

# Pftaps19760113 Wk02

HHHHHT	APS1	ISSUE - 760113
HHHHHT	APS1	ISSUE - 760113
PATN		
WKU	RE0286761	
SRC	5	
APN	4384873	
APT	2	
PBL	E	
ART	344	
APD	19740131	
TTL	Control apparatus	
ISD	19760113	
NCL	6	
ECL	1	
EXP	Wayner; William E.	
NDR	1	
NFG	5	
INVT		
NAM	Edelman; Walter E.	
CTY	San Marcos	
STA	CA	

# Pftaps19760113 Wk02

INVT

NAM Sutton; David J.

CTY Minneapolis

STA MN

ASSG

NAM Honeywell Inc.

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COD 2

REIS

COD 50

APN 406397

APD 19641026

PNO 3284002

ISD 19661108

CLAS

OCL 236 1C

XCL 165 26

XCL 236 68B

EDF 2

ICL G05D 2330

FSC 165

# Pftaps19760113 Wk02

FSS	26
FSC	236
FSS	68 B;68 R;1 C
FSC	337
FSS	377;398;112
UREF	
PNO	2564120
ISD	19510800
NAM	McLean
XCL	236 68
UREF	
PNO	2729719
ISD	19560100
NAM	Kronmiller
XCL	337377
UREF	
PNO	2855484
ISD	19581000
NAM	Kreuter
OCL	337344
UREF	

# Pftaps19760113 Wk02

PNO 2969916

ISD 19610100

NAM Shequen

XCL 165 26

UREF

PNO 3157801

ISD 19641100

NAM Shequen

XCL 236 68

LREP

FR2 Blinn; Clyde C.

FR2 Hanson; Henry L.

ABST

PAL .Iadd.A thermostat for controlling heating apparatus is converted to a thermostat for controlling heating and cooling apparatus by the addition of a subbase. The heating thermostat has a double switch attached to a bimetal and a heating anticipation heater whereby heating apparatus is controlled when connected to the terminals of the thermostat. When it is desired to use the thermostat to control both heating and cooling apparatus, the thermostat is removed from the wall and a subbase is placed under the thermostat. The subbase has a cooling anticipation heater which

# Pftaps19760113 Wk02

is thermally connected to the bimetal. The subbase has terminals to connect the assembly of thermostat and subbase to the heating and cooling apparatus. .laddend.

BSUM

PAR The present invention is concerned with an improvement in a thermostat for a heating and cooling system; in particular, a thermostat is provided with a double switch so one portion of the switch can be normally used to control heating apparatus and upon the addition of a subbase which has a heater to artificially heat the temperature responsive device in the thermostat, the thermostat can control both heating and cooling apparatus.

PAR Heretofore, when temperature controls were provided for controlling heating apparatus, a space temperature control or thermostat was not easily converted to control cooling apparatus should the temperature conditioning apparatus of the building or dwelling be modified to add cooling apparatus. Upon such a modification of the conditioning apparatus for cooling, a new thermostat which had provisions for controlling both heating and cooling apparatus was substituted for the old thermostat at a considerable expense to the home owner.

PAR Various ways are used to reduce the cost of the conversion from heating to a heating and cooling system. One particular scheme is to add an additional relay to the normal heating thermostat for reversing the switch

# Pftaps19760113 Wk02

operation of the heating thermostat so the heating thermostat can be used to control either heating or cooling apparatus. Obviously such a reversing relay becomes expensive and increases the overall cost of the modification of the existing heating system to a heating and cooling system. In addition, the heat effects of a relay may cause poor operation of the thermostat.

PAR

The present invention provides for the addition of a subbase to a heating thermostat which has a switch means adaptable to control a cooling apparatus. The subbase contains a heat anticipation heater means which is thermally connected to the temperature responsive means of the thermostat when the subbase is mounted on the thermostat. With such a subbase, the thermostat is adapted for controlling both heating and cooling apparatus, and the initial expense and expense of conversion of the heating system to a heating and cooling system is maintained at a minimum. The present invention provides for a reduction in the initial expense to the home owner by eliminating the anticipation heater used during the cooling operation in the thermostat. The anticipation heater for cooling is placed in the subbase to be thermally coupled to the thermostat when the subbase is mounted on the thermostat.

PAR

An object of the present invention is to provide an improved thermostat and subbase combination wherein the anticipation heater used during the

# Pftaps19760113 Wk02

cooling operation is mounted on the subbase and is thermally coupled to the temperature responsive means in the thermostat.

PAR

Another object of the present invention is to provide a thermostat with a temperature responsive means supported on a member attached to a base so the thermostat can normally control heating apparatus. Upon the attachment of a subbase, an artificial heating means is added which is supported by a resilient means biased against the member to conduct heat from the subbase to the temperature responsive means for anticipation purposes when cooling apparatus is controlled.

PAR

Another object of the present invention is to provide a subbase adapted to be connected to a thermostat with a heater in the subbase thermally coupled to the thermostat for anticipation when the thermostat controls cooling apparatus.

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PAR

These and other objects of the present invention will be understood upon a study of the following specification and claims of which:

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FIG. 1 is a schematic representation of a thermostat and subbase combination used to control heating and cooling apparatus.

PAR

FIG. 2 is a side cut away view of a typical thermostat having an anticipation heater mounted in the subbase to be thermally coupled to the temperature responsive means in the thermostat.

# Pftaps19760113 Wk02

PAR

FIG. 3 is another embodiment of the present invention disclosing the coupling of the heater in the subbase to the temperature responsive means of the thermostat by air flow through a hole in the base of the thermostat.

PAR

FIG. 4 is another embodiment of the present invention showing the heater in the subbase adjacent the support of the temperature responsive element in the thermostat to thermally couple the heater and temperature responsive means and

PAR

FIG. 5 is a detailed showing of the resilient support for the heater mounted in the subbase as shown in FIG. 2.

DETD

PAR

Referring to FIG. 1, a thermostat 10 is used to control the temperature in a space. Thermostat 10 has a temperature responsive means or bimetal 11 which is mounted on a support or post 12. Connected to the free end of bimetal 11 is a switch 13. The switch 13 is of an SPDT mercury switch type having two end electrodes 14 and 15 and a center common electrode 20 to form a circuit closing switch at each end when the mercury 21 covers either electrodes 14 and 20 or electrodes 15 and 20. Thermostat 10 is normally connected to control 22 for controlling heating apparatus. Apparatus 22 contains a source of power 23 having a primary winding 24 and a secondary winding 25. A heating relay 30 has a winding 31 and a normally

# Pftaps19760113 Wk02

open switch 32 which is adapted to be connected to temperature conditioning or heating apparatus.

PAR

Relay 30 is energized when switch 13 tips to the right to close the circuit between electrodes 15 and 20 through a circuit traced as follows: from secondary 25, a conductor 33, winding 31, a conductor 34, a terminal 35, a conductor 40, a terminal 41 on thermostat 10, a resistor 42 which is thermally connected to bimetal 11 for heat anticipation purposes, a conductor 43, electrode 15, electrode 13, a conductor 44, a terminal 45, a conductor 50, a terminal 51, conductor 52, and back to the other side of the secondary 25. Upon a drop in temperature of the space containing thermostat 10, bimetal 11 moves switch 13 to the right to close the circuit between electrodes 15 and 20 to energize relay 30 and the heating apparatus. The current circulating through the circuit passes through heater 42 to artificially heat the bimetal 11 to cause the bimetal temperature to rise to anticipate increase in space temperature due to the operation of the heating apparatus. The heating apparatus is then deenergized earlier than without anticipation.

PAR

In order to convert the system to a heating and cooling system by the addition of the cooling control 53, a subbase 54 is added to thermostat 10. The subbase may be physically connected as well as electrically connected by terminal screws 41, 45 and 46. Subbase 54 contains a

# Pftaps19760113 Wk02

change-over or cool-off-heat switch 55 which has a movable member 60 engaging contacts 61 and 62 when in the cool position and contact 63 when in the heat position for selectively switching the system to obtain cooling or heating or to turn the system off. Heater 64 mounted in subbase 54 is positioned to be thermally connected or coupled to bimetal 11 when the subbase 54 is mounted on the thermostat. Heater 64 is used for anticipation purposes when the thermostat is used to control the cooling apparatus. When thermostat 10 is used for controlling the heat apparatus 22 and the cooling apparatus 53, the connections for the thermostat are made through the subbase 54. The circuit for the control of the heat apparatus 22 is modified to be traced as follows: from the secondary winding 25 of the transformer, conductor 33, winding 31, conductor 34, a conductor 65, a terminal 70, a conductor 71, a terminal 72 on subbase 54, contact 63, movable member 60 when in the heat position, a conductor 73, terminal 45, conductor 44, electrode 20, electrode 15, conductor 43, heater 42, terminal 41, a conductor 74, a terminal 75 on subbase 54, a conductor 80, a terminal 81, a conductor 82, conductor 52, and back to the other side of a source of power. Upon the decrease in temperature of bimetal 11, switch 13 controls relay 30 to operate the heating apparatus in the same manner as was the case when the thermostat 10 was connected to control apparatus 22 by the circuit through conductors 40 and 50 which are

# Pftaps19760113 Wk02

not used for the heating and cooling connections.

PAR

The operation of the cooling apparatus is accomplished by thermostat 10 when the switch 55 of the subbase is moved to the cool position as shown with member 60 engaging contacts 61 and 62 through a circuit traced as follows: from the secondary 25, a conductor 83, an energization winding 84 of a relay 85 which has a normally open switch 90 attached to be connected to cooling apparatus, a conductor 91, a terminal 92, a conductor 93, a terminal 94 on subbase 54, conductor 95, terminal 46, conductor 100, electrode 14, electrode 20, conductor 44, terminal 45, conductor 73, member 60, contact 61, terminal 75, conductor 80, terminal 81, conductor 82, conductor 52, and back to the other side of the source of power. The anticipation heater 64 is connected in parallel with the switch formed by electrodes 14 and 20 by a circuit traced as follows: from conductor 44, terminal 45, conductor 73, member 60, contact 62, heater 64, terminal 46 and to conductor 100. When the switch of electrodes 14 and 20 is open, heater 64 is connected across secondary 25 through the circuit including winding 84 so bimetal 11 is artificially heated during the off cycle of the cooling operation of thermostat 10 to anticipate the effect of the operation of the cooling apparatus.

PAR

Referring to FIG. 2, a specific thermostat and subbase is shown. Bimetal 11 is mounted on a base or support means 101 by a post or support means 102.

# Pftaps19760113 Wk02

Heater 64 is mounted on subbase 54 by means of a platform 103 integrally molded into the subbase for supporting a resilient connection or spring 104. Spring 104 as shown in FIG. 5 has a cut section to provide two lower fingers 105 and 110 and an upper flanger 111 so resistor or heater 64 can be mounted between the fingers and finger 111 can be resiliently biased against support 102 to thermally conduct the heat from heater 64 to bimetal 11.

PAR Referring to FIG. 3, another embodiment discloses the thermostat and subbase. Bimetal 11 is mounted on the base of the thermostat by a support

ASSG

102. The base of the thermostat 112 has at least two holes 113 and 114. Heater 64 is mounted on the subbase by means of a spring clip 115 similar to that disclosed in FIG. 5 except that the clip does not engage support 102. Heater 64 is held in a position so the heat from the heater warms the air which passes through holes 113 and 114 to change the temperature surrounding bimetal 11. In such a manner, heater 64 is thermally connected to the temperature responsive means of the thermostat when subbase 54 is mounted on thermostat 10.

PAR Referring to FIG. 4, another embodiment of the invention discloses the thermostat 10 and subbase 54 with heater 64 mounted on subbase 54 away from the support 102 of bimetal 11 so that heat from heater 64 radiates to

# Pftaps19760113 Wk02

support 102 to be conducted through the support to the bimetal whereby the heater 64 can be thermally coupled to the bimetal 11 when the subbase 54 is mounted on thermostat 10.

PAC

Operation

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Initially when a home owner would have a thermostat for controlling heating apparatus, thermostat 10 would be connected to control apparatus 22 by conductors 40 and 50. The operation of the thermostat with the bimetal cooled down would be in a conventional manner to cause the switch formed by shorting electrodes 15 and 20 to energize relay 30 to bring about the operation of the heating apparatus. By providing thermostat 10 with the SPDT switch 13, even though the second circuit formed by electrodes 14 and 20 is not used when the thermostat is connected for heating only, the added cost to the home owner is relatively small as other parts of the thermostat which are necessary for use in heating and cooling systems are not contained in thermostat 10.

PAR

Later upon the addition of cooling apparatus to the house, the cooling control panel 53 is added and subbase 54 is added to thermostat 10. The subbase 54 connects the thermostat 10 to the heating and cooling controls 22 and 53, respectively, by conductors 71, 80 and 93. Subbase 53 contains the changeover switch 55 which provides for the selection of control by thermostat 10 of heating or cooling depending on the position of the

# Pftaps19760113 Wk02

movable member 60. Subbase 54 also contains the cooling anticipation heater 64 which is mounted in the subbase so as to be thermally connected to the bimetal. Upon the operation of thermostat 10 as a cooling thermostat, the heat from heater 64 artificially heats the bimetal during the off cycle for anticipation purposes only.

PAR The specific structure of the subbase is shown in FIG. 2. Heater 64 is held on the subbase by the resilient spring 104 and a finger 111 as shown in FIG. 5 is biased to the right as shown in FIG. 2 to engage the support 102. Heater 64 is thermally connected to bimetal 11 by the heat conduction through the spring 111 and the support 102.

PAR In FIGS. 3 and 4 two other alternate designs are shown for providing the heater 64 in the subbase and conducting the heat to the bimetal in the thermostat. The thermostat of FIG. 3 has two holes 113 and 114 to provide air flow so air can flow to the rear of the thermostat and back up heat from heater 64 which is mounted in the subbase to deliver the heat to the bimetal for anticipation purposes. The embodiment of FIG. 4 has the heater 64 mounted in the subbase so heat can be transferred to the support 102 to conduct the heat to bimetal 11.

PAR The present invention provides an improvement over thermostat and subbase combinations which heretofore have been used to provide a heating thermostat which can be readily adapted for heating and cooling

# Pftaps19760113 Wk02

installation by the addition of a subbase to make use of the heating thermostat for the heating and cooling system. When reversing relays and switches are used in the subbase to obtain a reversal of a normal heating thermostat, the added heat of the relays as well as the cost of the relays make such a thermostat and subbase combination objectionable. The present invention provides for an inexpensive design whereby with a slight additional cost to the thermostat by using a three electrode switch, the thermostat can be used with an inexpensive subbase to make a heating and cooling control system which provides good control results. The anticipation heater is mounted in the subbase to eliminate the cost of the heater from the thermostat alone and yet when the subbase is added to the thermostat, the heater is thermally coupled to the thermostat to provide an operative system which has been found to be very satisfactory at a minimum cost to the home owner.

CLMS

STM

The present invention is described and presented in various embodiments; however, the intent is to limit the scope of the invention only by the appended claims in which we claim:

NUM

1

PAR

1. In a thermostat for controlling heating .[.and cooling.]. apparatus, .ladd.and being adaptable for controlling cooling apparatus by adding a

# Pftaps19760113 Wk02

subbase, .laddend.a main unit having a base, temperature responsive switch means mounted on said base, a first heater mounted .ladd.on said base .laddend.in thermal relation to said temperature responsive switch means, and connection means adapted to connect said heater and said switch means in a circuit for controlling the heating apparatus, a subbase unit having a second heater, .ladd.and .laddend.means for mounting said main unit on said subbase unit to thermally connect said second heater to said temperature responsive switch means and electrically connect said .ladd.first and .laddend.second .[.heater.]. .ladd.heaters .laddend.to said switch means and .ladd.adapted to connect .laddend.said switch means to control the .ladd.heating and the .laddend.cooling .[.apparatus..]. .ladd.apparatuses. .laddend.

NUM

2

PAR

2. In a thermostat for controlling heating .[.and cooling.]. apparatus, .ladd.and being adaptable for controlling cooling apparatus by adding a subbase unit .laddend.a main unit having a base, temperature responsive means mounted on said base, first and second switch means, means connecting said first and second switch means to said temperature responsive means, a first heater mounted .ladd.on said base .laddend.in thermal relation to said temperature responsive switch means, and connection means adapted to connect said heater and said first switch

# Pftaps19760113 Wk02

means in a circuit for controlling the heating apparatus, and a subbase unit having a second heater, .ladd.and .laddend.means connecting said main unit and said subbase unit to thermally connect said second heater to said temperature responsive means and .ladd.adapted .laddend.to electrically connect said .ladd.first and .laddend.second switch means to control said .ladd.first and .laddend.second .[.heater.]. .ladd.heaters .laddend.and the .ladd.heating and the .laddend.cooling .[.apparatus.]. .ladd.apparatuses. .laddend.

NUM

3

PAR

3. In a thermostat for controlling heating apparatus and being adaptable for controlling cooling apparatus by adding an auxiliary base, a first base, temperature responsive means .ladd.having a first anticipation heater .laddend.mounted on said base, means connecting said temperature responsive means to control .ladd.said first heater and .laddend.the heating apparatus, a second auxiliary base, means connectively mounting said first and second bases together, .[.an.]. .ladd.a second .laddend.anticipation heater mounted on said second base, said .ladd.second .laddend.heater being thermally coupled to and effective to modify the temperature of said responsive means when said second base is mounted on said first base, and means including said second base connecting said temperature responsive means to control the .ladd.heating

# Pftaps19760113 Wk02

and the .laddend.cooling .[.apparatus.]. .ladd.apparatuses .laddend.said

last mentioned means connecting said .[.heater.]. .ladd.heaters

.laddend.to be selectively energized by said responsive means.

NUM

4

PAR

4. In a thermostat for controlling a first conditioning apparatus and being

adaptable for controlling a second conditioning apparatus by adding a base

unit, a first base .ladd.unit .laddend.temperature responsive means

mounted on said base .ladd. a first anticipation heater mounted on said

base unit, .laddend.means connecting said temperature responsive means to

control .ladd.said first heater and .laddend.the first conditioning

apparatus, a second base unit, means connecting said first and second base

units, .[.an.]. .ladd.a second .laddend.anticipation heater means mounted

on said second base unit, means thermally connecting said heater means to

be effective to modify the temperature of said responsive means when said

second base unit is mounted on said first base unit, and means included in

said second base unit electrically connecting said temperature responsive

means to control the .ladd.first and the .laddend.second conditioning

.[.apparatus.]. .ladd.apparatuses.laddend., said last mentioned means

electrically connecting said .[.heater.]. .ladd.heaters .laddend.to be

selectively energized. .[.5. A thermostat assembly comprising a main body,

a secondary body for modifying said main body, and means connecting said

# Pftaps19760113 Wk02

main body and said secondary body, said main body comprising a base member, a temperature responsive means, support means connected to said base member and said responsive means, switch means, and means connecting said switch means to said responsive means, said secondary body comprising an anticipation heater, a second base member, spring means supporting said heater on said second base member, said spring means engaging said support means to thermally connect said heater to said temperature responsive means when said main body is mounted on said secondary body, and connection means connecting said switch means to control the energization of said anticipation heater..]. .[.6. A thermostat assembly comprising a main body connected to control heating apparatus and a secondary body connected to said main body controlling both heating and cooling apparatus, said main body comprising

- PA1 a temperature responsive means,
- PA1 a base,
- PA1 support means mounting said temperature responsive means on said base,
- PA1 switch means,
- PA1 connection means connecting said switch means to said temperature responsive means,
- PA1 and electrical connection means adapted to connect said switch means to the heating apparatus,

# Pftaps19760113 Wk02

PA1 said secondary body comprising an anticipation heater,

PA1 resilient means thermally connected to said heater, said resilient means engaging said support means when said main body is mounted on said secondary body to conduct heat from said heater to said temperature responsive means,

PA1 connection means connecting said switch means to control the cooling apparatus,

PA1 and further connecting means connecting said heater to said switch means.]. [.7. A subbase to be connected to a thermostat having a temperature responsive switch means to control both heating and cooling conditioning apparatus but normally only controlling heating apparatus comprising, anticipation heater means, thermal connection means adapted to connect said heater means to said temperature responsive means when the thermostat is connected to said subbase, and electrical connection means connecting said heater means to the temperature responsive switch means when said switch means is connected to control the conditioning apparatus.]. [.8. A subbase to be connected to a thermostat having a temperature responsive switch means adapted to control both heating and cooling apparatus comprising, a base, anticipation heater means mounted on said base, resilient connection means connected to said heater means and adapted to be thermally connected to said temperature responsive means

# Pftaps19760113 Wk02

	when the thermostat is connected to said subbase, and electrical connection means adapted to connect said heater means to be controlled by the temperature responsive switch means when said switch means is connected to control cooling apparatus..]. .[.9. In a subbase adapted to be connected to a thermostat having a temperature responsive switch means,
PA1	a base,
PA1	means for connecting said base to the thermostat,
PA1	anticipation heater means,
PA1	resilient connection means connected to said base and said heater means, said resilient means being adapted to engage the temperature responsive switch means when the thermostat is connected to said subbase to conduct heat from said heater to said temperature responsive switch means,
PA1	and electrical connection means adapted to connect said heater means to a source of power when the switch means is connected to conditioning apparatus..]. 10. In a thermostat, .ladd.adaptable for controlling heating apparatus and being adaptable for controlling apparatus by adding a secondary unit, .laddend.
PA1	a main unit having a temperature responsive switch means .ladd.and an anticipation heating means .laddend.adapted to control heating .[.and cooling apparatuses,.]. .ladd.apparatus, .laddend.
PA1	electrical means adapted to connect said switch means to control one of the

# Pftaps19760113 Wk02

apparatuses,

PA1 a secondary unit having electrical means adapted to connect said switch means to control both said heating and cooling apparatuses,

PA1 and means connecting said main and secondary units,

PA1 an improvement comprising .ladd.a second .laddend.anticipation heating means in said secondary unit and means to thermally connect said .ladd.second .laddend.heating means to said temperature responsive switch means whereby said main unit when used separately to control heating apparatus can have a minimum cost and upon a need for the control of .ladd.heating and .laddend.cooling .[.apparatus.]. .ladd.apparatuses .laddend.said secondary unit can be added. .[.11. In a control system, temperature control means comprising a base, a bimetal, means mounting said bimetal on said base, a switch having first and second circuits, and means mounting said switch on said bimetal; heating control apparatus; a source of power; circuit means including said first circuit for connecting said heating control apparatus to said source; and a subbase for said temperature control means, means connecting said subbase to said base,

NAM Black Clawson Fibreclaim, Inc.

said subbase comprising an electrical heater, resilient means engaging said means mounting for thermally connecting said heater to said responsive means, cooling control apparatus, circuit means including said

# Pftaps19760113 Wk02

second circuit for connecting said cooling control apparatus to said source, and circuit means selectively connecting said heater means to said source..]. .[.12. In a thermostat for controlling a first conditioning apparatus and being adaptable for controlling a second conditioning apparatus by adding an auxiliary base unit,

PA1 a first base,

PA1 temperature responsive means,

PA1 support means mounting said temperature responsive means on said base,

PA1 means adapted to connect said temperature responsive means to control the first conditioning apparatus,

PA1 a second base unit,

PA1 an anticipation heater means,

PA1 means mounting said heater means on said second base unit, said first base having an opening for air flow, said heater means being effective to modify the temperature of said responsive means when said second base unit is mounted on said first base unit by the flow of heated air from said heater means through said opening, and

PA1 means including said second base unit when mounted on said first base unit adapted to electrically connect said temperature responsive means to control the second conditioning apparatus..]. .[.13. In a control system for controlling temperature control apparatuses,

# Pftaps19760113 Wk02

PA1 temperature control means comprising a base, a bimetal mounted on said  
base, a switch having first and second circuits, and means mounting said  
switch on said bimetal;

PA1 first temperature control apparatus;

PA1 a source of power;

PA1 circuit means including said first circuit for connecting said first  
control apparatus to said source;

PA1 a subbase,

PA1 means connecting said subbase to said temperature control means;

PA1 said temperature control means comprising an electrical heater, and means  
thermally connecting said heater to said responsive means;

PA1 second temperature control apparatus;

PA1 circuit means including said second circuit for connecting said second  
control apparatus to said source; and

PA1 circuit means connecting said heater means to said source.]. .ladd. 14. In  
a thermostat assembly, wherein a thermostat for controlling heating  
apparatus is used for controlling heating and cooling apparatus by the  
addition of a subbase, comprising

PA1 a thermostat adapted to be mounted on a wall, said thermostat comprising a  
base, temperature responsive means attached to said base, switch means  
connected to said temperature responsive means, said switch means having a

# Pftaps19760113 Wk02

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Middletown

first circuit and a second circuit, a heat anticipation heater mounted on said base and being thermally connected to said temperature responsive means, and connection means connecting said first circuit of said switch means and said heat anticipation heater in a circuit to terminals on said base so that heating apparatus can be controlled upon being connected to said terminals, and

PA1

a subbase adapted to be mounted between said thermostat and the wall to modify said thermostat when it is desired to convert said thermostat to control heating and cooling apparatus, said subbase comprising, a second heat anticipation heater, and connection means when said subbase is placed under said thermostat for connecting said first circuit of said switch means and said first heater to first terminals on said subbase so that heating apparatus can be controlled upon being connected to said first terminals and for connecting said second circuit of said switch means and said second heater to other terminals on said subbase so that cooling apparatus can be controlled upon being connected to said other terminals, said second heater being thermally connected to said temperature responsive means by a solid heat conducting connection made when said thermostat is mounted on said subbase.

PATN

# Pftaps19760113 Wk02

WKU	RE0286770
SRC	5
APN	4818822
APT	2
PBL	E
ART	325
APD	19740621
TTL	Waste treatment system
ISD	19760113
NCL	16
ECL	1
EXP	Custer, Jr.; Granville Y.
NDR	3
NFG	16
INVT	
NAM	Blakley; Earl T.
CTY	Cincinnati
STA	OH
INVT	
NAM	Chupka; David E.
CTY	Middletown

# Pftaps19760113 Wk02

STA	OH
INVT	
NAM	Harbron, Jr.; David L.
CTY	Wisconsin Rapids
STA	OH
INVT	
NAM	Marsh; Paul G.
CTY	Hamilton
STA	OH
INVT	
NAM	Seifert; Peter
CTY	Middletown
STA	OH
STA	OH
COD	2
REIS	
COD	50
APN	151762
APD	19710610
PNO	3713594
ISD	19730130

# Pftaps19760113 Wk02

## RLAP

COD 74

APN 6041

APD 19700126

PSC 1

PNO 3549092

## RLAP

COD 90

APN 861778

APD 19690928

PSC 1

PNO 3595488

## CLAS

OCL 241 4608

XCL 241 4617

XCL 241 86

XCL 241194

EDF 2

ICL B02C 1316

FSC 241

FSS 43;46;46.06;46.08;46.11;46.17;86;90;194

# Pftaps19760113 Wk02

UREF

PNO 2970777

ISD 19610200

NAM Hardy et al.

OCL 241 46.08

UREF

PNO 3073535

ISD 19630100

NAM Vokes

OCL 241 46.11

UREF

PNO 3305180

ISD 19670200

NAM Tomlinson

XCL 241 46.11

UREF

PNO 3339851

ISD 19670900

NAM Felton et al.

OCL 241 46.17

UREF

# Pftaps19760113 Wk02

PNO 3380669

ISD 19680400

NAM Hatton

OCL 241 46R

UREF

PNO 3584800

ISD 19710600

NAM Dodd

OCL 241 46.06

LREP

FRM Biebel, French & Bugg

ABST

PAL A waste treatment system which is capable of handling materials of widely  
48, as best seen in FIGS. 4 and 8.

different physical characteristics such as glass, metal, and fibrous and  
plastic waste, incorporates a rotor rotatably mounted in a waste receiving  
vessel, the rotor being adapted to fracture brittle material, compact  
malleable material, and otherwise pulverize the frangible waste to a  
particulate form small enough to be extracted through a perforated plate.

The rotor also circulates the material in a slurry form within the vessel  
in a vortical pattern so that the waste is repeatedly treated until it is

# Pftaps19760113 Wk02

ejected from the vessel. A series of space attrition bars are mounted outwardly of the rotor to provide an annularly shaped, discontinuous attrition surface, and hammers or flails are pivotally mounted on the rotor to reduce into smaller pieces materials which are flung upon or between the attrition bars by the rotor. Where the waste material contains a high proportion of rags, tubing and other stringy material, a rotating chopper blade is provided to chop this portion of the waste into smaller pieces which are more readily handled by the rotor and flails. Waste materials which are not readily reduced to a pulverized state by the system are segregated from those which are and removed separately.

BSUM

PAC CROSS-REFERENCE TO RELATED APPLICATION

PAR Application Ser. No. 6,041, filed Jan. 26, 1970, for METHOD AND APPARATUS FOR THE TREATMENT OF GARBAGE AND OTHER WASTES by Joseph Baxter, Jr. now U.S. Pat. No. 3,549,092, and application Ser. No. 861,778, filed Sept. 28, 1969, For Waste Treatment System, of which the present application is a division now U.S. Pat. No. 3,595,488.

PAC BACKGROUND OF THE INVENTION

PAR Municipal wastes will typically include materials of widely varying physical characteristics. These may include fibrous materials, such as paper, cardboard and rags, plastic materials, glass, wire, light gauge

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metallic containers, and relatively heavy, infrangible materials such as heavy metal pipes and iron castings. It is generally desirable to separate the relatively infrangible materials from those which may be readily broken down to a small particle size, reduce the latter in an aqueous medium and pump the resulting slurry to further treatment stages.

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This has conventionally required sorting the waste material prior to reducing the frangible fraction to a size capable of being suspended in an aqueous medium. Additionally, even though the relatively infrangible portion of the waste is removed, the disparate characteristics of the remaining fraction render them not readily amenable to reduction in a single treatment. This is particularly true where the waste materials contain a relatively high proportion of stringy materials, such as rags, tubing, and the like, as is usually found in waste materials received from hospitals.

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It has, therefore, been long recognized that it would be highly desirable to combine in one treatment the functions of separating the relatively frangible and infrangible portions of the waste material and at the same time efficiently reducing the frangible portion to a particulate state, even though the physical characteristics of the frangible portion are quite dissimilar.

