

Testing Machine

This invention is concerned with a testing machine for applying a loading to a test specimen, for example fine wire or pressure sensitive adhesive tape.

Fine wires are used in the semi-conductor and electronics industries, for example for wire bonding and it is important to ensure that the wire used has adequate tensile strength, otherwise there is a substantial risk that wires will break during manufacture of components or in their use, leading to circuit failures. Also in the electronics industry, electronic components are often packaged in pockets in plastics or cardboard tapes, being retained in the pockets by a cover tape bonded to the pocketed tape by a suitable adhesive, for example a hot melt adhesive, which is such as to allow the cover tape to be peeled off so that the components can be removed from the pockets. In order to ensure that machines using the tape-packaged components function satisfactorily, it is necessary to check the peel force needed to remove the tape, to ensure that the tape will be cleanly peeled off during use.

Currently available testing machines are unsatisfactory for both of these purposes in that most testing machines which are generally suitable for use for the above described purposes are designed to cope with a very wide range of loadings which makes them unacceptably expensive for the purpose of merely testing fine wire or the peel force required to peel the cover tape off tape-packaged electronic components (the loadings in both instances being of the same order). Furthermore, many known machines are, in general, too slow and inconvenient in operation to be useful for the purposes discussed above.

A testing machine according to the invention comprises a frame, first and second holding means by which a specimen to be tested can be mounted when the holding

means are spaced by a predetermined initial spacing, the first holding means being secured on the frame and the second holding means being secured on a carriage moveable on the frame to and from an initial position in which the holding means are spaced apart by the initial spacing, so that the second holding means is linearly moveable relative to the first holding means, and a motor arranged, when operated to move the carriage and thus the second holding means away from the first, wherein the motor is arranged to drive a pinion through a clutch and a rack is secured to the carriage and in engagement with the pinion whereby when the clutch is engaged the carriage is moved to move the second holding means away from the first, and the machine comprises means operative when the clutch is disengaged to return the carriage to its initial position.

A machine according to the invention preferably comprises means for measuring the loading applied to the specimen and means for measuring the relative movement between the holding means. Conveniently, a machine in accordance with the invention may comprises means,

25

30

35

1 conveniently comprising a photoelectric system, for
counting the revolutions of the drive means to measure the
relative movement between the holding means.

A machine according to the invention may comprise
5 means initiating disconnection of the drive means from the
holding means when a test has finished, for example means
detecting breakage of the test specimen, a timer which
operates a predetermined time interval after commencing a
test, or means detecting relative movement of the holding
10 means through a predetermined distance.

There now follow detailed descriptions, to be
read with reference to the accompanying drawings of two
machines for applying a loading to a test specimen, namely
a tensile testing machine and a tape peel force testing
15 machine. It will be realised that these machines have been
selected for description to illustrate the invention by way
of example and not of limitation of the invention.

In the accompanying drawings:-

Figure 1 is a perspective view of a tape peel
20 force testing machine;

Figure 2 is a perspective view of a tensile
testing machine for wire;

Figure 3 is a view partly in section and with
parts broken away of the tensile testing machine shown in
25 Figure 2;

Figure 4 is a front view, partly in section and
with parts broken away of the tensile testing machine; and

Figure 5 is a view showing jaws of clamp means of
the tensile testing machine.

30 The wire tensile testing machine and the tape
peel force testing machine are generally similar in
construction, except as hereinafter described, and for
convenience only the tensile testing machine will therefore
be described in detail.

35 The illustrative tensile testing machine
comprises a frame 2 by which is mounted the mechanical

1 testing apparatus and a control system comprising
 electronic computer means by which the testing machine is
 controlled and which calculates results; an out-put printer
 4 is also mounted in the frame. The illustrative tensile
 5 testing machine comprises holding means including first
 clamp means 6 secured on an upright member 8 of the frame 2
 and second clamp means 10 secured on a carriage 12.

