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BROAD BAND HIGH FREQUENCY AMPLIFIER

Filed May 27, 1942

FIG.1.

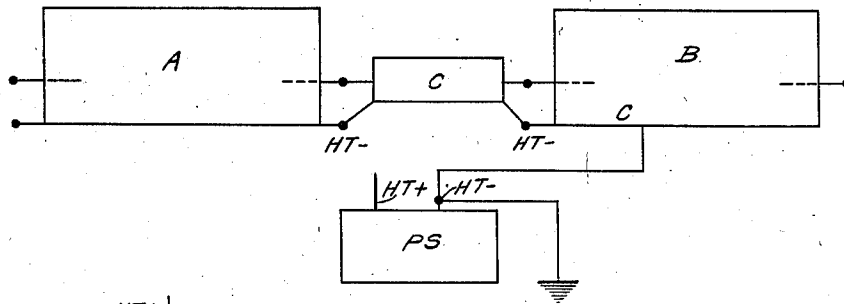


FIG.2.

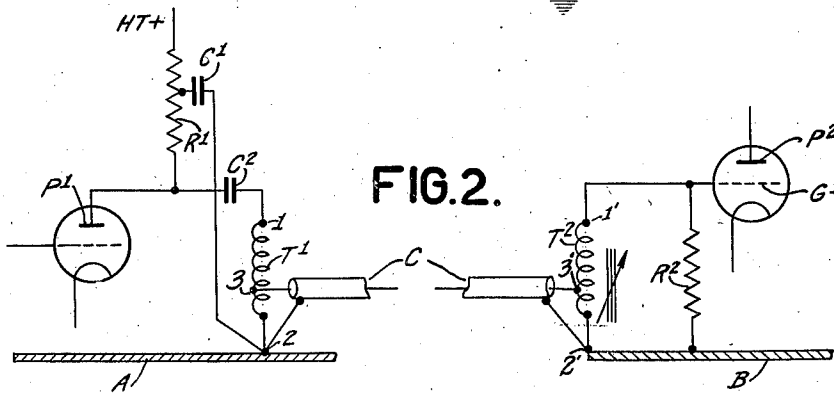


FIG.3.

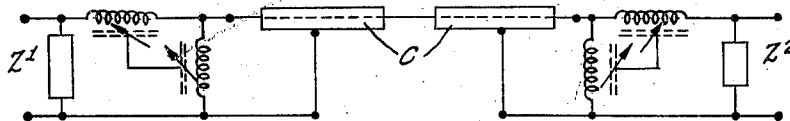
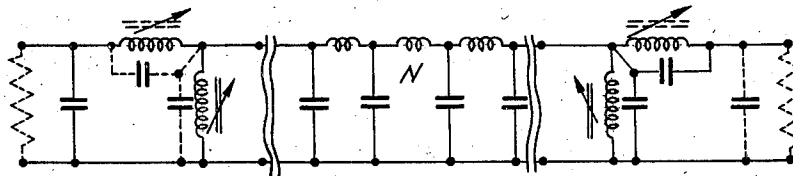


FIG.4.



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BROAD BAND HIGH FREQUENCY
AMPLIFIER

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11 Claims. (Cl. 179-171)

This invention relates to broad band high frequency electrical signal amplifiers where very high gain is required at and around the signal frequencies.

It is specially applicable to amplifiers wherein the ratio of the frequency band received to the signal frequency is comparatively high. Such amplifiers are generally known as "broad band" amplifiers and will herein be referred to as such.

The invention provides a novel method of cascading such amplifiers, providing inherently high stability, and improved overall signal/noise ratio over that obtainable with any other similar amplifiers.

If f =signal frequency to be amplified which may be referred to as the "carrier frequency" and Δf =spread of frequency adjacent to " f " then if the frequencies received by and passed at approximately the same level of amplification by the amplifier be:

$$f \pm \Delta f$$

then the overall band width is:

$$2\Delta f$$

and the ratio, frequency band/signal frequency mentioned above will be:

$$2\Delta f/f$$

and the invention particularly relates to cases in which the ratio

$$\frac{2\Delta f}{f}$$

is of the order of .1 and preferably higher.

In the case of an ordinary broadcast receiver the intermediate frequency amplifier has a ratio of

$$\frac{2\Delta f}{f}$$

in the region of 1/50 and is that the type considered here, but the television vision (or vision and sound combined) amplifiers fall within the realm of the present invention. Of necessity, under similar conditions of frequency level of the carrier frequency it is generally agreed and known from experience that the broader the band width, the higher is the noise level, other factors such as gain, carrier level, etc., being constant.

Moreover the higher the overall gain and lower the signal strength the more important is the noise in relation to the signal at the output of the amplifier.

It is generally recognized by those versed in

the art that the main component of noise is that generated in the input circuit and the first tube of an amplifier, since the noises generated in any later stage, though they may or may not add their components to the overall noise, will not have the same amplification as that at the input.

