May 10, 1966 L. KIRCHGESSNER 3,251,010

TWO-TERMINAL LOSSY RESONANT FILTER FOR SUPPRESSING INTERFERENCE FREQUENCIES IN IGNITION SYSTEMS

Filed March 29, 1961 2 Sheets-Sheet 1

FIG. 1




FIG. 2

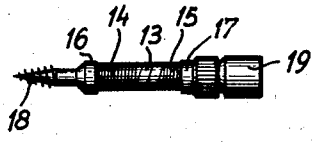
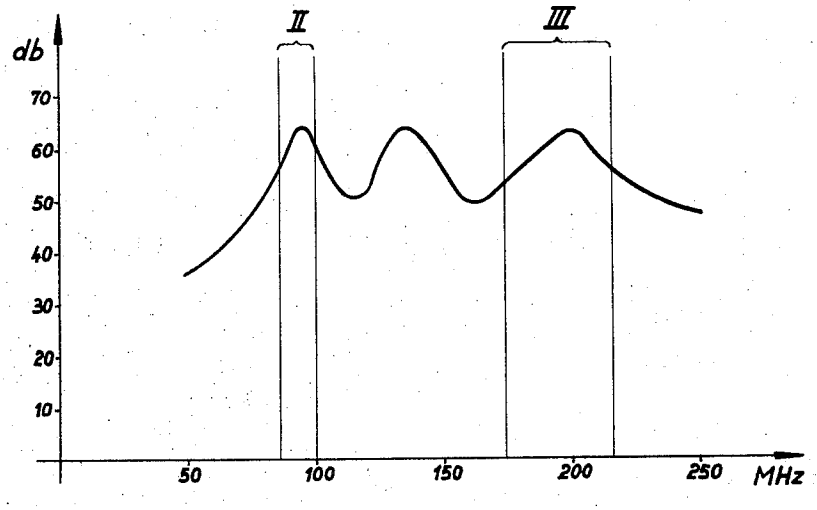



FIG. 3




INVENTOR
LEO KIRCHGESSNER

BY
Michael S. Striker
Attorney

May 10, 1966 L. KIRCHGESSNER 3,251,010
TWO-TERMINAL LOSSY RESONANT FILTER FOR SUPPRESSING
INTERFERENCE FREQUENCIES IN IGNITION SYSTEMS
Filed March 29, 1961 2 Sheets-Sheet 2

FIG. 4

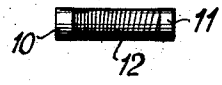



FIG. 5

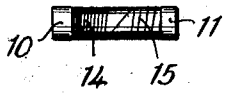
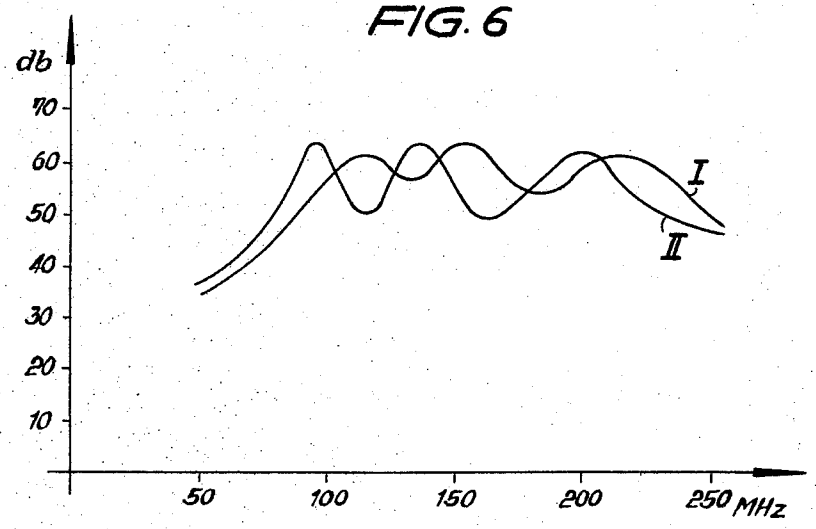



FIG. 6




INVENTOR
LEO KIRCHGESSNER

By Michael S. Striker
Attorney

United States Patent Office 3,251,010 Patented May 10, 1966



3,251,010

# TWO-TERMINAL LOSSY RESONANT FILTER FOR SUPPRESSING INTERFERENCE FREQUENCIES IN IGNITION SYSTEMS

Leo Kirchgessner, Stuttgart, Germany, assignor to Robert Bosch G.m.b.H., Stuttgart, Germany

Filed Mar. 29, 1961, Ser. No. 100,782
Claims priority, application Germany, Jan. 14, 1959, B 51,740; Apr. 2, 1960, B 57,318
18 Claims. (Cl. 333—79)

This is a continuation-in-part of my copending application Serial No. 2,150, filed January 13, 1960, now abandoned, for "Attenuation Dipole."