The carriage 12 comprises rail means 14 received
 between four guide wheels 16 mounted for rotation on the
 10 upright member 8; the carriage 12 is thus guided for
 vertical movement and the wheels 16 are adjusted so that
 there is little or no play, the carriage 12 thereby being
 accurately mounted for vertical sliding movement. The
 carriage 12 is urged to an uppermost initial position by a
 15 spring 18 extending between the carriage and a cross member
 20 of the frame 2. This initial position is determined by
 engagement of an adjustable stop screw 22 with the carriage
 12. The stop screw 22 is adjusted in the course of
 manufacture of the testing machine so that the first and
 20 second clamp means are spaced apart by a predetermined
 initial spacing. This spacing may be checked during the
 course of operation of the illustrative testing machine and
 adjusted by means of the stop screw 22 should this prove
 necessary.

25 A bracket 24 projects horizontally from the
 carriage 12 through a slot 26 in the upright member 8. A
 piston rod 28 of a pneumatic, damping piston and cylinder
 arrangement 30 mounted on the upright member 8, is secured
 to the bracket 24. The damping piston and cylinder
 30 arrangement 30 is intended to cushion the vertical return
 movement of the carriage 12 to its initial position (in
 which it is shown in Figure 3). A constant speed electric
 motor 32 is mounted on a bracket 34 secured to a rear plate
 member 36 of the frame 2 lying in a vertical plane
 35 perpendicular to the vertical plane in which the upright
 member 8 is disposed. An out-put shaft of the motor 32 is

1 connected, through a coupling 37, to a reduction gearing
system 38, the reduction gearing system 38 driving, through
an overload clutch coupling 40 and an electromagnetic
clutch 42, a pinion 44.

5 The pinion 44 is mounted in driving engagement
with a rack 46 fixed to the carriage 12. A notched disc 48
is secured to a shaft of the gearing system 38, the disc
having evenly spaced notches around a peripheral region.
The peripheral region of the disc passes through a groove
10 50 of a photoelectric system; the peripheral region of the
disc 48 is arranged, as it passes through the groove 50, to
intercept a beam of light directed at a photosensitive
device so that rotation of the disc creates a series of
electrical pulses each indicating rotation of the disc by
15 the spacing between the notches. In this way the rotation
of the gearing system 38 is measured and indicated
digitally. As the gearing system 38 is a reduction gearing
with a known reduction ratio, and assuming that both the
coupling 40 and clutch 42 are engaged, rotation of the disc
20 48 thus provides a digital representation of the amount of
rotation of the pinion 44. The pinion 44 is engaged with
the rack 46 so that there is little or no play between the
teeth of the pinion and rack and the teeth of both rack and
pinion are precisely machined: the pulses generated by
25 rotation of the disc 48 are therefore indicative of the
distance moved by the rack 46 and thus of the distance
moved by the carriage 12 to which the rack 46 is fixed and
of the second clamp means 10 fixed to the carriage. The
photoelectric system is arranged to record a distance
30 increment every eight pulses which is equivalent to half a
thousandth of an inch (about 0.0127 mm). The overall
accuracy of the distance measurement is about $\pm 0.1\%$
equivalent to ± 10 thousandth's of an inch, that is about
0.254 mm.

35 The second clamp means comprises a bracket 52
fixed to the carriage 12, the bracket 52 mounting at its

1 front end a spring collet 54. The spring collet 54
comprises a foundation plate 56 fixed to the bracket 52 and
an operating plate 58 pivotally mounted on the bracket 52.
A pair of collet jaws 60 are mounted with a conical portion
5 62 of the jaws received in a corresponding conical seating
in the bracket 52. A collar 64 at a base of the conical
portion 62 bears against a shoulder portion 66 in the
operating plate 58. A compression spring 68 acts between
the collar 64 and the foundation plate 56 to urge the
10 conical portion 62 into the corresponding conical seating
in the bracket 52, the two jaws 60 thereby being urged
towards one another. When the plate 58 is pivoted by an
operator towards the foundation plate 56, the jaws 60 are
moved against the action of the spring 68 to lift the
15 conical portion 62 from the seating in the bracket 52. The
construction and arrangement is such that as the jaws 60
are so moved, they part at a centre line allowing
introduction of a specimen to be tested. Upon release of
the operating plate 58, the spring 68 again urges the jaws
20 so that the conical portion 62 is engaged firmly in its
conical seating, thereby urging the gripping faces of the
jaws towards one another and thus gripping the specimen
between the jaws 60.

