July 11, 1950 C. A. MARTIN 2,514,779

WAVE GUIDE SYSTEM

Filed May 14, 1947

Fig. 1

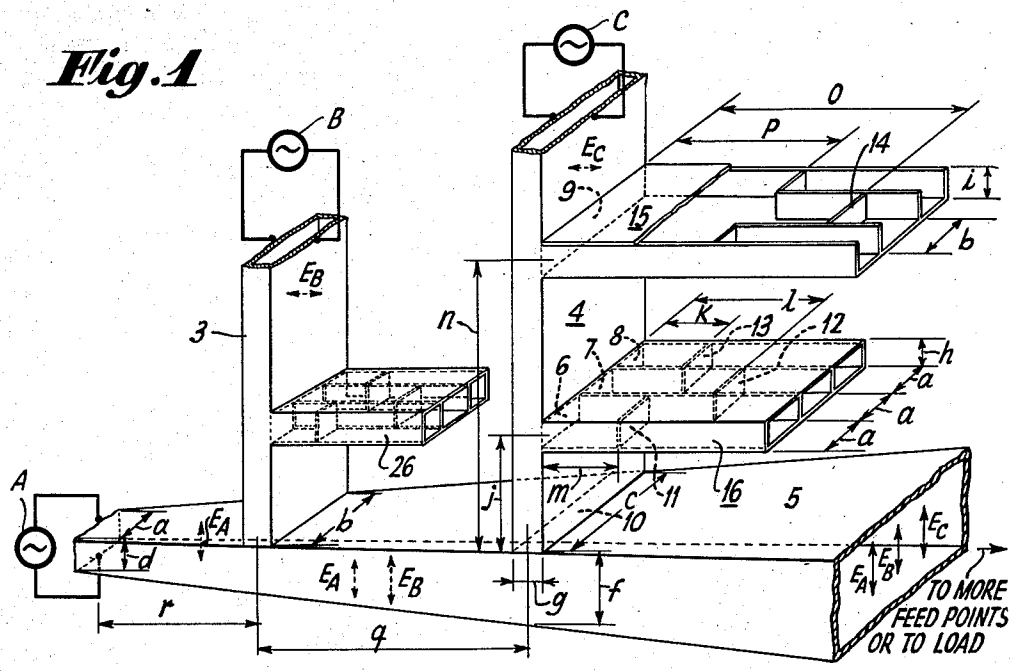


Fig. 2

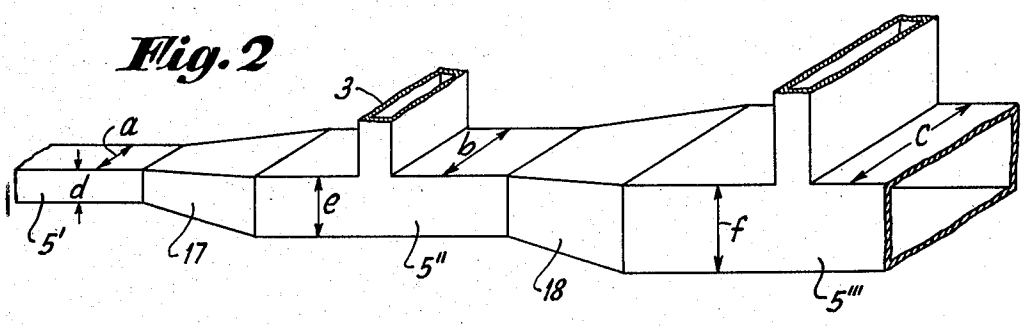
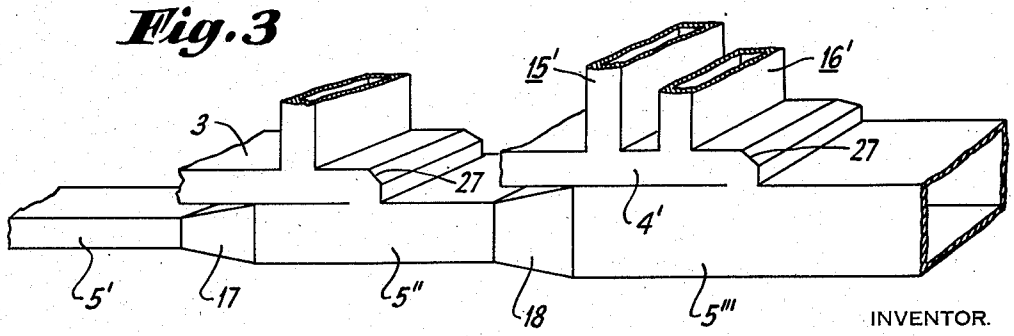


Fig. 3



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WAVE GUIDE SYSTEM

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The present invention relates to a system for combining a number of microwave radio waves into a single wave guide or electromagnetic horn structure.