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SUMMARY OF THE INVENTION

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The present invention combines, in one system, a series of elements which cooperate both to segregate the frangible and infrangible portions of the waste material being treated and to pulverize the frangible portion to a particle size which permits the waste to be readily suspended in an aqueous medium for pumping to further treatment stations.

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Thus apparatus according to the present invention includes a rotor mounted in a vessel and serving to set up destructive hydraulic shear forces in the vessel when the vessel is loaded with waste materials and a liquid suspending medium. The rotor can be of the disc type but may advantageously be constructed in accordance with the teachings of the patent to Vokes, U.S. Pat. No. 3,073,535. With this type of rotor a plurality of arms are provided which enhance the formation of a vortical flow pattern in the vessel which continuously causes the material to be driven outwardly and upwardly along the sides of the vessel to an overhanging wall of the vessel and then downwardly back into the path of the rotor arms. A perforated extraction plate may be positioned beneath the rotor so that as the waste is reduced to the desired size, the action of the rotor forces this portion of the material in slurry form through the extraction plate into a chamber, where means is provided for conveying the slurry away for further treatment.

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An annularly shaped, discontinuous attrition surface is formed by a

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plurality of spaced attrition bars positioned outwardly of the rotor and engaged by swinging hammers or flails mounted on the rotor. These elements cooperate with the rotor in reducing waste material to the desired size and are particularly effective in reducing tubing, rags and the like.

Thus, as tubing, for example, influenced by the vertical flow pattern set up by the rotor, passes between the spaced attrition bars, the rotating flails sever the tubing into shorter lengths. The outer surfaces of the attrition bars extend substantially vertically from the bottom of the treatment vessel and provide an annular pocket into which the currents set by the rotor deposit the relatively heavier, infrangible portions of the material, thereby segregating this portion from that which may be more readily pulverized.

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Additionally, where the material contains a high proportion of stringy materials such as tubing and rags, a rotary chopper blade may be mounted in the vessel and positioned so as to receive materials being circulated through the tank by the rotor arms and to chop these materials to a size more readily handled by the rotor, attrition surface and flails, and extraction plate.

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Thus the present invention incorporates in one system a series of elements which cooperate both to segregate the relatively frangible and infrangible portions of the material being treated and to subject the frangible

# Pftaps19760113 Wk02

portions to a pulverizing action, despite the widely different physical characteristics of the frangible portion, whereby the pulverized frangible portions are transformed into a homogenous slurry which can be readily pumped, transported, dewatered and otherwise treated.

DRWD

PAC BRIEF DESCRIPTION OF THE DRAWINGS

PAR FIG. 1 is an elevational view, partly in cross section, of apparatus of the present invention;

PAR FIG. 2 is a plan view with portions broken away for clarity;

PAR FIGS. 3 and 4 are cross sectional views taken on lines 3--3 and 4--4, respectively, of FIG. 9;

PAR FIG. 5 is an enlarged cross sectional view of a portion of the apparatus of the present invention showing structure adjacent the rotor of the system;

PAR FIG. 6 is a plan view of a portion of one of the flails and the discontinuous attrition surface;

PAR FIG. 7 is a view of a portion of the chopper blade;

PAR FIG. 8 is a view of a portion of the bottom of the rotor and an attached flail;

PAR FIG. 9 is a plan view of a portion of the top of the rotor and associated elements;

PAR FIG. 10 is a cross sectional view of a portion of apparatus according to a

# Pftaps19760113 Wk02

modified form of the invention;

PAR FIG. 11 is a perspective view of a portion of the attrition plate of FIG.

10;

PAR FIGS. 12-14 are somewhat schematic representations showing the various positions the chopper blade may assume according to the principles of the present invention;

PAR FIG. 15 is an elevational view showing a further embodiment of the present invention; and

PAR FIG. 16 is a somewhat schematic representation of a complete waste treatment system.

DETD

PAC DESCRIPTION OF THE PREFERRED EMBODIMENTS

PAR As seen in FIG. 1 of the drawings, apparatus according to the present invention may incorporate a vessel 10 having a bottom wall portion 11 and an upstanding, substantially cylindrical side wall 12. A continuation 13 of the side wall extends inwardly and downwardly and terminates in an overhanging lip 14. A ring 15 is positioned between the side wall 12 and lip 14 with its oppositely projecting flanges 16 and 17 secured thereto to provide an annular space 18, which may be filled with concrete or the like to stabilize the unit against vibrations imposed by the moving parts of the equipment. Extending downwardly from the right-hand side of the vessel as

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seen in FIG. 1 is a conduit 19 which permits ejection from the system of a portion of the waste as described below.

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Mounted in the bottom wall of the vessel 10 is a rotor 20 having outwardly projecting arms 21 and rotating in the direction indicated by the arrow in FIG. 2. The rotor 20 may be splined to a shaft 22 mounted in a bearing 23 and extending downwardly into operative association with drive means 24. Each of the arms 21, as best seen in FIG. 3, has a truncated air foil shape with a substantially flat leading edge 25 which is slightly inclined from the vertical in a direction downwardly and away from the direction of rotation of the arms 21. The upper and lower surfaces 26 and 27 of each arm 21 converge towards each other with the lower surface 27 being curved upwardly away from the bottom of the vessel. The leading edge of each arm 21 may be provided with a protective strip 28 of a hardened material such as tungsten carbide or the like, and a deflecting strip 29 of substantially rectangular cross section may be attached to the undersurface of the rotor, as more clearly shown in FIGS. 8 and 9.

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The portion of the bottom wall 11 immediately beneath the rotor 20 may be formed as a plate 30 having a series of perforations 31 therein to function as an extraction plate. Affixed to the upper surface of the plate 30, as by welding or the like, is a series of substantially rectangularly cross sectioned deflecting bars 32 mounted in opposition to the similarly

# Pftaps19760113 Wk02

cross sectioned rotor deflecting bars 29. It will be noted from FIG. 9 that each of the bars 29 and 32 extends at an angle to the radii of the rotor but in opposite directions, for a purpose to be presently explained. Immediately beneath the extractor plate 30, a support plate 33 is secured to provide, with plates 34 and 35, a substantially toroidal-shaped chamber 36 having an opening 37 therein attached to a conduit 38. Plate 33 is, of course, provided with openings 39 therethrough to permit communication between the vessel interior and the chamber 36 through the perforations 31

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At least a pair of oppositely extending arms 21 are modified as seen in FIGS. 2, 4 and 9 by providing a cutaway portion 40 having an opening 41 therethrough to receive a bolt 43. A flail 44 of substantially L-shape has a complementary cut-way portion 45 formed on its inner end with an aperture 46 therethrough for receiving the bolt 43. The bolt 43 may be provided with an enlarged shoulder 42, and a washer 47 is positioned between the opposing portions of the arm 21 and flail 44. Alternatively of course, the shoulder 42 may be replaced by a bushing. The purpose of the shoulder 42, or a corresponding bushing, and the washer 47 is to permit even wear of the more readily replaceable flails, bolts and washers. The outer end of each flail 44 has an upwardly and outwardly beveled surface

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Positioned outwardly of the rotor 20 are a series of attrition bar members

# Pftaps19760113 Wk02

50 of generally trapezoidal configuration separated by passages 56. The bars 50, as best seen in FIG. 2, are conveniently mounted in units on segment plates 57, which may be secured to the support plate 33 by means of bolts or the like 58 (See also FIG. 4). The trapezoidal configuration of the bars 50 provides, in addition to the upper and lower parallel sides 51 and 52, a pair of non-parallel sides 53 and 54, each of which serves an important function in the apparatus of the present invention.

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The substantially vertically oriented surface 53 of each of the bars forms a pocket 55 in the lower portion of the vessel 10 for a purpose to be presently explained and the surfaces 54 of the bars 50, which are complementary to the surface 48 of the flail 44, collectively define an annularly-shaped, discontinuous attrition surface. While a pair of oppositely positioned flails 44 have been described for purposes of illustration, it will be apparent that the number of flails utilized may be varied as desired, the only limitation being the avoidance of an unduly unbalanced system.

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A chopper blade 60 is shown in FIG. 1 as mounted in the side wall 12 of the vessel 10 on a shaft 61 which extends through the side wall and is shrouded at 62 and attached to a source of power 64 mounted outwardly of the vessel 10. As best seen in FIG. 7, the chopper blade 60 may be of saw-toothed construction with the teeth 65 of the blade inclined away from

# Pftaps19760113 Wk02

the direction of rotation of the blade.

PAR The apparatus thus far described may be operated on either a continuous or a batch basis. However, it will generally be preferable to operate on a continuous basis, and the description of the operation is therefore directed to a continuous process, although it will be apparent that it has facility in a batch process as well.

PAR In operation, waste material is delivered to the vessel 10 together with a change of liquid, which may initially be fresh water but which, as will be explained below may quite advantageously be raw sewage from a municipal sewage system. The consistency of the mixture in the vessel 10 will vary depending upon the amount of glass, metal and the like in the vessel. Thus, if there is a high percentage of these materials, the consistency may be as high as 10 percent. However, the consistency of the slurry passing through the plate will preferably be approximately 2 to 6 percent solids, and the total amount of material will usually be kept rather low to provide a more efficient reducing and segregating operation.

PAR The rotor 20, which may operate at a peripheral speed of approximately 1,000 to 6,000 feet per minute, establishes a vortical circulation path in the vessel, as indicated by the arrows 70, which subjects the material in the vessel to severe hydraulic shear forces. In this regard is should be

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noted that the horsepower to volume ratio is preferably maintained relatively high to insure a vigorous flow pattern, with the volume of material treated ranging from 1.5 to 7.5 cubic feet per unit of horsepower expended. This serves to break up a portion of the waste material to smaller sizes and appears to be particularly effective in reducing fibrous materials such as paper, cardboard and the like.

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In addition to the attrition caused by hydraulic shear, the arms 21 also exert a mechanical destructive force on the waste. Thus the leading edge of each arm 21, protected by the hardened strip of material 28, defines an impacting surface which extends nonparallel to the plane of rotation of rotor 20 and batters the objects it encounters as it sweeps about the bottom of the vessel, serving to compact light gauge metallic containers such as aluminum and tin cans and fracturing relatively brittle materials such as glass into small particles.

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The inclined leading edge of each of the arms 21 also tends to direct the waste material downwardly towards the extractor plate 30, where, if it is of a sufficiently small size, it passes through the apertures 31 and thence, into the toroidal chamber 36 from which it may be evacuated by the conduit 38. Material which is forced down toward the plate 30 but is too large to pass through the apertures 31 is sucked upwardly from the surface of the extractor plate by the negative pressure exerted by the passage of

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the upwardly curved surface 27 of each of the arms 21, and this upward and downward plusation provides an additional comminuting action. The deflector bars 29 and 32 cross each other in scissors fashion and serve to cut and otherwise sweep out any oversize gritty particles which tend to become lodge between the surfaces of the rotor and the extractor plate 31.

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Stringy material, such as rags and tubings, will be flung outwardly by the rotor toward the attrition bars 50. The space between these bars will preferably be dimensioned to be greater than the diameter of the types of tubing and the like which are likely to be encountered so that the majority of such tubing may pass between the bars. Therefore, as the tubing passes between the bars 50 it will be served into shorter lengths by the outer end of the flails 44, which are impelled outwardly by centrifugal force and engage the annularly-shaped discontinuous attrition surface defined by the inclined surface 54 of the bars 50.

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Because of the pivotal mounting, if a piece of hard waste material is encountered by a flail, it will move away from the direction of movement of the rotor, in the manner indicated by the arrow in FIG. 9, and damage to the flail prevented. Preferably, the outer ends 48 of the flails 44 are dimensioned to be wider than the space 56 between adjacent bars 50 to prevent the flails from being jammed between adjacent bars and damaged. Additionally, the spaces 56 between adjacent attrition bars taper

# Pftaps19760113 Wk02

outwardly, as best seen in FIGS. 2, 6 and 9, to prevent material from becoming lodged between them, and the bars are angularly oriented with respect to the radii 59 of the rotor so as to be aligned with the outward flow created by the rotor 20 and indicated at 59' in FIG. 6.

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As noted previously, the consistency of waste material in the vessel 10 is deliberately kept at a level which allows the material to circulate in the vortical pattern indicated by the arrows 70. Thus, it is redirected downwardly back into the rotor and associated flails, thereby repeatedly subjecting the material to an extremely severe treatment. In this regard the overhanging lip 14 prevents material from being flung from the vessel when the amount of material in the vessel necessitates it. Heavier, relatively infrangible waste such as heavy gauge steel or cast iron, is also flung outwardly by the rotor where it tends to follow the general direction of the arrows 70. However, because of its greater weight, it will only travel a short distance up the bottom wall of the vessel and will then fall downwardly, where it migrates to the general vicinity of the pocket 55 formed by the vertical surfaces 53 of the attrition bars members 50. Continued circulation and accumulation of this relatively heavy infrangible material continues until the natural circulation within the vessel causes this portion to be ejected from the vessel 10 through the conduit 19. Thus rather than the relatively infrangible portion of the

# Pftaps19760113 Wk02

waste being retained in the system, where it would not only subject the system to excessive wear but would also occupy volume which could be best utilized by the more frangible portions of the waste, it is instead segregated and delivered out of the system at an early stage.

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While the system as thus far described operates efficiently in segregating the relatively frangible and infrangible portions of the waste and in pulverizing the frangible portion to a particulate size, in certain instances where the waste contains a high proportion of stringy or ropy materials such as tubing and rags, additional means may be provided for breaking down this stringy material to a size more readily handled by the rotor and associated flails.

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Thus as seen in FIGS. 1 and 2, the rotating, sawtoothed, chopper blade 60 rotating at a peripheral speed for 4,000-12,000 feet per minute may be mounted in the side wall of the vessel 10 in the path of the material flung outwardly and upwardly by the rotor 20; whereby any stringy or ropy portions are chopped into shorter lengths which are more conveniently handled by the rotor 20 and flails and attrition bars. In practice it has been found that if a chopper blade is not used in situations in which the proportion of stringy material is high, this material may wind into an increasingly larger bail and greatly inhibits the effectiveness of the operation.

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Turning now to FIGS. 10 and 11 of the drawings, a second preferred embodiment of the invention will be described. The embodiment of FIGS. 10 and 11, as in the case of the embodiment of FIG. 1, incorporates a rotor 20' in which certain arms thereof are modified for the attachment of flails 44' thereto. However, unlike the previous embodiment, the bottom wall portion 80 beneath the rotor 20' is, with the exception of the opening 81 accommodating the conduit 82, relatively imperforate. Additionally, the annular attrition surface is formed as an annular plate 83 having spaced ribs 84 formed thereon and a series of passages 85 extending through a portion of the plate 83 into the chamber 90.

PAR

The chamber 90 is coextensive with the apertured portion of plate 83 and is formed by the cover plate 91, substantially vertically extending walls 92 and 93 and a bottom wall 94, with egress from the chamber being provided by the conduit 95. Thus rather than the particulate material produced by the system being directed downwardly through an extraction plate, as in the embodiment of FIG. 1, it is ejected outwardly through the openings 85 in the apertured portion of the plate 83 and thence into the chamber 90, where it is drained by the conduit 95. The conduit 82 may be connected to a source of fluid under pressure which may be either intermittently or continuously delivered to the space 96 between the bottom of the rotor and the plate 80 and thereby assist in preventing an accumulation of material

# Pftaps19760113 Wk02

in this area.

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In the embodiment shown in FIG. 1 of the drawings, the axis of rotation of the chopper blade 60 is normal to the axis of rotation of the rotor 20 and on a line which would intersect a line running through the axis of rotation of the rotor. It will be noted from FIGS. 12, 13 and 14 of the drawings, however, that it is within the scope of the present invention to provide alternate mountings for the blade 60. Thus as seen in FIG. 12, the axis of rotation of the chopper blade 60a may be angularly disposed with respect to the axis of the rotor 20. Alternatively, as seen in FIG. 13, the axis of rotation of the chopper blade 60b is parallel to that of the rotor. FIG. 14 shows yet another embodiment wherein, although the axis of rotation of the chopper blade 60c is again normal to that of the rotor, it is offset with respect thereto. While in all of the embodiments shown only a single chopper blade is utilized, it will be apparent that multiple choppers can also be used to advantage, particularly in large installations.

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In FIG. 15 a further embodiment of the present invention is shown wherein a rotor 20a is provided mounted in the side wall of the vessel 10a. In this position the rotor is removed from the heavier materials which tend to collect at the bottom of the vessel. While the rotor 20a is shown as associated with an extraction plate 30a, it will be appreciated that the

# Pftaps19760113 Wk02

rotor may instead be associated with construction of the type shown in FIG. 10. Additionally, a second rotor 20b could also be provided with its axis extending normal to the axis of rotor 20a.

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FIG. 16 of the drawings somewhat schematically represents a complete system in which the apparatus of the present invention may be utilized. Thus a trash segregating and disintegrating unit, including a vessel 10, may be associated with a junk catcher 100 by means of a conduit 19 and continuously charged with waste material by means of the conveyor 101. Liquid, preferably water, may be fed to the vessel 10 by means of a line 102 connected to the junk catcher 100 and in communication with the vessel 10 via the conduit 19. The slurry of pulverized waste material and liquid passes from the vessel 10 by means of the conduit 103 and is pumped by means of the pump 104 to a separator 105, which may conveniently be of the cyclone type and which serves to separate gritty materials from the slurry. Grit thus separated from the slurry of waste material may be ejected through the line 106 and collected for disposal by land fill methods or utilized as an aggregate in low load bearing structures. The remaining slurry of waste material may then be conveyed by means of the line 107 to a sewer line 108. Since the grit has been removed in the cyclone there is no danger of it settling out in and clogging the sewer.

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Alternatively, the accepts from the cyclone 105 may be passed through a

# Pftaps19760113 Wk02

line 109 to a thickener 110, which may conveniently be of the screw type.

Liquid expressed at the thickener 110 may then be conveyed back to the junk catcher by means of line 111 in place of or in supplement to the liquid from the conduit 102. The relatively high consistency material delivered by the thickener 110 may then be passed through the line 112 to a conventional incinerator, an incinerator of the fluidized bed type, or otherwise disposed of.

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It is also possible to use the apparatus of the present invention in a system wherein the waste material is treated in more than a single comminuting operation. Thus the openings through which the pulverized material in the vessel 10 are expressed into the line 103 may be relatively large, for example, on the order of 1/2 - 1 1/2 inches, with the waste material consequently receiving only a fairly coarse treatment. This coarsely divided waste material may then be conveyed to the cyclone separator 105 to remove the grit fraction of the waste, and the accepts from the separator delivered through a line 113 to a second apparatus 114 which may be, but not necessarily is, of the same type as apparatus 10 and which has openings therefrom on a much smaller order of magnitude, for example, three-eighths of an inch, than the apparatus thereof. The waste material passing from this apparatus may then be treated as described above. A system which incorporates a multiple stage comminuting process

# Pftaps19760113 Wk02

has the advantage of a higher through-put rate, since the retention time in each stage need not be as long, and reduced equipment wear, particularly in the stages downstream of the separating apparatus.

PAR From the above, it will be apparent that the present invention provides apparatus which through a unique cooperation of elements, permits, in a single continuous operation, the segregation of the relatively frangible and infrangible portions of waste material, and the reduction of the frangible portion to a desired particulate size, despite widely varying physical characteristics of the waste.

PAR While the forms of apparatus herein described constitute preferred embodiments of the invention, it is to be understood that the invention is not limited to these precise forms of apparatus, and that changes may be made therein without departing from the scope of the invention.

CLMS

STM What is claimed is:

NUM 1

PAR 1. A waste treatment system comprising:

PA1 a. a vessel .ladd.adapted to receive relatively frangible and infrangible material therein for treatment, said vessel .laddend.including an upstanding side wall portion,

PA1 b. a rotor mounted in said vessel,

# Pftaps19760113 Wk02

PA1 c. means defining a discontinuous attrition surface mounted in said vessel intermediate said side wall portion and said rotor,

PA1 d. said side wall portion being of appreciably greater extent in a direction parallel to the axis of rotation of said rotor than said attrition means,

PA1 e. said discontinuous attrition surface being spaced from said side wall portion to accommodate material flow through and over said attrition surface into .[.said space.]. .ladd.the space between said attrition surface and said side wall portion .laddend.and upwardly along said side wall in a vortical pattern,

PA1 f. flail means mounted on said rotor and projecting outwardly therefrom,

PA1 g. said flail means being mounted on said rotor for movement with respect thereto and engagement with said attrition means.

NUM 2

PAR 2. The apparatus of claim 1 wherein:

PA1 a. at least a distal portion of said flail means is engageable with said attrition surface, and

PA1 b. said distal portion of said flail means and the portion of said attrition surface engageable thereby are complementary in shape.

NUM 3

PAR 3. The apparatus of claim 1 wherein:

# Pftaps19760113 Wk02

PA1	said flail means are pivotally mounted on said rotor.
NUM	4
PAR	4. The apparatus of claim 3 wherein:
PA1	a. said attrition surface is defined by one edge of a series of bar members, and
PA1	b. said bar members are positioned about said rotor in spaced relationship to each other.
NUM	5
PAR	5. The apparatus of claim 4 wherein:
PA1	a. said bar members are angularly disposed with respect to the radii of said rotor, and
PA1	b. the spacing between said bar members increases in a direction away from said rotor.
NUM	6
PAR	6. The apparatus of claim 4 wherein:
PA1	a. said bar members are substantially trapezoidal in configuration.
PA1	b. one of the non-parallel edges on each of said bar members extends substantially parallel to the axis of rotation of said rotor and defines an annular pocket surrounding said bar members,
PA1	c. the other non-parallel edge of each of said bar members constitutes said discontinuous attrition surface defining means, and

# Pftaps19760113 Wk02

PA1	d. means is provided for evacuating said pocket.
NUM	7
PAR	7. The apparatus of claim 3 wherein:
PA1	a. said flail means are substantially L-shaped.
NUM	8
PAR	8. The apparatus of claim 1 further comprising:
PA1	a. a chopper blade mounted in said vessel in spaced relationship to said rotor.
NUM	9
PAR	9. The apparatus of claim 8 wherein:
PA1	a. said chopper blade is rotatably mounted, and
PA1	b. said chopper blade is of saw-toothed configuration.
NUM	10
PAR	10. The apparatus of claim 9 wherein:
PA1	a. the surface of the teeth of said chopper blade are curved with respect to the radii thereof in a direction opposite to the direction of rotation of said chopper blade.
NUM	11
PAR	11. The apparatus of claim 1 further comprising:
PA1	a. a foraminous wall positioned beneath said rotor.
NUM	12

# Pftaps19760113 Wk02

- PAR 12. The apparatus of claim 1 wherein:
- PA1 a. said attrition surface defining means comprises an annularly shaped plate having a series of passages extending therethrough.
- NUM 13
- PAR 13. The apparatus of claim 12 wherein:
- PA1 a. a series of ribs are mounted on an inner surface of said annular plate and project inwardly toward said rotor, and
- PA1 b. a chamber is positioned outwardly of said annular plate opposite the apertured portion thereof.
- NUM 14
- PAR 14. Apparatus of the type described comprising:
- PA1 a. vessel having a bottom wall, a substantially cylindrical side wall, an inwardly projecting top wall and a downwardly extending lip,
- PA1 b. a rotor having outwardly extending arms mounted in said bottom wall,
- PA1 c. a portion of said bottom wall beneath said rotor having perforations formed therethrough and a chamber positioned beneath said portion,
- PA1 d. at least two of said arms having L-shaped flails mounted thereon and projecting outwardly toward said side wall,
- PA1 e. a series of trapezoidally shaped bars arranged outwardly of said rotor in spaced relation to each other to define a substantially inwardly and downwardly extending discontinuous attrition surface,

# Pftaps19760113 Wk02

- PA1 f. the outer portion of said flails being beveled to a configuration complementary to said attrition surface and engageable thereby,
- PA1 g. an outermost portion of each of said bars defining with a section of said bottom wall a substantially annularly-shaped pocket,
- PA1 h. said bars being oriented at an angle to the radii of said rotor, with the spacing between said bars increasing outwardly of said vessel and the spacing of the inner edges of said bars being smaller than said beveled portion of said flails,
- PA1 i. an outlet from said vessel positioned adjacent a portion of said pocket, and
- PA1 j. a rotatable chopper blade mounted in said vessel with the axis thereof spaced from the axis of said rotor,
- PA1 k. said blade being of saw-toothed configuration with the teeth curved in a direction away from the direction of rotation of said blade. .ladd. 15.
- The apparatus of claim 1 further comprising:
- PA1 a. means defining an outlet from said vessel adapted to remove said relatively infrangible material therefrom..laddend..ladd. 16. The apparatus of claim 15 wherein:
- PA1 a. said space between said attrition means and said side wall portion is substantially annular, and
- PA1 b. said outlet from said vessel communicates with said annular

# Pftaps19760113 Wk02

space..laddend.

PATN	
WKU	RE0286788
SRC	5
APN	4167058
APT	2
PBL	E
ART	257
APD	19731116
TTL	Electric exposure meter
ISD	19760113
NCL	9
ECL	8
EXA	Clark; Conrad J.
EXP	Smith; Alfred E.
NDR	2
NFG	5
INVT	
NAM	Yanagi; Akio
CTY	Komae
CNT	JA

# Pftaps19760113 Wk02

INVT

NAM Kakuta; Shoichiro

CNT JA

ASSG

NAM Minolta Camera Kabushiki Kaisha

CTY Azuchi

CNT JA

COD 3

PRIR

CNT JA

APD 19660429

APN 41-27268

REIS

COD 50

APN 48903

APD 19700616

PNO 3652168

ISD 19720328

RLAP

COD 71

APN 634320

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APD 19670427

PSC 3

CLAS

OCL 356215

EDF 2

ICL G01J 146

FSC 356

FSS 226;215;218;224

FSC 354

FSS 23;60

UREF

PNO 2208027

ISD 19400700

NAM Gorlich

OCL 356215

UREF

PNO 2360082

ISD 19441000

NAM Stone

XCL 356215

UREF

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PNO 2765703

ISD 19561000

NAM Ward et al.

OCL 356215

UREF

PNO 3049050

ISD 19620800

NAM Thomas

OCL 356215

UREF

PNO 3063354

ISD 19621100

NAM Matulik et al.

OCL 95 10C

UREF

PNO 3111889

ISD 19631100

NAM Quednow

XCL 356226

UREF

PNO 3147680

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ISD 19640900

NAM Stimson

OCL 356226

UREF

PNO 3418479

ISD 19681200

NAM Schmitt

OCL 356226

LREP

FRM Wolder & Gross

ABST

PAL An electric exposure meter for storing the brightness of a photographic object as an electric voltage of a magnitude corresponding thereto in order to control the exposure time by using the voltage thus stored.

PARN

PAR This application is a continuation of application Ser. No. 34,320, filed Apr. 27, 1967, now abandoned.

BSUM

PAR This invention is related to an electric exposure meter, more particularly to an electric exposure meter usable together with an electronic shutter, which is preferably mounted on a through the lens type camera hereinafter

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referred to as a "TTL" camera. Such cameras include, for example, single lens reflex camera.

PAR

There have been proposed so-called electronic shutters for electrically determining shutter speed or exposure time. A known electronic shutter includes an electric circuit comprising, in series, an electric power source, a switch adapted to open and close responsive to the movement of shutter blades, a photoconductive element for receiving light from a photographic object, said photoconductive element having a variable resistance responsive to the intensity of the light received thereby, and a capacitor. In such electronic shutter, upon depression of a shutter button, a shutter sector is opened by an electromagnet, and at the same time said switch is closed to complete the aforesaid electric circuit. In this case, the capacitor is charged until the voltage across it reaches a certain predetermined value, and then the capacitor is discharged. A current due to the capacitor discharge actuates an electromagnet for closing the shutter sector, so that the shutter is closed to complete the exposure. The time necessary for charging the capacitor of such electronic exposure meter up to a certain predetermined voltage varies in accordance with the brightness of the photographic object, because the electric resistance of the photoconductive element is changed responsive to the brightness of the light received by the element from the photographic

# Pftaps19760113 Wk02

object, and hence, the duration of the shutter opening or the exposure time is determined according to the brightness of the photographic object.

PAR

In an electronic eye camera having such electronic shutter, it is made possible to dispense with a complicated exposure control mechanism of conventional electric eye cameras, by taking advantage of the fact that the entire opening and closing operation of the shutter blade of the electronic shutter can be electrically controlled.

PAR

Such electronic shutter, however, has a disadvantage in that the photoconductive element thereof must be disposed to the light until the entire exposure is completed. Accordingly, such electronic shutter cannot be mounted on a TTL type monocular reflex camera, because the exposure in this type camera is determined by a photoconductive element located at a suitable point in the light path in the view-finder thereof for measuring the brightness of light passing through a photographing lens means, which light path during the brightness measurement is changed from that during exposure by means of rotation of a mirror.

PAR

Therefore, an object of the present invention is to provide a TTL type exposure meter for a monocular or single lens reflex camera having a focal plane shutter.

PAR

According to the present invention, the light from a photographic object, which passes through a photographing lens of a camera, is delivered to a

# Pftaps19760113 Wk02

photoconductive element located at a suitable position of the light path of a viewfinder thereof to generate electricity. The electricity thus generated is measured by a voltmeter and stored in a suitable storing means as a capacitor as a charge therein. The electricity thus stored is used for controlling the start of the motion of the rear plane of the focal plane shutter after the front plane thereof is moved.

DRWD

PAR Other objects and a fuller understanding of the present invention may be had by referring to the following description taken in conjunction with the accompanying drawings, in which:

PAR FIG. 1 is a diagrammatic illustration of the light path in a view-finder of a monocular reflex camera, on which an exposure meter according to the present invention can be mounted;

PAR FIG. 2 is an electric circuit diagram of an embodiment of the present invention;

PAR FIG. 3 is a graph illustrating resistance-terminal voltage characteristics of a light receiving element;

PAR FIG. 4 is an electric circuit diagram of a modification of the embodiment of FIG. 2; and

PAR FIG. 5 is a graph showing the relationship between the value of  $B_{sub.v}$  and output voltage.