In a high gain signal amplifier there has to be more than one stage of amplification, dependent on the gain level required. Also, in any amplifier using more than one stage, for high frequency signals, there is apt to be a certain amount of feed-back via various sources, even after all the known precautions have been taken. These feedback voltages will also have some of the noise components which will be re-amplified, though the noise components are of a random nature and may or may not all add in the full noise complement at the output. Also the change of time phase per stage of amplification of the signal is such that there is always a limit to the number of stages that can be connected in cascade before the output from one or more of the stages feeds back some signal and/or noise to one or more of the previous stages causing instability. Moreover, the number of stages involved is also limited by the band-width required. The higher the number of stages, in general, the narrower is the amplified band-width.

It is the object of this invention to overcome all these difficulties and to provide an arrangement wherein a considerable improvement in signal/noise ratio at the output of broad-band amplifiers is obtained.

According to the invention, a broad band high frequency amplifier comprising a plurality of amplifier stages connected in cascade is characterized in this, that the said stages are divided into groups of cascade connected stages, each group forming an insulated chassis unit, the stages being resonant at respective frequencies spread over the frequency spectrum to be amplified, the number of stages in each group being less by one or more than the number which would produce instability or other undesired effects on account of feedback, the output of one group being coupled to the next successive group through a four terminal band pass filter network having distributed and localized (or concentrated) inductance and capacity and earthed at one terminal whereby a high gain of the multi-stage amplifier is possible with a high signal/noise ratio.

The invention will be better understood from

the following description taken in conjunction with the accompanying drawing in which

Fig. 1 illustrates one embodiment thereof in schematic form.

Fig. 2 shows in more detail the coupling arrangement incorporated in Fig. 1 and

Figs. 3 and 4 show equivalent circuits of the coupling arrangement shown in Fig. 2 insofar as the operation of the present invention is concerned.

Referring to Fig. 1, this shows the invention embodied in an amplifier which may be of any well known and suitable type. Briefly, so far as concerns the present invention, the amplifier is split up into a plurality of unit groups or chassis, two of which, A and B are shown in Fig. 1 connected in cascade. Each unit chassis comprises (N-1) stages where N stages would cause instability. That is, if the phase change per stage is ϕ degrees, N is such that $N\phi=2\pi$ or any integral multiple of 2π .

Then in carrying out the present invention there is one chassis A Fig. 1 containing (N-1) stages, where the output of the last stage, i. e., the (N-1)th stage feeds an auto step-down transformer with a turns ratio in this case of about 2:1 then the stepped down output is connected via a low impedance screened concentric cable C (or an unscreened parallel cable one wire being earthed) the screen being earthed. The far end of this cable is connected to an exactly similar auto transformer but this time the transformer is arranged so that the input to it is stepped up to the input grid of the first tube in the second chassis B.

Thus the output of the (N-1) stage of chassis A is coupled to the 1st stage of chassis B via two auto transformers arranged back to back with a cable interlinking them. The earth connection between the two chassis A and B (each being otherwise insulated from the other and from earth) is solely via the earthed end of the cable C. The auto-transformer-cable-auto-transformer system is terminated by resistance as will be clearly understood by those skilled in the art. The power supply is indicated at P. S.

The invention has been explained with only two separate groups of amplifier chassis but any required number using similar arrangements may be connected in cascade.

In all known amplifiers in which high signal-noise ratio is required, great care has to be taken in designing the input stage and to separate it from the rest of the amplifier; and in nearly all cases the input stage has to have a separate voltage supply, the whole of the input stage being screened with extraordinary care. The problem involved in this invention does not appear to have arisen before in practice.

The requirement of band width has, it is recognised, been dealt with before but none of these broad band amplifiers required gains commensurate with that aimed at by the one now described, nor had any of them dealt with a signal level of the order of units of microvolts.

With the arrangements according to this invention such necessities as those aforementioned do not arise and general careful engineering requirements will provide the proper operation, giving the high signal to noise ratio and an almost phenomenal stability, as the link coupling the chassis helps considerably in providing the band-width required and a nearly perfect earth system.

Referring now to Figs. 2, 3 and 4, Fig. 2 shows a specific circuit arrangement, while Figs. 3 and 4

show equivalent circuits, as far as the operation of the circuit is concerned.

In Fig. 2, P1 is the anode of the last stage of the chassis A and R1 a resistance in the anode circuit. The output is tapped off from two points of the resistance R1 and fed through capacities C1, C2 to the input terminals 1 and 2 of the auto transformer T1. The output terminals 3, 2 of the auto transformer T1 are connected to the conductors of the concentric cable C. The other ends of the conductors of cable C are connected to the input terminals 3', 2' of the step up auto transformer T2, the output terminals 1', 2' of which are connected to the ends of a resistance R2 in circuit of the input grid G1 of the first stage of the chassis B. P2 is the anode of the first stage of chassis B and is coupled to the next stage in known manner. Terminals 2 and 2' are connected to chassis A and B respectively. The chassis mountings of A and B are insulated from ground as already stated and are connected electrically one to the other through the outer conductor of cable C and to the negative high tension supply terminal which is earthed.