An object of the present invention is to provide a combining structure for introducing a number of microwave radio waves into a single wave guide.

Another object of the present invention is the provision of a combining system as aforesaid in which each wave propagated in the wave guide is of the dominant type and, therefore, is more suitable for immediate radiation by electromagnetic horn or other wave directive structure.

Another object of the present invention is to provide a combining system for high frequency radio waves in which the feed point of each wave does not disrupt the continuity of the wave guide system for any other wave in the guide.

Another object of the present invention is the provision of a combining system as aforesaid wherein the energy from each source is prevented from entering the source of any other wave.

Still another object of the present invention is the provision of a microwave combining system in which each feed system is capable of feeding the wave guide with a relatively wide band of frequencies.

Another object of the present invention is the provision of a microwave combining system in which the necessary adjustments may be simply made and are straightforward in character.

The basic principle upon which the present invention is based is that no real power of an electromagnetic wave will propagate along a wave guide having lateral dimensions less than a certain critical magnitude; in other words, a wave guide inherently acts as a high pass filter. Thus, the present invention contemplates utilizing a tapered wave guide section with the individual frequencies being fed into the tapered wave guide at points such that the waves may propagate only in one direction along the guide; that is, in the direction of increased dimensions. Trap circuits are provided so that the entrance points of the lower frequency waves are effectively short circuited for high frequency waves originating in the smaller portions of the guide system.

In the system of this disclosure a wide pass band is provided in each feed system so that a number of signals of small wavelength differences may be introduced at each feed point of the wave guide by the usual practice of using filters. In addition, the remaining impedance function of each feed system is controlled to provide an effective short circuit across the feed

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point as far as all other waves, existing at the feed point in the wave guide, are concerned. Moreover, the adjustments necessary to regulate the rejection bands are substantially independent of those of the pass band and of each other, and, therefore, the tuning of the system is simple and straightforward.

While, for convenience, the foregoing brief description and the following detailed description are based on the assumption that the present invention is to be used for coupling a plurality of sources of high frequency energy to a high impedance horn antenna or load, it should be clearly understood that my invention is not limited thereto, but may also be used to couple a plurality of separate loads or receivers to a wave guide carrying a number of separate high frequency waves or to a horn antenna receiving any one of a number of separate waves without adjustment or a number of waves simultaneously.

The present invention will be more fully understood by reference to the following detailed description which is accompanied by a drawing in which:

Figure 1 illustrates in perspective and partly in section an embodiment of the present invention;

Figure 2 illustrates in perspective a modification of a portion of the structure of Figure 1, while

Figure 3 illustrates a further modification thereof.

Referring now to Figure 1 there is shown a tapered wave guide 5. Three sources of high frequency energy A, B, and C of progressively lower frequency are shown. For the purpose of explaining the present invention but with no intent of limiting the invention to the particular dimensions suggested, let us assume that the wavelengths bear the following relationship where λ_A, λ_B, and λ_C are the wavelengths of three sources:

$$\lambda_C = 1.73\lambda_B = 3\lambda_C$$

Now, at the point where the source A feeds its energy into wave guide 5, the dimension a of the wave guide is such that waves having a wavelength equal to that of source A may be propagated along this portion of the guide. The guide 5 expands in its dimensions until at the point where wave guide section 3 joins it, the width b permits the propagation of not only waves having a length equal to that of source A but also waves having a wavelength equal to that of source B. Also, at a still larger part of wave guide 5 where the dimension c is large enough to permit the propagation of all three waves, waves from source C are introduced into the wave guide by the in-

termediate section 4 through throat 10. The following table gives the numerical relationship between these dimensions and certain other dimensions which will later be described:

$a=0.7\lambda_A$ $\quad d=0.3\lambda_A$ $\quad q=3\lambda_C$
$b=0.7\lambda_B=0.4\lambda_C$ $\quad e=0.3\lambda_B$ $\quad r=3\lambda_B$
$c=0.7\lambda_C=0.4\lambda_B$ $\quad f=0.3\lambda_C$
$g=h=i=0.4\lambda_A$

It will be noted that the dimensions *a*, *b*, *c*, *d*, *e*, *f*, *q* and *r* are such that any real power of any of the waves is prevented from propagating back to the feed point of any other wave of shorter wavelength and such that electromagnetic waves of the dominant type and dominant type only are allowed to propagate from left to right in the figure.