# Pftaps19760113 Wk02

PAR

Referring to FIGS. 1 to 3, symbols L, M, P, E, S, and F represent respectively a photographing lens, a a mirror adapted to rotate as shown by an arrow during exposure, a penta-prism, an eye-piece, a focal plane shutter, and a film. A photoconductive element 10 is, for instance, made of cadmium sulfide (CdS), and a resistor 12 is connected in series with the photoconductive element 10. The photoconductive element 10 and the resistor 12 are respectively connected to rotary contact arms 14a and 14b of a gang-operated dial switch generally depicted by 14, as shown in FIG. 2. The mechanism of the gang-operated dial switch 14 is such that when the rotary arm 14b is positioned respectively at the corresponding terminal a', b', c', d', or e', the arm 14a is positioned at the corresponding terminal as shown in the figure.

PAR

The terminal a is connected to one end of a resistor r.sub.1, which is negatively biased by a battery 16, the terminal b to the joint between resistors r.sub.1 and r.sub.2, the terminal c to the joint between resistors r.sub.2 and r.sub.3, the terminal d to the joint between resistors r.sub.3 and r.sub.4, and the terminal e to the joint between resistors r.sub.4 and R. The corresponding terminals a', b', c', d', and e' are respectively connected to the joint between resistors R and r.sub.5, the joint between resistors r.sub.5 and r.sub.6, the joint between resistors r.sub.6 and r.sub.7, the joint between resistors r.sub.7

# Pftaps19760113 Wk02

and r.sub.8, and an end of the resistor r.sub.8, which is positively biased by a battery 18.

PAR

The battery 16 is connected to a closed circuit, which traces from the positive terminal thereof to the negative terminal thereof through a lead wire 20, resistors r.sub.6, r.sub.5, R, r.sub.4, r.sub.3, r.sub.2, and r.sub.1. The battery 18 is also connected to a closed electric circuit, which traces from the positive terminal to the negative terminal thereof through resistors r.sub.8 and r.sub.7 and the lead wire 20.

PAR

The joint between the photoconductive element 10 and the resistor 12 is connected to a terminal 26 of a double-throw selective switch 22 through a lead wire 24. A selective arm 28 of the selective switch 22 is normally connected to the terminal 26, and the arm 28 is in turn connected to a capacitor 30 which is grounded through the ground wire 32. A voltmeter 34 is connected to the lead wire 24 in parallel with the capacitor 30 in order to measure the voltage across the capacitor. In this particular embodiment, a capacitor is used, but any other suitable storing means can be also used in the exposure meter according to the present invention.

PAR

The other terminal 36 of the selective switch 22 is connected to the base of a transistor 40 through a resistor 38. The emitter of the transistor 40 is connected to the ground wire 32, while the collector thereof is connected to the negative terminal of the battery 16 through a capacitor

# Pftaps19760113 Wk02

42. The collector of the transistor 40 is also connected through a lead wire 44 to a relay 46 of suitable type for starting the rear plane of focal element shutter.

PAR

The operation of the circuit of the aforesaid structure will now be described. The selective contact arm 14a of the dial switch 14 is interlocked with a film sensitivity selector mounted on a camera body or a lens cylinder and adapted to cooperate with a lens aperture ring. Let it now be assumed that a film having a sensitivity of ASA 100 is loaded in the camera and the lens aperture  $f$  of the camera is set at  $f_{\text{sub.8}}$ , and the selective contact arms 14a are respectively positioned at terminals c

ICL

F23L 700 and c' upon setting a film sensitivity selector at ASA 100. Furthermore, it is assumed that the resistor  $r_{\text{sub.1}}$  to  $r_{\text{sub.8}}$  in the embodiment of FIG. 2 have the same resistance of  $r$  ohms and the resistor  $R$  thereof has a resistance of  $R$  ohms. The numerical value of the resistance  $r$  is selected to be identical with the resistance variation of the photoconductive element per unit brightness value (to be referred to as "Bv" hereinafter).

PAR

In this case, the voltage between terminals c and c' or the voltage across the selective arm 14a and 14b of the dial switch 14 is given by  $(R+4r)i$  volts, as a result of the voltage division by means of resistors  $r_{\text{sub.1}}$  to  $r_{\text{sub.8}}$  and  $R$ . Here,  $i$  represents the current flowing through the

# Pftaps19760113 Wk02

selective arms 14a and 14b. Due to the fact that the resistance of each of the resistors r.sub.1 to r.sub.8 is the same, the voltage across the selective arms 14a and 14b of the dial switch 14 is not affected by the position thereof, namely a--a', b--b', c--c', d--d', or e--e', as shown in FIG. 3.

PAR

Under such conditions, if a monocular reflex camera having a focal plane shutter together with an exposure meter according to the present invention is directed to a photographic object, the resistance of the photoconductive element 10 is varied responsive to the brightness of the object of the lens thereof, and a voltage representative of the brightness of the photographic object is produced in the lead wire 24. The capacitor 30 or a suitable storing means is charged by the voltage on the lead wire 24 through the terminal 26 and the selective contact 28. At the same time, the voltage on the lead wire 24 is read out by means of the voltmeter 34 having a graduation according to shutter speed.

PAR

If the voltage generated on the lead wire 24, as detected by the voltmeter 34 falls within the operative range of shutter speed of the camera, a shutter button is depressed. Such depression of the shutter button causes upward movement of the mirror, start of movement of the front plane (not shown) of the focal element shutter, and simultaneously turn-over of the selective arm 28 of the selective switch 22 to the terminal 36 thereof.

# Pftaps19760113 Wk02

Thus, the capacitor 30 is discharged through the resistor 38 and the transistor 40, and an electric signal for actuating the rear plane of the focal plane shutter is delivered to the relay circuit 46. After a certain time lag following the start of the front element, the relay circuit 46 actuates a relay (not shown) and starts the rear element (now shown) to complete the exposure. The aforesaid time lag depends on the intensity of the signal from the transistor 40, that is the magnitude of the voltage across the capacitor 30 established by the charge thereof.

PAR

If a lens aperture ring is turned so as to increase the aperture, the selective arms 14a and 14b of the dial switch 14 are also turned due its interconnection with the lens aperture ring, say to the terminals b and b' respectively. With the selective arms thus moved, the voltage across the arms 14a and 14b is not changed and kept at  $(R+4r)i$  volts, however the voltage on the lead wire 24 relative to the ground wire 32 is increased by  $ir$  volts (see FIG. 5), provided that the intensity of the light delivered to the photoconductive element 10 is kept constant. In effect, the voltage on the lead wire 24 is increased as if the lens aperture were not changed and the brightness of the photographic object is increased by a unit brightness value, i.e.,  $1Bv$ . Such increase in the voltage on the lead wire 24 results in an increase of a voltage across the capacitor 30, which causes an intensification of the signal on the relay circuit 46 for

# Pftaps19760113 Wk02

starting the rear element of the focal plane shutter. According to the invention, the relay circuit 46 is adapted to start the rear element earlier when a stronger signal is applied thereto, and hence, a faster shutter speed is obtained responsive to the aforesaid increase in the lens aperture.

PAR In a different embodiment of the invention, when the intensity or Bv of the incident light to a photoconductive element 10 is increased, the current flowing through the selective arms can be reduced for producing a weaker signal, and a relay circuit 46 can be so arranged as to result in a faster shutter speed for such weaker signal applied thereto.

PAR On the other hand, in the embodiment as shown in FIG. 2, if the lens aperture ring is so turned as to reduce the aperture by one step, and if the selective arms 14a and 14b are moved to the terminals d and d' respectively, then, it is apparent to those skilled in the art that the voltage on the lead wire 24 is decreased by an amount corresponding to the brightness change by a value, provided that the actual intensity of the incident light to the photoconductive element is unchanged, thereby the start of the rear element of the focal plane shutter is delayed for providing a slower shutter speed.

PAR Then, if the sensitivity of the film loaded in the camera is increased to ASA 200, the selective arms of the dial switch are turned accordingly, say

# Pftaps19760113 Wk02

to terminals b and b' respectively. Similarly, if the film sensitivity is reduced to ASA 50, the selective arms 14a and 14b are also moved, say to terminals d and d' respectively. Thus, the shutter speed can be adjusted in accordance with the sensitivity of the film loaded in the camera.

PAR FIG. 4 shows a modification of the embodiment of FIG. 2, in which a compound photoconductive element 10a is utilized instead of the simple photoconductive element 10, however, the operation of the circuitry is the same as the of FIG. 2.

PAR Although the present invention has been described by way of example, it is understood that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing

FSC 431  
from the spirit and the scope of the invention to. For instance, instead of a series of terminals, variable resistors can be used for achieving continuous control of the lens aperture, or instead of two batteries, one electric power means can be used.

CLMS

STM We claim:

NUM 1

PAR 1. An exposure measuring system comprising a gang switch including first and second movable contacts mechanically and electrically connected with

# Pftaps19760113 Wk02

	each other, and two groups of corresponding fixed contacts arranged so that when the first movable contact is engaged with any one of the first group of fixed contacts the second movable contact is engaged with the corresponding fixed contact;
PA1	a photoconductive element and a load resistance connected in series, said photoconductive element being connected to said first movable contact while said load resistance is connected to said second movable contact;
PA1	two groups of resistances each comprised of a plurality of equal value resistors connected in series, another resistance connected between said two groups of resistances, one end of said series connected resistances being connected to a DC electric source, each of said fixed contacts being connected to one end of an associated resistor so that in any contact position of said gang switch the voltage across the opposite ends of said series connection of the photoconductive element and load resistance is the same; and
PA1	measuring means connected between the photoconductive element and the load resistance for measuring the voltage across the load resistance;
PA1	whereby the output voltage is in linear relation relative to the brightness value of the object as sensed by the photoconductive member.
NUM	2
PAR	2. An exposure measuring system according to claim 1 wherein said measuring

# Pftaps19760113 Wk02

	means comprises a storing means for storing said output voltage for controlling the operation of a shutter of a camera.
NUM	3
PAR	3. An exposure measuring system according to claim 2 wherein said measuring means comprises an indicator means for indicating said voltage stored in said storing means.
NUM	4
PAR	4. An exposure system according to claim 3 wherein said indicator is a voltmeter.
NUM	5
PAR	5. An exposure measuring system according to claim 2 wherein said storing means is a capacitor.
NUM	6
PAR	6. An exposure measuring system according to claim 1 wherein said photoconductive element is made of cadmium sulfide.
NUM	7
PAR	7. An exposure measuring system according to claim 1 wherein said photoconductive element is a compound photoconductive member. .ladd. 8. An exposure measuring system comprising:
PA1	means including a voltage divider having a series connected network of a resistor and a photoconductive means, said photoconductive means being

# Pftaps19760113 Wk02

exposed to light, for producing a potential at the junction point of said resistor and photoconductive means, said potential varying relative to a predetermined point in a linear relation to the BV value of the brightness of the light incident on said photoconductive means;

PA1 means including a variable resistor device having a resistor portion connected in parallel with said series connected network and adjustable in accordance with a light unrelated photographing parameter in a manner to vary the potentials at both end terminals of said voltage divider equally and in the same direction and vary said potential at the said junction point with changes in said last mentioned potential for each increment of adjustment of said parameter corresponding to changes of potential effected by unit changes in the brightness of said incident light; and storage means connectable with said means for producing a potential for storing said potential in said storage means. .laddend. .ladd. 9. The system of claim 8 wherein said photoconductive means includes a pair of photoconductive elements coupled as a compound photoconductive cell.

PATN

WKU RE0286796

SRC 5

APN 3071995

APT 2

# Pftaps19760113 Wk02

PBL	E
ART	344
APD	19721116
TTL	Burners
ISD	19760113
NCL	34
ECL	1
EXP	Favors; Edward G.
NDR	2
NFG	7
INVT	
NAM	Robinson; Edgar Clarence
CTY	North Vancouver
CNT	CA
ASSG	
NAM	International Industries Ltd.
CTY	Burnaby
CNT	CA
COD	3
REIS	
COD	50

# Pftaps19760113 Wk02

APN	36987
APD	19700513
PNO	3620657
ISD	19711116
CLAS	
OCL	431 9
XCL	431116
EDF	2
FSS	9;115;116;188
UREF	
PNO	2918117
ISD	19591200
NAM	Griffin
XCL	431188
UREF	
PNO	3277945
ISD	19661000
NAM	Vermes
XCL	431116
UREF	
PNO	3366154

# Pftaps19760113 Wk02

ISD 19680100

NAM Walsh et al.

OCL 431116

UREF

PNO 3545902

ISD 19701200

NAM Bailey

OCL 431116

LREP

FR2 Kent; C. C.

FR2 Hill; K. M.

ABST

PAL An oil burner consists of an outer jacket surrounded and spaced from an inner burner tube to provide a surrounding counterflow chamber. Jacket and tube project horizontally inwards from the surrounding combustion chamber wall. Counterflow chamber is substantially closed at both ends. Tube projects inwardly beyond counterflow chamber and terminates in an upfacing burner head. Communication exists at opposite ends of the part of tube surrounded by counterflow chamber. At startup a tongue of flame travels through tube from an injector nozzle. Part of flame counterflows back through surrounding chamber and recirculates through tube. Another part of

# Pftaps19760113 Wk02

flame proceeds on to burner head. When parts sufficiently heated, flame in tube is caused to be extinguished and is replaced by hot clear blue flame jets from burner and a multiapertured band in tube within limits of counterflow chamber at end thereof remote from nozzle where counterflow originates. Combustion-supporting air to both chambers adjustably admitted at nozzle end.

BSUM

PAC

BACKGROUND OF THE INVENTION

PAR

The present invention relates to oil burners suitable for use in heating installations of various kinds but particularly for those intended for use in association with domestic heating units and especially domestic hot water heating units.

PAR

Oil-burning hot-water heaters of the type used in many households are unable to operate efficiently due in part to the design of the burners thereof and partly because the oil and air which provides the combustible mixture are both fed to such burners under considerable pressure. The combustion chambers of most domestic burners are considerably smaller than those of commercial hot water heaters for example. As a result of these considerations fuel tends to be swept through these chambers before it can be preheated and mixed thoroughly as is necessary if a high rate of heat release is to be achieved. A high-pressure burner requires that the

# Pftaps19760113 Wk02

combustion chamber associated therewith be lined with a refractory material, and to sustain combustion this material must be incandescent. However since the demand for hot water is not great or frequent, such burners only operate at fairly widely spaced intervals and then usually for only a short period of time. Accordingly, at each time of use the burner should be brought up to an operating temperature which will permit the fuel to burn properly. But length warmup further reduces the effectiveness of such burners because in fact the surrounding refractory material is not brought up properly to incandescence each time and as a result, conventional hot water heating equipment and especially conventional domestic hot-water heating equipment operates considerably below optimum efficiency from the standpoint of economy as well as from the standpoint of frequency of maintenance which is required to keep an inefficient burner clean.

PAC

BRIEF SUMMARY OF THE INVENTION

PAR

The invention consists of means for accomplishing the method steps which are characterized by initially projecting a relatively long jet or tongue of flame from ignited fuel longitudinally from an injecting nozzle assembly to a principal burning zone which is remote therefrom and well within (usually substantially centrally within) a surrounding axially vertical combustion chamber. Simultaneously with what has just been

# Pftaps19760113 Wk02

stated, a counterflow of a part of said jet or tongue is caused to travel oppositely or back toward the general region from whence the flame emerges from the nozzle assembly, the counterflowing part returning somewhat as might a fountain having a ring of jets around a central jet, or as petals might droop from a flower except that the flow here being referred to is horizontal. The originating location of the counterflow is between the nozzle assembly or source of flame and the aforesaid principal burning zone. The counterflow is reintroduced back into the main central jet or tongue near the said source or nozzle assembly.

PAR

The next step in the accomplishment of the present invention is that of separating the tongue of flame from the nozzle when a sufficient rise in ambient temperature has supervened. This separation and extinguishment of the flame tongue is caused by the turning off of the ignition electrode adjacent the aforesaid nozzle. In the action of extinguishment the flame leaves the vicinity of the nozzle assembly travelling the full length of the burner to appear in the form of a multiplicity of clean blue uniform flame jets at the mentioned principal burning zone. At the same time a band of similar clear blue flame jets appears at the originating location of counterflow. The principal burning zone is further from the nozzle assembly than the originating location of counterflow. While the aforesaid main tongue of flame travels horizontally, the firstmentioned multiplicity

# Pftaps19760113 Wk02

of blue flame jets are projected vertically upwards within the combustion chamber. In the conclusion, in this context, it will accordingly be recognized that there is visible within the combustion chamber from the outside thereof after the burner has been brought up to optimum oil vaporizing heat, only the horizontal upwardly facing disc of blue flame jets.

PAR The novel objects achieved by the burner structure which produces the above forms of visible heat may be stated as follows:

PAR The burner is designed for consuming any fuel from kerosene to Type 2 furnace oil without adjustment. At this point another particular novel feature of the burner may be stated as residing in the fact that it operates at atmospheric pressure and requires no forced draft, the only point at which a small quantity of air under pressure is admitted to the burner being at the injection nozzle assembly thereof where such pressure is in the order of up to 10 p.s.i. as a rule, this being substantially solely for the purpose of breaking up and impelling particles of oil mixed with air into the burner at the point where the fuel is ignited.

PAR A novel advantage flowing from the last aforementioned objective lies in the fact that such a burner both starts up and operates at sound levels which are low and comparable to existing gas fired units which are well known to have acoustic advantages. At the same time, due to its high

# Pftaps19760113 Wk02

recovery rate the present burner would appear to be favorably competitive with gas in terms of consumption costs.

PAR

A further novel objective achieved by the present burner and also flowing from what has already been stated resides in that operation at atmospheric pressure, or in other words, with natural draft, eliminates one of the biggest service problems which is that of the `linting up` of oil burners. By this is meant the accumulation of dust and lint upon the fan blades of a forced draft blower, also the accumulation of such materials upon the parts surrounding and adjacent the fan whereby the area of air entry into the burner is diminished, and also the charring of the burner orifices with lint mixed with incompletely burned oil due to the slowing down of the fan blades consequent upon the deposit of said lint thereon whereby the air intake capacity is decreased and hence the combustibility of fuel within the burner.

PAR

A yet further novel feature of the present burner arising out of its quietness of running is its suitability for oil-burning use (particularly when the burner plates are made rectangular instead of circular as herein) in association with clamshell heat exchangers as used in automobile

13:30

trailers, cabin cruisers and the like, which are extremely easy to manufacture and assemble, and are relatively deep, wide, cross-sectionally

# Pftaps19760113 Wk02

narrow, and more or less corrugated being formed of two similar stampings edge joined and between which the burner is placed usually in multiples of three. .ladd.

PAR

A further important novel object is the provision of means for feeding separate air to the initial mixing zone between the burner tube and fuel nozzle, and to the combustion chamber so that the two main bodies of combustion supporting air may be "balanced" according to atmospheric conditions. These means essentially embody an air distributing housing secured against the combustion chamber wall so as to cover and enclose both the air passages to said mixing zone and said combustion chamber within a common plenum, the said air passages thus being served from one air body inside the distributor housing, all to the end of maintaining as nearly as possible a substantially constant volumetric intake of air into the burner tube regardless of the air pressure (i.e., barometric conditions) in the combustion chamber surrounding the burner so that, in turn, a hot blue flame will be maintained at the burner head substantially regardless of barometric combustion chamber variations. .laddend.

PAR

A further objective achieved by the burner consists of efficiencies in the order of 84 percent combined with the employment of a burning process which is nearly perfect, the combustion gases containing only traces of CO and no visible smoke or soot. As a result, the low stack temperature

# Pftaps19760113 Wk02

achieved can be advanced to the authorities concerned in favor of permitting the main chimney for such a burner to employ type "B" vents as presently allowed for gas-fired units only.

PAR A further object is to vaporize a tongue of fuel within an inner burner type by a surrounding counterflow to provide means for preventing it from becoming reignited.

PAR Further objectives attained by the present burner reside in the design and arrangement of the same which renders it easily adaptable to replacement of existing oil-fired burners, quick and easy withdrawal of the unit for maintenance purposes and consequent reduction in maintenance costs, fewness of moving parts thus further simplifying servicing due to wear-out, the provision of a nozzle the exit orifice of which is very considerably larger than with conventional burners resulting in a relatively cool nozzle temperature and the elimination of plugging by dirt and hence carbon buildup while at the same time providing a nozzle assembly which is located externally of the fuel combustion chamber and hence away from the high-temperature zone with its quickly deteriorating effect upon a nozzle, and the production of a flame which does not need a refractory or stainless steel combustion chamber hence resulting in reduced weight, price and maintenance.

PAR Further novel objectives reside in that the purchaser is not obliged to

# Pftaps19760113 Wk02

outlay the expense of a fan or blower and in that a useful space saving is achieved particularly in small housing units due to the elimination of a fan or blower and associated motor for operating the same.

DRWD

PAR With the foregoing in view, and such other or further purposes, advantages or novel features as may become apparent from consideration of this disclosure and specification, the present invention consists of the inventive concept which is comprised, embodied, embraced, or included in the method, process, construction, composition, arrangement or combination of parts, or new use of any of the foregoing, herein exemplified in one or more specific embodiments of such concept, reference being had to the accompanying Figures in which:

PAR FIG. 1 is a plan representation of the invented oil burner.

PAR FIG. 2 is a sectional elevation substantially on the line 2--2 of FIG. 1.

PAR FIG. 3 is an end elevation as viewed from the right of FIG. 2.

PAR FIG. 4 is a plan representation for the purpose of orientating and depicting in situ the invented oil burner in and with respect to an enclosing combustion chamber.

PAR FIG. 5 is a representation of the flame travel immediately following startup.

PAR FIG. 6 is a representation similar to FIG. 5 some 60 to 90 seconds after

# Pftaps19760113 Wk02

startup.

PAR FIG. 7 is a circuit detail showing an example of a means for causing the flame tongue to be extinguished when a sufficient rise in ambient temperature is supervened.

PAR In the drawings like characters of reference designate similar parts in the several Figures.

DETD

PAC PRELIMINARY DESCRIPTION

PAR Stated in terms generally consonant with those of the accompany claim or claims to aid in construing the same the invention includes an inner burner tube A, a surrounding jacket B, said tube and jacket each having first ends C and D respectively, and adjacent second ends E and F respectively, said jacket being spaced from said tube, a fuel nozzle assembly G, and an ignition electrode H characterized by including (i) a burner head J on the first end of said tube, (ii) means in the form of a first end wall K (the second end wall being L), the multi-apertured first and second annular bands M and N, and the tube and jacket A and B respectively defining the surrounding counterflow chamber O, for providing a counterflow of ignited fuel P (FIG. 5) through said counterflow chamber O, said counterflow P being opposite in direction to the flow, and consisting of a portion of, a tongue Q of flammable fluid projected

# Pftaps19760113 Wk02

through tube A from nozzle assembly G, (iii) the original location R of the aforesaid counterflow being between the said nozzle assembly and the said burner head, (iv) means comprising in combination the aforesaid second band N and the annular space S for reintroducing counterflow P back into inner tube A, and (v) means consisting of a thermostatic cutout for causing flame tongue Q to be extinguished when a sufficient rise in ambient temperature has supervened, and simultaneously therewith thereby causing the generation of a blue flame T at originating location R and at a principal burning zone U, said burning zone being further from nozzle assembly G than originating location of counterflow R. .ladd.Burner tube A encloses a fuel chamber V. Arranged closely around jacket B are air intake apertures X. Covering and enclosing the pathways of ambient air into both the air and fuel mixing funnel of assembly G and the said apertures X is a variable air distributing housing Y. .laddend.

PAC

DETAILED DESCRIPTION

PAR

The burner collectively designated 10 is secured to the wall 12 of the surrounding conventional combustion chamber 14 so as to project horizontally into the combustion chamber.

PAR

The burner per se comprises, in combination with the aforesaid inner burner tube A, surrounding jacket B, wherein the jacket is spaced from the tube, a fuel nozzle assembly G and an ignition electrode H when characterized by

# Pftaps19760113 Wk02

including the following features:

PAR A first end generally designated 16 and a second end generally designated 18, the first end having an imperforate end wall 20 and the second having an imperforate second end wall 22. These end walls, together with the jacket B, and the portion 24 of tube A which is between said end walls define the aforesaid counterflow chamber O which is best seen from FIG. 2 to be relatively elongated and of annular configuration.

PAR Although it has been said that the end walls 20 and 22 are imperforate, they are nevertheless provided with the central apertures 26 and 28 respectively, through the former of which tube A extends, and with sufficient clearance, centrally of said aperture as to provide .ladd.what is collectively designated as .laddend.an annular combustion supporting structure 30. Second end wall 22 is centrally apertured at 28 to provide an intake orifice for the elongated flame tongue Q, a frustoconical funnel 32 being secured to the perimeter of aperture 28 upon the external side of chamber 14 to accommodate ignition assembly G and electrode H.

PAR Burner head J is in the form of an outflared and rimmed formation or somewhat circular washbasin shaped. Spanning the rim thereof is a pair of slightly spaced multiapertured fuel jet plates 34. Burner tube A is held centered within jacket B by two discoid rings, one of which is styled an apertured air distributor 36 slightly spaced from plate 20 within chamber

# Pftaps19760113 Wk02

O. The other is a flame arrestor plate 38, secured to tube A and jacket B as clearly depicted to prevent reignition of the flame of tongue Q after

Test Number (d) 1 2 3 4

it has been extinguished and vaporized as will hereinafter be explained.

PAR

Communication between inner tube A and counterflow chamber O is provided by means of a first annular band 40, a second annular band 42, and an annular space 44. Both annular bands are multiapertured, said apertures being designated 46. Annular space 44 is located between the second end D and second end wall L. A pair of aligned central and relatively enlarged apertures 48 are provided in jet plates 34. Flanges 50 overlap the opposite ends of jacket B (which is for all practical purposes coincident with combustion chamber wall 12). Secured upon the external side of said wall (in other words to the right of said wall as appears from FIG. 2) are adjustable .ladd.air distributing .laddend.means collectively designated 52 .ladd.(including the housing Y) .laddend.for .[.varying the admission of.] .ladd.a .laddend.combustion supporting air .ladd.stream which flows simultaneously and according to demand through the funnel 32 and apertures X .laddend.to the interior of tube A and the surrounding combustion chamber 14 .ladd.respectively.laddend.. These means consist of an annular outwardly projecting wall 54 and end plate 56. Wall 54 is provided with a set of spaced .ladd.air .laddend.apertures 58. Overlying wall 54 is a ring

# Pftaps19760113 Wk02

60 provided with apertures of the same size as apertures 58 and capable of registration or partial registration therewith upon rotation of the ring which is normally held clamped to wall 54 by means of the conventional nut and bolt bracket assembly collectively designated 62 (FIG. 3).

PAC

## OPERATION

PAR

Upon operation of the associated pump (not shown) air therefrom at 4 to 7 p.s.i. enters nozzle assembly G where it creates a partial vacuum thereby attracting oil from the associated oil pump, (also not shown) to be mixed with said air and expelled through the orifice 28. Approximately on the plane of such orifice electrode H ignites the oil and air mixture to create a long luminous tongue flame commencing substantially at the nozzle orifice and extending clear through burner tube A and through burner head J. At the same time an outer annular layer of the tongue of flame is so to say stripped off and proceeds through first annular band 40 into the original location of the commencement of counterflow R it counterflows through chamber O oppositely back through flame arrestor plate 38, annularly or radially inwards through second apertured annular band 42 as well as through annular space S to recirculate again toward burner head J within burner tube A.

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The just-stated process continues for some 60 to 90 seconds. At that time ignition electrode H is automatically inactivated. This causes the flame

# Pftaps19760113 Wk02

of the tongue Q to be extinguished since it is to be understood that under normal operating conditions after some 60 to 90 seconds a sufficient rise in ambient temperature has supervened to vaporize the air and oil mixture expelled from orifice G. At the same time as electrode H is inactivated, a multiplicity of small blue jets of flame 64 are established on the outer surface of first annular band 40 as a result of the intake of .[.fresh.] air as indicated by arrow 66 .[.around the annular combustion supporting.] .ladd.through .laddend.aperture .[.30.] .ladd.26.laddend.. Such intake of air is also distributed in the narrow annular space 68 between the otherwise imperforate end plate 20 and perforated distributor ring 36 .[. Thus.] .ladd., thus .laddend.assisting the completion of combustion not only at the location R but usefully throughout the entire adjacent region of counterflow chamber O and to some extent through the entire chamber.

PAR

It is to be understood that by this time the temperature of the burner has reached a point where the air and oil mixture is immediately vaporized into a gas upon entry past orifice 28. The kinetic energy of the nozzle assembly G also draws air as indicated at 70 through apertures 58 into funnel 32 to mix with the air oil mixture. In addition, combustion supporting air also enters through said apertures 58 as indicated at 72 for the purpose of aiding the completion of combustion within chamber 14.

# Pftaps19760113 Wk02

.ladd.As a result, combustion-supporting input air in the form of what is herein designated as primary and secondary air streams 72 and 70 respectively entering the right or second end (with respect to FIG. 2) is "balanced across the burner" so that if for example high barometric stack pressure is obtaining, more air is admitted to 14 but less to burner tube A so as not to change the character of flame, such as would happen if air were admitted to the tube A proportionately with an increase in negative pressure. It will be noted by best reference to FIG. 2 and the shown openings X and 28 therein that the said primary and secondary air streams 70 and 72 are separate from each other. The intake at aperture 26 may for convenience be referred to as a tertiary air stream.

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If the burner has been preset for example so as to provide a hot blue flame at or about normal ambient barometric pressure, the performance of the air distributing means 52 in the achievement of its object, namely the maintenance of such a flame regardless of ambient barometric variation can be described as follows:

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Let it be assumed that there is .02 inches of water column negative in combustion chamber 14. Air enters Y through ports 58 and then divides into the primary stream 72 to enter 14 through aperture X, and secondary stream 70 to enter the burner tube A by way of funnel 32.