The first clamp means 6 also comprises a bracket
25 70 at a front end portion of which is carried a spring
collet 72 similar to the collet 54, the collet 72 being
vertically aligned above the collet 54. The bracket 70 is
mounted on a vertical member 74 of a strain gauge system
76. The vertical member 74 extends between two horizontal
30 spring members 78 to which it is secured at front end
portions thereof. Four strain gauges 79 are mounted at
rear ends of each of the spring members 78 and connected to
form a bridge network. Application of a load to the
bracket 70 transmits the load through the vertical member
35 74 and spring members 78 to the strain gauges 79 which are
calibrated to give a signal indicative of the load applied.

- 1 The load resolution is such that an accuracy of about ± 0.1 grammes is achieved.

The strain gauge system 76 is fixed to the upright member 8. A bracket 80 of the strain gauge system
5 76 projects beneath the lower most one of the spring member 78 and carries at its front end portion a stop screw 82. The stop screw 82 is positioned in alignment with the vertical member 74 and is so adjusted as normally to be spaced slightly from the vertical member 74 so that should
10 an excessive load be applied to the bracket 70, the spring member 78 will yield until the vertical member 74 engages the stop screw 82, whereupon the vertical member 74 and bracket 70 will be supported through the bracket 80 directly by the upright member 8, thereby avoiding
15 excessive strain on the spring members 78.

Mounted on an upper portion of the frame 2 is means for supporting a specimen to be tested. This means, in the illustrative tensile testing machine, comprises a support bracket 84 which carries an axle 86 on which is
20 rotatably mounted a spool 88 on which wire 90 to be tested is wound. The spool 88 is positioned in alignment with the clamp means 6, 10 so that wire 90 to be tested can readily be unwound from the spool, fed between the jaws 60 of the collets 72, 54 and clamped therebetween.

25 A front portion of the machine is enclosed by a hinged transparent plastic cover 108 whilst the test is underway which gives protection to the test piece during the test.

In the operation of the illustrative tensile
30 testing machine in testing fine wire, the machine is arranged to deal with wire or fibres which have a breaking load of between 0 and 200 grammes, for example the fine wires commonly used in wire bonding in the semi-conductor industry. Such wires are commonly of gold or aluminium and
35 may commonly be as little as 30 microns in diameter. With the holding means, viz. the first and second clamp means 6,

1 10 in their initial relation, (that is with the second
clamp means 10 in its initial, uppermost position) the
first and second clamp means are spaced apart by a
predetermined initial distance. A specimen of wire 90 to
5 be tested is unwound from a spool 88 mounted on the axle 86
and clamped by the spring collets 72, 60 of the first and
second clamp means 6, 10. The first and second clamp means
are constructed so that the distance between the jaws of
the collets is ten inches (254 mm) so that the specimen
10 clamped thereby has a nominal length of ten inches (254
mm). Care is taken that the specimen to be tested does not
have undue slack between the collets 72, 54 and also that
the specimen is not taut. If an attempt is made to mount
a taut specimen between the clamp means 6, 10 there is a
15 substantial risk that the specimen will be subjected to
undue loading during the mounting of the specimen in the
clamp means 6, 10 and thus damaged so that the subsequent
test will not give a true record of the properties of the
specimen being tested: if this is done, the machine
20 detects this and stops, indicating that the specimen is
pre-loaded.

The illustrative tensile testing machine will
have already been connected to a suitable power supply and
switched on so that the motor 32 will be running at its
25 constant speed (a suitable motor may run at a speed of 1500
revolutions per minute); however, the electromagnetic
clutch 42 will at this time remain disengaged. Having
mounted a specimen to be tested in the clamp means 6, 10 as
hereinbefore described, an operator presses a start switch
30 92 to commence the test. Operation of the start switch
causes the electromagnetic clutch 42 to engage thereby
transmitting the drive from the motor 32 to the pinion 44
and starting to move the rack 46 and thus the carriage 12
to which the rack is fixed, downwardly (viewing the Figures
35 2 to 4 of the drawings) so that the distance between the
first and second clamp means 6, 10 gradually increases.

