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Siems et al.

[11] **3,859,573**

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[54] **SIMULTANEOUS MULTI-CORE DEMAGNETIZATION**

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[56] **References Cited**
UNITED STATES PATENTS

| 2,959,722 | 11/1960 | Gilinson, Jr. | 317/157.5 |
| 3,482,163 | 12/1969 | Peek et al. | 317/157.5 |

[57] **ABSTRACT**

This invention relates to demagnetizing the cores of a plurality of input transformers, each transformer having a primary winding and a secondary winding connected to a load subject to becoming non-linear. The load has a linear operating mode when the amplitude of a sinusoidal signal applied to the primary winding is below a critical value and a non-linear operating mode when the amplitude of the applied AC signal exceeds this critical value. The demagnetization is achieved by "wiping" each transformer core with a decaying AC signal having an initial amplitude up to the critical value and a frequency corresponding to the initial amplitude which is sufficient to saturate each core.

4 Claims, 2 Drawing Figures

FIG. I.

FIG. 2.

I_1 = Primary current

I_2 = Secondary load current

R_1 = Resistance of primary

R_2 = "   " secondary

R_3 = Secondary load

X_1 = Primary leakage reactance

X_2 = Secondary "   "

g = Conductance of exciting circuit

b = Susceptance of exciting circuit
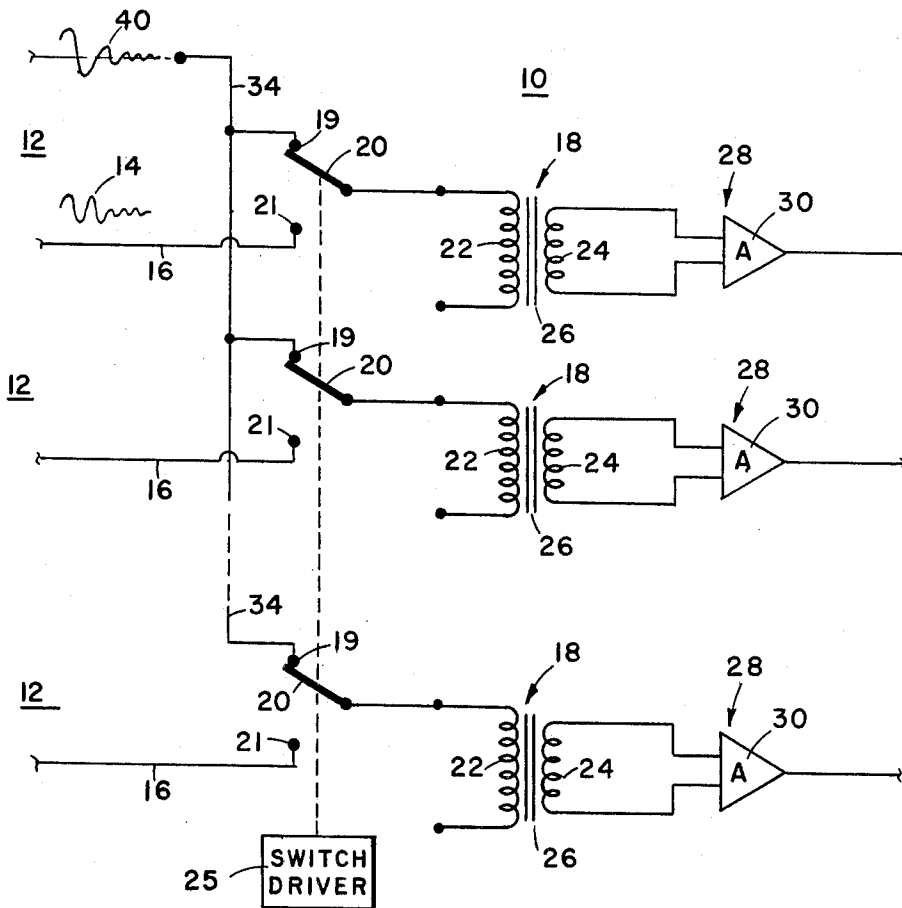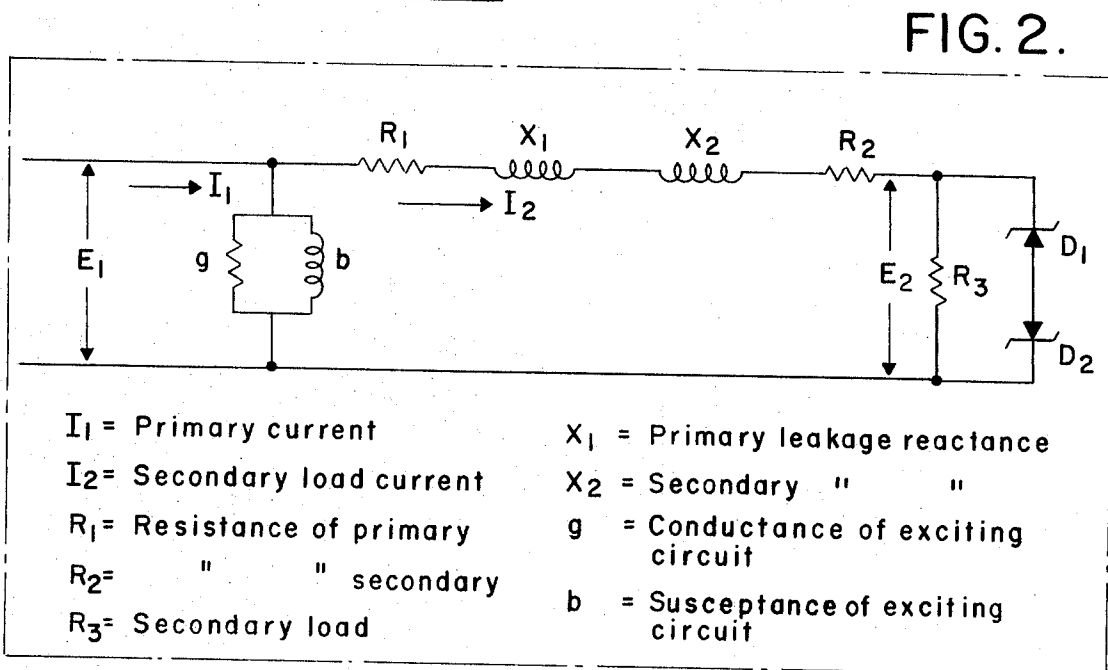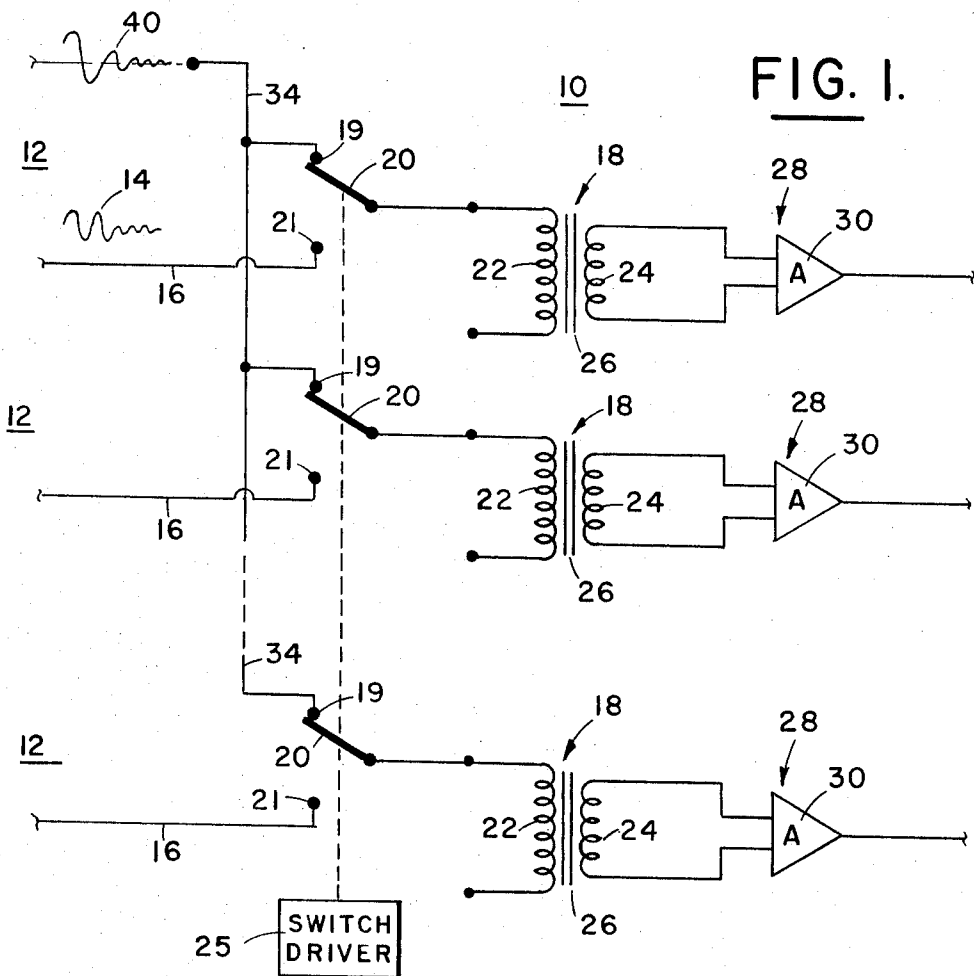
SIMULTANEOUS MULTI-CORE DEMAGNETIZATION