The branch wave guide 4 coupling source C to the main wave guide 5 will now be described in detail. Trap circuit elements 15 and 16 branching from the branch guide 4 prevent coupling of sources A and B into source C and also maintain the continuity of the main wave guide 5 at junction 10 as far as the waves of sources A and B propagated in 5 are concerned.

The branch 16 has three parallel portions 6, 7 and 8 closed by plungers 11, 12 and 13 respectively. These three portions each have lateral dimensions *a* large enough to allow energy of source A to enter them but small enough to exclude energy from sources B and C. The position of the plungers 11, 12 and 13 within the parallel guide sections may be varied to tune the circuit elements 6, 7 and 8 so that their effective impedance at the junction with the guide 4 may be made substantially infinite at the wavelength λ_A. This effect may be obtained if, for example, the dimensions *k* and *e* are made approximately equal to a quarter of the guide wavelength of the source A. Now, by suitably choosing the dimension *j*, the distance between element 16 and the junction of guide 4 and guide 5, the effective high impedance at the throat of guide 16 is converted at the throat 10 to a short circuit effectively for waves of the wavelength of source A. Since the dimension *a* is less than $\frac{1}{2}\lambda_B$ and also less than $\frac{1}{2}\lambda_C$, the presence of the element 15 has but a small effect on waves of the sources B and C which may exist in the wave guide 4.

The branch 15 has the same function in regard to waves of source B that 16 has for waves of source A. The branch wave guide section of width *b* is large enough to admit energy of source B but small enough to exclude energy of source C. The plunger 14 may be varied to tune the circuit element 15 so that the effective impedance at the junction 9 is substantially infinite at the wavelength λ_B. Then by suitably choosing the dimension *n*, the distance between the branch 15 and the guide 5, the effective high impedance at the throat of 15 is converted at the throat 10 to a short circuit effectively for waves of the wavelength of source B. In addition to the above-described action on waves of source B, 15 may be used to have a favorable effect on waves from source C. This is accomplished by constructing 15 so that it is composed of a section of width *c* (the width of the guide 4) extending from wave guide 4 a distance *p*. This distance *p* may be selected so that this section of 15 at least partially compensates for the effects on waves of source C of the wave guide discontinuities at 10, 6, 7 and 8.

Trap 26 on wave guide 3 functions similarly to 15 on 4. The dimensioning of 26 is such that the smaller wave guide section of width *a* prevents energy of source A entering guide 3 and the larger section of width *b* at least partially compensates for the discontinuity at the junction of 3 and 5.

While the elements described above may be classified as the essential elements of the system various modifications in dimensioning and construction of the elements may be necessary depending mainly on the wavelengths and the bandwidth of wavelengths which are to be transmitted. For example, it may be desirable to obtain a more favorable impedance match to the source C over a wide bandwidth by using such well known devices in the wave guide 4 as diaphragms or tuning screws. As a further example, supposing source A is to transmit a wide bandwidth of signals, it may be desirable to use an additional element such as 16 suitably positioned along 4. Then by varying the length of the various parallel portions of 16 and the added element a greater bandwidth of wavelengths near λ_A may be prevented from entering wave guide 4.

A modified system is shown in Figure 2 in which the main wave guide 5 of Figure 1 is replaced by discontinuous sections in the form of hollow rectangular prisms 5', 5'' and 5''' joined by tapered or truncated pyramidal sections 17 and 18. Under some circumstances this form of construction may be desirable in that it provides more freedom in the longitudinal positioning in the feed point of branch guide 4. Losses in the main wave guide may also, under some circumstances, be reduced by the increase in the taper angle in the sections 17 and 18. Except as noted the structure of the modification of Figure 2 is the same as that described above with reference to Figure 1.

