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United States Patent [19]

Snow et al.

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[45] **Date of Patent: Jul. 16, 1996**

[54] **METHOD AND APPARATUS FOR DETECTING HIGH-IMPEDANCE FAULTS IN ELECTRICAL POWER SYSTEMS**

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[73] Assignee: **New York State Electric & Gas Corporation**, Binghamton, N.Y.

[21] Appl. No.: **141,308**

[22] Filed: **Oct. 22, 1993**

[51] **Int. Cl.**[6] **G06F 15/22**; G01R 31/08

[52] **U.S. Cl.** **364/483**; 364/481; 364/482; 395/50; 395/21; 395/22; 395/23; 395/907; 361/91; 361/92; 361/93

[58] **Field of Search** 364/483, 482, 364/481, 492; 361/93, 76, 30, 91–92; 324/508, 509; 395/907, 915, 21–23, 50, 54, 75, 77

[56] **References Cited**

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Abstract Title: "High Impedance fault detection using artificial nerual network techniques", Society of Automotive Eng. 1992 vol. 2870 pp.

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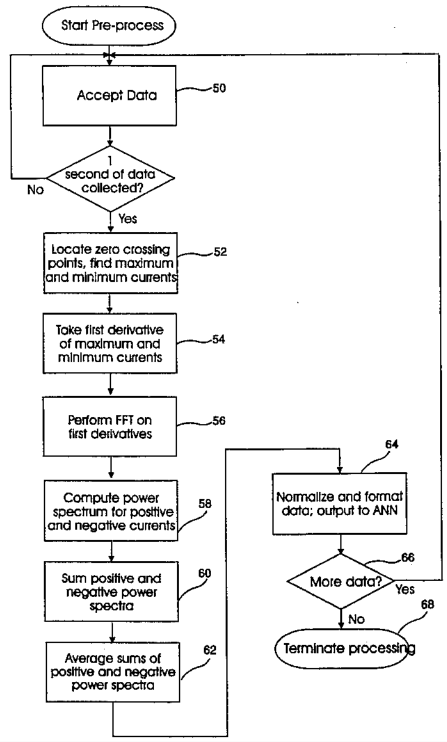
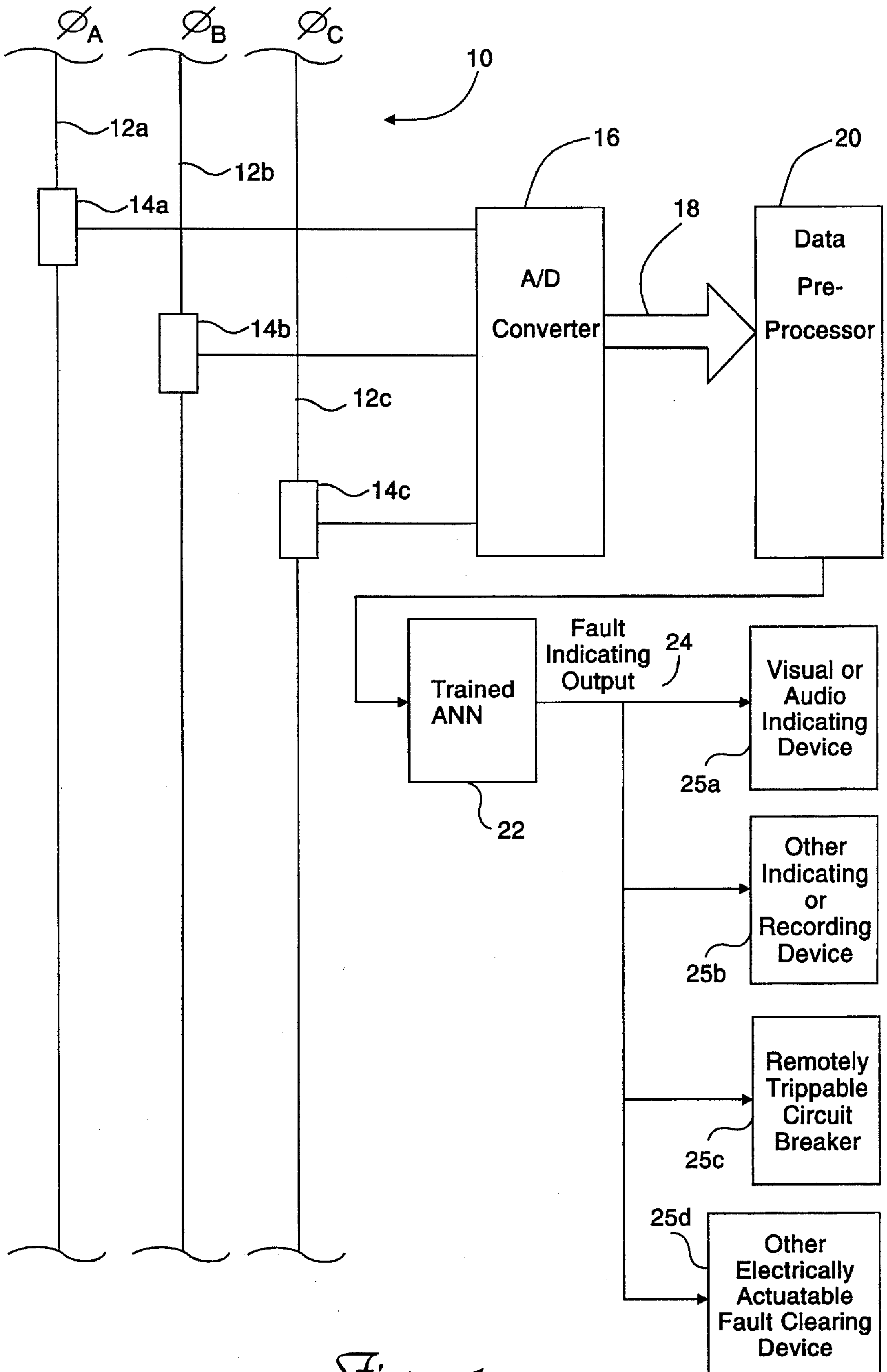
Primary Examiner—Emanuel T. Voeltz
Assistant Examiner—Kamini Shah
Attorney, Agent, or Firm—Salzman & Levy