BACKGROUND OF THE INVENTION

In multi-channel systems, such as for example in seis-   5
mic recording systems, a small input transformer is
connected in each channel between the incoming seis-
mic signals and a pre-amplifier, typically of the semi-
conductor type. To obtain a high inductance with a
small transformer, the core laminations are made from   10
high-mu metal. Input transformers for seismic systems
are susceptible to magnetization by the nature of the
environment in which these systems operate. A DC
component introduced into the input of the trans-
former will partially or fully magnetize the core of the   15
transformer. By virtue of the high permeability of these
cores, modern seismic transformers will exhibit magne-
tostrictive properties when magnetized. The magne-
tized transformers will then act as seismic transducers,
when subjected to mechanical vibrations, thereby pro-   20
ducing undesired noise into the seismic systems.

In accordance with prior practice, residual core mag-
netization is removed by subjecting the core to a
slowly-diminishing, alternating magnetic field pro-
duced by an alternating voltage applied to the trans-   25
former's primary winding. The effective peak-to-peak
value of the positive and negative voltage swings must
be sufficient to saturate the core. Desirably, following
initial application, the voltage should be allowed to
slowly decay to zero, whereupon all residual magneti-   30
zation should become erased. This decaying alternating
voltage is known as a "wiping signal."

In practice, the wiping signal will be effective only if
the core's resulting hysteresis loop collapses symmetri-
cally to zero.   35

We have discovered that an operational pre-
amplifier, when connected across the secondary wind-
ing of the transformer, will operate in a non-linear
mode unless the characteristics of the wiping signal are
carefully selected. When the wiping signal drives the   40
pre-amplifier into its non-linear mode, the magnetiza-
tion curve of the input-transformer core exhibits an un-
symmetrical hysteresis loop and, hence, unless properly
selected as to amplitude and frequency, the wiping sig-
nal will be ineffective to demagnetize the core. Accord-   45
ingly, in prior art practice, it was felt necessary to dis-
connect each transformer (or at least its secondary
winding) from its load prior to the application of a wip-
ing signal thereto.

In multi-channel seismic recording systems, up to 96   50
separate input transformers may be employed. To dis-
connect all of the secondary windings from their associ-
ated pre-amplifiers requires a considerable amount of
time and there is even risk of damage to the equipment.

Accordingly, there is a need for an effective method   55
and apparatus for demagnetizing the cores of input
transformers without having to disconnect the trans-
formers from their pre-amplifiers.

SUMMARY OF THE INVENTION

In accordance with this invention the cores of the   60
input transformers are properly demagnetized while
the secondary windings thereof are connected to their
loads. Applied to the primary windings of the trans-
formers is a wiping signal whose amplitude is equal to   65
or slightly less than a critical value so that the con-
nected loads will operate within their linear modes. The

wiping signal's frequency corresponding to the selected
amplitude will have a value which will cause the wiping
signal to saturate the cores.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic representation of a portion of
a multi-channel seismic recording system employing
this invention; and

FIG. 2 is an equivalent circuit useful in explaining the
operation of the circuit in FIG. 1.

BRIEF DESCRIPTION OF THE DRAWINGS

A multi-channel system, which could be a multi-
channel seismic recording system, generally designated
as 10, includes a plurality of channels 12. Each channel
12 receives an input seismic signal 14 on an input line
16 connected to a transformer, generally designated as
18, through a terminal 21 of a switch 20.