- 1 The speed of the motor 32 and the ratios of the reduction gearing system 38 are such that the strain rate is 10% per minute, that is, the distance between the first and second clamp means increases by one inch (25.4 mm) every minute.
- 5 Operation of the start switch 92 at the same time starts a distance recorder of the control system, the recorder being set to have as the initial distance a distance of ten inches (254 mm), that is the spacing between the jaws 60 of the collets 54, 72 when the clamp
- 10 means 6, 10 are in their initial relation. The strain gauge system 76 is also actuated at this time to measure strain and to record the strains measured. Should the strain gauge system 76 indicate, when the start switch is operated, that the test specimen is already loaded (that is
- 15 that the specimen may have been stretched during mounting between the clamp means) a signal is given which results in the test being stopped and recorded as a failure. The control system of the machine is arranged to record the distance moved by the second, moving collet 54 and the load
- 20 registered by the strain gauge system 76 at incremental intervals of distance. The control system is also arranged to record the maximum load indicated by the strain gauge system 76. The control system is designed to include a factor in the recording of the distance moved by the
- 25 moveable second clamp means 10 to compensate for movement of the bracket 70 of the strain gauge system caused by the load applied thereto.

Assuming that there is no initial failure, the motor 32 continues to drive the carriage downwardly thereby

30 increasing spacing between the first and second clamp means 6, 10. Pulses generated by the notched disc 48 interacting with the photoelectric system are transmitted to the distance recorder and added to the initial distance recorded of ten inches (254 mm). After the carriage 12 has

35 moved a small distance, the strain gauge system 76 should start to record a load on the test specimen. However, if

1 the specimen was mounted between the clamp means 6, 10 in
too slack a manner, the distance moved by the carriage 12
before the strain gauge system 76 starts to record any load
on the specimen will be too great to allow a satisfactory
5 test. The control system of the tensile testing machine is
therefore arranged so that should the distance between the
first and second clamp means 6, 10 reach a predetermined
distance before the strain gauge system 76 records any load
on the specimen, an alarm signal is given and the test is
10 indicated to be a failure due to the slackness of the
specimen.

Should the strain gauge system 76 start to record
a load on the test specimen before the failure distance
between the clamp means 6, 10 is reached the test will
15 continue with the motor 32 moving the carriage 12 and thus
the second clamp means 10 at the rate previously mentioned.
As the spacing between the first and second clamp means 6,
10 gradually increases the load measured by the strain
gauge system 76 and recorded by a suitable recorder of the
20 machine control system gradually increases. After some
time, the rate of increase will reduce as the test specimen
starts to yield and the load recorded may ultimately fall.

Finally, in most instances, the test specimen
will break. Breakage of the test specimen will of course
25 mean that the load registered by the strain gauge system 76
will drop substantially immediately to zero. The control
system of the tensile testing machine, on recognising
breakage of the specimen by the sudden falling of the load
to zero immediately signals the electromagnetic clutch 42
30 to disengage, thus allowing the carriage 12 to be returned
by the spring 18 to its initial position, the pinion freely
rotating as the carriage returns. The return movement of
the carriage is cushioned by the damping piston and
cylinder arrangement 30 which acts as a dash pot ensuring
35 that the carriage 12 is not returned violently to its
initial position.

1 On recognising breakage of the test specimen not
only does the control system signal disengagement of the
clutch 42, but also causes print out of the test results on
the out-put printer 4. The control system may be arranged
5 to calculate and print various results but will normally be
arranged to print out the maximum tensile strength (that is
the maximum load recorded), the ultimate tensile strength
(that is the load at which the test specimen breaks) and
the percentage elongation at break. Elongation at break is
10 calculated using as the base length of the test specimen
the initial spacing of the clamps (ten inches) plus the
distance moved by the second clamp means 10 when the strain
gauge system 76 first records a load (that is when any
slack in the test specimen has been taken up): from that
15 point the further distance moved until breakage is, of
course, the extension of the test specimen. The printer is
also usually programmed to print a graph of load versus
extension. The control system may also be arranged to
calculate the proof stress.

20 Occasionally the specimen may slip in one of the
collets 54, 72: if this happens, there will usually be a
sudden fall in the load recorded by the strain gauge system
76, followed by a further increase. The control system of
the tensile testing machine is arranged to recognise
25 slippage and signal a failure of the test, signalling
disengagement of the clutch 42 and terminating the test.