A further modification is shown in Figure 3 wherein the branch wave guides 3 and 4 of Figure 2 are bent at right angles at their junction point with the guides 5'' and 5''' in order to run parallel thereto. The junction between guide 3 and 5'', now it will be seen, takes the form of a right angle corner. The planes 27 at the corners improve the match between the two merging wave guides and reduce reflections which would otherwise occur at a sharp right angle bend.

While I have illustrated a particular embodiment of the present invention, it should be clearly understood that it is not limited thereto since many modifications may be made in the several elements employed and in their arrangement and it is therefore contemplated by the appended claims to cover any such modifications as fall within the spirit and scope of the invention.

What is claimed is:

1. A wave guide system including a main guide adapted to be coupled to a load circuit at one end and having a source of high frequency energy coupled to the other end, said guide having increasing transverse dimensions in the direction toward said load, said dimensions at said other end being only large enough to transmit energy of the frequency of said source, and branch guides, each having a source of energy of lower frequency than said first mentioned source coupled to one end, said branch guides being coupled to said main guide at points therealong where its dimensions become large enough to transmit said lower frequency energies.

2. A wave guide system including a main guide adapted to be coupled to a load circuit at one end and having a source of high frequency energy coupled to the other end, said guide having in-

creasing transverse dimensions in the direction toward said load, said dimensions at said other end being only large enough to transmit energy of the frequency of said source, and branch guides, each having a source of energy of lower frequency than said first mentioned source coupled to one end, said branch guides being coupled to said main guide at points therealong where its dimensions become large enough to transmit said lower frequency energies, each of said branch guides having wave guide elements coupled therewith to present a negligible impedance to the energy within said branch guide and being adjusted to present a substantially short circuit at the junction of said branch guides and said main guide to energy from sources of higher frequency.

3. A wave guide system according to claim 2 in which said main guide has alternate rectangular hollow prismatic sections and hollow truncated pyramidal sections, said branch guides being coupled to said main guide in said prismatic sections.

4. A wave guide system including a main guide adapted to be coupled to a load circuit at one end and having a source of high frequency energy coupled to the other end, said guide having increasing transverse dimensions in the direction toward said load, said dimensions at said other end being only large enough to transmit energy of the frequency of said source, a first branch guide having a source of energy of lower frequency than said first source coupled thereto and a second branch guide having a source of energy of lower frequency than either of the other of said sources coupled thereto, said branch guides being coupled to said main guide at points along said guide where its transverse dimensions are large enough to transmit energy from the source coupled thereto.

5. A wave guide system including a main guide adapted to be coupled to a load circuit at one end and having a source of high frequency energy coupled to the other end, said guide having increasing transverse dimensions in the direction toward said load, said dimensions at said other end being only large enough to transmit energy of the frequency of said source, a first branch guide having a source of energy of lower frequency than said first source coupled thereto and a second branch guide having a source of energy of lower frequency than either of the other of said sources coupled thereto, said branch guides being coupled to said main guide at points along said guide where its transverse dimensions are large enough to transmit energy from the source coupled thereto, said first branch having a further branch guide coupled thereto, the transverse dimensions of said further guide being such as to be responsive only to energy from said first-mentioned source and having a length at which a low impedance is presented at the junction between said main guide and said first branch guide.

6. A wave guide system according to claim 5 in which said main guide has alternate rectangular hollow prismatic sections and hollow truncated pyramidal sections, said branch guides being coupled to said main guide in said prismatic sections.

7. A wave guide system including a main guide adapted to be coupled to a load circuit at one end and having a source of high frequency energy coupled to the other end, said guide having increasing transverse dimensions in the direction toward said load, said dimensions at said other end being only large enough to transmit energy

of the frequency of said source, a first branch guide having a source of energy of lower frequency than said first source coupled thereto and a second branch guide having a source of energy of lower frequency than either of the other of said sources coupled thereto, said branch guides being coupled to said main guide at points along said guide where its transverse dimensions are large enough to transmit energy from the source coupled thereto, said first branch having a further branch guide coupled thereto, the transverse dimensions of said further guide being such as to be responsive only to energy from said first-mentioned source and having such length that at the junction between said main guide and said first branch guide a low impedance shunt is presented, said second branch guide having further branch guides coupled thereto, said further branch guides having transverse dimensions to render them responsive only to energy from said first and second sources of energy and having lengths at which a low impedance is presented to energy from said first and said second sources at the junction of said main guide and said second branch.