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Since the two air streams 70 and 72 are separate, substantially the only

# Pftaps19760113 Wk02

draw upon 70 is that caused by the aspirating effect of the nozzle assembly G which is invariant. If therefore the barometric pressure in combustion chamber 14 be increased to 0.08 WC negative there is an

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immediate increase in demand upon the air within the distributing housing Y. This is satisfied by an increase of air stream 72 through apertures X at the expense of air stream 70 which is slightly reduced due to the creation of a small pressure drop between the intake of funnel 32 and the adjacent end plate or wall 56. Thus the combustion air entering housing X due to being split into two streams which are separate, and led, the one to the combustion chamber 14 and the other to the burner tube, is automatically balanced resulting in a substantially constant blue flame. This condition would not obtain if the combustion chamber air intake 72 and the burner tube intake 32 each communicated separately directly with the surrounding air. In that case by contrast there would be an equal pressure draw into the combustion chamber and into the burner tube. Such draw in the case of air stream 70 would be mainly through the burner plate orifices detrimentally changing the character of the flame T. .laddend.

PAR

During the first 60 to 90 seconds of operation while the flame Q is luminous it will be understood that it is luminous flame which also counterflows in chamber O and which proceeds onwardly to and through jet

# Pftaps19760113 Wk02

plates 34 including the central spire of flame 74. When vaporizing heat has been achieved, the tongue Q is in the form of a gas and it is as a gas that the fuel counterflows backwardly through chamber O as indicated in FIG. 6. Thus it will be understood that all that is visible when vaporizing or gasifying heat has been achieved is a ring of blue flame jets T, and an upper facing disc of such jets at the principal burning zone generally designated 76, such disc being horizontal in virtue of the generally right-angular disposition of the inner burner tube to the head J.

PAR

When the burner is up to vaporizing heat, the maximum temperatures tested on the upper plate 34 have been 1,100.degree.-1,200.degree. F. However the normal operating temperatures, reached in 2 to 3 minutes at this place are 700.degree.-800.degree. F. Between approximately the limits of bracket 78 (FIG. 1) maximum recorded temperatures have been 1,200.degree.-1,400.degree. F. and between approximately the limits of bracket 80 they have been 1,200-1,400.degree.C F. However, the normal operating temperature approximately between the limits of brackets 78 and 80 are 850.degree.-1,000.degree. F. and 1,000.degree.-1,100.degree. F. respectively and reached in 2 to 3 minutes as aforesaid. In the regions of the arrows 82 and 84, on the surface of jacket B maximum recorded temperatures have been 1,100.degree.-1,200.degree. F. and

# Pftaps19760113 Wk02

900.degree.-1,000.degree. F. respectively, and after 2 to 3 minutes, normal temperatures at these two regions are approximately 900.degree.-1,000.degree. F. and 700.degree.- 800.degree. F. respectively.

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From all the foregoing it will now be recognized that the invented oil burner is a low-pressure air-aspirating and atomizing burner. Fuel oil is drawn through the inlet valve of an associated gear-type oil pump and discharged into the float chamber thereof, which float chamber contains a float-operated oil return control valve. From this float chamber a zero pressure regulator is fitted to the nozzle assembly supply line. A vane-type air pump driven by an electric motor common to the oil pump provides air at a pressure of approximately 6 p.s.i. to the nozzle. Oil is lifted to the nozzle mixing zone by the aspirating action of the atomizing primary air. As already stated a relatively large nozzle is employed. The primary air-oil mixture passes through a horizontal preheating and vaporizing zone being that which has already been described in detail and illustrated in the accompanying drawings before being deflected by a 90.degree. elbow (the angulation between A and J) to discharge across a diffuser plate, or as heretofore designated, the plates 34 where it is ignited. .[.Secondary combustion air.]. .ladd.The tertiary air stream 66 .laddend. is drawn in concentrically at the aperture .[.30.]. .ladd.26 .laddend.as also already described, about the burner tube A to counterflow

# Pftaps19760113 Wk02

chamber O.

PAR In tests, two water heaters fired by the described burner were employed. Efficiency was determined using the indirect method, namely by establishing an analysis of the flue gases. The apparatus used was the standard Orsat apparatus capable of measuring the CO.sub.2, CO and oxygen in flue gases to a volumetric accuracy of better than 0.2 percent.

PAR Since the Orsat apparatus could not indicate CO of less than 0.1 percent by volume or about 1,000 p.p.m. a more accurate check using Bacharach Industrial Instrument Co. CO Tester was carried out. The results of testing indicated only traces of CO, in the order of 1 p.p.m.

PAR The fuel used was standard Esso Furnace Oil ASTM Specification D-306 Grade No. 2 distillate fuel.

PAR For each of the two heaters tested the apparent variation in efficiency was found to be well within the possible errors involved in measurement and computation of such efficiency. The variation was less than one-half of 1 percent from the average. The average efficiency computed for heater No. 1 was 83.8 percent and for heater No. 2 was 83.04 percent. Combustion was found to be complete and evidenced by the practically imperceptible traces of CO in the exhaust gases. The gases expelled are CO.sub.2 and water vapor with traces of SO.sub.2 and SO.sub.3 depending on the fuel used. The exhaust gases also were clear and contained no visible smoke or sooty

# Pftaps19760113 Wk02

deposits. Here follows the results of the flue gas analysis and the evaluated efficiencies in respect of heater No. 2:

TBL

11:04

11:15

11:30

13:05

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Flue gas analysis; (e) percent

CO.sub.2      10.6 10.2 10.4 0.8

O.sub.2      6.8 7.8 8.2 7.8

CO

Temperatures .degree.F.

Ambient      .sup.(1)

70 72 77 73

Stack      .sup.(1)

390 390 400 400

Water in      .sup.(1)

46 46 46 46

Water out      .sup.(1)

-- 140 140 142

# Pftaps19760113 Wk02

Excess air percent

.sup.(1)

45.3 56.3 61.7 55.9

Flue gas loss percent

.sup.(1)

8.34 8.52 8.53 9.07

Comb. H.sub.2 O loss percent

.sup.(1)

7.20 7.19 7.19 7.21

Air H.sub.2 O loss percent

.sup.(1)

0.14 0.15 0.15 0.15

Other loss percent (a)

.sup.(1)

1.0 1.0 1.0 1.0

Calculated efficiency

percent 83.32

83.14

83.13

82.57

Average efficiency 83.04

83.04

# Pftaps19760113 Wk02

83.04

83.04

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.sup.1 Start up of second unit.

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In the above table (a) means other loss taken as radiation plus unaccounted for loss, assumed at 1 percent: (d) heater run continuously from startup.

Water flow approximately 3.75 lb./minute: (e) Orsat Apparatus accuracy better than 0.2 percent volumetric.

PAR

Reverting in conclusion to the burner as exemplified, there is shown in FIG. 7 a means for causing the flame of tongue Q to be extinguished when a sufficient rise in ambient temperature has supervened. The circuitry shown is purely exemplary and not that which is actually used since the circuitry actually used is considerably complicated beyond what has herein been shown having regard for other purposes such as demand startup, safety controls and the like common to oil burner installations. The circuitry of FIG. 7 is however sufficient to indicate a means for the precise purpose just stated and it is to be understood that the same will be housed within the control box 86 from which, or adjacently from which projects a conventional probe 88 which could also be adapted for use as the means for causing the flame of the tongue to be extinguished under the circumstances

# Pftaps19760113 Wk02

just mentioned, both the utilization of the probe for such a purpose and the circuit of FIG. 7 being well within the skill of those versed in the art to which this invention pertains.

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With the foregoing understood, a grounded heater coil 90 is provided on one side of the electrode circuit 92, as an element in the series circuit 94.

A shunt 96 to one of a pair of terminals 98 and 100 is located in the shunt circuit 96. A bimetallic strip thermostat 102 is connected in the circuit 94. When the heater coil deflects the thermostat from the position shown and out of contact with terminal 98, circuit 92 is interrupted and the electrode H inactivated. As a consequence the visible tongue of flame is quenched in favour of the condition which has already been fully described herein.

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Various modifications can be made within the scope of the inventive concept disclosed. Accordingly, it is intended that what is set forth herein should be regarded as illustrative of such concept and not for the purpose of limiting protection to any particular embodiment thereof, and that only such limitations should be placed upon the scope of protection to which the [.inventor hereof.]. .ladd.patentee .laddend.is entitled as justice dictates.

CLMS

STM

What is claimed is:

NUM

1

# Pftaps19760113 Wk02

- PAR 1. In the art of combusting flammable fluid fuel for creating heated gas,  
the method steps which are characterized by:
- PA1 i. initially projecting a relatively long tongue of ignited fuel  
longitudinally from a source to a principal burning zone remote from said  
source,
- PA1 ii. causing an opposite, counterflow of a part of said tongue back towards  
said source, the originating location of said counterflow being between  
said source and said principal burning zone,
- PA1 iii. reintroducing said counterflow back into said tongue near said source,
- PA1 iv. causing the flame of said tongue to be extinguished when a sufficient  
rise in ambient temperature has supervened, and substantially  
simultaneously therewith
- PA1 v. causing the generation of a blue flame at the said originating location  
of counterflow, and at said principal burning zone, and
- PA1 vi. introducing sufficient air to .[.meet the requirements aforesaid, said  
burning zone being further from said source than said original location of  
counterflow..]. .ladd.said burner to support combustion..laddend.
- NUM 2
- PAR 2. The method according to claim 1 which includes the step of admitting  
additional counterflow air to mix with said first mentioned counterflow.  
.[.3. The method according to claim 1 which is effected within a

# Pftaps19760113 Wk02

surrounding combustion chamber and which includes the steps of:

PA1 i. admitting additional counterflow air to mix with said first mentioned counterflow, and

PA1 ii. admitting air to said combustion chamber from a location near said source to mix with said tongue of ignited fuel within said combustion chamber..]. .[.4. A fluid fuel burner embodying an inner burner tube, a surrounding jacket, said tube and said jacket each having a first end and adjacent second ends, said jacket being spaced from said tube, a fuel nozzle assembly, an ignition electrode and sufficient air intake means, the foregoing being characterized by including:

PA1 i. a burner head, on the first end of said tube,

PA1 ii. means for providing a counterflow of ignited fuel through a counterflow chamber existing between and by virtue of said tube and said jacket, said counterflow being opposite in direction to the flow of, and consisting of a portion of, a tongue of flammable fluid projecting through said tube from said nozzle assembly

PA1 iii. the originating location of said counterflow being between said nozzle assembly and said burner head

PA1 iv. means for reintroducing said counterflow back into said inner tube near said nozzle assembly, and

PA1 v. means for causing the flame of said tongue to be extinguished when a

# Pftaps19760113 Wk02

sufficient rise in ambient temperature has supervened, and substantially simultaneously therewith thereby causing the generation of a blue flame at the said originating location of counterflow, and at a principal burning zone, said burning zone being further from said nozzle assembly than said originating location of counterflow..]. 5. A fluid fuel burner .[.embodying.]. .ladd.including in combination with .laddend.an inner burner tube, a surrounding jacket, said tube and jacket each having a first end and adjacent second ends said jacket being spaced from said tube, a fuel nozzle assembly, an ignition electrode and .[.sufficient.]. .ladd.combustion supporting .laddend.air intake means .[., the foregoing being characterized by including.]. :

PA1 i. a burner head .[.on.]. .ladd.at .laddend.the first end of said tube

PA1 ii. first and second end walls for said jacket providing a counterflow chamber therebetween surrounding said inner tube, said inner tube admitting fuel at said second end and discharging it at said first end,

PA1 iii. said second wall extending between said jacket and inner tube adjacent said nozzle assembly

PA1 .[.iv. said inner tube being vented to an external side of said chamber at the first end of said jacket,.].

PA1 v. said first end wall being predominantly imperforate but .[.sufficiently apertured as to permit.]. .ladd.having aperture means for permitting

# Pftaps19760113 Wk02

.laddend.a limited volume of counterflow air into said surrounding

.ladd.counterflow .laddend.chamber,

PA1

vi. said inner tube being of greater length than said jacket and projecting through an aperture provided therefor in said first end wall,

PA1

vii. said inner tube providing communication with said chamber adjacent both said end walls for the counterflow .ladd.from .laddend.and reintroduction .[,respectively.], to said inner tube of products of combustion burnt within said inner tube,

PA1

viii. said burner head being upon the first end portion of said inner tube which end projects through said first end wall to said external side of

PAR

said .ladd.counterflow .laddend.chamber. 6. The invention according to claim 5 in which said communication between said inner tube and said .ladd.counterflow .laddend.chamber adjacent the first end wall thereof is in the form of an annular band comprised of a multiplicity of apertures in

PAR

said inner tube. 7. The invention according to claim 6 in which said communication between said inner tube and said .ladd.counterflow .laddend.chamber adjacent the second end wall thereof includes an annular space between the second end of said tube and said second end wall. .[.8.

The invention according to claim 6 in which said communication between said inner tube and said chamber adjacent the second end wall thereof is in the form of an annular band comprised of a multiplicity of apertures in

# Pftaps19760113 Wk02

said inner tube.]. .[9. The invention according to claim 8 in which said communication between said inner tube and said chamber adjacent the second end wall thereof also includes an annular space between the adjacent end of said tube and said second end wall.]. 10. The invention according to claim .[9.]. .ladd.7 .laddend.which is also characterized by the provision of an air intake aperture in said second wall, a frustoconical funnel secured to the rim of said aperture substantially on the vertex plane thereof, said fuel nozzle assembly .[.and said ignition electrode.].  
PAR projecting into said funnel. 11. The invention according to claim 10 in which said burner is secured to and projects inwardly from the wall of a combustion chamber, and .[adjustable.]. .ladd.air distributing .laddend.means on the external side of said wall for .[varying the admission.]. .ladd.balancing the volume .laddend.of combustion supporting air .[to.]. .ladd.between .laddend.the interior of said combustion chamber and .[into.]. .ladd.the vicinity of .laddend.said .[funnel through venting.]. .ladd.combustion tube through aperturing in said funnel and .laddend.in said wall upon the outer side of said jacket .[...]. .ladd., all said aperturing being within the confines of said distributing means. .laddend. 12. The invention according to claim 5 which is also characterized by including a multiapertured air-distributing plate on the counterflow chamber side of said first end wall, slightly spaced

# Pftaps19760113 Wk02

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PAR therefrom. 13. The invention according to claim .[.9.]. .ladd.7  
.laddend.which is also characterized by including a multiapertured  
air-distributing plate on the counterflow chamber side of said first end  
PAR wall, and slightly spaced therefrom. 14. The invention according to claim  
5 in which said burner head is characterized by being secured to the fuel  
discharge end of said inner tube, said head being in the form of an  
outflared and rimmed head formation, and at least one multiapertured fuel  
PAR jet plate spanning said rim. 15. The invention according to claim .[.10.].  
.ladd.7 which is also characterized by the provision of an air intake  
operture in said second wall, a frusto-conical funnel secured to the rim  
of said aperture substantially on the vertex plain thereof, said fuel  
nozzle assembly and said ignition electrode projecting into said funnel  
and .laddend.in which said burner head is characterized by being secured  
to the first end of said inner tube, said head being in the form of an  
outflared and rimmed head formation and at least one multiapertured fuel  
PAR jet plate spanning said rim. 16. The invention according to claim 5 in  
which said burner head is characterized by being secured to the first end  
of said inner tube, said head being in the form of an outflared and rimmed  
head portion, and a pair of closely spaced and parallel, multiapertured  
fuel jet plates spanning said rim, said burner in situ being axially

# Pftaps19760113 Wk02

horizontal with said inner tube horizontal and said burner head generally right-angularly disposed with said inner tube axis so that said head formation opens upwardly with the rim thereof lying in a horizontal plane.

PAR

7. The invention according to claim 10. 15. in which said burner head is characterized by being secured to the first end of said inner tube, said head being in the form of an outflared and rimmed head portion, and a pair of closely spaced and parallel multiapertured

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fuel jet plates. 18. The invention according to claim 6 which is also characterized by including a multiapertured air-distributing plate on the counterflow chamber side of said first end wall, and slightly spaced

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therefrom. 19. The invention according to claim 6 in which said communication between said inner tube and said chamber adjacent the second end wall thereof includes an annular space between the adjacent end of

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said tube and said second end wall. 20. The invention according to claim 19 in which said burner is secured to and projects inwardly from the wall of, a combustion chamber, and adjustable. air distributing means on the external side of said wall for varying the admission. admitting variable volumes of combustion supporting air and distributing said air separately to the vicinity of the second end of said inner burner tube and to the interior of said combustion chamber and into said counterflow chamber.

# Pftaps19760113 Wk02

PAR .ladd...laddend. 21. The invention according to claim .[.3.]. .ladd.1  
which is effected within a surrounding combustion chamber and which  
includes the steps of:

PA1 admitting additional counterflow air to mix with said first mentioned  
counterflow, and

PA1 admitting air to said combustion chamber from a location near said source  
to mix with said tongue of ignited fuel within said combustion chamber,  
and .laddend.which includes the step of preventing the reignition of said  
tongue by said counterflow after it has been vaporized by said temperature  
rise and extinguished. 22. .[.The invention according to claim 4 which  
includes.]. .ladd.A fluid fuel burner embodying an inner burner tube, a  
surrounding jacket, said tube and said jacket each having a first end and  
adjacent second ends, said jacket being spaced from said tube, a fuel  
nozzle assembly, an ignition electrode and combustion supporting air  
intake means, and including in combination:

PA1 i. a burner head, on the first end of said tube

PA1 ii. means for providing a counterflow of ignited fuel through a counterflow  
chamber existing between said tube and said jacket, said counterflow being  
opposite in direction to the flow of, and consisting of a portion of, a  
tongue of flammable fluid projecting through said tube from said nozzle  
assembly,

# Pftaps19760113 Wk02

- PA1 iii. the originating location of said counterflow being between said nozzle assembly and said burner head,
- PA1 iv. means for reintroducing said counterflow back into said inner tube near said nozzle assembly, and
- PA1 v. means for causing the flame of said tongue to be extinguished when a sufficient rise in ambient temperature has supervened, and substantially simultaneously therewith thereby causing the generation of a blue flame at the said originating location of counterflow, and at said burner head, and
- PA1 vi. .laddend.means for preventing the reignition of said tongue by said counterflow after it has been vaporized by said temperature rise and
- PAR extinguished. 23. The invention according to claim 5 which includes flame arrestor means in said counterflow chamber for preventing the reignition of said tongue by said reintroduced products of combustion after said
- PAR tongue has been vaporized by said temperature rise and extinguished.
- PAR 24. The invention according to claim 12 which includes an annular apertured flame arrestor plate spanning said counterflow chamber between said tube and said jacket, said plate being relatively near the second ends of said tube and jacket, said plate preventing the reignition of said tongue by said counterflow after .[.it.]. .ladd.said tongue .laddend.has been vaporized by said temperature rise and extinguished. .ladd. 25. For use in combination with a burner tube adapted and designed to project into

# Pftaps19760113 Wk02

a combustion chamber from the enclosure defining said chamber, air distributing means on the exterior side of said enclosure, said

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distributing means being apertured for air admission and communication

with:

PA1

a. the interior of said burner tube,

PA1

b. said combustion chamber, means for automatically, separately, and simultaneously feeding air into said tube and into said combustion chamber according to the relative barometric demands of said tube and combustion chamber, and means for isolating the proportion of air fed into said combustion chamber against entry into said burner tube at least in the vicinity of said location from which said burner tube projects into said combustion chamber;

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said air distributing means being secured to and projecting outwardly from said enclosure, said enclosure being apertured within the confines of said housing so as to be enclosed thereby and permit the passage of air within said distribution housing therethrough into said combustion chamber.

.laddend..ladd. 26. The invention according to claim 25 which includes a venturi funnel for a fuel nozzle positioned in said distributing housing, said funnel being secured and substantially sealed around its reduced discharge end against air admission other than through the enlarged intake

# Pftaps19760113 Wk02

end thereof, said funnel being substantially co-axial with said tube.

.laddend..ladd. 27. The invention according to claim 26 in which said funnel is situated substantially central of said distributing housing the aperturing in said enclosure being arranged about said funnel and spaced

therefrom. .laddend..ladd. 28. The invention according to claim 27 in which said air intake housing includes a surrounding apertured wall secured against and projecting outwardly from said enclosure and an end plate spanning said apertured wall, a plenum chamber occupying the space between said apertured wall, said end plate, and the portion of said combustion chamber enclosure bounded by said apertured wall.

.laddend..ladd. 29. The invention according to claim 22 in which said burner projects into a combustion chamber from a location at least near to a portion of the enclosure defining said chamber, air distributing means on the exterior side of said enclosure, said distributing means being apertured for air admission thereto and air communication with:

PA1 a. the interior of said burner tube,

PA1 b. said combustion chamber,

PAL means for automatically, separately, and simultaneously feeding air into said tube and into said combustion chamber from said air distributing means according to the barometric demands of said combustion chamber, and means for isolating the proportion of air fed into said combustion chamber

# Pftaps19760113 Wk02

against entry into said burner tube at least in the vicinity of said

location from which said burner tube projects into said combustion

chamber. .laddend..ladd. 30. The invention according to claim 5 in which

said burner projects into a combustion chamber from a location at least

near to a portion of the enclosure defining said chamber, air distributing

means on the exterior side of said enclosure, said distributing means

being apertured for air admission and communication with:

PA1 a. the interior of said burner tube,

PA1 b. said combustion chamber,

PAL means for automatically, separately, and simultaneously feeding air into

said tube and into said combustion chamber from said air distributing

means according to the barometric demands of said combustion chamber, and

means for isolating the proportion of air fed into said combustion chamber

against entry into said burner tube at least in the vicinity of said

location from which said burner tube projects into said combustion

chamber. .laddend..ladd. 31. The invention according to claim 7 in which

said burner projects into a combustion chamber from a location at least

near to a portion of the enclosure defining said chamber, air distributing

means on the exterior side of said enclosure, said distributing means

being apertured for air admission and communication with:

PA1 a. the interior of said burner tube,

# Pftaps19760113 Wk02

PA1 b. said combustion chamber,

PAL means for automatically, separately, and simultaneously feeding air into said tube and into said combustion chamber according to the barometric demands of said combustion chamber, and means for isolating the proportion of air fed into said combustion chamber against entry into said burner tube at least in the vicinity of said location from which said burner tube projects into said combustion chamber. .laddend..ladd. 32. The invention according to claim 22 in which said burner projects into a combustion chamber from a location at least near to a portion of the enclosure defining said chamber, air distributing means on the exterior side of said enclosure, said air distributing means being apertured for air admission and communication with:

PA1 a. the interior of said burner, and

PA1 b. said combustion chamber,

PAL means for automatically, separately, and simultaneously feeding air into said tube and into said combustion chamber according to the barometric demands of said combustion chamber, and means for isolating the proportion of air fed into said combustion chamber against entry into said burner tube at least in the vicinity of said location from which said burner tube projects into said combustion chamber, said air distributing means being in the form of an apertured air intake housing secured to and projecting

# Pftaps19760113 Wk02

outwardly from said enclosure, said enclosure being apertured within the confines of said housing to permit the passage of air within said distribution housing therethrough into said combustion chamber, said burner tube lying within the produced boundary of said housing, a venturi channel for a fuel nozzle positioned in said distributing housing, the

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reduced end of said funnel lying substantially on the plane of said enclosure, said funnel being secured on said plane and substantially sealed around its reduced discharge end against air passage other than through the enlarged intake end thereof, said funnel being substantially co-axial with said tube, said funnel being situated substantially central of said distributing housing, the aperturing in said enclosure being arranged about said funnel and spaced therefrom, said air intake housing including a surrounding apertured wall projecting outwardly from said enclosure and an end plate spanning said apertured wall, a plenum chamber occupying the space between said apertured wall, said end plate, and the portion of said combustion chamber enclosure bounded by said apertured wall. .laddend..ladd. 33. The invention according to claim 5 in which said burner projects into a combustion chamber from a location at least near to a portion of the enclosure defining said chamber, air distributing means on the exterior side of said enclosure, said air distributing means being

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# Pftaps19760113 Wk02

apertured for air admission and communication with:

PA1

a. the interior of said burner, and

PA1

b. said combustion chamber,

PAL

means for automatically, separately, and simultaneously feeding air into said tube and into said combustion chamber according to the barometric demands of said combustion chamber, and means for isolating the proportion of air fed into said combustion chamber against entry into said burner tube at least in the vicinity of said location from which said burner tube projects into said combustion chamber, said air distributing means being in the form of an apertured air intake housing secured to and projecting outwardly from said enclosure, said enclosure being apertured within the confines of said housing to permit the passage of air within said distribution housing therethrough into said combustion chamber, said burner tube lying within the produced boundary of said housing, a venturi funnel for a fuel nozzle positioned in said distributing housing, the reduced end of said funnel lying substantially on the plane of said enclosure, said funnel being secured on said plane and substantially sealed around its reduced discharge end against air passage other than through the enlarged intake end thereof, said funnel being substantially co-axial with said tube, said funnel being situated substantially central of said distributing housing, the aperturing in said enclosure being

# Pftaps19760113 Wk02

arranged about said funnel and spaced therefrom, said air intake housing including a surrounding apertured wall projecting outwardly from said enclosure and an end plate spanning said apertured wall, a plenum chamber occupying the space between said apertured wall, said end plate, and the portion of said combustion chamber enclosure bounded by said apertured wall. .laddend..ladd. 34. A fluid fuel burner including an inner burner tube having at a first end thereof a burner head, and a jacket surrounding part of said tube, characterized in that said jacket has a first end wall and a centrally apertured second end wall, said jacket and end walls defining a counterflow chamber around said inner tube, said inner tube being annularly perforated in the vicinity of said first end wall and within the confines of said first and second end walls, said inner tube and counterflow chamber being in communication in the vicinity of said second end wall and within the confines of said first and second end walls, an air distributing housing overlying said second end wall on the exterior side thereof, means for admitting air into said housing, a venturi funnel within said housing communicating with the interior of said housing and with said second end wall central aperture, said funnel being substantially coaxial with said inner tube, an injection nozzle for pulverized fuel, and aperture means within the confines of said housing and communicating between the interior of said housing and the space

# Pftaps19760113 Wk02

surrounding said burner. .laddend. .ladd. 35. The invention according to claim 5 in which said first end wall is sufficiently apertured to admit said limited volume of counterflowing air. .laddend. .ladd. 36. The method according to claim 1 which is effected within a surrounding combustion chamber and which includes the steps of admitting air to an air distributing means and dividing said air within said distributing means into two essentially enclosed and separate air streams one of which mixes with said ignited fuel and the other of which enters said combustion chamber. .laddend..ladd. 37. A fluid fuel burner embodying an inner burner tube, a surrounding jacket, said tube and said jacket each having a first end and adjacent second ends, said jacket being spaced from said tube, a fuel nozzle assembly, an ignition electrode and combustion supporting air intake means, and including in combination:

- PA1 i. a burner head, at the first end of said tube,
- PA1 ii. means for providing a counterflow of ignited fuel through a counterflow chamber existing between said tube and said jacket, said counterflow being opposite in direction to the flow of, and consisting of a portion of a tongue of flammable fluid projecting through said tube from said nozzle assembly,
- PA1 iii. the originating location of said counterflow being between said nozzle assembly and said burner head,

# Pftaps19760113 Wk02

PA1 iv. means for reintroducing said counterflow back into said inner tube near said nozzle assembly, and

PA1 v. means for causing the flame of said tongue to be extinguished when a sufficient rise in ambient temperature has supervened, and substantially simultaneously therewith thereby causing the generation of a blue flame at the said originating location of counterflow, and at said burner head.

.laddend..ladd. 38. The invention according to claim 15 in which said burner is secured to and projects inwardly from the wall of a combustion chamber having air venting in said wall upon the outer side of said jacket and air distributing means on the external side of said wall enclosing said venting, for admitting combustion supporting air to (a) the interior of said combustion chamber through said venting, and (b) through said funnel to said burner tube..laddend.

PATN

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ART 223

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# Pftaps19760113 Wk02

TTL Apertured nonwoven fabrics and methods of making the same

ISD 19760113

NCL 3

ECL 1

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STA NJ

COD 2

REIS

COD 50

APN 104174

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PNO 3741724

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## CLAS

OCL	81155
XCL	19161P
XCL	28 76R
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XCL	264168
EDF	2
ICL	B29C 2300
ICL	D04H 1100
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NAM	Cline

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OCL 8115.5

UREF

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NAM Kalwaites

NAM Osugi et al.

OCL 8115.5

UREF

PNO 3167383

ISD 19650100

NAM Chezand et al.

OCL 8115.5

UREF

PNO 3512230

ISD 19700500

NAM Luzzatto

XCL 264168

UREF

PNO 3563241

ISD 19710200

NAM Evans

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XCL 264 88

ABST

PAL

Apertured nonwoven textile fabrics comprising polyvinyl alcohol fibers and having a predetermined pattern of fabric apertures and fiber bundles created by applied fluid forces; and methods of making the same which comprises: chemically treating and modifying heat-sensitive, water-soluble polyvinyl alcohol fibers to (a) raise their wet softening temperature whereby they are essentially wet heat-insensitive up to a temperature of at least about 150.degree. C. and (b) give them an average degree of acetalization of from about 20 mol percent to about 35 mol percent whereby they develop the necessary balance of hydrophobic-hydrophilic properties and are sufficiently water-insensitive and water-insoluble as to be capable of controlled movement and manipulation by applied fluid forces; forming a cohesive fibrous web from said heat-insensitive, water-insoluble fibers; and applying fluid forces to said fibrous web to move and rearrange said heat-insensitive, water-insoluble fibers into a predetermined pattern of fabric apertures and fiber bundles constituting an apertured nonwoven fabric.

BSUM

PAR

This invention relates to apertured nonwoven fabrics having a predetermined pattern of fabric apertures and fiber bundles comprising polyvinyl alcohol

# Pftaps19760113 Wk02

fibers, and to methods of making the same.

PAR Polyvinyl alcohol fibers are obtainable, for example, by dry or wet extruding or spinning from their aqueous solutions and, by definition, are composed of at least about 50 percent by weight of vinyl alcohol units ( $-\text{CH}_2-\text{CHOH}-$ )<sub>n</sub> and in which the total of the vinyl alcohol units and any one or more of the various acetal units is at least about 85% by weight of the fiber.