The transformer has a primary winding 22, a secon-
dary winding 24 and a core 26. Connected to the sec-
ondary winding is a load, generally designated as 28,
which in the seismic recording system is an operational
pre-amplifier 30. Amplifier 30 has a linear operating
mode and a non-linear operating mode. So long as the
amplitude of the AC signal E_i applied to the input of
the primary winding of the input transformer does not
exceed a critical value E_c, the amplifier will operate in
its linear mode. The critical value of the signal's voltage
amplitude can be experimentally determined, or it can
be computed from the gain of the amplifier and the
turnsratio of the transformer. When the signal's ampli-
tude applied to the primary winding 22 exceeds this
critical value, the operational amplifier 30 will operate
in its non-linear mode, that is, the input to the opera-
tional amplifier and the output therefrom will not be
related by a linear function.

In one embodiment of this invention, an amplifier
output voltage exceeding 10 volts peak-to-peak drove
the amplifier into a non-linear operating mode. With a
typical overall gain of $\times 128$ (including transformer and
amplifier), the critical value of the wiping voltage E_c
applied to the primary was $0.707 (10/128) = 55.2$ milli-
volts.

The critical value of the voltage E_c applied to the pri-
mary winding can also be computed from:

$$E_c = E_{oc} N_1 / G N_2,$$

where
E_{oc} = amplifier's output critical voltage;
N_1 = primary turns;
N_2 = secondary turns;
G = amplifier gain.

If the amplifier's linear operating range is exceeded,
the amplifier will saturate. In the saturation or non-
linear region of operation the amplifier presents a low
impedance to the transformer's secondary winding.

Therefore, as used in the specification and claims,
the expression "critical value" defines the amplitude of
the voltage of an AC signal applied to the primary
winding which will cause the amplifier to change from
its linear to its non-linear operating mode.

FIG. 2 illustrates the equivalent circuit of a trans-
former 18 and an amplifier 30. In its linear operating
region, amplifier 30 presents a very high-resistance
load R_3 to secondary winding 24. In its non-linear oper-
ating mode, the amplifier can be represented by a pair
of Zener diodes D_1 and D_2 which become conducting

when the voltage thereacross equals E_{oc} thereby shorting out resistor R_3 and presenting a low impedance to the transformer's secondary 24. In the non-linear mode, with a low impedance across the secondary, the primary's resistance R_1 will limit the current to the primary winding 22 such that the core cannot become saturated.

In accordance with this invention, a wiping signal 40 is applied, preferably simultaneously, to each primary winding 22 by a line 34 through another terminal 19 of switch 20. The switches 20 can be operated simultaneously by a switch driver 25. The maximum initial amplitude of the voltage of wiping signal 40 is made equal to or slightly less than the critical value E_c. The corresponding required frequency f of the applied wiping signal 40 can be experimentally determined or can be computed as follows:

$$f = E_c / 4.44 \ N_1\phi$$

where

E_c = critical value;
N_1 = number of primary turns;
$\phi = 6.452 \ BA \times 10^{-8}$,

where

B = magnetic flux in gauss,
A = core area in square inches.

For further description, reference can be had to "Alternating Current Fundamentals" by Arthur P. Dillow, Page 286, Bobbs-Merrill Co., New York. The last equation is only valid for a substantially open-circuit secondary.

In one embodiment, the transformer's characteristics were as follows:

$A = 0.125$ in^2
$N_1 = 2900$ turns
$B = 20,000$ gauss
$E_c = 0.0552$ volts

From Equation 2, the required maximum frequency f was found to be 0.026Hz.

What is claimed is:

1. In a method for demagnetizing the cores of a plurality of input transformers, each transformer having a core, a primary winding and secondary winding connected to a load, the load having a linear operating mode when the amplitude of an AC signal applied to the primary winding of the load's input transformer is below a critical value, and the load having a non-linear operating mode when the amplitude of the applied AC signal exceeds said critical value, the improvement comprising:

wiping each core with a decaying AC signal having an initial amplitude up to said critical value and a frequency corresponding to said critical value, the value of said frequency being selected to saturate each core.

2. The method of claim 2 wherein the cores of said plurality of transformers are wiped simultaneously.

3. The method of claim 3 wherein said load is a preamplifier.

4. A method for demagnetizing an input transformer having a core, a primary winding and a secondary winding connected to a load, the load having a linear operating mode when the amplitude of an AC signal applied to the primary winding of the load's input transformer is below a critical value, and the load having a nonlinear operating mode when the amplitude of the applied AC signal exceeds said critical value, the improvement comprising:

wiping said core with a decaying AC signal having an initial amplitude up to said critical value and a frequency corresponding to said critical value, the value of said frequency being selected to saturate each core.

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