[57] **ABSTRACT**

The present invention features a method and apparatus for detecting and enabling the clearance of high impedance faults (HIFs) in an electrical transmission or distribution system. Current in at least one phase in a distribution system is monitored in real time by sensors. Analog current signature information is then digitized for processing by a digital computer. Zero crossings are identified and current maxima and minima located. The first derivatives of the maxima and minima are computed and a modified Fast Fourier Transform (FFT) is then performed to convert time domain to frequency domain information. The transformed data is formatted and normalized and then applied to a trained neural network, which provides an output trigger signal when an HIF condition is probable. The trigger signal is made available to either a network administrator for manual intervention, or directly to switchgear to deactivate an affected portion of the network. The inventive method may be practiced using either conventional computer hardware and software or dedicated custom hardware such as a VLSI chip.

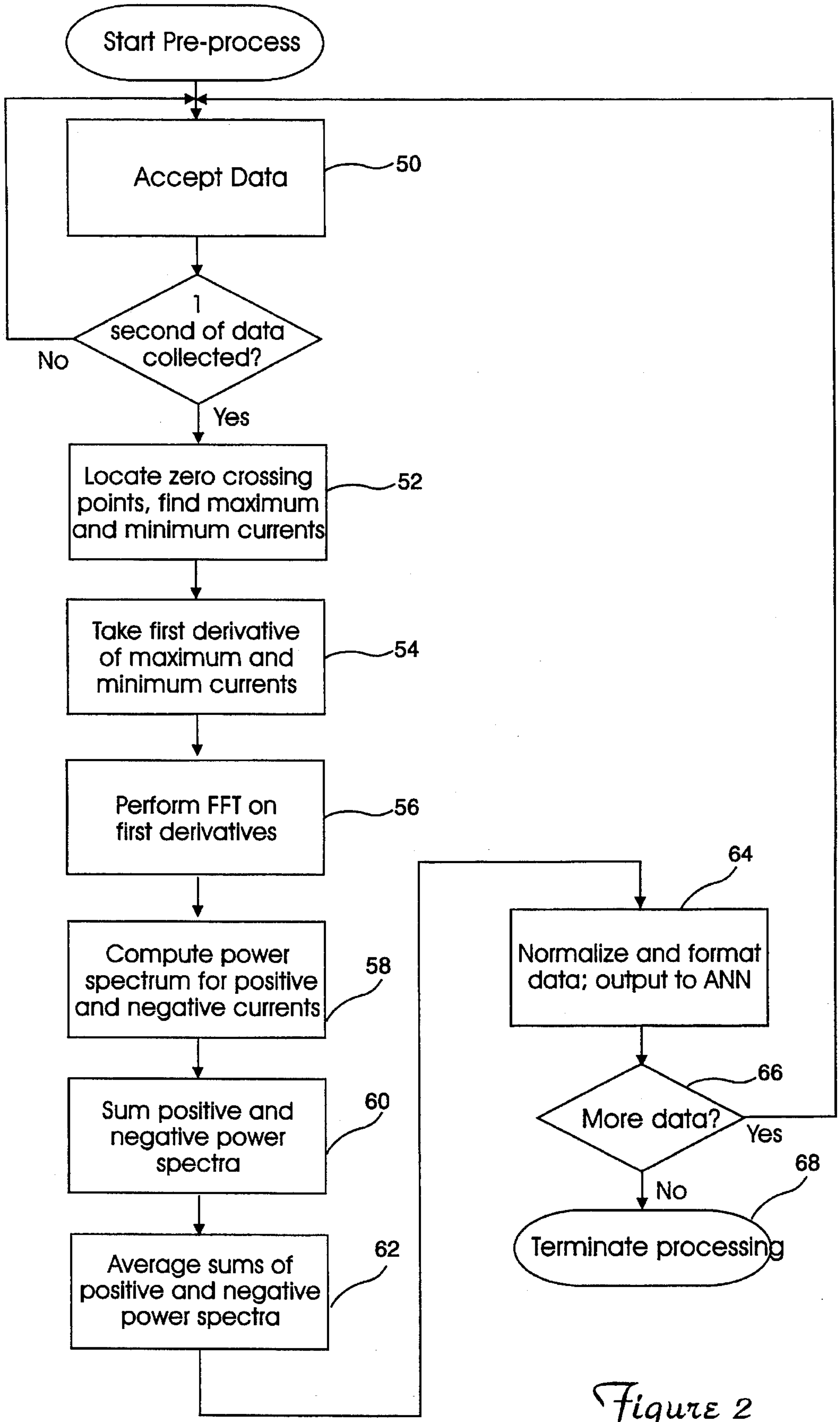
32 Claims, 6 Drawing Sheets





ØA
ØB
ØC
10
12a
12b
12c
14a
14b
14c
16
A/D Converter
18
20
Data Pre-Processor
Trained ANN
22
Fault Indicating Output
24
Visual or Audio Indicating Device
25a
Other Indicating or Recording Device
25b
Remotely Trippable Circuit Breaker
25c
25d
Other Electrically Actuatable Fault Clearing Device