PAR The simplest molecular structure of polyvinyl alcohol is therefore seen as idealistically possessing the following characteristic polymer chain, of which five typical units are shown, as follows:

##EQU1##

PAR Inasmuch as the vinyl alcohol molecule as such is unknown as a monomer,

PAC EXAMPLE I

polyvinyl alcohol is usually prepared by polymerization of vinyl acetate into polyvinyl acetate, followed by conversion by alcoholysis, hydrolysis, saponification, or the like, to polyvinyl alcohol.

PAR It is therefore to be appreciated that the above structural formula assumes (primarily for illustrative purposes) the substantially complete alcoholysis, hydrolysis, saponification, or other conversion of the polyvinyl acetate into polyvinyl alcohol. This assumption of 100% conversion, will be followed throughout this disclosure to simplify the

# Pftaps19760113 Wk02

chemistry involved and is not intended to limit the scope of the applicability of the inventive concept.

PAR

Polyvinyl alcohol fibers are naturally strong and abrasion resistant and have high resistance to chemicals, including acids and alkalis. Resistance to fungi, mildew, and insects is good. Polyvinyl alcohol fibers, can be manufactured at relatively low cost and have many excellent physical and chemical properties and characteristics. Unfortunately, however, such fibers, as they are originally produced, have an undesirable sensitivity to heat and water, and particularly to hot water. Specifically, if they are immersed in water at room temperature, they shrink by more than about 10%, and, if they are immersed in hot water at a temperature of about 65.degree. C., they become soluble and dissolve.

PAR

Such heat-sensitive, water-soluble polyvinyl alcohol fibers have some utility in the textile and related industries but have very little applicability in the manufacture of apertured nonwoven textile fabrics by the well-known fluid techniques described in U.S. Pat. No. 2,862,251 which issued Dec. 2, 1958 to F. Kalwaites. Efforts to utilize such heat-sensitive, water-soluble polyvinyl alcohol fibers in the apparatus illustrated, for example, in FIGS. 7-12 of this patent, have lead to completely undesirable results which come about especially when the heat-sensitive, water-soluble polyvinyl alcohol fibers are exposed to the

# Pftaps19760113 Wk02

applied fluid forces during their movement and manipulation into the predetermined patterns of the desired fabric apertures and fiber bundles.

PAR

In order to overcome such shortcomings, the freshly spun polyvinyl alcohol fibers have been subjected to heat treatments, usually in the range of from about 200.degree. C. to about 250.degree. C. whereby their wet-softening temperature, that is, by definition, the temperature at which the fibers shrink 10% of their original length, can be raised to a range of from about 60.degree. C. to about 100.degree.C. Unfortunately, however, although the fibers have far less heat sensitivity, they are still essentially water-soluble and will still dissolve in hot water at a temperature of about 110.degree. C.

PAR

However, if the heat-treated fibers are further subjected to an insolubilizing or a cross-linking operation by treatment with aldehydes,

EDF

2  
such as an acetalization by means of formaldehydes, their wet softening temperature can be raised to a value in excess of about 150.degree. C. Additionally, they become less water sensitive and they do not dissolve in water at such temperature. .ladd.

PAR

It is not essential, however, that the wet softening temperature always be raised to a value in excess of about 150.degree. C., provided the fibers are capable of meeting the previously-mentioned standard of not being

# Pftaps19760113 Wk02

essentially water-soluble and not dissolving in hot water at a temperature of about 110.degree. C. .laddend.

PAR

Unfortunately, when efforts are made to form these heat treated and acetalized heat-insensitive, water-insoluble polyvinyl alcohol fibers into fibrous webs by exposure to the fluid processing and manipulation involved in the manufacture of apertured nonwoven textile fabrics, as described in the above-mentioned patent, the results are still unsuccessful. The polyvinyl alcohol fibers do not make completely satisfactory fibrous webs and, although the fibers do not dissolve when treated by the fluid techniques of the above-described patent, they do not make commercially satisfactory apertured nonwoven textile fabrics.

PAR

The reasons for such lack of success have not been discovered and the purpose and object of this inventive concept is to disclose and illustrate methods for successfully manufacturing commercially acceptable apertured nonwoven textile fabrics from polyvinyl alcohol fibers by the above-mentioned fluid processes.

PAR

It has been discovered that apertured nonwoven textile fabrics having a predetermined pattern of fabric apertures and fiber bundles can be successfully made from polyvinyl alcohol fibers by the fluid processing techniques of the above-described patent if such fibers possess specific chemical and physical properties and characteristics which can be built

# Pftaps19760113 Wk02

into them by selective manufacturing and processing techniques. These specific chemical and physical properties and characteristics which are necessary require that the fibers have an average degree of acetalization of from about 20 mol percent to about 35 mol percent whereby they develop the necessary balance of hydrophobic-hydrophilic properties and are sufficiently heat-insensitive and water-insoluble as to be capable of controlled movement and manipulation by the applied fluid forces used in the processes of said patent. Additionally, the heat-insensitive and water-insoluble fibers are to be given a crimping treatment whereby from about six crimps to about 16 crimps are formed in the fibers and they are thus rendered more amenable to the formation of fibrous webs which are cohesive, do not split, and are well adapted for fluid processing into apertured nonwoven textile fabrics by applied fluid forces.

PAR

Although the present inventive concept will be described with reference to

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heat-insensitive, water-insoluble polyvinyl alcohol fibers which have been subjected to a specific heat treatment at a selected temperature range to improve their resistance to heat shrinking and a subsequent cross-linking or acetalization preferably with formaldehyde to improve their resistance to water-sensitivity, it is to be appreciated that other processing techniques can be resorted to in order to create the desired and necessary

# Pftaps19760113 Wk02

physical and chemical properties and characteristics.

PAR This is particularly true of the cross-linking or insolubilizing step wherein a large number of other insolubilizing agents are of use. Such other insolubilizing or acetalizing agents include other aldehydes, both aliphatic and aromatic, such as acetaldehyde, propionaldehyde, n-butyraldehyde, isobutyraldehyde, n-valeraldehyde, isovaleraldehyde, n-caproaldehyde, n-heptaldehyde, stearaldehyde, acrolein, crotonaldehyde, benzaldehyde, furfural, naphthaldehyde, etc. Substituted aldehydes are also of use and include chloroacetaldehyde, bromoacetaldehyde, chlorobenzaldehyde, nitro-benzaldehyde, hexahydrobenzaldehyde, etc.

PAR Aminoaldehydes are also of use and include aminoacetaldehyde, beta-amino-propionaldehyde, beta-amino-butyraldehyde, the isomeric amino valeraldehydes, cyclohexylaminoacetaldehyde, beta-(amino-ethoxy) acetaldehyde, N-methyl-amino-acetaldehyde, N-ethyl-amino-acetaldehyde, N-methyl-amino-propionaldehyde, beta-N-methyl-amino-butyraldehyde, etc.

PAR Dialdehydes, which are bi-functional, similarly, are of use and include glyoxal, succinaldehyde, malonaldehyde, glutaraldehyde, terephthal-aldehyde, etc.

PAR However, regardless of the particular heat treatment employed or the specific aldehydes selected for the insolubilizing treatment, the average degree of acetalization or the mol percent of hydroxy groups which are

# Pftaps19760113 Wk02

reacted with the selected aldehyde is in the range of from about 20 mol percent to about 35 mol percent.

PAR

The following molecular structure is shown to illustrate polyvinyl alcohol in which 20 mol percent of the hydroxy groups are reacted, for this particular segment of the polymer chain:

##EQU2##

PAR

The molecular structure is idealistically shown in its simplest form and it is to be appreciated that many other similar ether linkages are possible.

Additionally, other types of ether linkages are possible, such as, for example, a cyclic ether linkage between adjacent hydroxy groups on the same polymer chain. Such can be illustrated as follows, showing a 40 mol percent acetalization for this particular segment of the polymer chain:

##EQU3##

PAR

When the polyvinyl alcohol fibers have an average degree of acetalization of from about 20 mol percent to about 35 mol percent, they develop the necessary balance of hydrophobic-hydrophilic properties and are sufficient heat-insensitive and water-insoluble, as to be capable of controlled movement and manipulation by the applied fluid forces which are employed in the process described in the patent to rearrange the individual fibers into a predetermined pattern of fabric apertures and fiber bundles.

PAR

Average degrees of acetalization which are definitely above about 35 mol

# Pftaps19760113 Wk02

percent are not desirable inasmuch as such degrees of acetalization tend to possess too much hydrophobicity and tend to resist the desired movement and rearrangement by the applied fluid forces. Also, average degrees of acetalization which are definitely below about 20 mol percent are not desirable as such degrees of acetalization tend to possess too much hydrophilicity and tend to be too water-sensitive or water-soluble.

PAR

The average degree of acetalization is noted as also having an inverse effect upon the moisture regain of the polyvinyl alcohol fibers. This is evidenced in the following Table, developed at 40.degree. C. and a Relative Humidity of 90%:

TBL

TABLE I

---

Mol % Acetalization	% Moisture Regain
---------------------	-------------------

---

10	11
20	10
32	8
40	7 1/2
60	7
70	6

---

# Pftaps19760113 Wk02

---

PAR Additionally, in order that a fibrous web be formed which is sufficiently cohesive and self-sustaining and does not split apart during conventional commercial handling and processing, crimps are formed in the fibers, preferably subsequent to the heat treatment and insolubilizing step and, of course, prior to the formation of the fibrous web.

PAR The number of crimps per inch of fiber will vary according to the denier and length of the fiber, upon the nature, shape and amplitude of the crimp itself, and other related factors. From about six crimps per inch to about 16 or more crimps per inch is satisfactory, with a preferred commercial range extending from about eight crimps per inch to about 12 crimps per inch.

PAR These crimps may be obtained in many ways, such as, for example, mechanically, as by passage of the fibers through intermeshing heated gears. The particular nature, shape, and amplitude of the crimps is controlled by the nature and shape of the teeth or intermeshing elements, of the heated intermeshing gears and by the depth to which these gears intermesh. Other crimping techniques may, of course, be utilized.

PAR Although the invention will be described and illustrated with particular reference to starting fibrous materials comprising carded webs in which the individual fibers are generally oriented in the machine or long

# Pftaps19760113 Wk02

direction, it is to be appreciated that such is done because the invention is of primary importance in connection with such carded or oriented webs.

PAR

However, the inventive concept is also applicable to other types of starting fibrous materials. One such type is the so-called "isotropic" web formed by air-laying techniques in which the fibers are disposed at random and are not oriented in any particular direction.

PAR

Still another aspect of the present invention is its application to fibrous webs made basically by conventional or modified papermaking techniques. Such fibrous webs are also not oriented but are basically "isotropic" and generally have like properties in all directions.

PAR

These fibrous webs normally comprise individualized overlapping and intersecting fibers and, in the case of the carded or oriented fibrous webs, have an average length of from about 1/2 inch to about 2 1/2 inches or more. This range is, of course, most desirable and in most respects necessary when the starting fibrous materials are carded or oriented webs.

PAR

When the starting fibrous materials are "isotropic" webs derived from air-laying techniques or from conventional or modified papermaking techniques, shorter lengths of fibers may be employed provided they are of sufficient length to be handled in the subsequent fluid rearranging process. Usually, fiber lengths down to about 1/4 inch are capable of use, with shorter lengths of use by means of special handling techniques.

# Pftaps19760113 Wk02

PAR

Other fibers of a natural, synthetic or man-made base or origin may be used in various proportions and various blends to partially replace the polyvinyl alcohol fibers. Such other fibers include cellulosic fibers such as cotton or rayon; polyamide fibers notably nylon 6 and nylon 6/6; polyester fibers such as "Dacron," "Fortrel," and "Kodel;" acrylic fibers such as "Acrilan," "Orlon," and "Creslan;" modacrylic fibers such as "Verel" and "Dynel;" polyolefinic fibers derived from polyethylene and polypropylene; cellulose ester fibers such as "Arnel" and "Acele," etc.

PAR

The denier of the synthetic fibers used in applying the principles of the present inventive concept may be selected from a relatively wide range of sizes. A denier range of from about 1 to about 3 is generally preferred for conventional commercial purposes, although for special purposes, deniers as low as 1/2 or as high as 5, 10, 15 or even more find utility in special cases.

DETD

PAR

The invention will be further illustrated in greater detail by the following examples. It should be understood, however, that although these examples may describe in particular detail some of the more specific features of the invention, they are given primarily for purposes of illustration and the invention in its broader aspects is not to be construed as limited thereto.

# Pftaps19760113 Wk02

PAR A carded fibrous web is prepared from dull, crimped polyvinyl alcohol fibers which are chemically treated and modified by a heat treatment and by reaction with formaldehyde. The fibers have the following properties and characteristics:

TBL Degree of formalization  
10%  
Formalization treating time

2 minutes

Denier 1.32

Tenacity (grams/denier)

5.110000000000003

Elongation (%) 16.5

Staple length (mm) 35

DFA (mol % by analysis)

10

PAR The carded fibrous web is exposed to fluid rearranging techniques similar to those set forth and illustrated in FIGS. 7-12 of Kalwaites U.S. Pat. No. 2,862,251 which issued Dec. 2, 1958.

PAR A rearranged nonwoven fabric having fiber bundles and fabric apertures or openings is obtained. Formation of fiber bundles and fabric apertures or openings, however, is not well defined and is not commercially acceptable.

# Pftaps19760113 Wk02

It is believed that such unsatisfactory formation is due to the hydrophilicity of the fibers.

PAR

A materials balance determination of the weight of the product before rearranging and after rearranging indicates a substantial and commercially uneconomical loss of fiber weight during the rearranging process.

Additionally, there is considerable evidence of autogenous bonding between the individual fibers, created presumably by the softening and adhering of such fibers as a result of the fluid rearranging process. Such bonding leads to undesirable loss of softness, hand, and drape.

PAR

The rearranged nonwoven fabric is economically and commercially unsatisfactory and unacceptable to industry.

PAC

EXAMPLE II

PAR

A carded fibrous web is prepared from dull, crimped polyvinyl alcohol fibers which are chemically treated and modified by a heat treatment and by reaction with formaldehyde. The fibers have the following properties and characteristics:

TBL

Degree of formalization

20%

Formalization treating time

5 minutes

Denier

1.32

# Pftaps19760113 Wk02

	Tenacity (grams/denier)
	5.29
	Elongation (%) 16.8
	Staple length (mm) 35
	DFA (mol % by analysis)
	19.3
PAR	The carded fibrous web is exposed to fluid rearranging techniques similar
FSC	75
	to those set forth and illustrated in FIGS. 7-12 of Kalwaites U.S. Pat.
	No. 2,862,251 which issued Dec. 2, 1958.
PAR	A rearranged nonwoven fabric having fiber bundles and fabric apertures or
	openings is obtained. Formation of fiber bundles and fabric apertures or
	openings is well defined and is commercially acceptable. The materials
	balance determination of the weight of the product before rearranging and
	after rearranging is satisfactory and within commercially acceptable
	limits. There is substantially no evidence of autogenous bonding between
	the individual fibers. The nonwoven fabric has a high degree of softness,
	hand, and drape.
PAR	The rearranged nonwoven fabric is economically and commercially
	satisfactory and acceptable to industry.
PAC	EXAMPLE II-A

# Pftaps19760113 Wk02

PAR	The procedures of Example II are followed substantially as set forth therein with the exception that the polyvinyl alcohol fibers are not crimped.
PAR	Fibrous lap and web formation is produced only with extreme difficulty because of lack of crimp and cohesiveness of the fibers. The fibrous laps and webs also split very badly when they are carded.
PAR	The difficulties were such as to render the use of uncrimped polyvinyl alcohol fibers commercially unsatisfactory and unacceptable to industry.
PAC	EXAMPLE II-B
PAR	The procedures of Example II are repeated substantially as set forth therein with the exception that the polyvinyl alcohol fibers have a degree of formalization of about 20.2%. The moisture regain of such fibers is about 10% at a temperature of 40.degree. C. and a relative humidity of 90%.
PAR	The results are generally comparable to the results obtained in Example II.
PAC	EXAMPLE III
PAR	A carded fibrous web is prepared from dull, crimped polyvinyl alcohol fibers which are chemically treated and modified by a heat treatment and by reaction with formaldehyde. The fibers have the following properties and characteristics:
TBL	Degree of formalization

# Pftaps19760113 Wk02

30%

Formalization treating time

17 minutes

Denier 1.39

Tenacity (grams/denier)

4.88

Elongation (%) 16.2

Staple length (mm) 35

DFA (mol % by analysis)

30.4

PAR

The carded fibrous web is exposed to fluid rearranging techniques similar

to those set forth and illustrated in FIGS. 7-12 of Kalwaites U.S. Pat.

No. 2,862,251 issued Dec. 2, 1958.

PAR

A rearranged nonwoven fabric having fiber bundles and fabric apertures or

openings is obtained. Formation of fiber bundles and fabric apertures or

openings is well defined and is commercially acceptable. The materials

balance determination of the weight of the product before rearranging and

after rearranging is satisfactory and within commercially acceptable

limits. There is substantially no evidence of autogenous bonding between

the individual fibers. The nonwoven fabric has a high degree of softness,

hand, and drape.

# Pftaps19760113 Wk02

PAR	The rearranged nonwoven fabric is economically and commercially satisfactory and acceptable to industry.
PAC	EXAMPLE III-A
PAR	The procedures of Example III are followed substantially as set forth therein with the exception that the polyvinyl alcohol fibers are not crimped.
PAR	Fibrous lap and web formation is produced only with extreme difficulty because of lack of crimp and cohesiveness of the fibers. The fibrous laps and webs also split very badly when they are carded.
PAR	The difficulties were such as to render the use of uncrimped polyvinyl alcohol fibers commercially unsatisfactory and unacceptable to industry.
PAC	EXAMPLE III-B
PAR	The procedures of Example III are followed substantially as set forth therein with the exception that the polyvinyl alcohol fibers have a degree of formalization of about 32.2%. The moisture regain of such fibers is about 71/2% at a temperature of 40.degree. C. and a relative humidity of 90%.
PAR	The results are generally comparable to the results obtained in Example III.
PAC	EXAMPLE IV
PAR	A carded fibrous web is prepared from dull, crimped polyvinyl alcohol

# Pftaps19760113 Wk02

fibers which are chemically treated and modified by a heat treatment and by reaction with formaldehyde. The fibers have the following properties and characteristics:

TBL

Degree of formalization

40%

Formalization treating time

2 hours

Denier            1.38

Tenacity (grams/denier)

5.16

Elongation (%)    15.2

Staple length (mm)    35

DFA (mol % by analysis)

40.20000000000003

PAR

The carded fibrous web is exposed to fluid rearranging techniques similar to those set forth and illustrated in FIGS. 7-12 of Kalwaites U.S. Pat. No. 2,862,251 issued Dec. 2, 1958.

PAR

A rearranged nonwoven fabric having fiber bundles and fabric apertures or openings is obtained. Formation of fiber bundles and fabric apertures or openings, however, is not well defined and is marginal but not commercially acceptable. It is believed that such satisfactory formation

# Pftaps19760113 Wk02

is due to the increased hydrophobicity of the fibers. The resulting appearance of the rearranged nonwoven fabric is not pleasing.

PAR The rearranged nonwoven fabric is marginal but commercially unsatisfactory and unacceptable to industry.

PAC EXAMPLE V

PAR A carded fibrous web is prepared from dull, crimped polyvinyl alcohol fibers which are chemically treated and modified by a heat treatment and by reaction with formaldehyde. The fibers have the following properties and characteristics:

TBL Degree of formalization

50%

Formalization treating time

14 hours

Denier 1.35

Tenacity (grams/denier)

5.43

Elongation (%) 16.0

Staple length (mm) 35

DFA (mol % by analysis)

48

PAR The carded fibrous web is exposed to fluid rearranging techniques similar

# Pftaps19760113 Wk02

to those set forth and illustrated in FIGS. 7-12 of Kalwaites U.S. Pat.

No. 2,862,251 issued Dec. 2, 1958.

PAR

A rearranged nonwoven fabric having fiber bundles and fabric apertures or openings is obtained. Formation of fiber bundles and fabric apertures or openings, however, is not well defined and is not commercially acceptable.

It is believed that such unsatisfactory formation is due to the increased hydrophobicity of the fibers. The resulting appearance of the rearranged nonwoven fabric is not pleasing.

PAR

The rearranged nonwoven fabric is commercially unsatisfactory and unacceptable to industry.

PAC

EXAMPLE VI

PAR

Polyvinyl alcohol fibers are treated with a conventional heat treatment at elevated temperatures and an insolubilizing step with formaldehyde to raise their wet-softening temperature and make them heat insensitive at a temperature of 150.degree. C. (less than 10% shrinkage) and give them an average degree of acetalization of about 35 mol percent.

PAR

A card web is prepared weighing 442 grams per square yard and comprising such heat-insensitive, water-insoluble polyvinyl alcohol fibers having a denier of 21/2, a staple length of 38 mm. (1 1/2 inch), and 8 crimps per inch. The polyvinyl alcohol fibers have a moisture regain of 7.8% at a temperature of 40.degree. C. and a relative humidity of 90%.

# Pftaps19760113 Wk02

PAR This fibrous card web is exposed to fluid rearranging techniques in the apparatus illustrated in FIGS. 7-12 of U.S. Pat. No. 2,862,251 and the fibers are rearranged into a predetermined pattern of fabric apertures and fiber bundles.

PAR The apertured nonwoven textile fabric is bonded with National Starch NS4260, a non-ionic, cross-linking acrylic resin. The final weight of the bonded nonwoven textile fabric, after drying and curing, is 532 grains per square yard.

PAR Physical tests show that the nonwoven textile fabric made of polyvinyl alcohol fibers is exceptionally strong in both the machine direction and cross direction, both in the dry and wet conditions.

TBL TABLE II

---

Tensile Strength - Dry

Machine Direction

Cross Direction

Thwing Albert - 3 ply

(Pounds) (Pounds)

---

38.1 6.8

38.9 7.0

# Pftaps19760113 Wk02

39.1 7.2

Average

38.7 7.0

28.7 5.6

29.1 5.2

26.6 5.2

Average

28.13 5.33

Tensile Strength - Cross Direction

Instron - 1 ply (Pounds)

2.02

2.2000000000000002

1.8

1.93

1.9

Average 1.97

---

PAR

The softness of the nonwoven textile fabric is excellent. Its absorbency rate and absorbent capacity is very good. Its elongation and its bulk are comparable to similar products made of rayon fibers.

PAR

The product is of use as a facing for absorbent products such as diapers.

# Pftaps19760113 Wk02

In a lighter weight, it is of use as a facing for sanitary napkins.

PAC

EXAMPLE VII

PAR

The procedure of Example VI are followed substantially as set forth therein with the exception that the polyvinyl alcohol fibers have a denier of 1.4, rather than 21/2. The results are generally comparable.

PAC

EXAMPLE VIII

PAR

The procedures of Examples VI and VII are followed substantially as set forth therein with the exception that the polyvinyl alcohol fibers do not possess any substantial crimp. Web formation is rendered extremely difficult; there is a lack of cohesiveness and laps split badly when the fibers are carded.

PAC

EXAMPLE IX

PAR

The procedures of Example VI are followed substantially as set forth therein with the exception that the acetalization with formaldehyde is carried out to a much higher degree. The average degree of acetalization of the polyvinyl alcohol fibers is approximately 70 mol percent. The moisture regain of such fibers is low and is less than 6% at 40.degree. C. and a relative humidity of 90%. Such fibers tend to exhibit a greater degree of hydrophobicity and do not respond satisfactorily to applied fluid forces exerted during the fluid rearranging techniques disclosed in FIGS. 7-12 of U.S. Pat. No. 2,862,251.

# Pftaps19760113 Wk02

PAC

EXAMPLE X

PAR

The procedures of Example VI are followed substantially as set forth therein with the exception that the acetalization with formaldehyde is carried out to a much lower degree. The average degree of acetalization of the polyvinyl alcohol is only about 9 mol percent. The moisture regain of such fibers is very high and is greater than 12% at 40.degree. C. and a relative humidity of 90.degree.. Such fibers tend to exhibit a greater degree of hydrophilicity and do not respond satisfactorily to applied fluid forces exerted during the fluid rearranging techniques disclosed in FIGS. 7-12 of U.S. Pat. No. 2,862,251. Additionally, a materials balance determination of the weight of the product before rearranging and after rearranging reveals a relatively large loss of fiber weight during the rearranging process. There is also undesirable evidence of autogenous bonding between the individual fibers which makes the product harsh, papery, and boardy, and lacking in softness, hand and drape.

PAC

EXAMPLE XI

PAR

The procedures of Example VI are followed substantially as set forth therein with the exception that benzaldehyde is used instead of formaldehyde in the insolubilizing treatment. The results are generally comparable and the resulting nonwoven textile fabrics are commercially acceptable.

# Pftaps19760113 Wk02

PAR Although several specific examples of the inventive concept have been described, the same should not be construed as limited thereby nor to the specific features mentioned therein but to include various other equivalent features as set forth in the claims appended hereto. It is understood that any suitable changes, modifications and variations may be made without departing from the spirit and scope of the invention.

CLMS

STM What is claimed is:

NUM 1

PAR 1. A method of making an apertured nonwoven textile fabric having a predetermined pattern of fabric apertures and fiber bundles created by applied fluid forces which comprises: (1) chemically treating and modifying heat-sensitive water-soluble polyvinyl alcohol fibers by (a) a heat treatment in the range of from about 200.degree. C. to about 250.degree. C. to raise their wet softening temperature whereby they are essentially wet heat-insensitive up to a temperature .[.of at least about 150.degree. C..] .ladd.in the range of from about 60.degree. C. to about 100.degree. C. .laddend.and by (b) insolubilizing or cross-linking treatment with an aldehyde to give them an average degree of acetalization of from about 20 mol percent to about 35 mol percent and a moisture regain at 40.degree.C. and a relative humidity of 90% down to about 10% but not

# Pftaps19760113 Wk02

to as low as 71/2% whereby they develop the necessary balance of hydrophobic-hydrophilic properties and are sufficiently heat-insensitive and water-insoluble .ladd.as not to dissolve in hot water at a temperature of about 110.degree. C. and .laddend.as to be capable of controlled movement and manipulation by applied fluid forces; (2) crimping said relatively heat-insensitive, water-insoluble polyvinyl alcohol fibers so that they possess from about six to about 16 crimps per inch; (3) forming a cohesive fibrous web from said crimped, heat-insensitive, water-insoluble fibers; and (4) applying fluid forces to said fibrous web to move and rearrange said crimped, heat-insensitive, water-insoluble fibers into a predetermined pattern of fabric apertures and fiber bundles constituting an apertured nonwoven fabric.

NUM

2

PAR

2. A method as defined in claim 1 wherein the polyvinyl alcohol fibers are chemically treated and modified by a reaction with formaldehyde.

NUM

3

PAR

3. A method as defined in claim 1 wherein the polyvinyl alcohol fibers are chemically treated and modified by a reaction with benzaldehyde.

PATN

WKU

RE0286818

SRC

5

# Pftaps19760113 Wk02

APN	5981115
APT	2
PBL	E
ART	111
APD	19750729
TTL	High temperature alloys
ISD	19760113
NCL	57
ECL	50
EXP	Dean; R.
NDR	4
NFG	7
INVT	
NAM	Baldwin; James French
CTY	Delray Beach
STA	FL
REIS	
COD	50
APN	346815
APD	19730402
PNO	3869284

# Pftaps19760113 Wk02

ISD 19750304

CLAS

OCL 75134F

XCL 75171

XCL 148 325

FSS 134 F;170;171

FSC 148

FSS 32;32.5

UREF

PNO 2975051

ISD 19610300

NAM Wilson et al.

OCL 75171

UREF

PNO 3061426

ISD 19621000

NAM Bieber

OCL 75171

UREF

PNO 3067030

ISD 19621200

# Pftaps19760113 Wk02

NAM Dunn et al.

OCL 75171

UREF

PNO 3164465

ISD 19650100

NAM Thielemann

OCL 75171

UREF

PNO 3310399

ISD 19670300

NAM Baldwin

OCL 75171

UREF

PNO 3486887

ISD 19691200

NAM Yoda et al.

OCL 75171

FREF

PNO 863,912

ISD 19610300

CNT GB

# Pftaps19760113 Wk02

FREF

PNO 1,013,347

ISD 19651200

CNT GB

FREF

PNO 1,034,603

ISD 19660600

CNT GB

FREF

PNO 1,268,844

ISD 19720300

CNT GB

FREF

PNO 1,302,160

ISD 19730100

CNT GB

OREF

PAL F. F. Khimiushin, High Temperature Steels and Alloys, Metallurgiya, Pub.  
House, Moscow, (1969), FTD--HC--23-391, Parts I and II, (1971).

LREP

FRM Finnegan, Henderson, Farabow & Garrett

# Pftaps19760113 Wk02

ABST

PAL Nickel base superalloys in which critical amounts of boron are employed to enhance creep-rupture strength and ductility in the 1,300.degree. F-1,800.degree. F. temperature range. Creep-rupture strength and ductility at temperatures around 1,800.degree. F. also is enhanced by employing amounts of carbon below a critical upper limit. These alloys are particularly useful in the form of castings as gas turbine engine components.

BSUM

PAC FIELD OF THE INVENTION

PAR This invention relates to nickel-base alloys having relatively great tensile strength at high temperatures and to castings made from such alloys. The nickel-base superalloys of the present invention are particularly useful for fabricating components of gas turbine engines, such as turbine blades, turbine vanes, integral wheels, and the like.

PAC BACKGROUND OF THE INVENTION

PAR There are a number of precipitation strengthened nickel-base superalloys which, because of their strength at high temperatures, are used as materials in fabricating components for use in high temperature sections of gas turbines. The precipitate involved is an intermetallic compound, generally referred to as gamma prime, having the generic formula Ni.sub.3

# Pftaps19760113 Wk02

(Al, Ti). Alloys hardened by such precipitates are referred to as gamma prime strengthened superalloys. In recent years, while characteristics of such alloys at lower temperatures have not altogether been ignored, the greater emphasis in the development of improved alloys has been centered around performance at high temperatures. High temperature performance has been of concern because of the fact that in new engine designs, as gas turbine operating temperatures are increasing to meet the demands for higher efficiency and power output. High temperature performance properties of particular concern include stress-rupture and creep strength, resistance to thermal fatigue, and corrosion resistance.