In Fig. 3 Z1 and Z2 represents the impedances respectively of the output of chassis A unit and the input of chassis B unit terminating a transmission chain comprising two M-derived type of filters linked by a short transmission line.

From known theory, the cable can be replaced by its equivalent T or π type filter network N as shown in Fig. 4. Depending on the length and electrical constants of the transmission line, the equivalent network N is terminated by inductances or capacities. The line is in general a low impedance multi-section filter and may thus be incorporated in the tuning of the two auto transformers T1, T2, these being tuned to near the mean signal frequency for the amplifier.

This combination of the two effective tuned M-derived type networks and a transmission line forming a filter, is used to provide the following characteristics.

(i) Increased band width with a large number of tuned stages in cascade by the "band pass" type of effect of the combination.

(ii) Lessening of extraneous noise as arriving either at the input of the amplifier or in any other stage of the chassis unit A.

(iii) Cutting down the possibility of hum voltages or their harmonics travelling through from chassis unit A to chassis unit B.

(iv) Frequency selective changing of phase of signal across Z1, thereby (a) lessening the possibility of unwanted feedback to cause oscillation, (b) locating the "earth" of the system, (c) limiting the outlying range of frequencies and hence "noise" in those regions, improving amplifier cutoff characteristics.

(v) Each chassis unit can be separately used in general for a much broader band amplifier at lesser gain than the whole amplifier.

(vi) H. T. negative which is connected to the chassis separately has to pass directly to earth, and it has been found during experiments that only one earth point can be practically obtained in such an arrangement. Hum (and its harmonic up to 5th) level was found to be too low to be measurable.

(vii) The step-down transformer-cable-step-up transformer combination helps the phasing of the various frequency components of the signals and gives a satisfactory phase-frequency characteristic of the feedback.

The use of such a combination as is described

herein obviates various known problems of high gain low noise amplifiers besides providing the extra benefit of broad-band reception with a conveniently low overall noise level at the amplifier output.

What is claimed is:

1. A broad band high frequency amplifier comprising a plurality of amplifier stages connected in cascade characterized in this that said stages are divided into groups of cascade-connected stages, each group forming an insulated chassis unit, the stages being resonant at respective frequencies spread over the frequency spectrum to be amplified, the number of stages in each group being less by one or more than the number which would produce instability or other undesired effects on account of feedback, the output of one group being coupled to the next successive group through a four terminal band-pass filter network having substantially uniformly distributed inductance and capacity and earthed at one terminal whereby a high gain of the multi-stage amplifier is possible with a high signal to noise ratio.

2. A broad band high frequency amplifier as claimed in claim 1, wherein the output of one group is fed to an auto transformer and the input to the next succeeding group is fed through an auto transformer the said output and input transformers being coupled by a transmission line having distributed inductance and capacity so that said elements together form said band pass filter.

3. A broad band high frequency amplifier as claimed in claim 1, wherein the output of one group is fed to an auto transformer and the input to the next succeeding group is fed through an auto transformer the said output and input transformers being coupled by a transmission line of the concentric conductor type, the outer conductor of which is earthed.

4. A broad band high frequency amplifier as claimed in claim 1, wherein the output of one group is fed to an auto transformer and the input to the next succeeding group is fed through an auto transformer the said output and input transformers being coupled by a transmission line having distributed inductance and capacity so that said elements together form said band pass

filter, said auto transformers being tuned to approximately the mean signal frequency of the amplifier.

5. A broad band high frequency amplifier comprising a plurality of amplifier stages connected in cascade, the stages being resonant at frequencies spread over the frequency spectrum to be amplified, said stages being divided into groups, and means for coupling successive groups comprising a four terminal band pass filter network having substantially uniformly distributed inductance and capacity and grounded at one terminal.

6. An amplifier as set forth in claim 5, comprising a separate conductive chassis for each group connected to the ground terminals of the stages in such group, the chassis for successive groups being coupled through said network.

7. An amplifier as set forth in claim 5, comprising a separate conductive chassis for each group connected to the ground terminals of the stages in such group, the chassis for successive groups being coupled through said network, and the chassis of one group being grounded through the chassis of a succeeding group.

8. An amplifier as set forth in claim 5, in which the network comprises a concentric conductor connected at its ends to said groups.

9. An amplifier as set forth in claim 5, in which the network includes auto-transformers connected across the output and input respectively of said groups, and a concentric conductor connected to said auto-transformers.

10. An amplifier as set forth in claim 5, in which the network includes a step-down auto-transformer connected across the output of one of said groups, a step-up transformer connected across the input of the other group, and a concentric conductor connecting said auto-transformers.

11. An amplifier as set forth in claim 5, in which the network includes auto-transformers connected across the output and input respectively, of said groups and tuned to approximately the mean signal frequency of the amplifier.

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