Figure 1

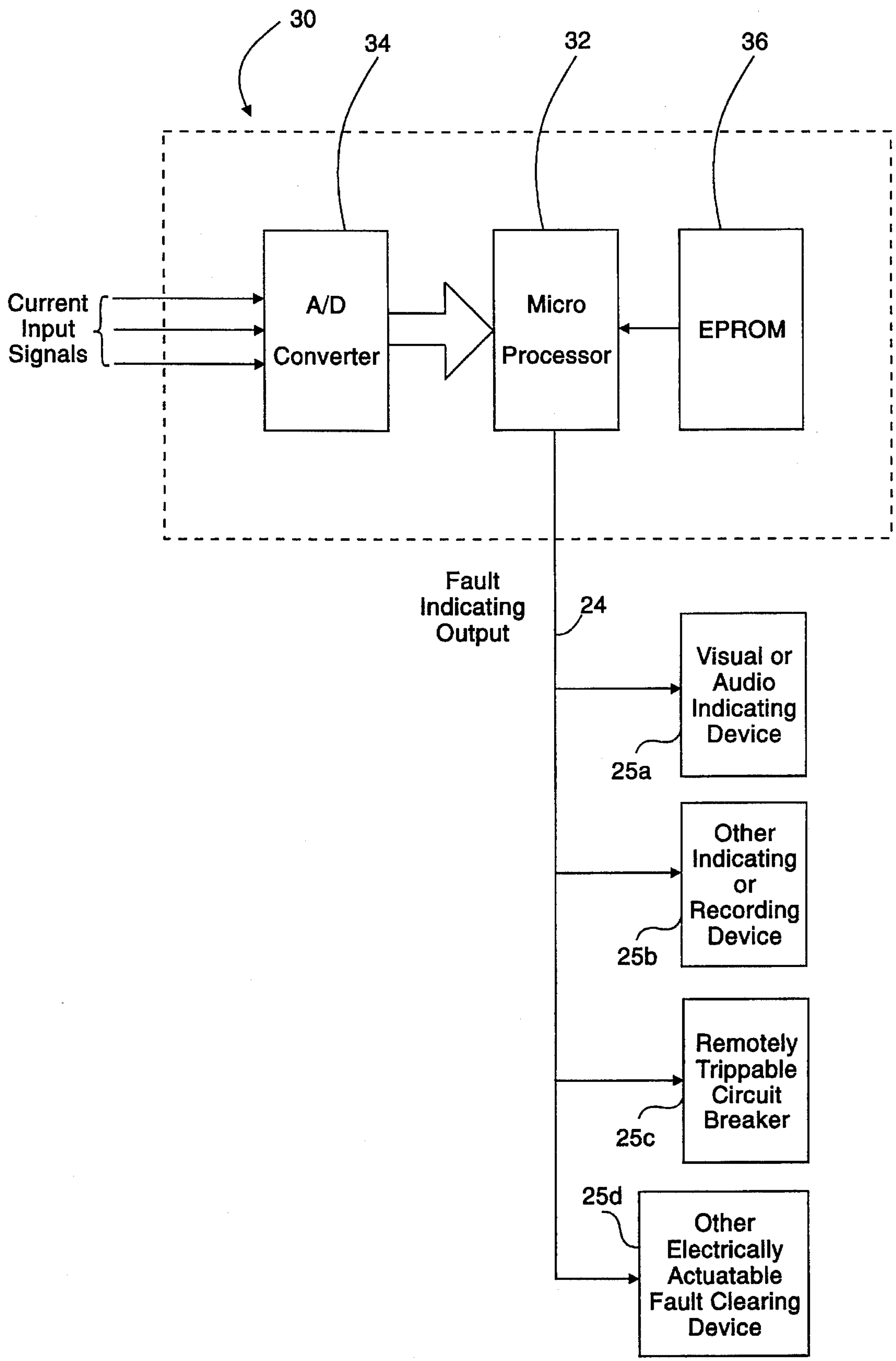


Start Pre-process
Accept Data
50
1 second of data collected?
No
Yes
Locate zero crossing points, find maximum and minimum currents
52
Take first derivative of maximum and minimum currents
54
Perform FFT on first derivatives
56
Compute power spectrum for positive and negative currents
58
Sum positive and negative power spectra
60
Average sums of positive and negative power spectra
62
64
Normalize and format data; output to ANN
66
More data?
Yes
No
68
Terminate processing

Figure 2

```
% HIZPROC
% Developed by Dr. Peter B. Snow for NYSEG  March 9, 1993
% enter a file for processing - for example \ksc\hiz42_3.dat
% now put the file in vector a - for example a = hiz42_3
% now type in hizproc to activate this processing program
% clear the old matrices
clear b cl c2;
% first get the size of the input vector
[jd, ja] = size(a);
% now shift the signal to the origin y=0
avg1 = mean(a);
a = a - avg1;
%now find the element numbers of the zero current crossings
k = 1;
for i=1:jd-1;
   if a(i) < 0.0;
      if a(i+1) > 0.0;
         b(k) = i;
         k = k + 1;
      end;
   end;
end;
[jd, ja] = size(b);
k = 1;
% now find maximum values for each cycle
for i = 1:ja-1;
   j1 = b(i);
   j2 = b(i+1);
   c1(k) = max(a(j1:j2));
   c2(k) = min(a(j1:j2));
   k = k + 1
end;
% now take first derivative of max, min vectors
e1 = diff(c1);
e2 = diff(c2);
% now take the FFT and convert to power spectrum
g1 = fft(e1, 512);
g2 = fft(e2, 512);
pg1 = g1 .*conj(g1) / 512;
pg2 = g2 .*conj(g2) / 512;
sumfft1 = sum(pg1);
sumfft2 = sum(pg2);
sumfft = ( sumfft1 + sumfft2 ) / 2;
```

Figure 3


30
34
32
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Current Input Signals
A/D Converter
Micro Processor
EPROM
Fault Indicating Output
24
Visual or Audio Indicating Device
25a
Other Indicating or Recording Device
25b
Remotely Trippable Circuit Breaker
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Other Electrically Actuatable Fault Clearing Device

Figure 4a

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