The present invention refers to ignition circuits of Otto-type motors, and more specifically to an attenuation dipole to be inserted in the high voltage circuits of the ignition installations of such motors for purposes of blocking or eliminating high frequency oscillations caused by the spark gaps used for the purpose of ignition. It is desirable to block or eliminate such high frequency oscillations in order to avoid an interference with the reception of wireless transmission of radio or other communications or of television transmissions.

In the past, it has been proposed to render ineffective the interference frequencies emanating from ignition installations of the type mentioned above, either by metallically screening or shielding the entire ignition installation or by providing in the high frequency connections of the ignition installation resistors of high ohmic resistance for attenuating the interference oscillations. None of these means for blocking or eliminating the interference frequencies are quite desirable. Shielding or screening devices are very complicated and rather costly. In addition, it is very difficult to provide for a shielding which will totally surround the installation without leaving any gaps. Therefore, it cannot be applied except in rare cases. The second way of counteracting the effect of disturbing frequencies has been widely applied. In this case, resistors having a resistance of 10,000 to 20,000 ohms are connected in each one of the high voltage connections of the ignition installation. However, such an arrangement entails the great disadvantage that these resistors constitute a very substantial load for the ignition circuits and therefore considerably reduce the available energy for carrying out the ignition. Particularly, in the case of internal combustion engines operating with high compression it is very likely that due to the reduction of the electrical energy available at the spark plugs, ignition failures may occur. It is clear that this danger can only be avoided by considerably increasing the power output of the ignition installation, which is certainly undesirable for obvious reasons.

It has been generally assumed up to now that the interference oscillations emanating from the ignition installations of the type set forth can only be blocked, unless shielding is provided, by arranging in the high voltage connections resistors of as high a resistance as possible. However, it has been found now that this common assumption is not correct. At least blocking or elimination of disturbing high frequencies cannot be attained for all frequency ranges by insertion of resistors. The desired result can be only obtained in this manner for the range of medium and lower frequencies because in the case of higher frequencies of the frequency band produced by sparks, the respective resistors are bridged by the natural capacitance thereof so that the resistors are finally, at very high frequencies, without any noticeable attenuation effect.

However, while a satisfactory blocking or attenuation effect in specified or selected frequency ranges is quite sufficient in many cases, there are circumstances and



conditions where it is desirable to broaden the width of the frequency band in which the desired attenuation is to be obtained, and to provide in this manner for a substantially increased attenuation or blocking effect.

It is therefore a main object of this invention to provide for attenuator means which would be satisfactory both in the higher and highest ranges of the occurring interference frequencies but nevertheless would also be capable of blocking oscillations that may occur in a lower frequency range.

It is therefore a further object of this invention to provide for attenuator means as set forth in the preceding paragraph but taking effect in broader frequency ranges.

It is another object of this invention to provide for attenuator means of simple and rigid construction which can easily be introduced into existing installations and are substantially less expensive than the known devices for eliminating interference frequencies.

With above objects in mind, the present invention provides an attenuation dipole for blocking interference oscillations in motor ignition circuits, comprising, reactance means having two terminals and including in parallel connection capacitance means and inductance means selected in relation to one another so as to determine a resonance frequency thereof located within the range of high frequency oscillations which are to be blocked, the inductance means including coil means made of resistance wire having a resistivity and being dimensioned for being capable of blocking by its ohmic resistance oscillations at frequencies in a range substantially below that of the high frequency oscillations.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings, in which:

FIG. 1 is an elevation of an attenuation dipole according to the invention suitable for dealing with a frequency band in the frequency range of radio communications;

FIG. 2 is an elevation of another embodiment of the invention suitable for dealing both with high frequencies in the range of radio communications and with still higher frequencies of the frequency range of television transmissions;

FIG. 3 illustrates as a diagram the resonance characteristic of the device illustrated by FIG. 2;

FIGS. 4 and 5 are elevations of further embodiments of the invention similar to that of FIGS. 1 and 2, but having wire coils wound at a pitch steadily increasing according to an arithmetic function; and

FIG. 6 is a diagram illustrating, for comparison, the resonance characteristics of the devices illustrated by FIGS. 2 and 5.

