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## (54) Test apparatus.

(57) Test apparatus for vibration diagnosis of a printed circuit board and its components includes a portable probe (1) having a vibrating head (12) which is held in contact with each integrated circuit on the board. Vibration levels are monitored by an accelerometer (7) whose output is incorporated in a feedback loop, thereby maintaining a controlled level of excitation.

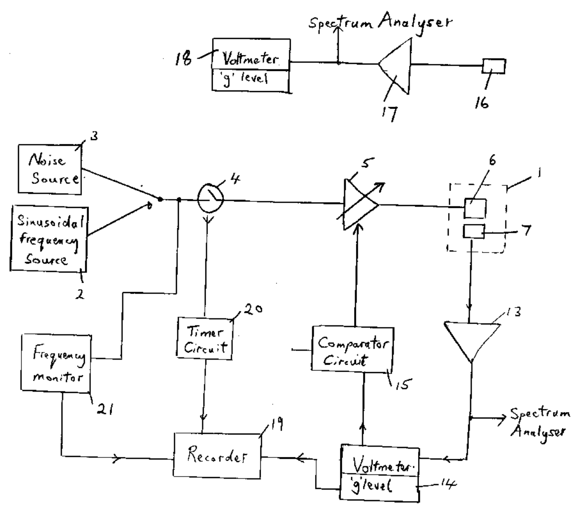


FIG. 1

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This invention relates to apparatus and methods suitable for the testing of electronic components which are mounted on printed circuit boards.

To ensure that an item of electronics equipment is reliable in the field it is standard practice to condition equipment to eliminate early failures. This process is known by a number of terms including:- Environmental Stress Screening, In-Process Conditioning, and the related term Burn-In.

These processes involve placing equipment in environmental chambers and subjecting them to repeated cycles of temperature extremes (typical -30°C +50°C) plus vibration over a total period of 4 to 40 hours typical. Units are stimulated by external equipment such as a vibrating platform, for example, and critical signals are monitored by computer to record any failures. All equipment that survives such tests can be statistically proven to be more reliable.

With a large throughput of such equipment there are bound to be failures that require diagnosis. If something breaks or shows the same problem under ambient conditions this is not too difficult to resolve. If it sometimes only fails at a temperature extreme or with vibration applied this is a difficult problem to diagnose.

Whereas there are a number of items which can be used to diagnose thermally induced problems e.g. heat guns, freezer sprays, this invention aims to provide a method and apparatus for diagnosis of vibration related failures. Further more the invention aims to provide a controlled, portable, local source of vibration.

Hence this invention consists of test apparatus comprising a probe head, a probe body incorporating means for vibrating the probe head, and means for monitoring the levels of vibration brought about by said probe head.

The invention also consists of a method for vibration diagnosis of a structure including the steps of;

applying a localised source of vibration of controlled magnitude and frequency to a point on the structure, monitoring the magnitude and frequency of vibration of the structure, and

monitoring the function of said structure whilst said vibration is being applied and observing any ensuing failure.

The means for vibrating the probe head could comprise a high-power electro-magnetic transducer.

The means for monitoring vibration of the structure could comprise a miniature piezo-electric accelerometer which could be fixed to the probe body. Velocity, force or displacement transducers may be preferred alternatives for some applications. The vibration monitor could be incorporated in a feedback loop for controlling the operation of the vibration source.

Instead of, or in addition to a vibration level monitor fixed to the probe body, a "roving" sensor moveable to various locations around a printed circuit board could be used to monitor the actual vibration levels of the board and its components. Again, this roving sensor could be used in a feedback loop to control the vibration source. The sensor could be an accelerometer or velocity or displacement transducer as appropriate.

The output from either fixed or roving accelerometer could be integrated electronically to provide velocity and displacement levels.

The probe body and probe head could be incorporated into a pistol-grip, hand-held device, for example, which would allow the direct excitation of standard electronic packages such as Dual in line, TO5 and surface mount devices. This would allow typical faults occurring only during vibration to be reproduced or diagnosed outside the conventional test chamber.

Some embodiments of the invention will now be described, by way of example only, with reference to the drawings of which;

Figure 1 is a schematic view of vibration diagnosis equipment in accordance with the invention, and

Figure 2 is a cross-sectional view of a vibrating probe.

In Figure 1 a probe 1 receives an electrical signal generated by either a sinusoidal frequency source 2 or a noise source 3 (of variable bandwidth). The signal reaching the probe 1 is controlled by an on/off switch 4 and an amplifier 5 of variable gain. The probe 1 incorporates an electro-magnetic vibrator 6 and a first miniature piezoelectric accelerometer 7 and is shown in greater detail in Figure 2.

In Figure 2 the probe 1 comprises an outer casing 8 which houses a magnet 9 and a moving coil assembly 10. The moving coil assembly 10 is attached to a vibration plate 11 on which is mounted a dome-shaped probe head 12 made of plastics and the miniature piezoelectric accelerometer 7.

