups and movement which causes the closed end of said U-shape to move away from said pickups effectively lengthens the conductive strip material between said pickups.

5. A line stretcher comprising a movable member having a conductive strip line thereon, a coaxial transmission line having a relatively small matching cavity therefor, in a housing made of electrically conductive material...
and having a cavity formed therein, said cavity having a relatively large coupling volume and an intermediate volume in communication with said large volume for matching the impedance of said large volume with the impedance of said moveable strip line, at least one radiation energy pick-up stationarily mounted in said large volume cavity and connected to said coaxial line, and means for mounting and moving said moveable member through said cavity past said pick-up in said cavity, said conductive strip having a geometry which effectively increases or decreases the length of said coaxial line as a function of the position of said card relative to said pick-up.

6. The line stretcher of claim 5 wherein said cavity in said housing has a cross-section which changes along the length thereof as follows: a strip line transmission space which has approximately the same characteristic impedance as the coaxial cable line, said intermediate volume impedance matching cavity, said large volume coupling cavity, another strip line space which contains a non-contacting short circuit for said moveable member, and another strip line space which contains microwave absorption material.

7. The line stretcher of claim 6 and at least one generally L-shaped plate positioned adjacent to said large volume coupling cavity to provide a quarter wave length non-contacting short circuit to cause said conductive strip to resonate in the larger volume chamber.

8. The line stretcher of claim 6 wherein said moveable member comprises a printed circuit card including at least one member made of dielectric supporting material carrying said conductive strip line and having substantially rectangular cross section, and said mounting means is provided by said strip line supporting spaces having rounded upper and lower sides for providing low friction guideways in which said printed circuit slides.

9. A line stretcher comprising a printed circuit card carrying a generally U-shaped strip line of conductive material, and two radiant energy pick-ups, each of said pick-ups being positioned adjacent an individually corresponding one of the straight line sections of said U-shape, whereby movement of said printed circuit card which causes the closed end of said U-shape to advance toward said pick-ups is effectively shortens the conductive strip material between said pick-ups and movement of said card which causes the closed end of said U shape to move away from said pick-ups effectively elongates the conductive strip material between said pick-ups.

10. A microwave transducer comprising a coaxial cable, a printed circuit strip line, means for non-contacting transferring energy between said cable and said strip line, and means for matching the impedances of said cable and said strip line, said impedance matching means comprising an elongated chamber entered by said coaxial cable at right angle to the axis of said elongation, one end of said chamber being terminated by a non-contacting short circuit and the other end of said chamber comprising an impedance matching cavity.

11. A microwave transducer comprising a housing of electrically conductive material having a chamber formed therein, a conductive strip line in said chamber, a coaxial cable entering said chamber and terminating in said chamber by a connection to one end of a plate of conductive material having a length of one-quarter wave length of a desired center frequency, the other end of said plate being fixed at ground potential, said chamber terminating at an end opposite to the grounded end of said plate by a microwave short circuit to the conductive strip line, said plate being positioned adjacent said strip line.

12. The transducer of claim 11 wherein said microwave short circuit comprises a non-contacting short means followed by RF absorbing material.

13. The transducer of claim 11 wherein the end of said chamber adjacent the grounded end of said plate terminates in an impedance matching chamber.

14. A transducer for making a 90° or other angle elbow in a microwave transmission line comprising a transmission line terminating in a plate of conductive material extending at an angle of approximately 90° from the end of said line, a strip of conductive material supported in spaced parallel relation to said plate, and a ground potential chamber enclosing said plate and said strip line, wherein said chamber has a generally elongated configuration terminated in one end by an impedance matching cavity and in the other end by a non-contacting microwave short circuit, said short circuit comprising at least one plate of electrically conductive material shaped to have a generally L-shaped configuration followed in said chamber by RF absorbing material.

References Cited by the Examiner

UNITED STATES PATENTS
2,718,665 8/1955 Collard 335--35
2,738,285 8/1956 Le Vina 333--31
2,760,035 8/1956 Johannesen 333--10
2,794,174 5/1957 Arditi et al. 333--84
2,938,175 5/1960 Sommers et al. 333--84 X
2,961,620 11/1950 Sommers 333--31

OTHER REFERENCES

HERMAN KARL SAALBACH, Primary Examiner.
M. NUSSBAUM, Assistant Examiner.