Before describing in detail the illustrated embodiments of the invention, it should be understood that the most important frequency ranges in which the interference effect of ignition-caused oscillations is to be eliminated, are the high frequency radio tranmission band between 87 and 100 mc., and the very high frequency band of television transmissions between 174 and 216 mc. Obviously, the attenuation components of the attenuator dipole according to the invention must be selected depending upon the frequency ranges which they are expected to deal with. For instance, if the main purpose of the attenuator dipole is to eliminate an interference with the radio frequencies between 87 and 100 mc., then the attenuator dipole should be aranged to have a resonance

frequency in the order of 90 mc. If attenuator dipoles of this character are connected in the high voltage connections of motor ignition installations, the operation of the ignition devices will not interfere with radio reception in the above mentioned frequency range. However, disturbing frequencies which may only occur in a substantially lower frequency range in which for obvious reasons the inductance of the inductive component of the attenuation dipole could not be effective, will still be eliminated by the same device because the coil means is provided with a sufficiently high ohmic resistance. Experiments have shown that this latter result can usually be obtained with an ohmic resistance of the order of 1000 ohms, i.e. with a resistance which is not capable of substantially reducing the energy available in the ignition installation. It is advisable to install the attenuation dipoles according to the invention in substantially close proximity to the location where the sparks causing the generation of the interference oscillations occur, and the installation may even take place substantially within the spark plugs or in a connector connecting the ignition cable with the spark plug, or finally within the distributor of the ignition installation. In exceptional cases, it may even be desirable or advisable to install several identical attenuation dipoles according to the invention in different locations within the high voltage connections of the ignition installations.

Referring now to FIG. 1, the attenuation dipole illustrated thereby is designed for being installed within a distributor of a high voltage ignition installation for multicylinder Otto-type engines.

The dipole according to FIG. 1 consists of a ceramic core of 5 mm. diameter and having a dielectric constant of 6, carrying at either end a terminal cap **10** and **11**, respectively, attached with press-fit. A wire coil **12** is wound around the core and connected at either end with the caps **10** and **11**, respectively. In the case of the present example, the self-capacitance of the assembly, namely of the ceramic body with its two terminal caps and including an allowance for stray capacitance and for the capacitance of the wire coil **12**, has been calculated to amount to .12 micromicrofarad. By providing for an inductance of the wire coil **12** amounting to .26 microhenry, the resonance frequency of the whole arrangement can be determined in such a manner that it is located approximately in the center of the frequency range of radio transmissions between 87 and 100 mc. For this purpose, the number of turns of the coil should be 170. On the basis of these calculations, the wire coil would have a length 17 mm. between the two terminal caps **10** and **11**, and it would have an ohmic resistance of 1000 ohms on account of being made of a resistance wire of .04 mm. diameter and having a resistivity of 50 microhm-centimeter.

With an attentuation dipole of this construction a fully satisfactory elimination of interference oscillations in the above mentioned frequency range can be obtained. Nevertheless the ohmic resistance of 1000 ohms simultaneously yields effective interference elimination also in considerably lower frequency ranges related to short, medium and long wave lengths.

It stands to reason that in determining the ohmic resistance in an attenuation dipole according to the invention the resistance value of 1000 ohms need not be adhered to without exception. The rule to be followed in this respect is rather the following one: If an attenuation dipole is to be adjusted or selected for a resonance frequency in the particular frequency range in which disturbances are to be eliminated, then its quality or effectiveness is characterized by the ratio between inductance and resistance in relation to the particular frequency which ratio is expressed by the fraction $\omega L/R$ wherein $\omega=1/\sqrt{LC}$. This ratio should always be larger than 1, for instance between 2 and 10, preferably $=5$.