PAR

It is known that thermal fatigue properties are associated with intermediate temperature (1,300.degree.F - 1,500.degree.F) ductility. The greater the ductility in this range, the more resistant the alloy is to thermal fatigue. As a general rule, alloys with high temperature rupture and creep strength have inadequate thermal fatigue and hot corrosion resistance. Conversely, alloys with good hot corrosion resistance show poor high temperature rupture, creep and thermal fatigue properties.

PAR

While much work has been done in the development of precipitation strengthened high temperature superalloys, no alloy has been found to be entirely satisfactory with respect to fulfilling the strength, ductility and thermal fatigue requirements needed in gas turbine components. Indeed,

# Pftaps19760113 Wk02

in recent superalloy developments, strength improvements obtained through composition modification generally have resulted in reduced ductility. In the same manner, alloys designed for improved ductility or toughness or hot corrosion resistance generally possess inadequate strength.

PAR

Superalloys suitable for fabricating gas turbine components desirably possess good creep-rupture strength, i.e., resist excessive creep or rupture for long periods of time while under stress at high temperatures. Such alloys also desirably possess good creep-rupture ductility, i.e., deform uniformly and predictably while under stress at high temperature, rather than crack and fracture. Alloys that lack ductility will tolerate little deformation before the onset of crack nucleation, rapid crack propagation, and failure. Use of a material lacking adequate ductility can result in unpredictable and catastrophic engine component failure. A characteristic peculiar to the gamma prime strengthened superalloys is that they are subject to a sharp decrease in creep-rupture ductility and tensile strength at temperatures between about 1,300.degree.F. and 1,500.degree.F. The decrease in ductility is commonly referred to as the "ductility trough," as ductility is higher at temperatures below 1,300.degree.F. and above 1,500.degree.F. It generally has been observed that the higher the strength of an alloy, the more pronounced will be the ductility decrease within the "ductility trough" temperature range. An

# Pftaps19760113 Wk02

example would be MAR-M200 (U.S. Pat. No. 3,164,465). This alloy possesses adequate strength for most advanced gas turbine engine requirements, but lack of 1,400.degree.F. ductility in the conventionally cast material precludes its usefulness for turbine components.

PAR

To circumvent the low ductility problem while retaining usable high temperature strength, the art, in recent years, has turned to a casting process known as directional solidification. This technique, disclosed in U.S. Pat. No. 3,260,505, eliminates grain boundaries that lay in a direction transverse to the direction of applied stress in the component.

While directional solidification eliminates a major cause of low longitudinal creep-rupture ductility, it is an expensive procedure and is therefore used only in specialized cases where cost is not a major concern.

PAR

It has also been attempted to circumvent ductility trough problems by introducing hafnium to nickel-base superalloys (see, e.g., U.S. Pat. Nos. 3,005,705; 3,677,746; 3,677,746; 3,677,747; and 3,677,748). The addition of very dense and expensive hafnium imposes higher raw material costs and increases the unit weight of the alloys. Increased weight, of course, is a serious disadvantage in alloys intended for aircraft engine components. As is apparent, the lack of the combination of high temperature creep-rupture strength and ductility remains a major inadequacy in existing superalloy

# Pftaps19760113 Wk02

compositions. These inadequacies are particularly acute since they impair the usefulness of superalloys for many of their intended applications, i.e., formation of gas turbine components.

PAR The alloys of the present invention have improved high temperature strength and corrosion resistance. These alloys are capable of withstanding (wt.%) prolonged operation at temperatures up to about 2,000.degree.F. or higher, and may be formed into highly advantageous castings.

PAR In accordance with the present invention, alloy compositions have been discovered which possess unique and unusually high creep-rupture strength and ductility in the polycrystalline (non-directionally solidified) form. Specifically, a previously unrecognized criticality has been discovered in the amounts of two alloying elements (boron and carbon) included in chromium, aluminum, and titanium containing nickel base superalloy compositions.

PAR The desirability of adding boron and carbon to high temperature alloys is well documented in the prior art technical and patent literature. The alloy characteristics generally enhanced by the addition of some boron and carbon include ductility, strength, forgeability and in some cases, castability. The present level of technology in the field of superalloy physical metallurgy does not enable precise definition or explanation of

# Pftaps19760113 Wk02

the exact mechanism responsible for this property enhancement. Yet one versed in the art of superalloy development recognizes the necessity for the presence of both elements.

PAR

while it is known that the role of both carbon and boron in nickel superalloys is complex and dynamic, some generalizations can be drawn.

Carbon appears in the form of complex carbides which prefer grain boundaries as location sites. Detrimental effects on ductility have been noted with certain grain boundary carbide morphologies. This indicates that carbon should be maintained at low levels. On the other hand, it also has been observed that low carbon content results in sharply reduced high temperature creep life. It is generally believed, since carbides exert a significant and beneficial effect on rupture strength at high temperature, that carbon should be part of superalloy composition.

PAR

Boron is considered an essential ingredient in superalloys. In superalloys, boron in the form of complex borides, is also located at grain boundaries. Grain boundary morphology of superalloys is significant because high temperature creep and rupture failures initiate at and propagate along grain boundaries. Complex borides at grain boundaries reduce the onset of grain boundary tearing under rupture loading.

PAR

Typical cast superalloys of the prior art preferably contain carbon in an amount of about 0.10% to about 0.25% by weight. In typical prior art

# Pftaps19760113 Wk02

wrought alloys, the carbon content range is between about 0.03% and about 0.15% by weight. For example, in a commercial alloy known as INCO 713, the carbon content is kept as low as 0.05% by weight. Boron content in over fifty prior art alloys studied, preferably is held between 0.007% and 0.03% by weight of the composition. The very small amount of boron used in these commercial alloys demonstrates the potency of the element in affecting properties.

PAR

The present invention is based, in part, on the discovery of an unusual and unexpected improvement, in both 1,400.degree.F. creep-rupture strength and ductility of gamma prime strengthened nickel-base superalloys, obtained by increasing boron content up to about twenty times the accepted optimum level. Maintenance of the boron content within this critical range of the present invention not only eliminates the problem discussed earlier, relating to the ductility trough present at temperatures between about 1,300.degree.F. and 1,500.degree.F., but results in a marked increase in creep-rupture strength at those temperatures.

PAR

It has also been discovered, in accordance with the present invention, that by reducing the carbon content to a critical upper limit below the amount generally employed in superalloys, it is possible to both effect the improvement in 1,400.degree. F. properties and maintain or improve creep-rupture strength and ductility at temperatures around 1,800.degree.

# Pftaps19760113 Wk02

F. This aspect of the present invention is important with respect to items such as gas turbine components requiring enhanced properties at both 1,400.degree. F. and 1,800.degree. F.

PAR

Among the alloys of the prior art which will exhibit enhanced properties by following the teachings of the present invention are those disclosed in U.S. Pat. Nos. 3,310,399; 3,164,465; 3,061,426; and 3,619,182. While many of the alloy compositions disclosed in these patents are similar to, and generically overlap with, the alloys of the present invention, none of these patents disclose, nor do corresponding commercial alloy have, the unusual and surprisingly advantageous properties and characteristics of the alloys of the present invention. This is because the prior art fails to recognize the critical carbon and boron content ranges of the alloys of the present invention. All of the commercial alloys derived from the patents referred to above contain substantially less than the minimum boron content used in the alloys of the present invention. Additionally, while at least some of these patents suggest broad boron content ranges which overlap the boron content range of the present invention, there is no recognition that high temperature properties will maximize in a narrow range within these broadly disclosed ranges.

PAR

The alloys of the present invention, which have very good stress rupture life at elevated temperatures, contain required minimum amounts of nickel,

# Pftaps19760113 Wk02

chromium, aluminum and titanium. The chromium affords primary corrosion resistance while the remaining components are essential to the formation of the gamma prime intermetallic compound. Ni.sub.3 (Al, Ti), which forms the basic superalloy structure of this invention. The Ni.sub.3 (Al, Ti) precipitate lends to these alloys their required high temperature strength, and titanium is an important element in providing the strength properties of the present alloys at both room temperature and at elevated temperatures. The presence of significant amounts of Ti strengthener in the present alloys renders them significantly different in character from lower temperature alloys such as those of U.S. Pat. No. 3,005,704, which excludes Ti from its alloys.

PAC

## SUMMARY OF THE INVENTION

PAR

In general terms, the present invention pertains to gamma prime phase strengthened superalloys. These alloys are specifically adapted to be employed in cast shapes under conditions of high stress at high temperature. The invention also concerns cast components for use in gas turbine engines made from such alloys.

PAR

The alloys of the present invention are predominantly nickel, i.e., at least 35% nickel, and contain in varying amounts, chromium, aluminum, titanium, and boron. One or more of the elements carbon, cobalt, zirconium, molybdenum, tantalum, rhenium, columbium, vanadium, and

# Pftaps19760113 Wk02

tungsten may also be included in these alloys. In addition, the alloys of the present invention may contain minor amounts of other elements ordinarily included in superalloys by those skilled in the art which will not substantially deleteriously effect the important characteristics of the alloy or which are inadvertently included in such alloys by virtue of impurity levels in commercial grades of alloying ingredients.

PAR

It is a principal object of the present invention to include in the aforescribed alloys amounts of boron within the range of 0.05% to 0.3% by weight to enhance creep-rupture strength and ductility at temperatures around 1,400.degree. F. In accordance with preferred embodiments of the present invention, in addition to maintaining the boron content within the range specified, the carbon content of the alloys is maintained below about 0.05% by weight. By additionally maintaining the carbon content below this critical upper limit, it is possible to effect creep-rupture strength and ductility improvement at temperatures around 1,400.degree.F. while, at the same time, maintaining or improving creep-rupture strength and ductility at temperatures around 1,800.degree. F.

PAR

Table I sets forth a broad range and two different narrower ranges, in terms of percent by weight, of elements employed in the alloys of the present invention. It should be understood that the tabulation in Table I relates to each element individually and is not intended to solely define

# Pftaps19760113 Wk02

composite of broad and narrow ranges. Nevertheless, composites of the narrower ranges specified in Table I represent preferred embodiments.

PAR

A particularly preferred alloy composition, in percentages by weight, consists essentially of about 8.0% to about 10.25% chromium, about 4.75 to about 5.5% aluminum, about 1.0% to about 2.5% titanium, about 0.05 to about 0.30% (and more preferably about 0.075% to about 0.2%) boron, up to about 0.17% (and more preferably less than 0.05%) carbon, about 8% to

B\* 3,310,399 B-1910

about 12% cobalt, about 0.75% to about 1.8% columbium, about 11% to about 16% tungsten, up to 0.20% zirconium, and the balance essentially nickel and minor amounts of impurities and incidental elements which do not detrimentally affect the basic characteristics of the alloy.

TBL

TABLE I

---

ELE-

MENT BROAD RANGE NARROWER RANGES

---

Cr 5.0 - 22 6.0 - 17 5 - 12

Al 0.2 - 8 2 - 8 4 - 8

Ti 0.5 - 7 0.75 - 3 0.75 - 2.5

B 0.05 - 0.30 0.07 - 0.25 0.075 - 0.20

# Pftaps19760113 Wk02

C	0.00 - 0.35				
Co	0.00 - 20	2	- 17	5	- 15.5
Cb	0.00 - 3	0.25	- 3		
Mo	0.00 - 8				
Ta	0.00 - 10				
V	0.00 - 2	--	--		
W	0.00 - 20	5	- 20		
Zr	0.00 - 1.00	0.001	- 0.5		
Re	0.00 - 2	--	--		
Ni	35 - 85	40	- 80	40	- 80

PAR

Another particularly preferred alloy composition, in percentages by weight, consists essentially of about 7.5% to about 8.5% chromium, about 5.75% to 6.25% aluminum, about 0.8% to about 1.2% titanium, about 0.05% to about 0.30% (and more preferably about 0.075% to about 0.2%) boron, up to about 0.13% (and more preferably less than 0.05%) carbon, about 9.5% to about 10.5% cobalt, about 5.75% to about 6.25% molbdenum, about 4.0% to about 4.5% tantalum, 0.05% to 0.10% zirconium, and the balance essentially nickel and minor amounts of impurities and incidental elements which do not detrimentally affect the basic characteristics of the alloy.

PAR

Impurities and incidental elements which may be present in the alloys of

# Pftaps19760113 Wk02

the present invention include manganese, copper, and silicon in amounts of not more than 0.50%, sulfur and phosphorus in amounts of not more than 0.20%, and iron in amounts of not more than 2.0%. Impurities such as nitrogen, hydrogen, tin, lead, bismuth, calcium, and magnesium should be held to as low a concentration as practical.

DRWD

PAC

## BRIEF DESCRIPTION OF THE DRAWINGS

PAR

FIG. 1 is a graphical plot of percent creep elongation against time for two alloys, one within the ambit of the present invention, and the other outside the ambit of the present invention.

PAR

FIG. 2 is a plot of creep-rupture life in hours against the boron content in weight percent of certain nickel base alloys at both 1,400.degree. F. -- 94,000 psi and 1,800.degree. F. -- 29,000 psi. The creep-rupture life at 1,400.degree. F -- 94,000 psi and 1,800.degree. F -- 29,000 psi for commercial alloys similar to the alloy of the plot, but outside the ambit of the present invention, is also noted on the plot.

PAR

FIG. 3 is similar to FIG. 2 but plots percent creep elongation against boron content, rather than creep rupture life against boron content.

PAR

FIG. 4 is a reproduction of a photomicrograph at a magnification of 300, of a commercial alloy outside the ambit of the present invention.

PAR

FIG. 5 is a reproduction of a photomicrograph, at a magnification of 300,

# Pftaps19760113 Wk02

of an alloy (comparable to the alloy of FIG. 4) within the ambit of the present invention.

PAR

FIG. 6 is a reproduction of a photomicrograph, at a magnification of 7,000, of the same alloy shown in the photomicrograph of FIG. 4.

PAR

FIG. 7 is a reproduction of a photomicrograph, at a magnification of 7,000, of the same alloy shown in the photomicrograph of FIG. 5.

DETD

PAC

## DESCRIPTION OF EXAMPLES AND PREFERRED EMBODIMENTS

PAR

The alloys of the present invention, containing boron within the critical range of 0.05% to 0.3% by weight, exhibit enhanced creep rupture strength and ductility in the 1,300.degree. F. to 1,500.degree. F. temperature range over prior art gamma prime strengthened nickel base superalloys. Thus the alloys of the present invention are capable of withstanding an applied stress of 94,000 psi at 1,400.degree.F without rupture for a time in excess of 120 hours. Further, this improvement in strength and ductility properties in the intermediate temperature range (1,300.degree.F. - 1,500.degree.F) is accompanied by a pronounced beneficial effect on high temperatue (above 1,700.degree.F.) thermal fatigue properties. Alloys of the present invention, having improved intermediate temperature strength and ductility, demonstrate great advantage in resistance to high temperature thermal fatigue cracking over

# Pftaps19760113 Wk02

alloys containing boron in amounts outside the critical range of the present invention.

PAR

Designers of gas turbine engines place great importance upon the selection of capable and reliable materials. This is particularly true for rotating components in large aircraft engines where unpredictable engine component failure could endanger the aircraft and its occupants. One of the more critical components in this class of engines is the hot section or turbine blade. Because of the severe conditions of temperature and stress to which these components are subjected, they must be formed of high strength superalloys.

PAR

Usual designs involve the mechanical attachment of turbine blades around the periphery of a wheel or disk which rotates at high speed. In operation, hot gases pass over the airfoil portion of the blades, causing  $C^* 3,164,465 \text{ MAR-M200}$  the blades and disk to rotate at high speed. The hot gases raise the metal temperatures and the high rotational speed of the disk imposes stress due to centrifugal loading. The attachment, or root portion of the blade is heated only to moderate temperatures due to the cooling effect of the massive disk. The temperature to which the root section of the blade is heated is frequently in the ductility trough temperature range (1,300.degree. F. to 1,500.degree. F.). It is an essential mechanical

# Pftaps19760113 Wk02

property of an alloy being used for such blades that it be capable of deforming predictably in the root section at temperatures around 1,400.degree. F. while withstanding mechanically imposed strain without cracking, i.e., the alloy must possess reasonable ductility. The alloys of the present invention, containing boron within the critical range of 0.05% to 0.30% by weight, demonstrate great advantage in strength and ductility in the 1,400.degree. F. temperature range over prior art alloys intended for use in turbine blades.

PAR

The rotating turbine disk, to which the blade root is attached, also requires high resistance to creep and rupture along with ductility and strength to resist fatigue and crack propagation. Accordingly, the alloys described herein provide enhanced properties desirable in disk alloys.

PAR

Manufacturers of small gas turbine engines generally employ an integral wheel rather than an assembly of individual disks and blades. These integral wheels, consisting of a single component comprising a disk having radially extending blade airfoils at the disk periphery, is usually manufactured by investment casting. Normal modes of operation for small engines subject such components to rapid heating and cooling. This normal mode of operation results in premature cracking at the disk rim between the blade airfoils, because of low cycle thermal and mechanical fatigue. Since the disk rin in many engine designs operates up to about

# Pftaps19760113 Wk02

1,400.degree. F., the alloys of the present invention enhance the overall performance of integral wheels.

PAR

The formulations of several of the more important prior art alloys which are currently commercially used in turbine engines are tabulated in Table II. The values tabulated represent the amount of each ingredient present in terms of weight percent. The amount of boron and carbon present in each formulation is considered by the prior art to be approximately optimum.

With respect to each of the alloys, designated A, B, C, D, E, and F, the U.S. Patent and commercial designation is indicated in the table.

PAR

For purposes of comparison, example alloys, compositionally similar to the commercial alloys of Table II, but containing boron within the critical range of the present invention, were prepared. Analyses of these example alloys (designated A-1, B-1, etc.) are presented in Table III. Standard cast-to-size test bars (0.25 inch in diameter) of the alloys of Table II and the example alloys of Table III were prepared by melting and casting under vacuum into shell molds. All example alloy specimens were heat treated under a protective atmosphere at 1,975.degree. F. for four hours and then air cooled. The example alloys were also subjected to an aging heat treatment at 1,650.degree. F. for ten hours. Each of the commercial alloys of Table II was heat treated in accordance with the practice recommended by the alloy developer.

# Pftaps19760113 Wk02

PAR Table IV shows the comparative creep-rupture strength (as measured by time to rupture) and ductility, (as measured by prior creep) of both commercial alloys A, B, C, and E, and example alloys A-1, B-1, C-1, C-2, C-3 and E-1. All alloys were tested at 1,400.degree. F. under a stress of 94,000 psi.

PAR The data in Table IV shows a very significant improvement in both 1,400.degree. F. creep-rupture strength and ductility for alloys having a boron content within the critical range of the present invention. At 0.20 weight percent boron, the properties of Example C-3, although decreasing from Example C-2, still show a marked improvement over Alloy C.

PAR The data set forth in Tables II - IV demonstrates that the utility of nickel-base superalloys for use in gas turbine engine components in which maximum service temperature does not exceed about 1,400.degree. F. is greatly enhanced by increasing boron content to an effective level previously considered excessive.

TBL

TABLE II

---

A\* B\* C\* D\* E\* F\*

---

C 0.10 0.10 0.15 0.15 0.18 0.21

# Pftaps19760113 Wk02

Cr

8.0 10.0 9.0 9.0 10.0 12.5

Co

10.0 10.0 10.0 10.0 15.0 9.0

W -- -- 12.5 10.0 -- 3.9

Mo

6.0 3.0 -- 2.5 3.0 2.0

Ta

4.25 7.0 -- 1.5 -- 3.9

Ti

1.0 1.0 2.0 1.5 4.7 4.2

Al

6.0 6.0 5.0 5.5 5.5 3.2

B 0.015 0.015 0.015 0.015 0.015 0.02

Zr

0.10 0.10 0.05 0.05 0.06 0.10

Cb

-- -- 1.0 -- -- --

V -- -- -- -- 1.0 --

Ni

(1) (1) (1) (1) (1) (1)

# Pftaps19760113 Wk02

—  
A\* 3,310,399 B-1900

D\* 3,164,465 MAR-M246

E\* 3,061,426 IN-100

F\* 3,619,182 IN-792

(1)Balance

TBL

TABLE III

---

EXAMPLE NO.

A-1 B-1 C-1 C-2 C-3 E-1

---

C 0.12 0.11 0.15 0.09 0.15 0.18

Cr 7.87 10.2 8.75 9.30 8.75 10.1

Co 10.15 10.0 10.1 10.3 10.1 15.1

W -- -- 12.0 12.81 12.0 --

Mo 6.06 3.05 -- -- -- 3.01

Ta 4.40 6.75 -- -- -- --

Ti 1.08 1.12 1.98 2.08 1.98 4.80

Al 5.95 6.30 4.99 4.80 4.99 5.33

B 0.10 0.10 0.10 0.13 0.20 0.10

Zr 0.05 0.14 0.06 0.03 0.06 0.06

Cb -- -- 1.23 1.20 1.23 --

# Pftaps19760113 Wk02

V -- -- -- -- 0.86

Ni (1) (1) (1) (1) (1) (1)

---

(1)Balance

TBL

TABLE IV

---

Creep-Rupture Properties

Boron Content

1400F/94,000 psi

(wt. %) Rupture Life (hr)

Prior Creep' (%)

---

Alloy A 0.016 31.0 1.98

Example No.:

A-1 0.10 229.6 6.80

Alloy B 0.015 102.1 3.68

Example No.:

B-1 0.10 297.2 8.95

Alloy C 0.015 46.7 0.51

# Pftaps19760113 Wk02

Example No.:

C-1 0.10 400.6 3.60

C-2 0.13 442.6 6.45

C-3 0.20 245.5 2.35

Alloy E 0.012 26.6 0.96

Example No.:

F-1 0.10 345.0 5.25

'Prior creep indicates the last-creep reading prior to specimen failure

PAR

The need for improved higher temperature (greater than 1,700.degree.F) creep capability in gas turbine alloys is of comparable importance to effecting an improvement in 1,400.degree. F. creep-rupture strength and ductility. Therefore, the effect of the high boron range upon the creep-rupture properties in the 1,700.degree. F. to 1,900.degree.F. temperature range was studied by conducting creep-rupture tests on heat treated standard cast-to-size test bars at 1,800.degree. F. under a stress of 29,000 psi.

PAR

Results of that testing show that the high boron levels, demonstrated as being unusually effective for 1,400.degree. F. properties, were deleterious to 1,800.degree. F. rupture strength. The effect was a weakening of the resistance of all alloys in Tabe II to creep deformation

# Pftaps19760113 Wk02

and a noticeable increase in ductility, i.e., a weaker but more ductile material. For gas turbine components requiring both 1,400.degree. F. and 1,800.degree. F. creep-rupture strength and ductility, use of the alloys shown in Table II would involve the unacceptable tradeoff of improved 1,400.degree. F. ductility at the expense of decreased 1,800.degree. F. strength.

PAR

It has been discovered, in further accord with the present invention, that by reducing the carbon content to a critical upper limit of no more than about 0.05 weight percent, it is possible to both effect the improvement in 1,400.degree. F. properties and approximately maintain, and in some cases improve, creep-rupture strength and ductility at 1,800.degree. F. Alloys of the present invention, containing less than 0.05 weight percent carbon are capable of withstanding an applied stress of 29,000 psi at 1,800.degree. F. without rupture for a time in excess of 40 hours.

PAR

The low carbon aspect of the present invention is particularly important with respect to turbine components requiring enhanced properties at both 1,400.degree. F. and 1,800.degree. F. As previously noted, properties at around 1,400.degree. F. are particularly important with respect to the root sections of turbine blades. However, the hot gases passing across the airfoil portion of the blade raise metal temperatures into the 1,700.degree. F. to 1,900.degree. F. temperature range. Accordingly, turbine blades desirably require an alloy having good high temperature

# Pftaps19760113 Wk02

properties throughout the temperature range of from about 1,300.degree. F. to about 1,900.degree. F. or higher.

PAR

To demonstrate the utility and advantages of the low carbon feature of the present invention, thirty pound heats of example alloys A-2, B-2, C-4 through 13, D-1, E-2 through 9, and F-1 were prepared by melting under vacuum. Standard test bars (0.25 inch diameter) were cast under vacuum into shell molds and all specimens were heat treated under a protective atmosphere at 1,975.degree. F. for four hours. After air cooling, all specimens were subjected to an aging heat treatment of 1,650.degree. F. for ten hours. Analyses for series A,B,D, and F example alloys are shown in Table V. Analyses for series C and E example alloys are shown, (wt.%) respectively, in Tables IV and VII. In all six series compositions, carbon has been reduced to as low a level as possible using normal master alloys and metals in the preparation of each heat. Such a technique is representative of typical commercial practice. Intentional carbon was added however, where appropriate, to determinate the critical upper limit.

PAR

Creep-rupture tests were conducted at 1,800.degree. F. under a stress of 29,000 psi and at 1,400.degree. F. under a stress of 94,000 psi on all low carbon example alloys. For comparative purposes, the same tests were conducted on the commercial alloys A,B,C,D,E, and F of Table II. The

# Pftaps19760113 Wk02

commercial alloy test bars were heat treated in accordance with the procedures recommended by the producers to achieve maximum mechanical properties. Creep-rupture data for commercial alloys D and F under these conditions were obtained from technical literature provided by the respective alloy producers.

PAR

The data of Table VII demonstrates the applicability of the present invention to a wide range of superalloys. The four example alloys corresponding to the four commercial alloys designated A,B,D, and F had boron and carbon levels approaching the target compositions, i.e., 0.01 weight percent carbon and 0.10 to 0.12 weight percent boron. The comparative test results between the commercial alloys A, B, D, and F and corresponding series A, B, D and F example alloys set forth in Table VIII shows in all cases that very significant improvements are effected at both 1,400.degree. F. and 1,800.degree. F in rupture life and ductility.

TBL

TABLE V

---

EXAMPLE NO.

A-2    B-2    D-1    F-1

---

C    0.014    0.040    0.009    0.009

Cr    9.75    10.56    9.66    11.35

---

# Pftaps19760113 Wk02

Co 12.15 11.76 10.91 9.43

W -- -- 9.66 4.18

Mo 5.89 3.10 2.43 2.04

Ta 3.71 5.70 1.50 4.23

Ti 0.96 0.99 1.38 3.69

Al 5.95 6.03 5.19 3.92

B 0.081 0.109 0.084 0.096

Zr 0.073 0.084 0.062 0.083

Ni (1) (1) (1) (1)

---

(1)Balance

TBL

TABLE VI

---

EXAMPLE NO.

C-4 C-5 C-6 C-7 C-8 C-9 C-10 C-11 C-12 C-13

---

C 0.011 0.010 0.014 0.012 0.011 0.018 0.018 0.045 0.023 0.033

Cr

9.33 8.33 8.89 8.61 8.64 8.97 8.96 9.50 9.54 10.00

# Pftaps19760113 Wk02

Co

10.66 10.70 10.64 10.66 10.71 10.78 10.60 10.50 10.69 10.54

W 12.41 12.40 12.74 12.84 12.48 12.55 12.41 12.5 11.84 13.15

Ti

1.76 1.78 1.77 1.78 1.75 1.77 1.76 2.0 1.75 1.75

Al

5.65 5.53 5.63 5.80 5.41 5.13 5.15 4.98 4.76 4.76

B 0.02 0.03 0.08 0.14 0.15 0.20 0.235 0.10 0.28 0.39

Zr

0.077 0.075 0.079 0.068 0.074 0.065 0.054 0.060 0.053 0.038

Cb

0.95 0.95 0.92 0.92 0.92 0.91 0.85 1.09 0.88 0.79

Ni

(1) (1) (1) (1) (1) (1) (1) (1) (1) (1)

---

(1)Balance

TBL

TABLE VII

---

EXAMPLE NO.

E-2 E-3 E-4 E-5 E-6 E-7 E-8 E-9

# Pftaps19760113 Wk02

---

—  
C 0.010 0.008 0.008 0.008 0.010 0.011 0.012 0.012

Cr

8.56 9.10 8.95 9.67 9.87 9.87 10.22 10.05

Co

16.60 16.67 16.62 16.62 16.62 16.86 16.80 16.69

Mo

3.01 2.94 3.17 3.06 3.03 3.25 3.33 3.32

Ti

4.89 4.90 4.88 4.74 4.91 4.64 4.64 4.56

Al

5.58 5.71 5.60 5.61 5.63 5.22 5.23 5.23

B 0.018 0.044 0.088 0.090 0.125 0.170 0.180 0.220

Zr

0.079 0.067 0.074 0.071 0.060 0.067 0.069 0.064

V 1.06 1.07 1.07 1.08 1.06 0.996 1.01 1.01

Ni

(1) (1) (1) (1) (1) (1) (1) (1)

---

—  
(1)Balance

# Pftaps19760113 Wk02

TBL

TABLE VIII

---

Creep-Rupture Properties

1400F/94,000psi

1800F/29,000psi

Boron

Carbon

Life Prior Life

Final

(hr.)

Creep(%)

(hr.)

Elong(%)

---

Alloy A 0.016

0.12 31.0

1.98 53.2

6

Example No.:

A-2 0.081

# Pftaps19760113 Wk02

1.4E-2

146.5

7.3 44.8

9.9

Alloy B 0.010

0.11 102.1

3.68 50.3

9.3000000000000007

Example No.:

B-2 0.109

0.04

206

5.1 52.4

13

PAR

The most pronounced effect noted is with alloy F in which 1,400.degree. F. rupture life is increased by more than a factor of four, while ductility is doubled. At 1,800.degree. F. the time to rupture is more than doubled, an unusually large increase.

