The present invention relates to a method and means for perforating sheets of material and more particularly to a new and improved method and means for perforating sheets of heat fusible plastic material having relatively high dielectric strength.

In some instances, such as in the manufacture of lawn irrigator or sprinkler hose from thin plastic sheeting, it is necessary to provide a multiplicity of small diameter perforations through the plastic material without so weakening the material about the perforations that the water pressure within the hose can cause failure of the hose at such points. A cylindrical sharp edged punch is not feasible for forming fine perforations having a diameter such as from 7 to 20 thousandths of an inch. It is also impractical to pierce or puncture the sheet with a pointed instrument. Either the piercing or punching method is actually a tearing or shearing operation which creates fine, radially extending rips through the material adjacent the aperture or opening. If sheets perforated by such methods are placed under stress, the rips about the perforations creep through the sheet and rapidly lengthen to such an extent that the product formed of the perforated material is rendered useless.

Another method used heretofore to perforate sheets of various materials is to place the sheet to be perforated between a pair of pointed electrodes across which a high voltage is applied. The high voltage will cause the portion of the sheet between the electrodes to break down whereby an opening will be formed in the sheet. This method is not practical, however, for perforating relatively narrow strips of plastic and other material having a high dielectric strength since the potential necessary to break down the strip to perforate the same is so high that the electrodes frequently discharge about the side edges of the strip rather than through the strip and, of course, no opening will be formed. Also the life of the electrodes is extremely short because of the high temperature of the arc.

It is a general object of the present invention, therefore, to provide a new and improved method and apparatus for perforating sheets of material.

More particularly it is an object of the invention to provide a new and improved method and apparatus for perforating sheets of material of high dielectric strength.

A more specific object of the invention is to provide a method and means for perforating a sheet of material whereby the edges of the perforations will be smooth and continuous and the adjacent portions of the sheet free from rips and tears.

Another object of the invention is to provide apparatus for electro-perforating openings of predetermined diameter in sheet material of high dielectric strength.

Other objects and advantages of the present invention will become more apparent hereinafter.

In accordance with the illustrated embodiment of the invention, plastic strips are fed through a machine having means to break down the dielectric strength of the strip at selected points as, for example, by rupturing the strip by piercing or puncturing it at the selected points. The strip is thereafter passed between a pair of substantially planar faced electrodes between which is impressed a voltage sufficient to cause arcing through the strip at the ruptured points. The high temperature of the arc will cause the surrounding portions of the strip to melt and fuse and the arc is maintained for a predetermined length of time to form an opening in the strip of the desired diameter.

For a more detailed description of the invention reference is made to the accompanying drawings wherein:

Fig. 1 is a top plan view of a machine constructed in accordance with the present invention for perforating a strip of plastic;

Fig. 2 is a cross-sectional view taken substantially along line 2—2 of Fig. 1;

Fig. 3 is an enlarged cross-sectional view taken along line 3—3 of Fig. 2;

Fig. 4 is an enlarged fragmentary view taken substantially along the line 4—4 of Fig. 1 and showing the arrangement of the electrodes;

Fig. 5 is an enlarged top plan view of a section of the plastic strip;

Fig. 6 is a large cross-sectional view of the plastic strip taken along the line 6—6 of Fig. 5; and

Fig. 7 is a view of a sprinkler hose made from material perforated in accordance with the present invention.

