



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

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[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

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Sarosh; "Toast: The Power System Operator's Assistant"; IEEE; Jul. 1986, pp. 53-59.

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

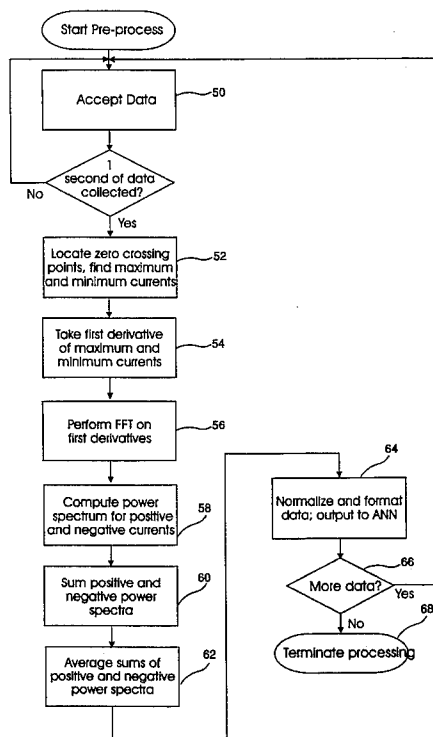
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[57] ABSTRACT

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



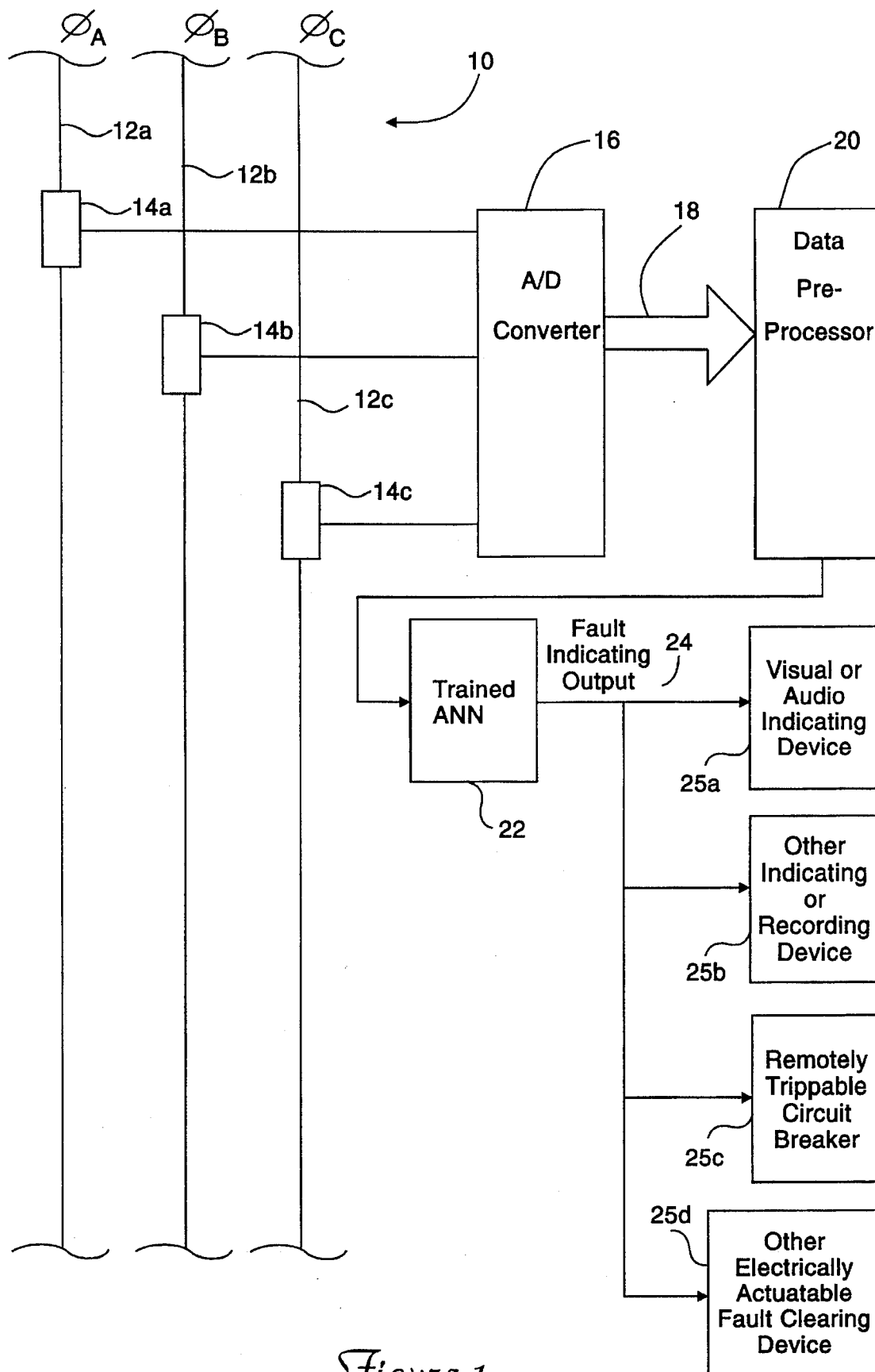