PAR

Comparative results of the testing between alloy C and the respective Series C example alloys is shown in Table IX. The 1,400.degree. F. results

# Pftaps19760113 Wk02

show strength comparable to the previous high carbon alloy results set forth in Table IV. This demonstrates that the boron is effective in improving 1,400.degree. F. properties regardless of carbon level. The 1,800.degree. F. results show creep-rupture life increasing with increasing boron to about 0.15 weight percent. Above 0.15 weight percent boron, strength falls off slightly. Example alloy C-4 shows very good rupture life at 1,400.degree. F., but the low level of both boron and carbon causes low ductility in the 1,800.degree. F. test. In addition, the combination of low boron and low carbon contents causes poor castability and a tendency for castings to crack on cooldown during solidification. The minimum boron required to circumvent these problems in the low carbon alloys is about 0.05 weight percent.

PAR Comparative results of testing between alloy E and the respective Series E example alloys is shown in Table X. In these data it is seen that although the 1,400.degree. F. strength is below the high carbon counterparts reported in Table IV, the improvement over commercial alloy E is significant.

TBL TABLE VIII-Continued  
11.4

---

Creep-Rupture Properties

# Pftaps19760113 Wk02

1400F/94,000psi    1800F/29,000psi

Boron

Carbon

Life Prior Life

Final

(wt.%)

(wt.%)

(hr.)

Creep(%)

(hr.)

Elong.(%)

—

Alloy D 0.015

0.15 120.0

2.2 50.0

5

Example No.:

D-1 0.084

8.9999999999999993E-3

432.8

4.3 58.1

# Pftaps19760113 Wk02

4.8

Alloy F 0.02 0.21 62.0

3.5 30.0

11

Example No.:

F-1 0.096

8.9999999999999993E-3

254.4

8.1 79.2

11.7

TBL

TABLE IX

Creep-Rupture Properties

1400F/94,000psi

1800F/29,000psi

Boron

Carbon

Life Prior Life Final

(wt.%)

# Pftaps19760113 Wk02

(wt.%)

(hr.)

Creep(%)

(hr.)

Elong.(%)

---

Alloy C 0.015

0.15 46.7 0.51 96.8 7.5

Example No.:

C-4 0.02 0.011

314.8

3.50 73.6 2.2

C-5 0.03 0.010

392.2

2.57 85.2 2.4

C-6 0.08 0.014

448

2.36 113.9

4.2

C-7 0.14 0.012

452.9

# Pftaps19760113 Wk02

3.53 122.4

6

C-8 0.15 0.011

468.6

2.21 128.3

5.8

C-9 0.20 0.018

459.8

2.03 117.1

4.5

C-10 0.235

1.7999999999999999E-2

458.6

1.57 64.8 4.2

C-11 0.10 0.045

397.2

2.59 92.3 7.0

C-12 0.28 0.023

347.4

2.11 43.0 4.6

C-13 0.39 0.033

80.7 1.56 14.7 11.1

# Pftaps19760113 Wk02

---

TBL

---

TABLE X

---

---

Creep-Rupture Properties

1400F/94,000psi

1800F/29,000psi

Boron

Carbon

Life Prior Life

Final

(wt.%)

(wt.%)

(hr.)

Creep(%)

(hr.)

Elong.(%)

---

---

Alloy E 0.015

0.18 26.6

---

# Pftaps19760113 Wk02

0.95 41.9

8.5

Example No.:

E-2 0.018

0.01

38.6

2.32 27.0

5.2

E-3 0.044

8.0000000000000002E-3

68.099999999999994

5.44 48.6

E-4 0.088

8.0000000000000002E-3

104.2

5.92 41.3

12.3

E-5 0.090

8.0000000000000002E-3

117.2

5.91 38.1

# Pftaps19760113 Wk02

11.7
E-6 0.125
0.01
174.1
4.86 41.2
13.8
E-7 0.170
1.0999999999999999E-2
266.3
5.03 36.5
11.9
E-8 0.180
1.2E-2
302.2
4.90 31.9
10.1
E-9 0.220
1.2E-2
357.6
5.50 27.6
11.8

# Pftaps19760113 Wk02

---

PAL In addition, the 1,800.degree. F. properties are maintained within a boron range of about 0.05 to 0.15 weight percent. At 0.22 weight percent boron in Example alloy E-9, the 1,800.degree. F. strength is about sixty percent that of commercial alloy E.

PAR The creep-rupture data discussed previously and presented in Tables IV, V, VIII, IX and X were developed using standard cast-to-size test bars with a 0.250 inch diameter gage section. To demonstrate that the property enhancement is applicable to turbine components, several turbine blade castings were produced from alloy C-7 and specimens cut from those castings. Testing was conducted under the same temperature and stress conditions previously employed and results are present in Table XI. The data show the expected reduction in capability compared to test bar properties, but the level of strength and ductility are exceptionally attractive for specimens machined from turbine component castings.

PAR Another major concern of gas turbine engine builders in the selection of high temperature materials is the ability of the selected alloy to retain initial or starting properties after long time, high temperature exposure. Example Alloy C-7 cast-to-size test bars were subjected to creep testing at 1,500.degree.F under a stress of 40,000 psi for 1,000 hours and

# Pftaps19760113 Wk02

examined microstructurally. No deleterious phase formation was observed

APN

5851548

and subsequent creep-rupture testing was conducted at 1,400.degree.F and 94,000 psi for comparison with the same alloy in the as-heat treated condition.

TBL

TABLE XI

Creep-Rupture Properties

1400F/94,000psi

1800F/29,000psi

Life Prior Life Final

Specimen No.

(hr.) Creep(%) (hr.) Elong.(%)

1	371.9	4.36	42.5	4.5
2	264.4	3.38	63.3	7.1
3	172.4	2.00	54.4	5.1
4	281.5	3.50	39.6	11.4
5			49.4	7.2
b			46.1	11.5

TBL

TABLE XII

# Pftaps19760113 Wk02

---

Creep-Rupture

Properties

1400F/94,000psi

Life Prior

Example No.

Specimen Condition

(hr.) Creep(%)

---

C-7 As-heat treated 452.9 3.53

C-7 Heat treated plus

463.3 4.03

1500F exposure for

1000 hours under

stress of 40,000psi

---

PAL

Results shown in Table XII reveal essentially no change in rupture life and an improvement in 1,400.degree.F ductility.

PAR

FIG. 1 shows the creep characteristics of typical Alloy C and one of the example alloy C-7 test bars in the 1,400.degree.F test. In FIG. 1, percent creep elongation is plotted against time. The improved results obtained

---

# Pftaps19760113 Wk02

with the alloys of the present invention are dramatically demonstrated.

PAR

FIGS. 2 and 3 further demonstrate the critical relationship between boron content and strength and ductility. FIG. 2 is a plot of creep rupture life in hours against the boron content in weight percent of C series, low carbon (less than 0.05% by weight), alloys at both 1,400.degree.F -- 94,000 psi and 1,800.degree.F -- 29,000 psi. The creep rupture life for commercial alloy C at 1,400.degree.F - 94,000 psi and 1,800.degree.F -- 29,000 psi for commercial alloy C is noted on the plot at, respectively, points A and B. As is apparent, substantial improvements in crees rupture life are obtained at 1,400.degree.F by maintaining the boron content within the critical range of the present invention.

PAR

FIG. 3 is a plot of percent creep elongation against boron content for C series, low carbon alloys at both 1,400.degree.F -- 94,000 psi and 1,800.degree.F -- 29,000 psi. The percent creep elongation for commercial alloy C at both 1,400.degree.F -- 94,000 psi and 1,800.degree.F -- 29,000 psi is also noted on this plot, respectively, at points A and B. Again substantial improvements are apparent at 1,400.degree.F. with respect to alloys containing boron within the critical range of the present invention. While the percent creep elongation obtained at 1,800.degree.F with alloys within the ambit of the present invention is not as high as that of the commercial alloy, highly acceptable levels are achieved.

# Pftaps19760113 Wk02

PAR Metallographic examination was conducted in an attempt to explain the mechanism responsible for the observed property enhancement. FIG. 4 shows the normal microstructure of commercial Alloy C in the as-cast condition at 300 magnifications. The light etching dendrite arms or branch-like areas indicate tungsten segregation. A few titanium rich carbides are visible in the lower center portion of the photomicrograph.

PAR The photomicrograph of FIG. 5 also at 300 magnifications, shows the profound microstructural change resulting from the added boron and reduced carbon of example alloy C-7. Reducing carbon to less than 0.02 weight percent frees titanium previously tied up as a stable carbide. The increased available titanium in the alloy results in the formation of gamma-gamma prime eutectic in the grain boundaries, a microstructural effect known to enhance 1,400.degree.F ductility. The boron addition results in the formation of discrete grain boundary particles, identified by electron-beam micro-probe analysis as an M.sub.3 B.sub.2 type boride where M (in the C alloy series) is chromium and tungsten. These grain boundary particles are responsible for restoring 1,800.degree.F creep-rupture ductility to low carbon alloys.

PAR Electron photomicrographs of commercial alloy C and example alloy C-7, at 7,000 magnifications, are shown, respectively, in FIGS. 6 and 7. FIG. 6 shows, as previously stated to be the general case, borides located at the

# Pftaps19760113 Wk02

grain boundaries. In FIG. 7, a boride precipitate within each gamma prime particle may be observed, a phenomenon absent in superalloys of the more conventional compositions. The presence of the very fine boride particles appears to retard dislocation movement through the gamma-prime particles and, in essence, provides dispersion strengthening for improved resistance to creep deformation at 1,800.degree.F. This microstructural effect has not been observed in commercial alloys.

PAR

Many of the alloys of the present invention may be extruded and hot forged. Wrought, high strength nickel-base superalloys are generally employed in applications where ductility and fracture toughness in the 1,000.degree.F to 1,500.degree.F temperature range are of prime concern. Such applications include gas turbine engine turbine and compressor disks. The series E alloys of the present invention may be hot forged, using conventional techniques, into shaped articles having the characteristics considered to be essential in advanced wrought alloys. For example, alloys E-1 and E-5 have responded very satisfactorily to extrusion and forging in the 2,000.degree.F to 2,200.degree.F temperature range in anticipation of the requirements for advanced wrought disk and blade materials.

PAR

The present invention also anticipates the use of powder metallurgy for controlling the size, morphology and distribution of the boride microconstituents previously described.

# Pftaps19760113 Wk02

PAR The invention in its broader aspects is not limited to the specific embodiments shown and described. Departures may be made therefrom within the scope of the accompanying claims without departing from the principles of the invention and without sacrificing its chief advantages.

CLMS

STM What is claimed is: .[.

NUM 1

PAR 1. A nickel base alloy for use at relatively high temperatures consisting essentially of the following elements in the weight percent ranges set forth:

Elements	Percent
Chromium	5-22
Aluminum	0.2-8
Titanium	0.5-7
Boron	0.07-0.25
Carbon	less than 0.05%
Cobalt	0.00-20
Columbium	0.00-3
Molybdenum	0.00-8
Tantalum	0.00-10

# Pftaps19760113 Wk02

Vanadium	0.00-2
Tungsten	0.00-20
Rhenium	0.00-2
Zirconium	0.00-1.00

PAL

the balance of the alloy being essentially nickel and minor amounts of impurities and incidental elements which do not detrimentally affect the basic characteristics of the alloy, said nickel being present in an amount of from about 35% to 85% by weight..]. .[.2. The nickel base alloy of claim 1 wherein the carbon content is no more than 0.025% by weight..]. .[.3. the nickel base alloy of claim 1 wherein the boron content is about 0.075% to 0.2% by weight..]. .[.4. A cast component for use in a gas turbine engine formed of the alloy of claim 1..]. .[.5. The component of claim 4 in which said component is a turbine blade..]. .[.6. The component of claim 4 in which said component is a disk..]. .[.7. The component of claim 4 in which said component is an integral wheel comprising a disk and turbine blade..]. .[.8. A cast component for use in a gas turbine engine formed of the alloy of claim 3..]. .[.9. The component of claim 8 wherein said component is a turbine blade..]. .[.10. The component of claim 8 wherein said component is a disk..]. .[.11. The component of claim 8 wherein said component is an integral wheel comprising a disk and turbine

# Pftaps19760113 Wk02

PAR blade.]. 12. A shaped object of the alloy of claim .[.1.]. .ladd.50  
.laddend.capable of withstanding an applied stress of 94,000 psi at  
PAR 1,400.degree.F. without rupture for a time in excess of 120 hours. 13. A  
shaped object of the alloy of claim .[.1.]. .ladd.12 .laddend.capable of  
withstanding an applied stress of 29,000 psi at 1,800.degree.F. without  
PAR rupture for a time in excess of 40 hours. 14. The alloy of claim .[.1.].  
.ladd.50 .laddend.which contains, on a weight basis, about 6.0% to about  
17% chromium, about 2% to about 8% aluminum, .[.about 0.75% to about 3%  
titanium, about 2% to about 17% cobalt,.] and about 40% to 80% by weight  
PAR nickel. 15. The nickel base alloy of claim 14 wherein the carbon content  
PAR is no more than 0.025% by weight. 16. A cast component for use in a gas  
PAR turbine engine formed of the alloy of claim 14. 17. A cast component for  
PAR use in a gas turbine engine formed of the alloy of claim 15. 18. The alloy  
of claim .[.1.]. .ladd.50 .laddend.which contains, on a weight basis,  
about 5% to 12% chromium, about 4% to about 8% aluminum, .[.about 0.75% to  
about 2.5% titanium,.] about 5% to about 15.5% cobalt, and about 40% to  
PAR 80% by weight nickel. 19. The nickel base alloy of claim 18 wherein the  
PAR carbon content is no more than 0.025 by weight. 20. A cast component for  
PAR use in a gas turbine engine formed of the alloy of claim 18. 21. A cast  
component for use in a gas turbine engine formed of the alloy of claim 19.  
PAR 2. A nickel base alloy for use at relatively high temperatures consisting

# Pftaps19760113 Wk02

essentially of the following elements in the weight percent ranges set

forth:

TBL	Elements	Percent
	Chromium	6 - 17
	Aluminum	2 - 8
	Titanium	0.75 - 3
	Boron	0.05 - 0.3
	Carbon	0.00 - 0.05
	Cobalt	2 - 17
	Columbium	0.25 - 3
	Molybdenum	0.00- 3
	Tantalum	0.00 - 3
	Tungsten	5 - 20
	Zirconium	0.001 - 0.5

PAL the balance of the alloy being essentially nickel and minor amounts of impurities and incidental elements which do not detrimentally affect the basic characteristics of the alloy, said nickel being present in an amount

PAR of from about 40% to 80% by weight. 23. The nickel base alloy of claim 22

PAR wherein the boron content is about 0.07% to about 0.25% by weight. 24. The

# Pftaps19760113 Wk02

nickel base alloy of claim 22 wherein the carbon content is no more than

PAR 0.025 by weight. 25. A cast component for use in a gas turbine engine

PAR formed of the alloy of claim 22. 26. A cast component for use in gas

PAR turbine engine formed of the alloy of claim 24. 27. A nickel base alloy

for use at relatively high temperatures consisting essentially of the

following elements in the weight percent ranges set forth:

TBL	Elements	Percent
	Chromium	8 - 10.25
	Aluminum	4.75 - 5.5
	Titanium	1 - 2.5
	Boron	0.05 - 0.3
	Carbon	0.00 - 0.05
	Cobalt	8 - 12
	Columbium	0.75 - 1.8
	Tungsten	11 - 16
	Zirconium	0.00 - 0.20

PAL the balance of the alloy being essentially nickel and minor amounts of

impurities and incidental elements which do not detrimentally affect the

PAR basic characteristics of the alloy. 28. The nickel base alloy of claim 27

# Pftaps19760113 Wk02

PAR wherein the boron content is about 0.07% to about 0.25% by weight. 29. The nickel base alloy of claim 27 wherein the carbon content is no more than 0.025% by weight. 30. A cast component for use in a gas turbine engine formed of the alloy of claim 27. 31. The component of claim 30 in which said component is a turbine blade. 32. A cast component for use in a gas turbine engine formed of the alloy of claim 29. 33. The component of claim 32 wherein said component is a turbine blade. 34. A shaped object of the alloy of claim 27 capable of withstanding an applied stress of 94,000 psi at 1,400.degree. F. without rupture for a time in excess of 120 hours.

PAR A shaped object of the alloy of claim 29 capable of withstanding an applied stress of 29,000 psi at 1,800.degree. F. without rupture for a time in excess of 40 hours. 36. A nickel base alloy for use at relatively high temperatures consisting essentially of the following elements in the weight percent ranges set forth:

TBL	Elements	Percent
	Chromium	5 - 12
	Aluminum	4 - 8
	Titanium	0.75 - 2.5
	Boron	0.05 - 0.3
	Carbon	0.00 - 0.05

# Pftaps19760113 Wk02

Cobalt	5 - 15.5
Columbium	0.00 - 0.20
Molybdenum	3 - 8
Tantalum	2.3 - 10
Tungsten	0.00 - 2.5
Zirconium	0.00 - 1

PAL the balance of the alloy being essentially nickel and minor amounts of  
 impurities and incidental elements which do not detrimentally affect the  
 basic characteristics of the alloy, said nickel being present in an amount  
 PAR of from about 40% to 80% by weight. 37. The nickel base alloy of claim 36  
 PAR wherein the boron content is about 0.07% to about 0.25% by weight. 38. The  
 nickel base alloy of claim 36 wherein the carbon content is no more than  
 PAR 0.025% by weight. 39. A cast component for use in a gas turbine engine  
 PAR formed of the alloy of claim 36. 40. A cast component for use in a gas  
 PAR turbine engine formed of the alloy of claim 38. 41. A nickel base alloy  
 for use at relatively high temperatures consisting essentially of the  
 following elements in the weight percent ranges set forth:

TBL	Elements	Percent
	Chromium	7.5 - 8.5

# Pftaps19760113 Wk02

Aluminum 5.75 - 6.25

Titanium 0.8 - 1.2

Boron 0.05 - 0.3

Carbon 0.00 - 0.05

Cobalt 9.5 - 10.5

Molybdenum 5.75 - 6.25

Tantalum 4.0 - 4.5

Zirconium 0.05 - 0.10

---

PAL the balance of the alloy being essentially nickel and minor amounts of  
impurities and incidental elements which do not detrimentally affect the  
PAR basic characteristics of the alloy. 42. The nickel base alloy of claim 41  
PAR wherein the boron content is about 0.07% to about 0.25% by weight. 43. The  
nickel base alloy of claim 41 wherein the carbon content is no more than  
PAR 0.025% by weight. 44. A cast component for use in a gas turbine engine  
PAR formed of the alloy of claim 41. 45. The component of claim 44 in which  
PAR said component is a turbine blade. 46. A cast component for use in a gas  
PAR turbine engine formed of the alloy of claim 43. 47. The component of claim  
PAR 46 wherein said component is a turbine blade. 48. A shaped object of the  
alloy of claim 41 capable of withstanding an applied stress of 94,000 psi  
at 1,400.degree. F. without rupture for a time in excess of 120 hours.

# Pftaps19760113 Wk02

PAR A shaped object of the alloy of claim 43 capable of withstanding an applied stress of 29,000 psi at 1,800.degree. F. without rupture for a

PAR time in excess of 40 hours. 50. A nickel base alloy for use at relatively high temperatures consisting essentially of the following elements in the weight percent ranges set forth:

TBL	ELEMENTS	PERCENT
	Chromium	5-22
	Aluminum	0.2-8
	Titanium	0.5-7
	Boron	0.05-0.3
	Carbon	less than 0.05
	Cobalt	2-17
	Columbium	0.00-3
	Molybdenum	0.00-8
	Tantalum	0.00-10
	Vanadium	0.00-2
	Tungsten	0.00-20
	Rhenium	0.00-2
	Zirconium	0.00-1.00

# Pftaps19760113 Wk02

PAL the balance of the alloy being essentially nickel and minor amounts of impurities and incidental elements which do not detrimentally affect the basic characteristics of the alloy, said nickel being present in an amount of from about 35% to 85% by weight. 51. The nickel base alloy of claim 50 wherein the boron content is about 0.07% to about 0.25% by weight. 52. The nickel base alloy of claim 51 wherein the carbon content is no more than 0.025% by weight. 53. A cast component for use in a gas turbine engine formed of the alloy of claim 50. .ladd. 54. The nickel base alloy of claim 50 wherein the molybdenum content is 0.00 - 3% and the tungsten content is 5 - 20%. .laddend..ladd. 55. The nickel base alloy of claim 50 wherein the molybdenum content is 3 - 8%, the tungsten content is < 2.5%, and the tantalum content is 2.3 - 10%. .laddend..ladd. 56. The nickel base alloy of claim 50 wherein the cobalt content is 5 to 15.5% cobalt. .laddend. .ladd. 57. A nickel base alloy for use at relatively high temperatures consisting essentially of the following elements in the weight percent ranges set forth:

TBL	Elements	Percent
	Chromium	5 - 12
	Aluminum	2 - 8
	Titanium	0.5 - 7

# Pftaps19760113 Wk02

Boron	0.05 - 0.3
Carbon	less than 0.05%
Cobalt	2 - 17
Columbium	0.00 - 3
Molybdenum	0.00 - 8
Tantalum	0.00 - 3
Vanadium	0.00 - 2
Tungsten	< 2.5
Rhenium	0.00 - 2
Zirconium	0.00 - 1.00

---

PAL

the balance of the alloy being essentially nickel and minor amounts of impurities and incidental elements which do not detrimentally affect the basic characteristics of the alloy, said nickel being present in an amount of from about 35% to 85% by weight. .laddend..ladd. 58. The nickel base alloy of claim 57 wherein the tungsten and vanadium contents are essentially 0. .laddend..ladd. 59. A cast component for use in a gas turbine engine formed of the alloy of claim 57. .laddend..ladd. 60. The nickel base alloy of claim 57 wherein the carbon content is no more than 0.025% by weight. .laddend. .ladd. 61. A nickel base alloy for use at relatively high temperatures consisting essentially of the following

# Pftaps19760113 Wk02

elements in the weight percent ranges set forth:

TBL	ELEMENTS	PERCENT
	Chromium	5-22
	Aluminum	0.2-8
	Titanium	0.5-7
	Boron	0.05-0.3
	Carbon	less than 0.05
	Columbium	0.00-3
	Cobalt	5-15.5
	Molybdenum	< 3
	Tantalum	0-10
	Vanadium	0.00-2
	Tungsten	0.00-20
	Rhenium	0.00-2
	Zirconium	0.00-1.00

PAL

the balance of the alloy being essentially nickel and minor amounts of impurities and incidental elements which do not detrimentally affect the basic characteristics of the alloy, said nickel being present in an amount of from about 35% to 85% by weight. .laddend..ladd. 62. The nickel base

# Pftaps19760113 Wk02

alloy of claim 61 wherein the carbon content is no more than 0.025% by weight. .laddend..ladd. 63. The nickel base alloy of claim 61 wherein the chromium content is 5 - 12% and the tungsten content is 5 - 20%. .laddend. .ladd. 64. The alloy of claim 61, which contains, on a weight basis, about 2.3% to about 10% tantalum. .laddend..ladd. 65. The alloy of claim 64 which contains, on a weight basis, 5-20% tungsten. .laddend..ladd. 66. The alloy of claim 61, which contains, on a weight basis, less than 3% tantalum. .laddend..ladd. 67. The alloy of claim 14 which contains, on a weight basis, 0 to about 3% molybdenum, 0 to about 3% tantalum, about 5% to about 20% tungsten, and about 0.001 to about 0.5% zirconium. .laddend..ladd. 68. The alloy of claim 18, which contains, on a weight basis, about 3% to about 8% molybdenum, about 2.3% to about 10% tantalum, and 0 to about 2.5% tungsten.

PATN	
WKU	RE0286826
SRC	5
APT	2
PBL	E
ART	164
APD	19750609
TTL	Decorative laminate

# Pftaps19760113 Wk02

ISD	19760113
NCL	4
ECL	1
EXP	Van Balen; William J.
INVT	
NAM	Hoey; Charles E.
CTY	Marlton
STA	NJ
ASSG	
NAM	Rohm & Haas Company
CTY	Philadelphia
STA	PA
COD	2
REIS	
COD	50
APN	255879
APD	19720510
PNO	3804700
ISD	19740416
CLAS	
OCL	428196

# Pftaps19760113 Wk02

XCL	428159
XCL	428201
XCL	428202
XCL	428211
XCL	428315
EDF	2
ICL	B32B 326
FSC	428
FSS	159;196;201;202;211;315;321;322
FSC	156
FSS	77;78;79
UREF	
PNO	3336180
ISD	19670800
NAM	Werner
OCL	428315
UREF	
PNO	3446685
ISD	19690500
NAM	Goldstone et al.
OCL	428167

# Pftaps19760113 Wk02

UREF

PNO 3496043

ISD 19700200

NAM Ragan

OCL 428315

UREF

PNO 3528866

ISD 19700900

NAM Stevens

OCL 428322

UREF

PNO 3591401

ISD 19710700

NAM Snyder et al.

OCL 428310

UREF

PNO 3607341

ISD 19710900

NAM Goins et al.

OCL 428314

UREF

# Pftaps19760113 Wk02

PNO 3647607

ISD 19720300

NAM Hillers

OCL 428159

UREF

PNO 3700515

ISD 19721000

NAM Terry

OCL 428 97

OREF

PAL Plastics/Paper, Warren Co. Div. Scott Paper, Nov. 1968, 6 pages.

PAL Release Paper Information, Warren Co. Div. Scott Paper, Nov. 1970, 2 pages.

PAL Plastics/Paper, Warren Co. Div. Scott Paper, 1971, 14 pages.

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LREP

FR2 Strobaugh; Terence P.

ABST

PAL A procedure is provided for producing a laminate having a textile backing, a crushed, thermoset plastic foam bonded thereto, and a transparent polymeric film, preferably also a thermoset, which may be printed or colored overall overlying the foam. The structure is self-bonded, i.e., no

# Pftaps19760113 Wk02

adhesive is used to bond the laminate to one another. The preferred procedure is to apply a thin layer of foamed latex of a thermosettable polymer on a textile followed by drying the foam, the thickness of the foam being between about 10 mils and 150 mils. The transparent film, preferably thermosetting, is suitably formed by casting a latex upon a release surface such as silicone release paper and drying the same without causing thermosetting (if a thermosettable polymer is utilized). The dry film, still on the release paper, is then suitably coated or printed with a decorative design. The decorated side of the film is then placed against the dried foam layer and bonded thereto by pressure. The thermosetting may be done simultaneously with bonding or subsequently thereto.

BSUM

PAR

This invention relates to a decorative laminate such as a simulated oil painting and a process for its manufacture. The laminate consists of a substrate such as a textile fabric, a crushed, thermoset foam self-adhered thereto and a top layer of of a clear film, which may be printed or otherwise colored by coating, pigmenting, or dyeing. The printed or coated side of the film can be adhered to the foam to encapsulate the color in order to protect it from abrasion, cleaning, etc. Preferably the film is also thermoset. The laminae are self-adhered or self-bonded; i.e., no extraneous adhesive is needed.

# Pftaps19760113 Wk02

PAR

In the past, similar laminates have been made without a foam interlayer, and unless the clear film is exceptionally thick, the product is not exemplified below.

subject to embossing in such a way as to keep the backing in substantially planar form. Where an interlayer has been used between the decorative material and the substrate, it has either been a resilient material of a relatively massive thickness or in some cases a thermoplastic material. Where forms have been used for this function, the foam is either of such light weight and low density that a fabric-like hand could not be obtained, or is a dense foam provided by controlling the amount of blowing or foaming agent or controlling the extent of expansion, the product thus being relatively stiff and inflexible and again does not have the hand of a soft fabric. Commonly in laminating fabrics to foams or foams to other layers such as a transparent film, the practice is to use a separate adhesive layer for such bonding or to use thermoplastic materials which can be softened and bonded by heat and pressure. The present invention makes it unnecessary to use such adhesive, thus substantially reducing the number of operations necessary to achieve the product of the invention.

PAR

In a preferred embodiment of the present invention, the clear film is prepared from a latex as is the foam interlayer. Also, it is preferred that the clear film be thermosetting and that it be cured only after being

# Pftaps19760113 Wk02

in contact with the dry thermosettable foam and that the curing take place, of course, subsequent to or simultaneous with crushing or embossing the foam. Curing of the composite may also be delayed until fabrication, where the composite can be heat sealed to produce seams without sewing.

PAR

In a specific preferred embodiment, a clear cross-linkable or thermosettable acrylic film is desposited in the form of a latex onto release paper coated with a silicone release coating, the film is dried without thermosetting, and a decorative material is printed on the dried clear film while still on the release paper. A similar crosslinkable acrylic polymer in latex form is foamed, preferably by means of whipped in air and in the presence of a foam stabilizer, the foam is then applied to a fabric, woven or non-woven, and gelled and dried without causing crosslinking. The printed side of the clear film and the foamed surface of the fabric-foam laminate are then juxtaposed, the foam is reduced in thickness by pressure, with or without embossing a design in the laminate, and the clear film and foam layer are heated to a temperature sufficiently high to crosslink and thermoset the polymers. Other clear films may be used and other thermosettable foams may be used, but in every case the foam is thermoset only after being reduced in thickness. The foam, when a latex, is initially foamed to a wet foam density of about 0.5 to 0.05 grams per cubic centimeter and is applied in a thickness of from about 10

# Pftaps19760113 Wk02

to 150 mils. The density, of course, will vary with the presence or absence of pigments and fillers and their identity. The foam is then dried without causing thermosetting, crosslinking, or vulcanization to a sensibly dry condition, for example, to an air-dry or sensibly dry state, for example, by heating at a temperature below that which causes said thermosetting, crosslinking, or vulcanization, an example being from 1 to 10 minutes at an oven temperature of 200.degree.-350.degree.F., followed preferably after having placed the decorated side of the clear film and the surface of the foam together, by crushing the foam to a thickness between 5 percent and 25 percent of its original dry thickness to give a density of about 0.2 to 3 g./cc..sup.3, followed by curing of the crushed foam. In general, the thickness of the dried foam prior to crushing may be substantially less than that of the wet foam, there at times being some shrinkage. This shrinkage is in the range of 0 to 30 percent of the thickness of the wet foam being lost during drying. Suitable moisture contents range from 5 percent to 15 or 20 percent in order to qualify as air dry or sensibly dry materials. The criteria as to moisture content is that the foam must be stable enough to be self-bonded to the top film. Of course, in a system wherein a chemical blowing agent is used to form the foam or in which a solvent system is utilized to form the foam, when the foam is dried it is essentially anhydrous. In some cases cross-linking may

# Pftaps19760113 Wk02

be accomplished by catalysis rather than primarily by the application of heat. Of course, the foam may be crushed before it is self-bonded to the surface film, but in this case a crushing roll having a release coating such as a silicone or Teflon is desirable. Normally no adhesive is needed between the foam and the textile or between the decorated surface of the clear film and the surface of the foam, since a thermosettable foam is used, and the final curing of the foam causes a firm bond between the layers.