Returning to Figure 1, the output from the first accelerometer 7 is fed to a charge amplifier 13 whose output is connected to a voltmeter 14 and, if desired, to a spectrum analyser (not shown). An output from the voltmeter 14 is used by a comparator circuit 15 to control the gain of the amplifier 5.

A second miniature piezoelectric accelerometer (remote from the probe 1) has its output connected to a second charge amplifier 17. The output of this amplifier 17 is connected to a second voltmeter 18 and if desired to a spectrum analyser (not shown).

The level of vibration applied to the probe 1, its frequency and its duration are all recorded by a recorder 19 which receives inputs from a timer circuit 20 (connected to the on/off switch 4), a frequency monitor 21 (associated with the sources 3 and 4) and the voltmeter 14.

In operation, the probe head 12 is held either by hand or by a clamping arrangement in contact with an integrated circuit which is mounted on the printed circuit board under test. The excitation frequency desired is set using the appropriate controls provided on the sources 2 and 3. The second "roving" accelerometer is fixed to a point of interest on the board with a thin layer of beeswax. Closing of the switch 4 will than activate the electro-magnetic vibrator 6, the vibrations of the vibration plate 11 being coupled to the integrated circuit via the probe head 12.

The vibrations of the plate 11 are constantly monitored by the first accelerometer 7 which produces a charge proportional to the acceleration applied thereto. The accelerometer's output is conditioned by the charge amplifier which produces a measurable voltage at its output. The rms. level of this voltage, proportional to the acceleration detected by the accelerometer 7 is measured by the voltmeter which can be provided with means for converting the voltage value to units of acceleration. This latter information can be displayed to the operator and is also fed to the recorder 19.

An output from the voltmeter 14 is used, in a feedback loop, to control the gain of the amplifier 16 and therefore the vibration level of the probe head 12. If the measured acceleration rises above a pre-set level, for example, then the comparator circuit 15 reduces the gain of the amplifier 5 accordingly. In this way, the probe head 12 and thus the component under test can be protected from overload.

Typical frequencies and acceleration levels applied range from 10Hz to 2KHz and 2g(rms) to 5g (rms.) respectively.

The acceleration level, frequency and length of time for which excitation persists are continually recorded by the recorder 19 using the inputs from the timed circuit 20, frequency monitor 21 and voltmeter 14.

During excitation the electrical functions of the printed circuit board are constantly monitored.

Also, during excitation, the roving, second accelerometer detects acceleration at the pre-chosen point of interest. In a similar fashion to the acceleration monitoring operation at the probe head, a 'g' level can be displayed by the second voltmeter 18.

The above operations can be repeated at different locations around the board under test until its design criteria have been reached or it fails electrically. The amount of vibration to which the board has been subjected can be ascertained by interrogating the recorder 19. Thus the operator can ensure that the board has not exceeded its design requirements and is therefore fit for sale if no electrical faults have been found during testing.

The recorder 19 also tells the operator the conditions under which any failure occurred. When an electrical failure does occur, then the diagnostic equipment is removed and further solely electrical tests are carried out on each integrated circuit or each printed track if necessary, to find out which component or soldered joint, for example has actually failed.

The arrangement of Figure 1 could also be used for modal analysis of board vibrations by examining the output of the roving accelerometer with a spectrum analyser and applying an impulse to the board through the probe head.

## Claims

1. Test apparatus including a probe head (12), a probe body (1) incorporating means (9, 10, 11) for vibrating the probe head (12), and means (7, 16) for monitoring the levels of vibration brought about by said probe head (12).

2. Test apparatus according to claim 1 in which the means (7) for monitoring the levels of vibration brought about by the probe head (12) include a sensor (7) connected to the probe body (1).

3. Test apparatus according to claim 1 in which the means (16) for monitoring the levels of vibration brought about by the probe head (1) include a sensor (16) remote from the probe head (12).

4. Test apparatus according to any preceding claim in which the means for monitoring the vibration of said probe head comprises an accelerometer (7, 16).

5. Test apparatus according to any preceding claim in which the means for vibrating the probe head comprises an electro-magnetic transducer (9, 10, 11).