It can be seen that if the above rule is followed, which in fact has been followed in the above described example referring to FIG. 1, then the designer has a free choice of selecting the proper resistance value in order to eliminate interference frequencies in the range of long and medium wave lengths. Nevertheless, it is certainly desirable and advisable to keep the resistance values as low as possible in order to avoid the above criticized reduction of the available ignition energy and to avoid ignition failures in the operation of the pertaining internal combustion engine. Extensive experiments have shown that a resistance value of 1000 ohms is entirely satisfactory in consideration of all pertaining conditions. On the other hand, it is of course possible, by changing the resistance value, to increase the value of the ratio $\omega L/R$ to values above 10, for instance, in the neighborhood of 20 or even above.

It is evident that in exactly the same manner as the above example of an attenuation dipole for the radio frequency range between 87 and 100 mc. was developed, a similar dipole for the higher frequency range of television transmission between 174 and 216 mc. can be developed. However, since generally the capacitance of the core means carrying the resistor element is fixed on account of its dimensions and by the size and nature of the terminal caps, the capacitance value of these elements must be first of all determined exactly because only on the basis of the capacitance value of these elements the inductance and the number of turns of the coil means can be determined.

In certain cases, it is of high interest to provide for an attenuation dipole which is capable of dealing both with the above mentioned radio frequency range and also with the above mentioned television frequency range and has resonance frequencies related to both these frequency ranges. Such a requirement may be met for instance by using two differently tuned attenuation dipoles according to the invention, connected in series in which case one of them will deal with the frequencies in one range and the other one will deal with frequencies in the other range. However, it is most convenient to arrange on one common core means an inductance coil which is so subdivided into two portions that one of them determines a first resonance frequency while the two portions determine a second resonance frequency, these resonance frequencies being respectively related to the frequency ranges in which interference oscillations are to be blocked.

An attenuation dipole according to the invention and capable of operating in the last described manner is illustrated by way of example in FIG. 2. In mechanical respects this dipole is designed for being installed within one end of an ignition cable. A ceramic core **13** is provided in this case with a first coil **14** having 70 turns and, spaced therefrom, with a second wire coil **15** having 27 turns. The conductive connection between the coil portions **14** and **15** is in this case constituted by several turns of the wire used for the coils **14** and **15**, but the connecting turns are very far spaced apart. The free ends of the combined coils **14** and **15** are conductively connected with terminal caps **16** and **17**, respectively, which are pressed onto the core **13**. The terminal **16** has an extension **18** in the form of a wood screw which permits the mounting of the dipole on the end of an ignition cable by screwing the threaded portion **18** into the conductive core of the cable. On the other hand, the terminal **17** has a plug-shaped extension **19** which may be used for plugging this dipole directly into a spark plug.

It will be understood that the metallic masses of terminals **16**, **18** and **17**, **19**, respectively, of the example of FIG. 2 are substantially larger than the masses of the terminal caps **10** and **11** in the case of FIG. 1, and that therefore these greater masses cause a substantially greater natural capacitance of the dipole according to FIG. 2 as compared with the capacitance of the dipole of FIG. 1. Consequently, the number of turns required for determining the resonance frequency in the case of FIG. 2 will

have to be smaller than the number of turns used in the dipole according to FIG. 1. However, these data can be easily determined by following the above given rules.

FIG. 3 is a diagram illustrating the resonance characteristic of an attenuation dipole according to FIG. 2 having two separate coil portions. The characteristic curve shows, in terms of decibels versus mc., three attenuation maxima at 95, 137 and 200 mc. The attenuation maximum at 95 mc. related to the above mentioned radio frequency range between 87 and 100 mc. is determined by the entire number of 97 turns of wire wound on the ceramic core **13**, while the partial resonances appearing at 137 mc. and 200 mc. are due to the effect of the partial coils 14 and 15, respectively. The attenuation maximum 200 mc. is, of course, related to the above mentioned television frequency range. While for average purposes this arrangement according to FIGS. 2 and 3 only the resonance conditions or attenuation maxima at 97 and 200 mc. are of direct value for dealing with the frequency ranges of radio and television transmissions, respectively, the additional attenuation maximum or resonance condition at 137 mc. is simply due to the subdivision of the coil means into the portions **14** and **15**. Thus, an additional attenuation effect is obtained in a frequency range located between the above mentioned two frequency ranges, but this intermediate range of operation may be useful for instance in case a disturbance or interference with aircraft communications is to be avoided which may work in that particular intermediate range.