 The use of the electromagnetic clutch 42 allows
substantially instantaneous re-setting of the testing
machine for testing a new specimen, thus increasing the
30 test rate, especially in comparison with previously used
screw operated tensile testing machines. In a screw system
it is necessary to screw the moveable clamp means back to
its initial position (that is the reverse movement to the
movement occurring in the actual test): because of the
35 fine pitch of the screw necessary to give the fine movement
which occurs in the actual test it is not possible readily

1 to reverse roles of driving and driven member to return the
 moveable jaw very rapidly to its initial position using a
 screw. The rack and pinion drive system is especially
 5 suitable for rapid re-setting in so far as the role of
 driving and driven member can readily be reversed. ~~Other~~
~~transmission systems which may be suitable include chain~~
~~(or toothed belt) and sprocket systems, although these may~~
~~give problems should the belt or chain prove to be somewhat~~
~~extensible for example such machines may need more frequent~~
 10 ~~adjustment; the rack and pinion drive system is preferred.~~
 It will be appreciated that the spring 18 ensures that the
 rack and pinion are maintained in positive meshing
 engagement so that the driving face of the teeth of the
 pinion 44 are always in engagement with the same face of
 15 the teeth of the rack when the machine is carrying out a
 test so that no errors are likely to arise due to any play
 between the rack teeth and pinion teeth.

The overload clutch coupling 40 is arranged to
 allow slippage of the drive between the gearing system 38
 20 and the electromagnetic clutch 42 should a safe loading of
 the testing machine be exceeded during a test - this also
 will result in the test being aborted.

The control system of the illustrative tensile
 testing machine also comprises means which will terminate
 25 the test when the holding means have moved relatively
 through a predetermined distance (viz. three inches, 76.2
 mm) from the start of the test, not as a "fail" but as a
 successful test causing the control system to initiate the
 same operations that are initiated by breakage of the test
 30 specimen. The tensile testing machine also comprises an
 overrun micro switch mounted in alignment with the carriage
 12 so that should the other termination systems fail, the
 carriage will operate the micro switch, disengaging the
 clutch and terminating any test underway.

35 It will be appreciated that in the illustrative
 tensile testing machine the collet jaws are so constructed

1 and arranged that the specimen to be tested will not be
damaged by the jaws when gripped - should the jaws grip the
specimen, especially a fragile and thin wire, too tightly
the specimen may be damaged which could lead to premature
5 breakage and generally inaccurate test results.

Whereas the strain gauge system in the
illustrative tensile testing machine is associated with the
fixed clamp means, the strain gauge system could be
associated with a moveable clamp means in a machine
10 otherwise similar to the illustrative tensile testing
machine, although in this instance the connections involved
would be more complicated.

As hereinbefore mentioned the tape peel force
testing machine is substantially identical in construction
15 to the tensile testing machine described hereinbefore apart
from a few minor details. One difference in detail which
arises is that a different gearing system 38 is used so
that the rate of movement of the second clamp means 10 of
the tape peel force testing machine is five inches (about
20 127 mm) per minute as compared with the one inch per minute
movement rate in the tensile testing machine. The tape
peel force testing machine (see Figure 1) comprises,
instead of the support bracket 84 at the top of the
machine, a support bracket 94 secured to a side portion of
25 the machine frame 2 and comprising an axle on which a reel
96 is mounted for rotation and retained in place by a nut
98 which can readily be removed to change reels. The reel
carries a pocketed component tape 100, having a cover tape
102 adhered by a suitable adhesive (which will allow the
30 cover tape to be peeled off when the components are to be
used) to the pocketed tape to retain electronic components
in the pocketed tape. The illustrative tape peel force
testing machine also comprises a tape guide 104 mounted on
a front plate 106 of the machine frame.

35 The first and second clamp means 6, 10 of the
tape peel force testing machine differ from those of the

1 tensile testing machine in that instead of the spring
collets 54, 72, the first and second clamp means 6, 10 are
provided with spring clips 110 of the type known as
crocodile clips, positioned with the jaws thereof facing
5 one another. However, any convenient form of clip may be
used provided that its holding force is sufficient to grip
the appropriate tape without the tape slipping during the
test, while yet not damaging the tape to such an extent
that the tape breaks or itself yields giving a false load
10 reading.