Referring now to the drawings, the machine of the present invention comprises a table 15 over the surface of which is drawn an elongated sheet or strip 11 of material to be perforated, such as, for example, a strip of vinyl chloride-acetate plastic which is characterized by its high dielectric strength. Rotatably mounted at one end of the table 10 is a pair of vertically disposed rollers 12 and 13 adapted to frictionally engage the strip 11 therebetween to draw the same
through the machine, or from right to left as viewed in Figs. 1 and 2. Any suitable means may be
provided to drive the rollers 12, 13 which means are indicated in the drawings by a shaft 14
carried by the upper roller 12 by suitable pulleys and belts indicated at 15 or any other suitable means.
A spool 17 is provided to wind the perforated strip as it leaves the machine, which spool is suitably journalled
on supports indicated at 18 and driven by suitable means as from the upper roller 12 by the pulley and
bell arrangement indicated generally at 19. To retain the strip 11 in a predetermined path suitable
guide means are provided on table 10 including the guides 20, 21 mounted on the table 10
just forwardly of the drive rollers 12, 13. On each of the opposite sides of the path of the strip 11 and
the guides 22, 23 mounted similarly at the foremost end of the table 10.
Means are provided on the machine for reducing the dielectric strength of the strip 11 at
selected points therealong as it passes through the machine. Mounted on the forward end of
the machine are means for piercing or puncturing openings through the strip at predetermined
points therealong comprising an upper puncturing roll 25 and a cooperative platens roll 26,
which rolls are mounted with their adjacent peripheral portions tangential to the surface of
the table 10, and between which rolls the strip 11 passes in its course through the machine.
The puncturing roll 25 is mounted on a shaft 27 which shaft is suitably journalled on a pair of oppositely disposed supporting brackets 28 up-
standing from the table 10. The platens roll 26 is mounted on a shaft 29 the opposite ends of
which shaft are suitably journalled in oppositely disposed supporting brackets 30 depending from
the table 10. Though the puncturing roll 25 and the platens roll 26 may be positively driven,
the frictional engagement of the moving strip therebetween will cause the rolls to rotate and to
perform their functions. As shown in the drawings, the rolls 25, 26 are mounted on the
table 10 so as to rotate freely about their respective axes.
The puncturing roll 25 includes an inner cylin-
drical portion 33 having a plurality of circum-
crurally spaced apart puncturing needles 34 mounted thereon. The needles 34 are coop-
eratively received in radially extending circular openings 35 formed in the cylindrical portion 33
and are releasably secured in place by lock screws 36 which are threaded through the side of
the cylindrical portion 33 as shown in Fig. 3.
The needles 34 each extend radially outwardly from the periphery of the cylindrical portion 33
in a substantially equal distance and are adapted to just contact the periphery of the platens roll
26 as the rolls 25, 26 rotate. Preferably, the platens roll 26 is rubber covered so that at least
the outer peripheral portion thereof has a slight degree of resiliency whereby the needles 34 may
more easily pierce the strip 11 and will not be so rapidly blunted as would be the case if the
platens roll were provided with a hard surface.
Means are provided to remove the strip 11 from the needles 34 after the piercing step which
means comprises an annular ring 38 of a compression resilient material such as sponge rub-
er disposed about the cylindrical portion 33.
The normal thickness of the ring 38 is such that
it is greater than the distance that the needles project from the periphery of the cylinder 33, 79
the material of the ring being compressible inwardly as it comes in contact with the portion of
the strip 11 adjacent the platens roll 26 whereas the needles will project outwardly of the
compressed ring to puncture the strip 11 as each needle rotates into contact with the platens roll.
As the compressed portion of the ring 38 rolls free of engagement with the platens roll 26, such
portion will expand to the normal thickness of the ring 38 disengaging the needles 34 and the
strip 11.
The needles are preferably very fine and sharp such as, for example, a No. 10 phonograph need-
dle, which needle will pierce or rupture the sheet as indicated at 39 in Figs. 5 and 6. Such a rup-
ture 39 really has no finite cross-sectional area but, as shown, merely comprises small tears
through the material. If the perforated strips are to be used in the formation of sprinkler units
as shown in Fig. 7 the perforations are preferably formed in a plurality of spaced apart rows
as indicated in Fig. 5 and which may be accomplished by staggering the needles 34 in roller 33
in different axially spaced apart radial planes. Mounted on the table 10 below the punctur-
ing rolls 25, 26 and the drive rollers 12, 13 is a pair of planar faced electrodes 43, 44 positioned
to receive the strip 11 therebetween with the faces of the electrodes substantially parallel with
the surfaces of the strip 11. Preferably, the lower
electrode 43 is embedded in the table 10 with
the surface of the electrodes 43 substantially flush with the surface of the table 10. The upper
electrode 44 is mounted on an arm 45 supported on the table 10 by a bracket including an
elbow used base portion 48 extending from and
extending longitudinally of the table 10. The arm 45 is releasably clamped between the base
portion 48 and a clamping bar 49 extending longitudinally of the base portion 48 and secured
at its opposite ends to the base portion 48 by
bolts 49. This arrangement permits longitudi-
nal adjustment of the position of the electrode
44 in respect to the electrode 43, the reason for
which adjustment will become apparent hereinafter. The arm 45 is preferably formed of an
electrically insulating, resilient material and is
arranged to bias the electrode 44 downwardly
into contact with the upper surface of the
strip 11.
The electrodes 43, 44 are each elongated in the
direction of travel of the strip 11 and at least
one of the electrodes should have a width con-
siderably less than the width of the strip 11. In
the embodiment shown in the drawing, the lower
electrode 43 is a flat metal plate which is of
greater width than the strip 11 to facilitate modifying the machine for various perforating
arrangements whereas the upper electrode 44 is
a plate of a width considerably less than the
width of the strip 11 and is disposed centrally in
the strip so that the opposite edges of the strip
11 extend downwardly from each of the
opposite side edges of the electrode 44. This
arrangement is preferred to minimize the possi-
bility of arcing occurring between the upper and
lower electrodes across the side of the strip 11
rather than through it. The electrode 44 has a
width at least as great as the distance between
the two outermost rows of perforations, as shown
in Fig. 5.
Circuit means are connected to the electrodes for impressing a potential between them which is
greater than the dielectric strength of the air gap between the electrodes and sufficient
to create an arc discharge through the ruptures in the strip. The potential applied to the electrodes is of course less than the normal dielectric strength of the material being perforated, and precludes the possibility of breaking down the material at unselected points. Suitable circuits will be readily apparent to those skilled in the art and the circuit means therefore has only been schematically illustrated in Fig. 7 and is indicated by the numeral 48. In perforating vinyl chloride-acetate sheets having a thickness of from about 0.006 inch to 0.010 inch, I have found it expedient to employ an ordinary 11,000 volt neon sign transformer with the opposite secondary terminals connected to the electrodes 43 and 44.