It is evident that the same resonance or attenuation characteristic as illustrated by FIG. 3 can be obtained also if two separate attenuation dipoles having coil means wound on separate ceramic cores are used and connected with each in series. In this case, one of the cores would carry a coil determining a resonance frequency for the higher frequency range, and the two separate coils wound on the two separate ceramic cores would have to be calculated and produced so as to determine jointly a resonance frequency corresponding to a lower frequency range to be dealt with. Also in this case, a third attenuation maximum would be obtained which is located in an intermediate frequency range. In certain cases, it may even be convenient to predetermine an attenuation maximum, resulting from the total number of coil turns of the two attenuation dipoles, which would be located in a frequency range still lower than the frequency range of the radio communication between 87 and 100 mc. In this case, the radio frequency band would be free of interference frequencies by the predetermined partial resonance frequency of the coil having the greater number of turns, while the higher frequency range would be dealt with by the partial resonance frequency of the coil having the smaller number of turns.

Referring now to FIGS. 4 and 5, it has been found that an improved attenuation or blocking effect can be obtained most conveniently by modifying the embodiment illustrated by FIG. 1 in such a manner that the resistance wire coil **12** wound on a ceramic core fitted with metallic end caps **10** and **11**, is not wound at a constant pitch, but as shown by FIG. 4 at a pitch which steadily increases from one end of the coil to the other. The pitch may increase according to an arithmetic, geometric or logarithmic function. It has been found that the result of this particular type of a resistance wire coil is that for instance at a frequency above that corresponding to the first resonance condition the decrease of attenuation is slower than that appearing in the embodiment according to FIG. 1, and, if in the embodiment according to FIG. 2 the coils **14** and **15** are wound with varying pitch in accordance with the showing of FIG. 4, the attenuation characteristic is flatter between the further resonance points i.e., it does not drop as much as it is the case if the coils **14** and **15** are each wound with a respective constant pitch and as is illustrated in FIG. 3. In other words, the advantageous effect of the wire coils wound at steadily increasing pitch is caused by a corresponding steady variation of the inductance and capacitance of the attenuator with varying frequencies, the values of maximum resistance being likewise changed.

Careful tests and measurements have proven that particularly attenuators according to the invention having wire coils wound with a pitch increasing in arithmetic progression have a remarkably better effect than those equipped with wire coils wound at constant pitch. It will be understood that the winding of coils at varying pitch does not constitute a problem because the guide means used during the winding operation can be guided easily to move under the control of a predetermined curve or cam.

It should be noted that the just described form of the invention applies also where a plurality of individual coils or combinations of partial coils wound respectively with pitches increasing according to different mathematical functions yield very satisfactory results.

In a tested and successful example of the embodiment according to FIG. 4, the wire coil **12** comprises 120 turns of resistance wire .035 mm. thick resulting in a total resistance of about 800 ohms.

FIG. 5 is the illustration of a modified embodiment roughly comparable to that illustrated by FIG. 2. However, according to FIG. 5 the two coil portions **14** and **15** are each wound at a varying pitch as discussed with respect to FIG. 4, the length and the pitch variation of portion **14** differing from those of portion **15**.

For the purpose of comparison, FIG. 6 illustrates the resonance or attenuation characteristic curve I of the embodiment according to FIG. 5, and the corresponding resonance and attenuation characteristic curve II which corresponds to the embodiment of FIG. 2 and is therefore a duplication of the curve shown in FIG. 3.

As can be seen from FIG. 6, curve I shows in the entire frequency range between approximately 100 megacycles and approximately 200 megacycles substantially smaller drops of attenuation between the resonance peaks, and less pronounced peaks than the characteristic curve II. Consequently, the type of attenuator corresponding to characteristic curve I has a substantially greater interference blocking efficiency, particularly in the frequency range shown, than the attenuator corresponding to characteristic curve II.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of attenuation dipoles differing from the types described above.

While the invention has been illustrated and described as embodied in an attenuation dipole for blocking high frequency interference oscillations, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

**1.** Attenuation dipole for blocking interference oscillations in the high voltage portion of motor ignition circuits, comprising, reactance means having two terminals and including in parallel connection capacitance means and inductance means selected in relation to one another so as to determine a resonance frequency thereof located within the range of high frequency oscillations which are to be blocked, said inductance means including coil means made of resistance wire having a resistivity and being di-

mensioned for being capable of blocking by its ohmic resistance oscillations at frequencies in a range substantially below that of said high frequency oscillations, the ratio between the inductance of said inductance means and said ohmic resistance in relation to said resonance frequency being $\omega L/R$ larger than 1, wherein $\omega$ is the resonance frequency, L is the inductance and R is the ohmic resistance.

