

July 22, 1941.

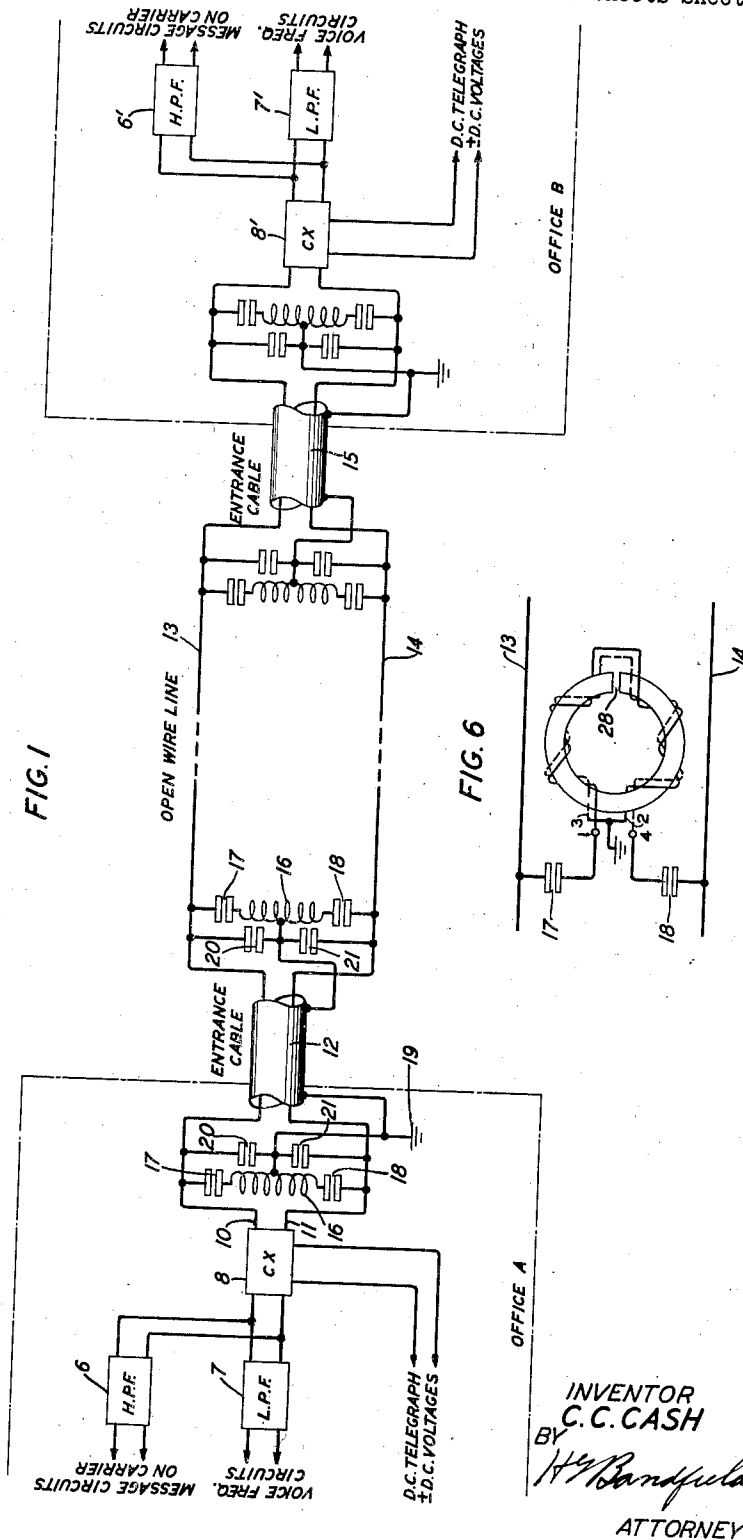
C. C. CASH

2,249,808

DRAINAGE SYSTEM

Filed Jan. 3, 1940

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

FIG. 2A

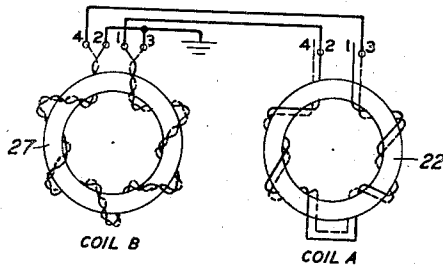


FIG. 2B

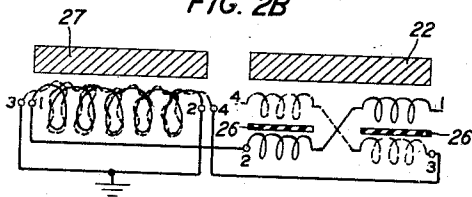


FIG. 4A

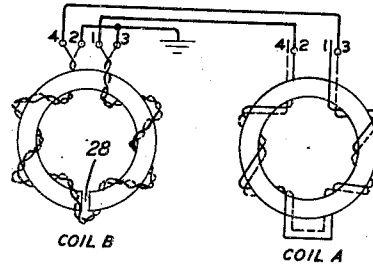


FIG. 4B

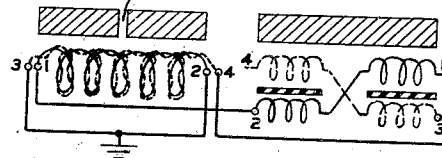


FIG. 3A

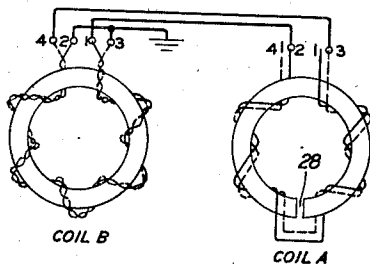


FIG. 3B

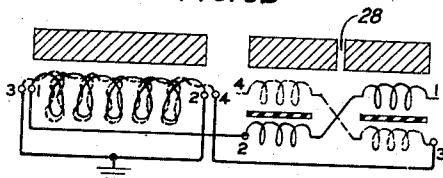


FIG. 5A

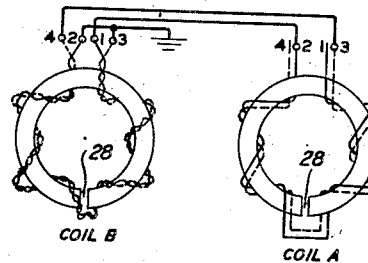
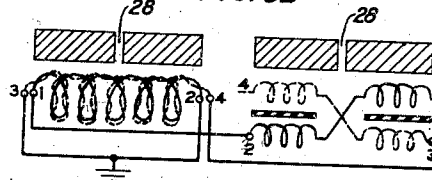


FIG. 5B



INVENTOR
C. C. CASH
BY *H. Bamfield*
ATTORNEY

UNITED STATES PATENT OFFICE

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DRAINAGE SYSTEM

Claude C. Cash, New York, N. Y., assignor to
Bell Telephone Laboratories, Incorporated,
New York, N. Y., a corporation of New York

Application January 3, 1940, Serial No. 312,299

9 Claims. (Cl. 179-78)

This invention relates to drainage systems and more particularly drainage systems for minimizing the effects of lightning interference on high frequency communication lines.

Drainage coils have been used in the past as a means of reducing interference but such drainage was obtained by using a coil having a low impedance to ground to the discharge currents and a high metallic circuit inductance to the normal telephone transmission. Such drainage coils have been used either for direct drainage or as discharge balance coils. In the first arrangement the coil is connected directly to the line wires and in the second arrangement the coil is connected to the line wires through open space protectors.

It has been found that such a coil is not good from the standpoint of reducing the metallic circuit interference on high frequency circuits when protector blocks are in series with the coil and when operating direct current telegraph voltages are on the line wires. In the first place, with a coil of high metallic circuit inductance and low longitudinal circuit impedance to ground, the coil possesses a very high distributed capacity which permits the high frequency currents generated by the arcing protectors to flow in the metallic circuit. In this way interference is generated and retained in the telephone circuit, thereby causing interference to the normal transmitted signals. This fact is particularly important in the higher frequencies of certain types of carrier systems which may have a frequency range of from 3 to 150 kilocycles. For example, a coil based on the philosophy of obtaining minimum impedance to ground may give a 95 per cent protection at 10 kilocycles but will afford practically no protection at a frequency of 140 kilocycles.