In the operation of the machine the driving rollers 12 and 13 are set in motion to draw the strip 11 through the machine at a desired rate of speed. The strip is first punctured as it passes between the puncturing roll 25 and the cooperating platen roll 26 as above described and then proceeds between the electrodes 43 and 44. Though the strip 11 may be of a high dielectric strength as, for example, if it is a sheet of a vinyl chloride-acetate-plastic type of plastic material, the ruptured areas through the strip provide a weakened path through which arc discharge between the electrodes will occur in preference to other portions of the strip. As the electrodes begin to discharge through the ruptures in the strip 11, the heat of the arc will, of course, melt the adjacent material, the surface tension of the molten material causing it to form meniscus like bulges 52 on each of the opposite surfaces of the sheet where molten material will solidify to define an opening 53 of finite diameter as most clearly shown in Fig. 6. The edge of the opening 53 resulting from such fusing or melting will be comparatively smooth and continuous and the strip will be free from any radially extending rips or tears so that upon application of stress to the strip the opening will merely expand and the strip will not tear or rip. Moreover, the bulges 52 will reinforce the opening to further deter the ripping or tearing of the strip. The size of the openings may be controlled by controlling the period of time an arc is maintained through an opening, which control may be effected by varying the effective length of the electrodes such as, for example, by changing the length of either electrode or by changing the position of the upper electrode 44 so that only a fractional portion thereof overlaps the lower electrode 43. The speed at which the strip 11 moves through the machine may be varied to lengthen or shorten the period of time within which any opening is between the electrodes and correspondingly lengthen or shorten the period of arcing through each puncture. The temperature of the arc may also be increased or decreased by increasing or decreasing the current value of the discharge, by changing the concentration of the puncturing liquid disposed between them. The overlapped portions are then pressed together, which pressing will express the liquid from the thread and effect a bond between the overlapped portions. A pair of tubes thus formed are then united together in any suitable manner so that the openings 53 in each tube will be in the relative positions shown in Fig. 7, that is with openings 53 in each tube arranged slightly to the side of the uppermost portion of a tube and away from the other tube so that water will spray laterally from the hose on each of the opposite sides thereof.

Having illustrated and described a preferred embodiment of the invention, it should be apparent to those skilled in the art that the invention permits of modification in arrangement and detail. I claim as my invention all such modifications as come within the true spirit and scope of the appended claims.