2. Attenuation dipole for blocking interference oscillations in motor ignition circuits, comprising, reactance means having two terminals and including in parallel connection capacitance means and inductance means selected in relation to one another so as to determine a resonance frequency thereof located within the range of high frequency oscillations which are to be blocked, said inductance means including coil means made of resistance wire having a resistivity and being dimensioned for being capable of blocking by its ohmic resistance oscillations at frequencies in a range substantially below that of said high frequency oscillations, the ratio between the inductance of said inductance means and said ohmic resistance in relation to said resonance frequency being $\omega L/R$ larger than 2 and smaller than 10, wherein $\omega$ is the resonance frequency, L is the inductance and R is the ohmic resistance.

3. Attenuation dipole for blocking interference oscillations in motor ignition circuits, comprising, reactance means having two terminals and including in parallel connection capacitance means and inductance means selected in relation to one another so as to determine a resonance frequency thereof located within the range of high frequency oscillations which are to be blocked, said inductance means including coil means made of resistance wire having a resistivity and being dimensioned for being capable of blocking by its ohmic resistance oscillations at frequencies in a range substantially below that of said high frequency oscillations, the ratio between the inductance of said inductance means and said ohmic resistance in relation to said resonance frequency being $\omega L/R$ equal to approximately 5, wherein $\omega$ is the resonance frequency, L is the inductance and R is the ohmic resistance.

4. Attenuation dipole as claimed in claim 1, wherein for the purpose of blocking interference oscillations in the frequency range of radio communications between 87 and 100 mc. said inductance means and capacitance means are selected for a resonance frequency of the order of 90 mc., and the ohmic resistance of said resistance wire is of the order of 1000 ohm.

5. Attenuation dipole as claimed in claim 4, wherein said core means is made of ceramic material, the self-capacitance of said reactance means is .12 micromicrofarad and the inductance of said coil means is 26 microhenry.

6. Attenuation dipole for blocking interference oscillations in motor ignition circuits, comprising, reactance means having two terminals and a first and a second reactance portion connected in series with one another, each of said reactance portions including a parallel combination of capacitance means and inductance means selected in relation to one another in such a manner that in each of said portions a resonance frequency is determined thereby which, in said first portion is located within a first range of high frequency oscillations to be blocked, and in said second portion is located within a second range of high frequency oscillations to be blocked, said inductance means including coil means made of resistance wire having a resistivity and being dimensioned for being capable of blocking by its ohmic resistance oscillations at frequencies in a range substantially below that of said high frequency oscillations.

7. Attenuation dipole as claimed in claim 6, wherein said reactance means include a common core means carrying said terminals and said coil means of said first and second reactance portions.

8. Attenuation dipole for blocking interference oscillations in the high voltage portion of motor ignition circuits, comprising, reactance means having two terminals and including in parallel connection capacitance means and inductance means selected in relation to each other so as to determine a resonance frequency thereof located within the range of high frequency oscillations which are to be blocked, said inductance means including coil means being wound helically at a pitch varying steadily between the ends of said coil means and made of resistance wire having a resistivity and being dimensioned for being capable of blocking by its ohmic resistance oscillations at frequencies in a range substantially below that of said high frequency oscillations, the ratio between the inductance of said inductance means and said ohmic resistance in relation to said resonance frequency being $\omega L/R$ larger than 1, wherein $\omega$ is the resonance frequency, L is the inductance and R is the ohmic resistance.

9. Attenuation dipole for blocking interference oscillations in the high voltage portion of motor ignition circuits, comprising, reactance means having two terminals and including in parallel connection capacitance means and inductance means selected in relation to each other so as to determine a resonance frequency thereof located within the range of high frequency oscillations which are to be blocked, said reactance means including core means carrying said terminals, and, connected therewith, coil means made of resistance wire having a resistivity and being dimensioned for being capable of blocking by its ohmic resistance oscillations at frequencies in a range substantially below that of said high frequency oscillations, said coil meanst being wound helically at a pitch varying steadily between the ends of said coil means.