In addition the coils used heretofore are not effective when direct current telegraph voltages are present since with such condition there may appear a voltage-to-ground on one wire ranging from zero to ± 110 volts and on the other wire a similar voltage-to-ground but unrelated in either magnitude or polarity. Thus, when the protectors in series with the coil operate, these direct current voltages are applied directly across the coil windings. If these voltages are equal and of the same polarity, their effect on the operation of the drainage coil will be nil since the magnetization in the two sides of the coil in the magnetic circuit would oppose and therefore balance each other out and there would be no resultant effect on the hysteresis loop of the coil and thus no change in inductance. However,

with one wire having a voltage differing in magnitude and polarity from the voltage on the other wire, there will occur unequal magnetization in the two sides of the coil, thereby permitting a condition of saturation at the time of the discharge. The various degrees of unbalanced magnetization would result in minor hysteresis loops which determine the extent of saturation. The magnitude of this saturation effect is of a random nature, varying with the varying direct current voltages. Thus with voltages of the same polarity but unequal magnitude there will occur an unbalance in the magnetization resulting in a certain degree of saturation; voltages of opposite polarity and unequal magnitude will cause a higher degree of magnetization and therefore a higher degree of saturation. The most serious case involves the full magnitude of the operating direct current telegraph voltages at opposite polarities. Under operating conditions these random effects on the coil are so severe that the coil loses some of its effectiveness in minimizing lightning interference. This is due to the fact that the inductance is so greatly reduced that the coil action in balancing the lightning discharge currents is impaired and at the same time the operation tends to produce a short circuit on the metallic pair. This condition will also exist where direct current telegraph systems may operate over the carrier wires on a metallic basis, since in this case, too, direct current voltages will appear across the coil when the protectors operate.

It is therefore an object of the present invention to reduce to a minimum the effects of lightning interference to communication circuits operating at carrier frequencies. A further object is to overcome the effects of lightning interference on such lines which also operate as composite telegraph lines.

To accomplish these and other objects and in accordance with the features of the invention there is provided a drainage system which has a relatively high inductance and a very low distributed capacity and at the same time a relatively low impedance to ground. The high inductance is necessary for adequate protection at the lower frequencies while the low distributed capacity is necessary for adequate protection at the higher frequencies. To obtain these characteristics the drainage system preferably comprises two separate and distinct retardation coils having their windings connected in series aiding. One of the coils of this system has a winding of twisted pair construction having a relatively high

inductance and is connected as the inside coil with its mid-point connected to ground. This coil, by virtue of its construction will have a relatively high distributed capacity and a very low leakage inductance. The second retardation coil has its windings so connected as to be in series aiding, one winding being connected to one terminal of the inside coil and the other winding to the other terminal of the inside coil. This second coil is so constructed as to have a low inductance, a low direct current resistance, a very low distributed capacity and a somewhat higher leakage inductance. By keeping practically all of the inductance in the inside coil, the resulting distributed capacity and leakage inductance of the arrangement will be a minimum. With such a combination there is obtained an effective drainage system having a very low minimum distributed capacity and a high metallic circuit inductance and at the same time a relatively low impedance to ground. Under certain conditions where the requirements are less severe the invention contemplates the use of a single coil having similar characteristics.

The invention may be more clearly understood by reference to the accompanying drawings in which Fig. 1 shows schematically the type of circuit in which applicant's drainage system is proposed for use, together with the drainage coils and associated protectors;

Fig. 2A shows one embodiment of the invention and Fig. 2B shows the relationship of the respective cores and windings of the arrangement of Fig. 2A;

Figs. 3A, 4A and 5A show modified coil arrangements;

Figs. 3B, 4B and 5B show the corresponding relationships between windings and cores; and

Fig. 6 shows an embodiment employing a single coil.

In Fig. 1, there is shown schematically a carrier system operating between office A and office B and protected with a drainage system in accordance with the present invention.

The high-pass filters 6 and 6' are connected in the carrier frequency circuits and low-pass filters 7 and 7' are connected in the voice frequency circuits at the respective stations and composite telegraph sets 8 and 8' are provided for the direct current telegraph circuits. Conductors 10 and 11 at office A pass through an entrance cable 12 and are connected to the line wires 13, 14 which pass through an entrance cable 15 at office B. At the outer end of cable 12 there is provided a drainage system 16, the outer terminals of which are connected through open space protectors 17 and 18 to the line wires 13 and 14. The mid-point of drainage system 16 is connected to the cable sheath and thence to ground at 19 and also to open space protectors 20, 21, the outer electrodes of which are connected to line wires 13 and 14. A similar arrangement is connected to the office end of cable 12 and similar arrangements are also connected to the opposite ends of cable 15 as shown.