In the operation of the illustrative tape peel
force testing machine a reel of tape to be tested is
mounted on the support axle carried by the bracket 94 and
locked in place by the nut 98. The tape is passed round
15 the tape guide 104 and a leading end portion of the cover
tape 102 is separated manually from a leading end portion
of the pocketed tape 100. The pocketed tape 100 is then
clamped by the spring clips 110 to the first clamp means 6
and the leading end portion of the cover tape 102 is
20 clamped by the appropriate spring clip to the second clamp
means 10. The peel point of the tape is thus between the
first clamp means 6 and the second clamp means 10 and is
preferably arranged to be sufficiently close to the first
clamp means 6 that the second clamp means when it is moved
25 by the motor 32 pulls the leading end portion of the cover
tape 102 in a plane in which the clamp means 6, 10 lie,
substantially coplanar with the leading end portion of the
pocketed tape 100 (see Figure 1).

In carrying out a tape peel force test the
30 control system of the testing machine is preferably
arranged to record the maximum peel force required during
the test and the minimum peel force required and to plot a
graph of load employed against distance moved by the second
clamp means.

35 As no breakage should occur during normal
operation of the peel force testing machine, the test will

1 usually be terminated by the control system after the
second, moving clamp means 10 has been moved through a
predetermined distance of three inches (76.2 mm). However,
should breakage or slippage occur the control system is
5 arranged to recognise this and indicate a test failure
while terminating the test by disengaging the clutch 42 as
hereinbefore described with reference to the tensile
testing machine.

Should the (control system) fail to terminate the
10 test as mentioned above, the test will ultimately be
terminated by engagement of the carriage 12 with the micro
switch mentioned previously.

Both of the illustrative machines described
herein are of simple construction and are easy to use. The
15 machines are rapidly re-set for further tests. Because the
machines are designed to deal with a relatively small load
range and to handle a restricted class of products, the
illustrative machines are also relatively inexpensive.

20

25

30

35

Claims:

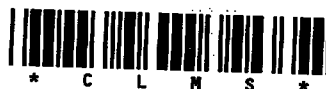
1. A testing machine for applying a loading to a test specimen comprising a frame, first and second holding means by which a specimen to be tested can be mounted when the holding means are spaced by a predetermined initial spacing, the first holding means being secured on the frame and the second holding means being secured on a carriage moveable on the frame to and from an initial position in which the holding means are spaced apart by the initial spacing, so that the second holding means is linearly moveable relative to the first holding means, and a motor arranged, when operated to move the carriage and thus the second holding means away from the first, wherein the motor is arranged to drive a pinion through a clutch and a rack is secured to the carriage and in engagement with the pinion whereby when the clutch is engaged the carriage is moved to move the second holding means away from the first, and the machine comprises means operative when the clutch is disengaged to return the carriage to its initial position.

2. A testing machine according to claim 1, wherein the means which returns the carriage comprises a spring.

3. A testing means according to claim 2, wherein the machine comprises cushioning means arranged to cushion the return of the holding means.

4. A testing machine according to any one of claims 1 to 3, wherein the motor is a constant speed motor arranged to move the holding means at a constant rate.

5. A testing machine according to any one of claims 1 to 4, wherein the machine comprises means for



counting revolutions of the motor whereby to measure the movement of the holding means.

6. A testing machine according to claim 5,
5 wherein the counting means comprises a photoelectric system.

7. A testing machine according to any one of
the preceding claims, wherein the machine comprises means
10 for measuring the loading applied to the specimen.

8. A testing machine according to claim 7,
wherein the means for measuring the loading applied
comprises a strain gauge system associated with the holding
15 means.

9. A testing machine according to any one of
claims 1 to 8, wherein the machine comprises means
initiating disengagement of the clutch when a test has
20 finished.

10. A testing machine according to claim 9,
wherein the means initiating disengagement of the clutch
comprises means detecting breakage of the test specimen.
25

11. A testing machine according to claim 9
wherein, the means initiating disengagement of the clutch
comprises means detecting relative movement of the holding
means through a predetermined distance.
30

12. A testing machine according to claim 9
wherein, the means initiating disengagement of the clutch
comprises a timer which operates to initiate disengagement
a predetermined time interval after commencing a test.
35





13. A testing machine according to any one of the preceding claims, wherein the machine comprises means for adjusting the initial spacing of the holding means.

14. A testing machine substantially as hereinbefore described with reference to and as shown in Figure 1 of the accompanying drawings.

15. A testing machine substantially as hereinbefore described with reference to and as shown in Figures 2 to 5 of the accompanying drawings.