I claim:

1. A machine for perforating at preseleced points an elongate strip of heat fusible material comprising means for drawing said strip through said machine at a predetermined rate, means for puncturing said strip at preseleced points therealong as it passes through said machine, and a high voltage discharge means including a pair of electrodes positioned to receive the punctured strip therebetweeen, said electrodes being elongate in the direction of travel of said strip and of predetermined length wherein an arc discharge will occur through each of said punctures for a predetermined length of time.

2. In a machine for perforating at preseleced points an elongate strip of heat fusible material comprising means for drawing said strip through said machine at a predetermined rate, means for puncturing said strip at preseleced points therealong as it passes through said machine, a pair of electrodes positioned to receive the punctured strip therebetweeen, said electrodes having opposed parallel, planar faces substantially parallel with the surfaces of said strip as it passes through said machine, said electrodes being of substantially surface area, at least one of said electrodes being of lesser width than the width of said strip, high voltage supply means operatively connected to said electrodes for impressing a potential therebetweeen and guide means for guiding said strip through the machine with the opposite side edges of said strip positioned outwardly from the corresponding side edges of said strip.

3. In a machine for perforating at preseleced points an elongate strip of heat fusible material comprising means for drawing said strip through said machine at a predetermined rate, means for puncturing said strip at preseleced points therealong as it passes through said machine, a pair of electrodes positioned to receive the punctured strip therebetweeen, said electrodes having opposed parallel, planar faces substantially parallel with the surfaces of said strip, and guide means for guiding said strip through the machine with the opposite side edges of said strip positioned outwardly from the corresponding side edges of said strip.
puncturing means and adapted to receive said strip therebetween, said electrodes having opposed parallel, planar faces positioned to be aligned substantially parallel with the surfaces of said strip, said electrodes being of substantial surface area and elongated in the direction of travel of said strip, at least one of said electrodes being of lesser width than said strip and arranged to receive said strip with the opposite edges of the strip extending outwardly of each of the opposite side edges of said one electrode, and circuit means connected to said electrodes for impressing a potential between said electrodes greater than the dielectric strength of the air gap therebetween whereby discharge will occur between said electrodes through the punctures in said strip as it passes between said electrodes.

4. In a machine for perforating an elongate strip of a heat fusible material having high dielectric strength, the combination comprising means for drawing said sheet lengthwise through said machine, means for puncturing a plurality of openings staggered in a plurality of parallel rows through said sheet, a pair of electrodes adapted to receive the punctured sheet therebetween, each of said electrodes having a width greater than the spacing between the outside rows of said punctured openings, and circuit means connected to said electrodes for impressing a high voltage therebetween whereby a high voltage arc discharge will occur through said openings to heat and fuse the annular edges of said punctured openings.

5. In a machine for perforating at preseleced points an elongate strip of heat fusible material of high dielectric strength, the combination comprising means to draw said strip longitudinally through said machine, a puncturing means to puncture openings in said strip in a plurality of laterally spaced apart rows, a pair of juxtaposed electrodes positioned to receive the punctured strip therebetween, said electrodes having opposed parallel, planar faces positioned to be substantially parallel with the surfaces of said strip, said electrodes being of substantial surface area and elongated in the direction of travel of said strip, each of said electrodes having a greater width than the spacing between the outside rows of punctured openings, said electrodes being positioned to receive said rows of punctured openings therebetween, at least one of said electrodes being of lesser width than said strip and arranged to receive said strip with the opposite edges of the strip extending outwardly of each of the opposite sides edges of said one electrode, and circuit means connected to said electrodes for impressing a potential between said electrodes greater than the dielectric strength of the air gap therebetween whereby discharge will occur between said electrodes through the punctures in said strip as it passes between said electrodes.

6. In a perforating machine of the class described, the combination comprising means for drawing a sheet to be perforated through said machine, high voltage discharge means including a pair of electrode means having opposed parallel, planar faces and adapted to receive said sheet therebetween with said faces parallel to the surfaces of said sheet and resilient means for urging said electrodes into contact with said sheet.

7. In a machine for perforating at preseleced points an elongate strip of heat fusible material, means for drawing said strip through said machine, means for puncturing said strip at preseleced points thereof as it passes through said machine, high voltage discharge means including a pair of electrodes positioned to receive the punctured strip therebetween, said electrodes being elongate in the direction of travel of said strip, and means adjustably supporting one of said electrodes for adjustment relative to the other in said direction of travel.

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