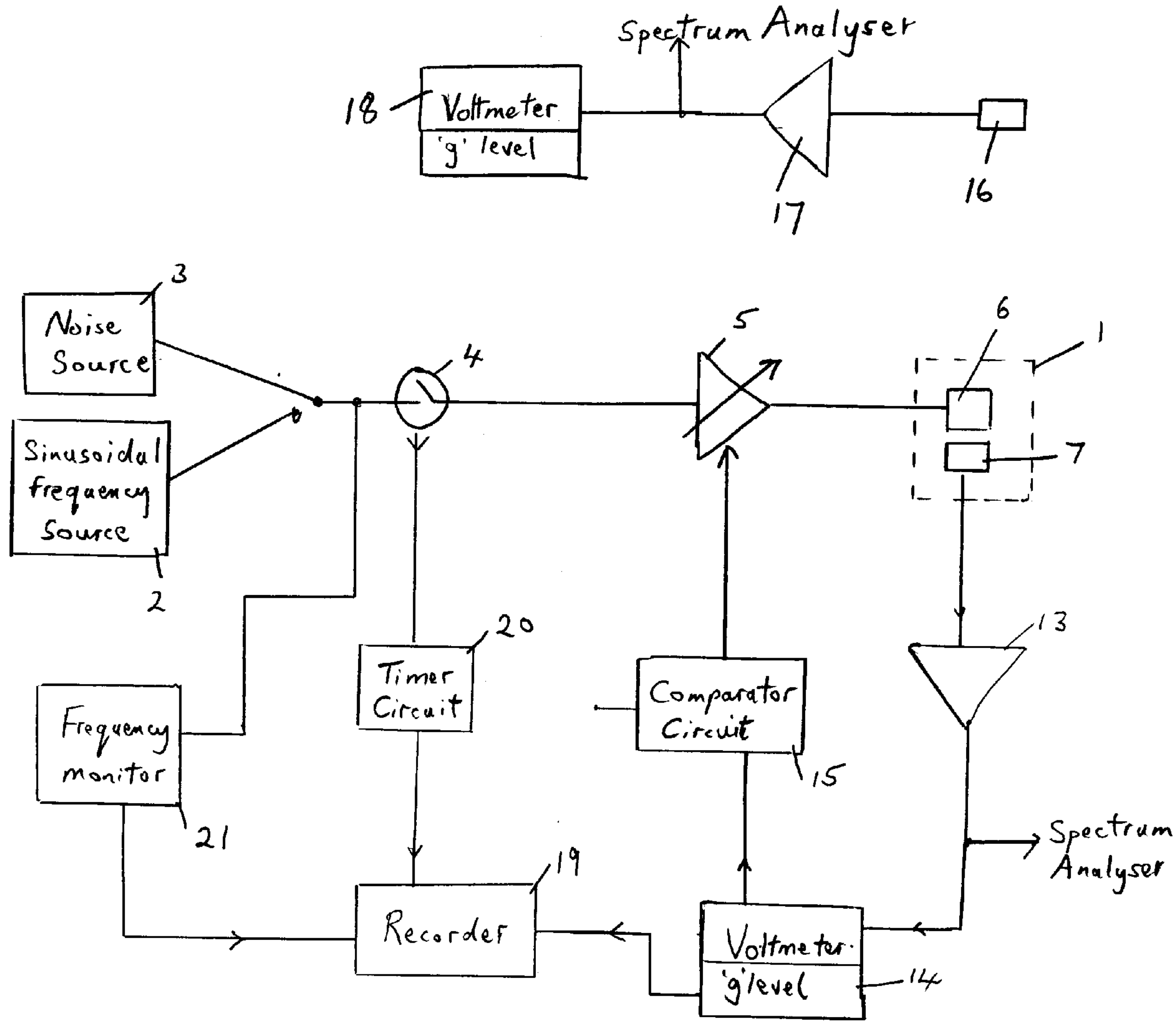
6. Test apparatus according to any preceding claim in which the means for vibrating the probe head (9, 10, 11) and the means for monitoring vibration (7) thereof form part of a feed-back loop.

7. A method for vibration diagnosis of a structure including the steps of;

   applying a localised source of vibration of controlled magnitude and frequency to a point on the structure,

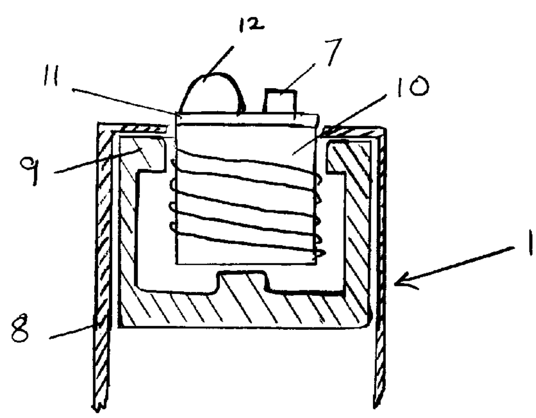
   monitoring the magnitude and frequency of vibration of the structure, and

   monitoring the function of said structure whilst said vibration is being applied and observing any ensuing failure.



Spectrum Analyser
18
Voltmeter
'g' level
17
16
3
Noise Source
Sinusoidal frequency Source
2
4
5
6
1
7
20
Timer Circuit
Comparator Circuit
15
13
Frequency monitor
21
Spectrum Analyser
19
Recorder
Voltmeter
'g' level
14


FIG. 1



12
7
11
10
9
1
8


FIG. 2

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# EUROPEAN SEARCH REPORT

Application Number

EP 94304098.0

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int. Cl.5) |
|---|---|---|---|
| X | WO - A - 89/12 379 (THOMSON) * Abstract * ---- | 1-3,5, 7 | G 01 R 31/28 |

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

G 01 R 31/00
H 05 K 13/00

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| VIENNA | 31-08-1994 | KUNZE |

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
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