10. Attenuation dipole for blocking interference oscillations in motor ignition circuits, comprising reactance means having two terminals and a first and a second reactance portion connected in series with each other, each of said reactance portions including capacitance means and inductance means selected in relation to each other in such a manner that in each of said portions a resonance frequency is determined thereby which, in said first portion is located within a first range of high frequency oscillations to be blocked, and in said second portion is located within a second range of high frequency oscillations to be blocked, each of said inductance means including coil means made of resistance wire having a resistivity and being dimensioned for being capable of blocking by its ohmic resistance oscillations at frequencies in a range substantially below that of said high frequency oscillations, respectively, each of said coil means being wound helically at a pitch varying steadily between the ends of said coil means.

11. Attenuation dipole as claimed in claim 10, wherein said capacitance means include a common core means of dielectric material carrying said terminals and said coil means of said first and second reactance portions.

12. Attenuation dipole as claimed in claim 11, wherein said pitch varies according to an arithmetic progression.

13. Attenuation dipole as claimed in claim 11, wherein said pitch varies according to a geometrical progression.

14. Attenuation dipole as claimed in claim 11, wherein said pitch varies according to a logarithmic progression.

15. Attenuation dipole as claimed in claim 11, wherein the ratio between the inductance of said inductance means and said ohmic resistance in relation to said resonance frequency is $\omega L/R$ larger than 1, wherein $\omega$ is the resonance frequency, L is the inductance and R is the ohmic resistance.

16. Attenuation dipole for blocking interference oscillations in the high voltage portion of motor ignition circuits, comprising, reactance means having two terminals and including in parallel connection capacitance means and inductance means selected in relation to each other so as to determine a resonance frequency thereof located within the range of high frequency oscillations which are to be blocked, said inductance means including coil means

being wound helically at a pitch varying steadily according to an arithmetic progression between the ends of said coil means made of resistance wire having a resistivity and being dimensioned for being capable of blocking by its ohmic resistance oscillations at frequencies in a range substantially below that of said high frequency oscillations.

17. Attenuation dipole for blocking interference oscillations in the high voltage portion of motor ignition circuits, comprising, reactance means having two terminals and including in parallel connection capacitance means and inductance means selected in relation to each other so as to determine a resonance frequency thereof located within the range of high frequency oscillations which are to be blocked, said inductance means including coil means being wound helically at a pitch varying steadily according to a geometrical progression between the ends of said coil means made of resistance wire having a resistivity and being dimensioned for being capable of blocking by its ohmic resistance oscillations at frequencies in a range substantially below that of said high frequency oscillations.

18. Attenuation dipole for blocking interference oscillations in the high voltage portion of motor ignition circuits, comprising, reactance means having two terminals and including in parallel connection capacitance means and inductance means selected in relation to each other so as to determine a resonance frequency thereof located within the range of high frequency oscillations which are to be blocked, said inductance means including coil means



being wound helically at a pitch varying steadily according to a logarithmic progression between the ends of said coil means made of resistance wire having a resistivity and being dimensioned for being capable of blocking by its ohmic resistance oscillations at frequencies in a range substantially below that of said high frequency oscillations.

**References Cited by the Examiner**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 1,961,140 | 6/1934 | Farnham | 333—76 |
| 2,139,055 | 12/1938 | Wright et al. | 333—31 |
| 2,238,915 | 4/1941 | Peters et al. | 333—84 |
| 2,258,261 | 10/1941 | Roosenstein | 333—31 |
| 2,443,109 | 6/1948 | Linder | 333—79 |
| 2,518,225 | 8/1950 | Dorst | 333—31 |
| 2,539,926 | 1/1951 | Rainwater | 335—70 |
| 2,682,037 | 6/1954 | Bobis et al. | 333—76 |
| 2,838,735 | 6/1958 | Davis | 333—31 |
| 3,002,136 | 9/1961 | Garstang | 333—79 |

FOREIGN PATENTS

| | | |
|---|---|---|
| 571,590 | 9/1958 | Belgium. |
| 660,936 | 7/1929 | France. |
| 432,040 | 7/1935 | Great Britain. |
| 939,611 | 10/1963 | Great Britain. |

HERMAN KARL SAALBACH, *Primary Examiner.*

ELI SAX, ELI LIEBERMAN, *Examiners.*