PAR

Crushed foam is essential, since if the initial foam is formed to the final density by control of the amount of foaming agent or by means such as using a chemical blowing agent and restraining the expansion in order to get the final density, the walls or struts connecting the air spaces are relatively thick. A crushed foam, on the other hand, initially having expanded to a number of times its final thickness, has connective walls or struts of a thin flexible nature. The result is that the crushed foam is much more flexible than a foam initially expanded to the density noted above. These foams are inherently opaque. The opacity can be compared with the opacity of whipped egg whites; the liquid egg white is substantially transparent and the gas cells incorporated therein confer opacity upon the whipped froth.

PAR

When pigmented compositions are contemplated, examples of the pigments that

# Pftaps19760113 Wk02

may be employed include clays especially of the kaolin type, calcium carbonate, blanc fixe, talc, titanium dioxide, colored lakes and toners, ochre, carbon black, graphite, aluminum powder or flakes, chrome yellow, molybdate orange, toluidine red, copper phthalocyanines, such as the "Monastral" blue and green lakes. If dyed compositions are used, examples of dyes for acrylic film and foam include basic and dispersed dyes. Other composites could be made dyeable, if not inherently so, through the use of additives such as methyl cellulose, hydroxyl ethyl cellulose, and the like. Other dyes which could be used include acid dyes, vat dyes, direct dyes, and fiber reactive dyes.

PAR

The clear film is preferably cast from a single acrylic latex (thickened if necessary) or other suitable latex such as carboxylated SBR containing antioxidants or UV stabilizers, polyvinyl chloride, ethylene polyvinyl chloride, polyvinylidene chloride, polyvinyl acetate, polyvinyl alcohol as well as copolymers of these latices. The film has delayed cure properties built into it where stringent durability requirements (resistance to multiple washing and drycleaning) exist.

PAR

The film may be cast from two or more latices to achieve specific effects. For example, the "first-down" basecoat latex can be selected for its toughness and its freedom from residual tackiness. The "second-down" topcoat can be a softer material providing more plastic flow under heat

# Pftaps19760113 Wk02

and pressure to achieve embossing, lamination and heat sealing where necessary.

PAR

The finish on release paper (or other suitable release medium) can be picked up by the transfer film when it is pulled off of the release medium to provide a surface finish for other specific effects. For example, silicone surfaced release paper can be engineered so that some of the silicone goes with the film when it is pulled off the release paper to provide the water repellency.

PAR

Solvent systems can be used instead of latices alone, or in combination with aqueous systems where multilayer films are made as previously described. For example, a solvent saran first-down coat can be topped with an aqueous coating so that the composite film, when pulled off release paper and inverted, would expose a tack-free saran outer surface.

PAR

The films can be made breathable by mechanically foaming the latex before casting, mechanically puncturing the film, using chemical blowing agents or dissolving or digesting out temporary fillers placed in the latex before it is cast. An example of the latter method would be the use of starch granules in the mix before casting, subsequently digesting the starch granules with an enzyme leaving pores in the film.

PAR

For specialty effects, the film can be colored by pigmenting the liquid medium before casting, adding dyes to the liquid medium before casting,

# Pftaps19760113 Wk02

post-dyeing the composite or vacuum metalizing the film after casting.

Another includes printing or coating the release medium with pigments or ink which would be transferred to the film after it is dried and pulled away from the release medium.

PAR

A delayed cure acrylic film is preferred which provides freedom from plasticizer as a means of minimizing pollution as well as avoiding the possibility that plasticizer migration will cause the foam and film to separate eventually. In addition, there is a distinct likelihood that the presence of plasticizers in either the film or the foam will cause printing inks to bleed distorting decorative effects.

PAR

While the preferred clear (essentially transparent) film is that obtained from a crosslinkable acrylic latex as suggested herein, other crosslinkable latices are useful as are preformed films. Examples of other latices are crude rubber in which 3 percent of the polymer is in the form of combined maleic anhydride, butadiene-styrene polymers and butadiene-acrylonitrile polymers containing 3 percent to 5 percent carboxylated groups, carboxylated polyisoprene, and other natural and artificial polymers modified to have cross-linkable or thermosettable functionality. In each case, external crosslinkers such epoxy epoxy resins are used. As is implied by the above, the same general types of crosslinkable polymers are useful for both the clear film and the foam.

# Pftaps19760113 Wk02

PAR

Thermoplastic films which may be used include polyvinyl chloride, ethylene-vinyl chloride copolymer, polyvinylidene chloride, polyvinyl acetate, polyvinyl alcohol and copolymers thereof, saran, polyurethane, Mylar, Tedlar (polyvinyl fluoride), ethylene-vinyl acetate, and the like. Similar preformed films can be made from ethylene-Vinyl acetate, ethylene-methyl acrylate, ethylene-ethyl acrylate copolymers, ionomers, vinyl chloride-propylene, vinyl chloride-ethylene, vinyl chloride-acrylate, polyethylene, nylons, and chlorotrifluoroethylene, polyester, polycarbonate, and the like. While many of the clear thermoplastic films are useful, they are not nearly so desirable as the thermosetting clear films deposited from latices, or less desirably from an organic solvent solution.

PAR

An embossed textured surface will not always be necessary and the composite can be made by simply adhering the film/foam/textile having a flat surface. Where a three dimensional effect is desired, this can be achieved by using embossed rolls or plates, nipping the composite through rolls or plates at the same time as embossed paper is passed through the nip or casting the film on release paper which has previously been embossed to such a depth that a flat surface of film is achieved for printing if necessary. Subsequently, the film on embossed release paper and the foam on the supporting substrate are run through a plain nip and the embossed

# Pftaps19760113 Wk02

pattern is imparted through the composite by the embossed release paper on which the film was originally cast. After the marriage, the embossed release paper can be pulled away from the composite and reused. After crushing the foam and embossing, if used, the laminate is cured (thermoset, cross-linked) by heating at a suitable temperature, for example, 1 to 5 minutes at 275.degree.-375.degree. F.

PAR

An important advantage in utilizing a dried but uncured foam of a crosslinkable polymer and a dried but uncured clear film, printed or not, is that the two elements can be passed through the nip of a pair of rollers, the distance between which is small enough to "marry" the two but insufficient to crush the dried foam, all without using an adhesive to bond the foam to the fabric or other substrate and to bond the foam to the clear printed or unprinted film. Of course, bonding of the dry foam and the clear film can be done at a pressure sufficient to crush the foam with or without embossing the same. Even after crushing, the foam has sufficient resilience to be embossed with a patterned roller. If desired, the embossing roller may be heated to the curing temperature of the thermosetting film and foam, although normally a period of time is required which necessitates passing the laminate through an oven.

PAR

For a description of suitable conventional foaming procedures and foam stabilizers and foaming agents, reference is made to Madge, E. W., "Latex

# Pftaps19760113 Wk02

Foam Ruber," John Wiley and Sons, New York (1962) and Rogers, T. H., "Plastic Foams," Paper, Reg. Tech. Conf., Palisades Sect., Soc. Plastics Engrs., New York, November, 1964. Most common are the alkali metal, ammonia, and amine soaps of saturated or unsaturated acids having, for example, from about 12 to about 22 carbon atoms. Examples of suitable soaps include tallow soaps and coconut oil soaps, preferably the volatile amine or ammonia soaps, so that the volatile portion is vaporized from the foam. Other useful foaming-foam-stabilizing agents include lauryl sulfate-lauryl alcohol, lauryl sulfate-lauric acid, sodium lauryl sulfate, and other commonly used foamed stabilizers or foaming agents.

PAR

It is to be understood that the foam may be laminated to other substrates. Examples of such substrates include woven and non-woven fabrics, plastic films, rigid plastics, leather substitutes, leather, paper, wood including plywood, metals such as of steel, iron, aluminum, copper, brass, zinc which may be bare or primed such as with an epoxy or with an epoxy/aminoplast priming layer, and so forth.

PAR

Suitable woven and non-woven textile substrates include fiberglass, nylon taffetas and tricots, texturized polyester fabrics, cotton duck, Spandex knits, woolens and worsteds, flocked fabrics, rayon fabrics and blends of natural and synthetic fibers. The textile may be simply a functional supporting substrate or a textile having a pre-finished "face" to serve as

# Pftaps19760113 Wk02

the outer surface of the composite or as a lining. An example is a synthetic pile fur fabric, the back of which is used to function as the supporting substrate for the foam/film to end up with a composite having two functional and aesthetically appealing surfaces. Such a composite could be used to make a reversible coat which would have a leather-like texture on one side and a fur texture on the other. Non-wovens are made by air lay, dry lay, wet lay and spun-bonded processes. Various forms of paper and paperboard may also be used. Tissue is included as paper in this description.

PAR

The latex, when formulated with the foam stabilizer and optionally, suitable pigments, is readily convertible into the foamed state. The polymer composition is such that excessive thickening of the formulation is not encountered under the acid or alkaline conditions employed to assure the most efficient operation of the foam stabilizing agent. In addition the copolymer is such that the crushed foam retains its softness and its flexibility at low temperatures at least to a temperature as low as 10.degree. F., and after curing is non-tacky. In addition, the foam is resistant to washing in normal detergents used for cleaning of textiles in general and drapery fabrics in particular and is resistant to drycleaning. By providing a foam that is durable to drycleaning and to washing the foam is quite useful for textiles which are frequently subjected to drycleaning

# Pftaps19760113 Wk02

and washing operations.

PAR

An important property of the polymer for both the foam and the clear film is the glass transition temperature (Tg) thereof, and consequently the selection of monomers and proportions thereof depends upon their influence on the Tg. The Tg of the polymer for the foam is suitably between -60.degree. and 35.degree. C. For the clear film, it is normally between -30.degree. and 100.degree. C. "Tg" is a conventional criterion of polymer hardness and is described by Flory, "Principles of Polymer Chemistry," pp. 56 and 57, (1953), Cornell University Press. While actual measurement of the Tg is preferred, it may be calculated as described by Fox, Bull. Am. Physics Soc. 1, 3, p. 123 (1956). Examples of the Tg of homopolymers and the inherent Tg thereof which permits such calculations are as follows:

TBL

Homopolymer of	Tg
n-octyl acrylate	-80.degree.C.
n-decyl methacrylate	-60.degree.C.
2-ethylhexyl acrylate	-70.degree.C.
octyl methacrylate	-20.degree.C.
n-tetradecyl methacrylate	9.degree.C.
methyl acrylate	9.degree.C.

# Pftaps19760113 Wk02

n-tetradecyl acrylate 20.degree.C.

methyl methacrylate 105.degree.C.

acrylic acid 106.degree.C.

---

PAL These or other monomers are blended to give the desired Tg of the copolymer. As is known, for a given number of carbon atoms in the alcohol

PAR Examples of compounds of formula IV include:  
moiety, the extent and type of branching markedly influences the Tg, the straight chain products giving the lower Tg. Most of the esters of acrylic acid or methacrylic acid having a low Tg are well known in the art.

PAR One of the monomers utilized in a substantial proportion to prepare the preferred clear films and foam is a "soft" monomer which may be represented by the following formula:

##EQU1##

wherein R is H or alkyl having one to four carbon atoms and R' is the straight chain or branched chain radical of a primary or secondary alkanol, alkoxyalkanol or alkylthiaalkanol, and having up to about 14 carbon atoms, examples being ethyl, propyl, n-butyl, 2-ethylhexyl, heptyl, hexyl, octyl, propyl, 2-methylbutyl, 1-methylbutyl, butoxybutyl, 2-methylpentyl, methoxymethyl, ethoxyethyl, cyclohexyl, n-hexyl, isobutyl, ethylthiaethyl, methylthiaethyl, ethylthiapropyl, n-octyl, 6-methylnonyl,

# Pftaps19760113 Wk02

decyl, dodecyl, and the like, said radicals R<sup>1</sup>, when alkyl, having from two to about 14 carbon atoms, preferably from three to 12 carbon atoms, when R is H or methyl. When R is alkyl and R<sup>1</sup> is alkyl, R<sup>1</sup> should have from about six to about 14 carbon atoms and when R is H and R<sup>1</sup> is alkyl, R<sup>1</sup> should have from about two to about 12 carbon atoms, in order to qualify as a soft monomer.

PAR

Other ethylenically unsaturated copolymerizable monomers having a T<sub>g</sub> of above 0.degree. C. are useful in combinations with the above mentioned soft monomers provided they do not adversely affect the desired properties of the polymer (e.g., unduly raise the overall T<sub>g</sub>) and do not seriously interfere with the crosslinking. These may be represented by the formula:

##EQU2##

wherein R is as above. R<sup>2</sup> is preferably alkyl and is methyl or alkyl having from about 13 to about 20 carbon atoms when R is H, and is alkyl of from one to about five carbon atoms or alkyl of from about 15 to about 20 carbon atoms when R is methyl. It can be seen from about that for alkyl acrylates and alkyl methacrylates the T<sub>g</sub> at first decreases with an increased chain length of the alkyl group and then the T<sub>g</sub> again increases; i.e., both hard and soft monomers are known to occur in each group of monomers. Examples of these hard monomers and other hard monomers include: methyl acrylate, acrylamide, vinyl acetate, tetradecyl acrylate,

# Pftaps19760113 Wk02

pentadecyl acrylate, methyl methacrylate, ethyl methacrylate, t-butyl acrylate, butyl methacrylate, styrene, pentadecyl methacrylate, vinyl toluene, methacrylamide, and N-methylolacrylamide.

PAR

The preferred emulsion copolymers, for both the foam and the clear layer, having a molecular weight of between about 70,000 and 2,000,000, and preferably between about 250,000 and 1,000,000 and are made by the emulsion copolymerization of the several monomers in the proper proportions. Conventional emulsion polymerization techniques are described in U.S. Pat. Nos. 2,754,280 and 2,795,564. Thus, the monomers may be emulsified with an anionic, a cationic, or a nonionic dispersing agent, about 0.05 percent to 10 percent thereof ordinarily being used on the weight of the total monomers. The acid monomer and many of the other functional or polar monomers may be soluble in water so that the dispersing agent serves to emulsify the other monomer or monomers. A polymerization initiator of the free-radical type, such as ammonium or potassium persulfate, may be used alone or in conjunction with an accelerator, such as potassium metabisulfite, or sodium thiosulfate. Organic peroxides, such as benzoyl peroxide and t-butyl hydroperoxide are also useful initiators. The initiator and accelerator, commonly referred to as catalyst, may be used in proportions of 0.1 percent to 10 percent each based on the weight of monomers to be copolymerized. The amount, as

# Pftaps19760113 Wk02

indicated above, may be adjusted to control the intrinsic viscosity of the polymer. The temperature may be from room temperature to 60.degree. C. or more as is conventional.

PAR

Suitable dispersing agents useful in emulsion polymerization include anionic types such as the sodium salts of the higher fatty acid sulfates, such as that of lauryl alcohol, the higher fatty acid salts, such as the oleates or stearates or morpholine, 2-pyrrolidone, triethanolamine or mixed ethanolamines, or any of the nonionic types, such as ethylene oxidemodified alkyl phenols, of which tert-octyl phenol modified by 20 to 40 ethylene oxide units is representative, ethylene oxide-modified higher fatty alcohols such as lauryl alcohol, containing 20 to 50 ethylene oxide units, similarly modified long-chain mercaptans, fatty acids, amines, or the like. Mixtures of nonionic and anionic dispersing agents are also useful.

PAR

Although emulsion polymers are preferred, polymers prepared in organic solutions, e.g., in xylene, methyl "Cellosolve" and the like, by well-known conventional means such as free-radical initiation with benzoyl peroxide or the like are also useful. Solution polymers useful in the invention preferably have a molecular weight of between about 10,000 and 1,000,000.00

PAR

There are essentially two types of latent cross-linking which can be used.

# Pftaps19760113 Wk02

These are (1) crosslinking subsequent to polymerization by including monomers in the polymer recipe which have functional groups capable of crosslinking by various mechanisms including self-crosslinking, or mutual crosslinking by different functional groups, both in the polymer chain, and (2) latent crosslinking by means of an external separately added chemical compound. Combinations can be used.

PAR

The foam is subjected to latent crosslinking, after drying and crushing.

Where addition polymers are involved, monomers which are suitable for this function include certain acrylics having crosslinkable functionality

PAR

Examples of the crosslinking reactions which are possible using heat, aging, and/or catalysis are:

##EQU3##

In the above, R is H or CH<sub>3</sub>. Addition polymerizable unsaturated monomers containing such groups are well known in the art, examples being isocyanates such as isocyanatoethyl methacrylate, epoxy compounds such as glycidyl methacrylate, aminoalkyl compounds such as methylaminoethyl methacrylate, and t-butylaminoethyl methacrylate, amides such as methacrylamide, guanamines such as 4-pentenoquanamine, hydroxyalkyl esters such as hydroxypropyl methacrylate and hydroxyethyl methacrylate, nitriles such as methacrylonitrile, N-alkoxyalkyl amides such as methoxymethyl methacrylamide, hydroxyalkyl amides such as N-methylol methacrylamide, the

# Pftaps19760113 Wk02

analogous of the above methacrylic acid derivatives with other unsaturated acids such as acrylic acid and itaconic acid, such acids themselves, dicarboxylic acids such as maleic acid and half esters and half amides thereof, vinyl ethers of glycols such as ethylene glycol, and so forth.

PAR As may be seen, the crosslinkable addition polymerizable unsaturated monomers have reactive polar groups selected from those including --OH, --SH,

##EQU4##

Such groups may be included as are mutually or self-crosslinkable, or separate crosslinking compounds such as a triazine-formaldehyde resin may be added, as is well known.

PAR Of course, water sensitive materials such as isocyanates should not be used in aqueous systems unless they are blocked by groups such as phenol groups which protect the isocyanate groups until subsequent heating or the use of other reaction mechanisms such as the use of a calcium, zinc, or tin compound catalyst conventional in the art.

PAR There is thus included within the copolymer up to 20 percent by weight of such functional, polar, or reactive monomer, preferably an unsaturated carboxylic acid, half esters and half amides of .alpha.-unsaturated dicarboxylic acids, and salts thereof with ammonia, an alkali-metal, such as sodium, potassium or lithium, or with a volatile water-soluble amine

# Pftaps19760113 Wk02

such as dimethylamine or triethylamine, in order to provide the cross-linking functionality. Examples of copolymerizable ethylenically unsaturated monocarboxylic or polycarboxylic acids are sorbic, cinnamic, vinyl furoic, .alpha.-chlorosorbic, p-vinylbenzoic, acrylic, methacrylic, maleic, fumaric, aconitic, atropic, crotonic, and itaconic acid, or mixtures thereof, with itaconic acid and the .alpha., .beta.-unsaturated monocarboxylic acids, particularly methacrylic acid and acrylic acid, being preferred. Other copolymerizable acid monomers include the alkyl half esters or partial esters of unsaturated polycarboxylic acids such as of itaconic acid, maleic acid, and fumaric acid, or the partial amides

APD

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thereof. Preferred half esters are the lower alkyl (C.sub.1 to C.sub.6) esters such as methyl acid itaconate, butyl acid itaconate, methyl acid fumarate, butyl acid fumarate, methyl acid maleate, and butyl acid maleate. Such partial esters and partial amides are considered to be ".alpha.,.beta.-unsaturated monocarboxylic acids," and the term as used herein includes such esters and amides.

PAR

In addition to or in place of the acids, amides such as acrylamide and methacrylamide, 2-sulfoethyl methacrylate, the materials disclosed in U.S. Pat. No. 3,446,777 to W. D. Emmons, U.S. Pat. No. 3,150,118 to D. H. Clemens, and U.S. Pat. No. 3,266,930 to W. D. Emmons and E. Hankins Owens,

# Pftaps19760113 Wk02

and various other functional, polar, or monomers having groups which remain reactive after the polymer is formed, for example, falling within the definitions of formulas II, III, IV, and V, are also useful, as

follows:

##SPC1##

PAL where R<sup>0</sup> is selected from the group consisting of H and alkyl groups having one to four carbon atoms, and

PA1 n is an integer having a value of 1 to 4,

PA1  $\text{CH}_2 = \text{C}(\text{R}^1)\text{R}^2$  (iii)

PAL where R is selected from the group consisting of H and CH<sub>3</sub>,

PA1 A is selected from the group consisting of O, S,

##EQU5##

Y is an alkylene group having two to four carbon atoms, R<sup>1</sup> is

selected from the group consisting of H and an alkyl group having one to four carbon atoms, and

PA1 R<sup>2</sup> is selected from the group consisting of H and an alkyl group having one to four carbon atoms,

##EQU6##

where R is the same as above, and Z is an alkylene group having two to three carbon atoms.

PAR Examples of compounds of formula II include: 2-vinylpyridine;

# Pftaps19760113 Wk02

4-vinylpyridine; 2-methyl-5-vinylpyridine; 5-methyl-2-vinylpyridine;

4-methyl-2-vinylpyridine; 2-ethyl-5-vinylpyridine;

2,3,4-trimethyl-5-vinylpyridine; 3,4,5,6-tetramethyl-2-vinylpyridine;

3-ethyl-5-vinylpyridine; 2,6-diethyl-4-vinylpyridine.

PAR

Examples of compounds of formula III include: dimethylaminoethyl acrylate

and methacrylate; diethylaminoethyl acrylate and methacrylate

dimethylaminopropyl acrylate and methacrylate; diethylaminopropyl acrylate

and methacrylate; dipropylaminoethyl acrylate and methacrylate;

di-n-butylaminoethyl acrylate and methacrylate; di-sec-butylaminoethyl

acrylate and methacrylate; di-t-butylaminoethyl acrylate and methacrylate;

dimethylaminoethyl vinyl ether and sulfide; diethylaminoethyl vinyl ether

and sulfide; aminoethyl vinyl ether and sulfide; monomethylaminoethyl

vinyl ether and sulfide; N,N-dimethylaminoethyl acrylamide and

methacrylamide; N,N-diethylaminoethyl acrylamide and methacrylamide.

N-[.beta.-(.alpha.-methacryloxyacetamido)ethyl]-N,N'-ethyleneurea;

N-[.beta.-(.alpha.-acryloxyacetamido)ethyl]-N,N'-ethyleneurea;

N-[.beta.-(.alpha.-acryloxyacetamido)ethyl]-N,N'-trimethyleneurea;

N-[.beta.-(.alpha.-methacryloxyacetamido)ethyl]-N,N'-trimethyleneurea.

##EQU7##

where R and Z are as defined above, of which an example is

N-[.beta.-(.methacrylamido)ethyl]-N,N'-ethyleneurea.

# Pftaps19760113 Wk02

PAR

Generally, such functional monomers are present in amounts of from 0.05 to 20 percent, preferably from 0.3 to 10 percent by weight, and more preferably 0.5 to 4.5 percent, based on the total monomers that form the coating or foamable resin.

PAR

The separate added crosslinker, when used, is useful with or without the use of mutual crosslinking groups and self-crosslinking groups. Among the external crosslinking methods or compounds is the use of organic peroxides such as benzoyl peroxide; the use of epoxy resins such as that obtained from bis-phenol A and epichlorohydrin; esterification, by means of dicarboxylic acids reacting with hydroxyl groups in the polymers, or by reacting diols or polyols such as neopentyl glycol, trimethylol propane, trimethylol ethane, or ethylene glycol with carboxyl groups in the polymer; use of aminoplasts such as melamine formaldehyde, urea formaldehyde, or butylated melamine formaldehyde; diamines and polyamines such as hexamethylene diamine, ethylene diamine, and the Versamids; polyisocyanates such as toluylene diisocyanate; compounds with mixed functionality such as ethanolamine, and other well-known external crosslinkers. The invention is not in the use of crosslinking per se but in the utilization of crosslinking and/or the bodying agent to obtain the desired physical characteristics of the foam or clear resin of the invention.

# Pftaps19760113 Wk02

DETD

PAC EXAMPLE 1

PAR An emulsion compolymer dispersion prepared from 2,575 parts deionized water, 87 parts sodium lauryl sulfate, 90 parts acrylic acid, 315 parts acrylamide, 900 parts acrylonitrile, and 7,695 parts n-butyl acrylate is compounded in the following formulation:

TBL Product Solids

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Dispersion	200	100
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Titanium Dioxide

(Titanox RA-45)	25	25
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Clay (Acme WW)	30	30
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Melamine-Formaldehyde

Resin (Aerotex MW)

4.6	3.7
-----	-----

Ammonium Stearate	14	4.6
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Water	70	--
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Ammonia (28%)	4	--
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347.6	163.3
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Solids - 47.0%

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# Pftaps19760113 Wk02

PAL	All parts and percentages are by weight unless otherwise stated.
PAR	Foams are made by whipping air into the formulation using a Kitchen-Aid Mixer (Model C) to a wet density of about 0.16 g. cm. <sup>3</sup> . The foam is then cast at 60 mils onto cotton twill cloth, 19 mils thick and dried for 1.75 minutes at 280.degree. F. to give a dry foam 45 mils thick.
PAR	On a silicone coated release paper 5 mils thick, a latex (50 percent solids) of 65 parts ethyl acrylate, 25 parts butyl acrylate, 5 parts acrylonitrile, 3.5 parts acrylamide and 1.5 parts itaconic acid is cast in a thickness to give a dry film 2 mils thick and dried at 95.degree. C. for 3 minutes. The exposed side of the clear film is printed with a decorative design, and the printed side and dried foam are then placed together and passed through a pair of rollers, at room temperature, with a nip of 20 mils. The release paper is then peeled off. The laminate is then passed between a smooth and an embossed roller, both heated to 250.degree.-300.degree. F., the embossed roll being adjacent the clear film. This embosses the film and foam, crushes the 45 mil thick dry foam to about 8 mils thick, and firmly bonds the film, foam, and fabric. To achieve more complete crosslinking of the foam and film, the composite is heated in an oven for 2 minutes at 300.degree. F.
PAR	The crushed foam has a cold-flex temperature of -15.degree. F.
PAC	EXAMPLE 2

# Pftaps19760113 Wk02

PAR Example 1 is repeated except that 135 parts of itaconic acid, 315 parts of acrylamide, 5,850 parts of ethyl acrylate, 405 parts of acrylonitrile and 2,305 parts of n-butyl acrylate are used as the monomers for the foam.

PAC EXAMPLE 3

PAR Example 1 is repeated except that for the foam 675 parts of acrylonitrile and 2,035 parts of n-butyl acrylate are used and polymer drapery fabric is used. The resultant crushed foam has a cold-flex temperature of 15.degree.

F.

PAC EXAMPLE 4

PAR Example 1 is repeated except that 180 parts of acrylic acid, 315 parts of acrylamide, 900 parts of acrylonitrile and 7,605 parts of n-butyl acrylate are used as the monomers, for the foam.

PAC EXAMPLE 5

PAR Example 1 is repeated except that 45 parts of acrylic acid, 315 parts of acrylamide, 1,800 parts of acrylonitrile and 6,840 parts of n-butyl acrylate are used as the monomers, for the foam.

PAC EXAMPLE 6

PAR Example 1 is repeated but the monomers for the foam consist of 270 parts methacrylic acid, 180 parts acrylamide, 375 parts acrylonitrile, 2,250 parts butyl acrylate, and 5,925 parts ethyl acrylate.

PAC EXAMPLE 7

# Pftaps19760113 Wk02

PAR The procedure described in Example 6 is repeated except the methacrylic acid is replaced with 45 parts of itaconic acid and the amount of butyl acrylate is changed to 2,475 parts.

PAC EXAMPLE 8

PAR The procedure described in Example 1 is followed with an emulsion polymer of 170 parts itaconic acid, 200 parts methacrylic acid, 135 parts acrylamide, 450 parts acrylonitrile, 2,700 parts butyl acrylate, and 3,485 parts ethyl acrylate, to prepare the foam.

PAC EXAMPLE 9

PAR The procedure described in Example 1 is carried out with an emulsion polymer of 135 parts methacrylic acid, 180 parts acrylamide, 630 parts acrylonitrile, 5,400 parts butyl acrylate, and 3,655 parts isopropyl acrylate.

PAC EXAMPLE 10

PAR Example 1 is repeated with an emulsion polymer of 135 parts itaconic acid, 270 parts acrylamide, 630 parts acrylonitrile, 5,400 parts butyl acrylate, 1,285 parts ethyl acrylate, and 1,285 parts methyl acrylate, as the foam. Similar results are obtained when isobutyl acrylate or 2-ethylhexyl acrylate are used in place of butyl acrylate or ethyl acrylate.

CLMS

STM I claim:

# Pftaps19760113 Wk02

NUM	1
PAR	1. A laminate consisting of
PA1	a. a transparent plastic surface film of a thermoset emulsion polymer .ladd.transferred from a release surface and .laddend.adhered to
PA1	b. a crushed, crosslinked thermoset resilient foam of a thermoset emulsion polymer adhered to
PA1	c. a textile fabric substrate, with
PA1	d. a decorative layer between (a) and (b) the crushed foam layer (b) being self-bonded to the substrate (c) and the surface film.
NUM	2
PAR	2. The article of claim 1 in which the surface film has printed thereon a decorative layer (d) between (a) and (b), the article has a fabric like hand, and the crushed foam is less than about 90 mils in thickness.
NUM	3
PAR	3. The article of claim 1 in which reaction products of one or more of a crosslinking group of the structure ##EQU8## provides the crosslinking.
NUM	4
PAR	4. The article of claim 3 in which the foam (b) and the film (a) contain a polymerized unsaturated acid and the crosslinking is provided by a water

# Pftaps19760113 Wk02

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