8. A wave guide system including a main guide adapted to be coupled to a load circuit at one end and having a source of high frequency energy coupled to the other end, said guide having increasing transverse dimensions in the direction toward said load, said dimensions at said other end being only large enough to transmit energy of the frequency of said source, a first branch guide having a source of energy of lower frequency than said first source coupled thereto and a second branch guide having a source of energy of lower frequency than either of the other of said sources coupled thereto, said branch guides being coupled to said main guide at points along said guide where its transverse dimensions are large enough to transmit energy from the source coupled thereto, said first branch having a further branch guide coupled thereto, said further branch guide being so arranged that at the junction between said main guide and said first branch guide a low impedance is presented to energy from said first-mentioned source.

9. A wave guide system according to claim 8 in which said main guide has alternate rectangular hollow prismatic sections and hollow truncated pyramidal sections, said branch guides being coupled to said main guide in said prismatic sections.

10. A wave guide system including a main guide adapted to be coupled to a load circuit at one end and having a source of high frequency energy coupled to the other end, said guide having increasing transverse dimensions in the direction toward said load, said dimensions at said other end being only large enough to transmit energy of the frequency of said source, a first branch guide having a source of energy of lower frequency than said first source coupled thereto and a second branch guide having a source of energy of lower frequency than either of the other of said sources coupled thereto, said branch guides being coupled to said main guide at points along said guide where its transverse dimensions are large enough to transmit energy from the source coupled thereto, said first branch having a further branch guide coupled thereto, said further branch guide being so arranged that at the junction between said main guide and said first branch guide a low impedance is presented to

energy from said first-mentioned source, said second branch guide having further branch guides coupled thereto, said further branch guides being so arranged that at the junction of said main guide and said branch guide a low impedance to energy from said first and second sources is presented.

11. A wave guide system including a main guide adapted to be coupled to a load circuit at one end and having a source of high frequency energy coupled to the other end, said guide having increasing transverse dimensions in the direction toward said load, said dimensions at said other end being only large enough to transmit energy of the frequency of said source, a first branch guide having a source of energy of lower frequency than said first source coupled thereto and a second branch guide having a source of energy of lower frequency than either of the other of said sources coupled thereto, said branch guides being coupled to said main guide at points along said guide where its transverse dimensions are large enough to transmit energy from the source coupled thereto, said first branch having coupled thereto a wave guide element having dimensions at which a high impedance is presented to energy from said first source and to the energy from the source associated with said guide, the spacing between said wave guide element and the junction between said main guide and said first branch having a value at which a low impedance across said branch is presented to energy from said first source.

12. A wave guide system including a main guide adapted to be coupled to a load circuit at one end and having a source of high frequency energy coupled to the other end, said guide having increasing transverse dimensions in the direction toward said load, said dimensions at said other end being only large enough to transmit energy of the frequency of said source, a first branch guide having a source of energy of lower frequency than said first source coupled thereto and a second branch guide having a source of energy of lower frequency than either of the other of said sources coupled thereto, said branch guides being coupled to said main guide at points along said guide where its transverse dimensions are large enough to transmit energy from the source coupled thereto, said first branch having coupled thereto a wave guide element having dimensions at which a high impedance is presented to energy from said first source and the energy from the source associated with said guide, the spacing between said wave guide element and the junction between said main guide and said first branch having a value at which a low impedance across said branch is presented to energy from said first source, said second branch having coupled thereto a number of high impedance wave guide elements spaced from the junction between said main guide and second guide to present a low impedance across said second branch to energy from said first sources and from the second of said sources.

13. A wave guide system according to claim 12 in which said main guide has alternate rectangular hollow prismatic sections and hollow truncated pyramidal sections, said branch guides being coupled to said main guide in said prismatic sections.

14. A wave guide system including a wave guide, a plurality of sources of high frequency energy of different frequencies coupled to said wave guide at spaced points along the longitudinal axis of said wave guide, said wave guide having dimensions transversely of said longitudinal axis between said spaced points at which energy from a source of lower frequency is prevented from flowing back over said wave guide toward a source of higher frequency.

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