While in Fig. 1 the drainage system is shown for the sake of clearness as a single winding, it is to be understood that in general it may consist of two distinct coils each of which comprises a pair of windings. As shown in Fig. 2A, coil A comprises a closed magnetic core 22 of toroidal shape provided with windings 1, 2 and 3, 4. The first half of winding 1, 2 is placed in position next to the core for a distance half-way around the core. An insulating material 25 preferably consisting of

layers of muslin or other insulating tape is placed over this half winding. The first half of winding 3, 4 is then wound as an outer winding over the first half of winding 1, 2. The second half of winding 3, 4 is then wound around the remaining portion of core 22 as an inner winding. Insulating material 26 is wound over this portion and the second half of winding 1, 2 is then wound as an outer winding over the second half of winding 3, 4. The construction of coil A is such as to provide a minimum of distributed capacity. Therefore, its inductance will be very small.

Coil B comprises a toroidal core 27 and a twisted pair of conductors comprising windings 1, 2 and 3, 4. The terminals 2, 3 are connected together and to ground so that the windings of coil B from terminal 1 to terminal 4 are inductively in series aiding. The windings are so placed that terminals 1 and 4 of coil A serve as the outer windings of the system and the windings 1, 2 and 3, 4 are connected inductively in series as are also the windings 1, 2 and 3, 4 of coil B, terminals 2 and 3 of coil A being connected to terminals 1 and 4 of coil B, respectively. With this arrangement there is obtained a drainage system having a very low distributed capacity and a relatively high metallic circuit inductance and at the same time a minimum impedance to ground.

The arrangement disclosed in Figs. 3A and 3B differs from that just described in that the core of coil A is provided with a small air-gap as shown in 28. This air-gap which preferably is only about 3 mils thick serves to stabilize the inductance and reduce the effects of saturation. The arrangement disclosed in Figs. 4A and 4B differs from that of Figs. 3A and 3B in that the air-gap 28 is provided in the core of the inner coil having a high distributed capacity. As disclosed in Figs. 5A and 5B air-gaps 28—28 are provided in the cores of both coils, the arrangement of the windings being the same as described in connection with Figs. 2A and 2B. Since the coil having a high distributed capacity is always connected in circuit as the inner coil the mid-point of which is connected to ground, the total distributed capacity of the system is relatively low while the metallic circuit inductance is relatively high. The method of placing the windings of coil A is such as to insure a low distributed capacity. The two windings of coil A in each case serve as outer windings of the system and since these windings are so placed as to have a low distributed capacity there results a drainage system in which the total distributed capacity is very low.

Under certain conditions in which the requirements are less severe or where the use of two coils is otherwise undesirable, fairly satisfactory results may be obtained by using a single coil as shown in Fig. 6. This coil is similar to coil A of Fig. 3A and possesses the features of low distributed capacity and an air-gap for stabilizing the inductance and reducing the effects of saturation. When used as a single coil the terminal leads 2 and 3 are connected together and to ground and terminal leads 4 and 1 are connected to the line conductors 13, 14 through the open space protectors 17 and 18.

Under normal operating conditions as may be noted from Fig. 1 the drainage system is not directly connected to the line conductors but is isolated therefrom by the open space protectors 17 and 18. It will thus be noted that this system permits the operation of the usual direct

current facilities of the communication plant such as the composited telegraph and direct current testing. However, when voltages of sufficiently high potential are induced upon the line conductors 13, 14 by lightning, these protectors break down and the drainage system immediately becomes operative to drain off the induced currents from the metallic line. At the same time the direct current telegraph voltages are impressed upon the drainage system through the arcs formed in the protectors. Since the protectors 20, 21 have a higher breakdown characteristic than the protectors 17 and 18, they do not operate under normal conditions, but are provided for the sole purpose of protecting the drainage coils from potentials which might endanger their insulation. The drainage systems disclosed herein provide broad band carrier systems with adequate protection from disturbances arising from lightning which break down the open space protectors. Under these conditions the arrangements force the high frequency generated currents caused by the arcing protectors to go to ground and at the same time provide sufficient balancing action and inductance when an impulse of direct current from the direct current telegraph system flows through the coil. These arrangements have been found to provide the maximum protection at the time of lightning discharge for the broad band present day carrier systems of from 3 to 150 kilocycles. The invention herein disclosed not only provides adequate protection for carrier systems of these frequencies but will be found effective for even a broader frequency band extending to 300 kilocycles.