Figure 1

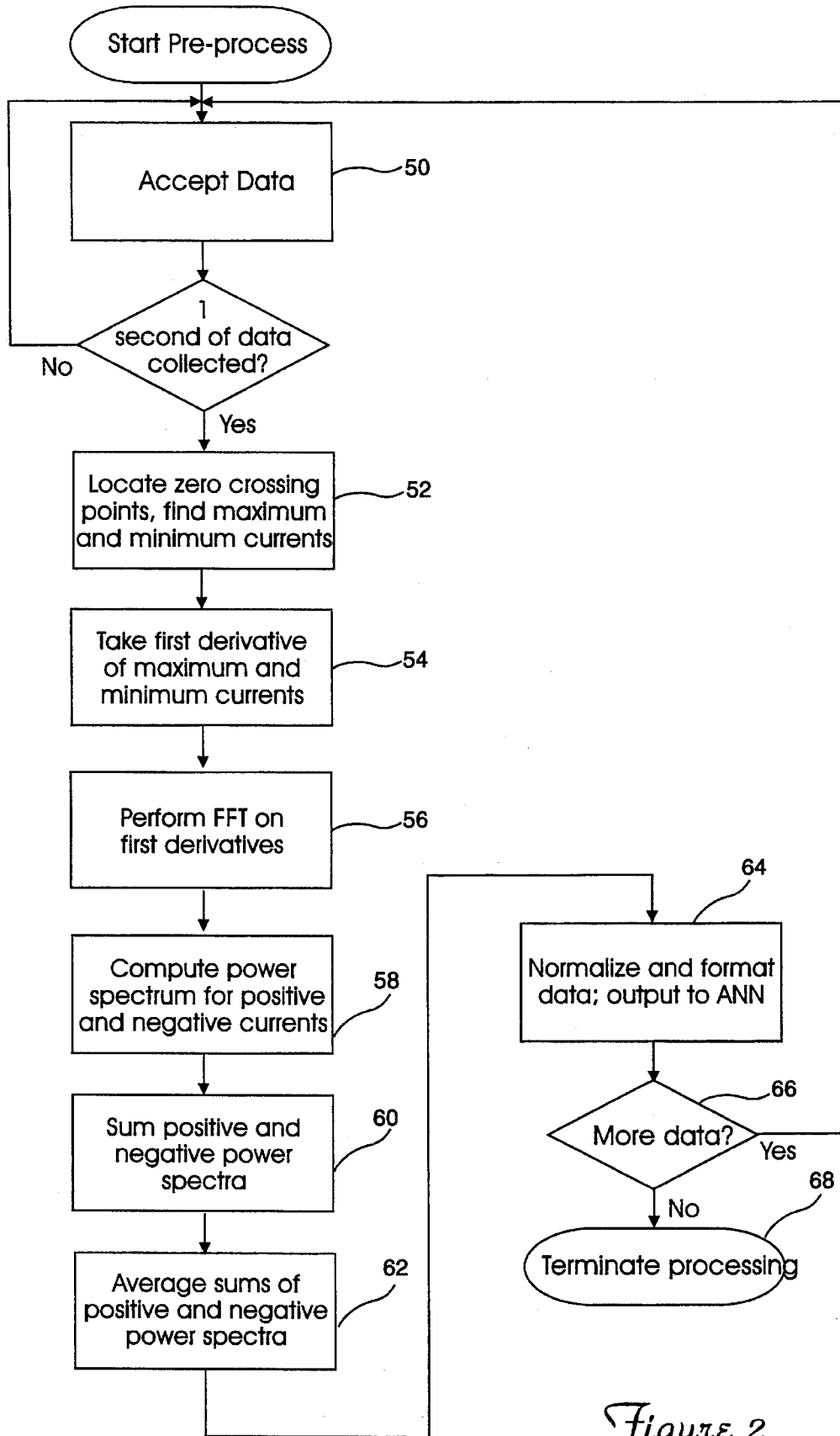


Figure 2

```
% 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 c1 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

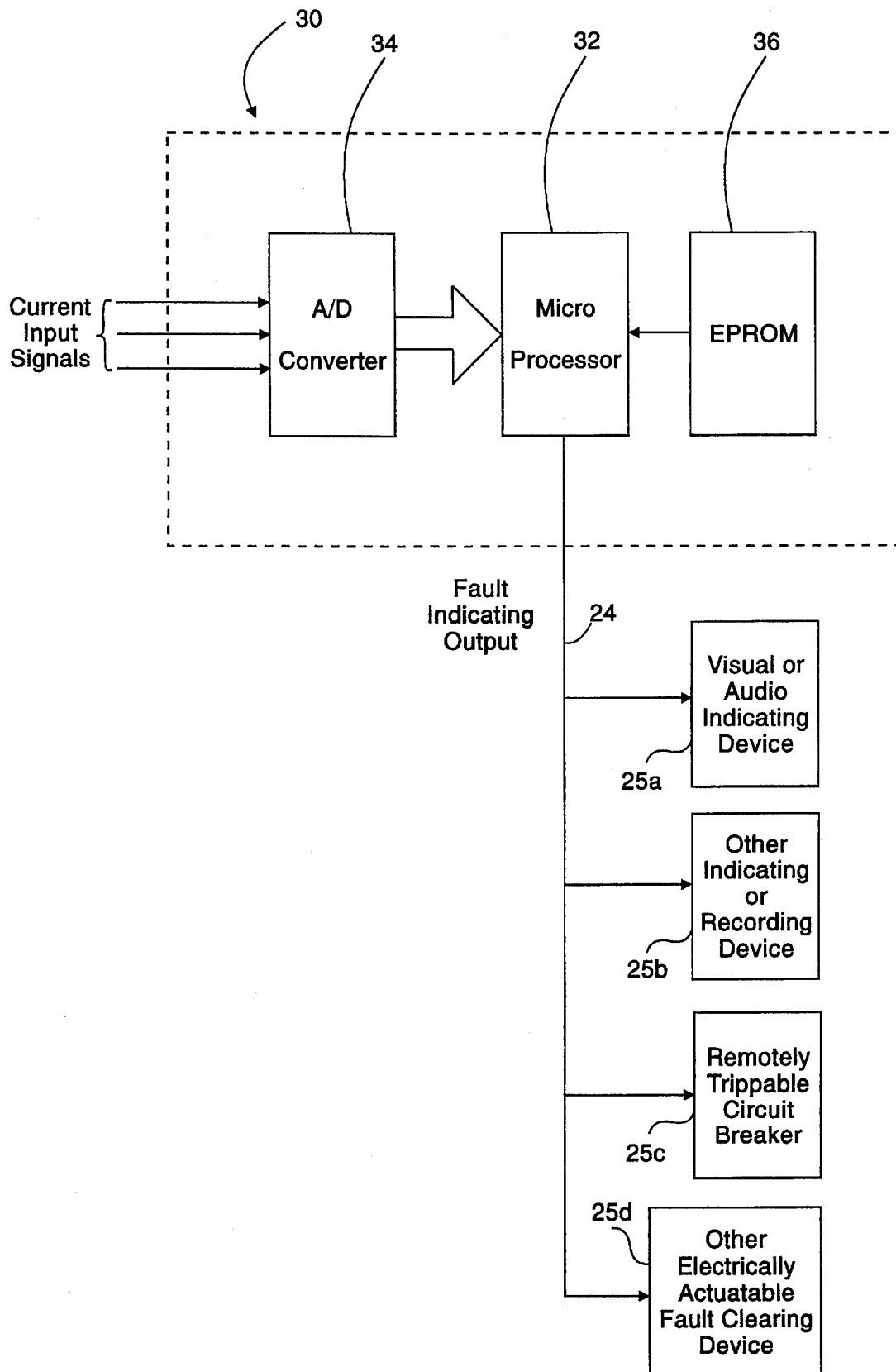


Figure 4a

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