What is claimed is:

1. In a protective system for high frequency communication lines, a pair of coils having their windings connected in series, the windings of each coil being connected inductively in series aiding and the free ends of said coils being connected to the line conductors through open space protectors, and means for connecting the mid-point of said combined coils to ground.

2. In the protection of high frequency communication lines, a drainage system comprising a pair of reactance coils each consisting of a magnetic core and a pair of balanced windings thereon, the windings of one of said coils being connected together in series aiding and forming the inner two windings of the drainage system, the windings of the other of said coils being connected respectively to the windings of said first coil so as to be inductively in series aiding and forming outer windings of the drainage system, means for connecting the mid-point of said system to ground, and means for connecting the outer terminal leads of the system between the conductors of the communication line.

3. In a protective system for high frequency communication lines, a coil comprising a magnetic core having a twisted pair of insulated conductors wound thereon to provide two balanced windings, said balanced windings being connected together in series aiding, a second coil comprising a magnetic core and a pair of spaced windings wound thereon, said windings being so connected to the windings of said first coil as to be inductively in series aiding, means for connecting the mid-point of said combined windings to ground, and means for connecting said windings between the conductors of the communication line.

4. In a protective system for high frequency communication lines, a coil comprising a magnetic core having a twisted pair of conductors wound thereon to provide two balanced windings, said windings being connected together in series aiding and having their mid-point connected to ground, a second coil comprising a magnetic core and a pair of spaced windings thereon, one of said windings having one terminal lead connected to one terminal of said first coil and the other of said spaced windings having one terminal lead so connected to the other terminal lead of said first coil that said windings are inductively in series aiding, and means for connecting the other terminal leads of said spaced windings between the conductors of the communication line.

5. In the protection of high frequency communication lines, a drainage system comprising four windings connected together inductively in series aiding, the inner two windings of said system being wound on a magnetic core and having their midpoint grounded, the two outer windings being wound on a second magnetic core and provided with means for connecting the combined windings to the conductors of a communication line.

6. In the protection of high frequency communication lines, a drainage system comprising four windings connected together inductively in series aiding, the inner two windings of said system being wound on a magnetic core and having their midpoint grounded, the two outer windings being wound on a second magnetic core and provided with means for connecting the combined windings to the conductors of a communication line, one of said magnetic cores being provided with an air-gap of approximately 3 mils thickness.

7. In a protective system for high frequency communication lines, a pair of reactance coils having their windings connected in series between the conductors of said lines, one of said coils comprising a pair of windings connected inductively in series aiding and so wound as to have high inductance and high distributed capacity, the other of said coils comprising a pair of windings connected inductively in series aiding and being wound to have low distributed capacity, and means for connecting the mid-point of said combined windings to ground.

8. In the protection of high frequency communication lines, a drainage system comprising four windings connected together inductively in series aiding, the inner windings of said system being wound as a pair of twisted conductors on a magnetic core and having their mid-point grounded, the two outer windings being wound on a second magnetic core, one of said windings being wound on one half of said core as the inner winding and on the second half of said core as the outer winding, the other of said windings being wound on the first half of said core as the outer winding and on the second half of said core as the inner winding, and a layer of insulating material separating said inner windings from said outer windings, and means for connecting the combined windings to the conductors of a communication line.

9. In the protection of high frequency communication lines, a drainage system comprising a magnetic core having a pair of balanced windings thereon connected inductively in series aiding, one of said windings being wound on

one half of said core as an inner winding and on the other half of said core as an outer winding, the other of said pair of windings being wound on the first half of said core as an inner winding, a layer of insulating material separating said inner windings from said outer windings, means for connecting the mid-point of said combined windings to ground, and means for connecting the outer ends of said combined windings to the conductors of a communication line.

CLAUDE C. CASH.