Oct. 4, 1966 P. E. SOLT ET AL 3,276,753

APPARATUS FOR LIFTING AND BLENDING LOOSE SOLIDS

Filed Aug. 17, 1964 2 Sheets-Sheet 1

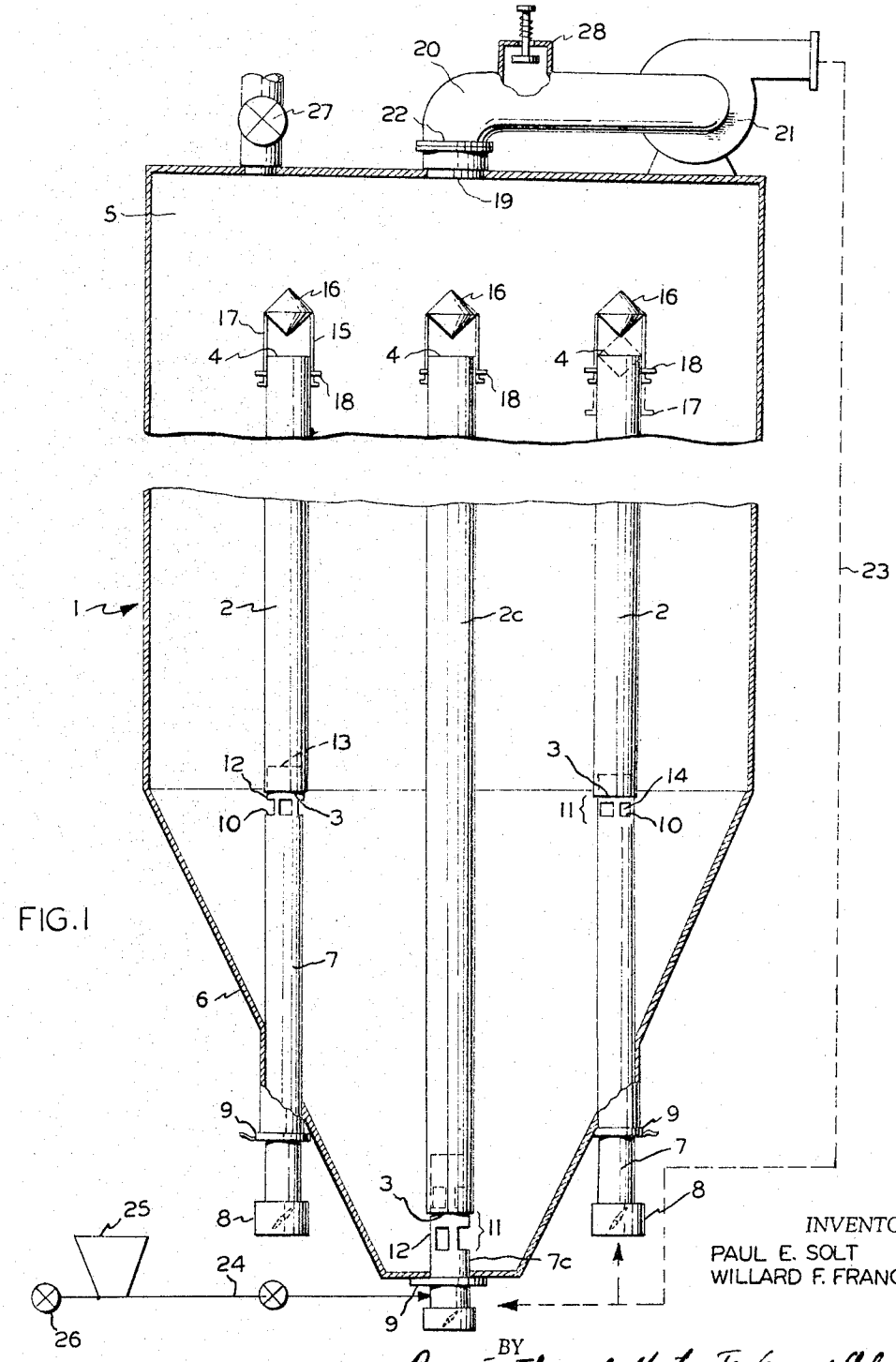

FIG. 1

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APPARATUS FOR LIFTING AND BLENDING LOOSE SOLIDS

Filed Aug. 17, 1964 2 Sheets-Sheet 2

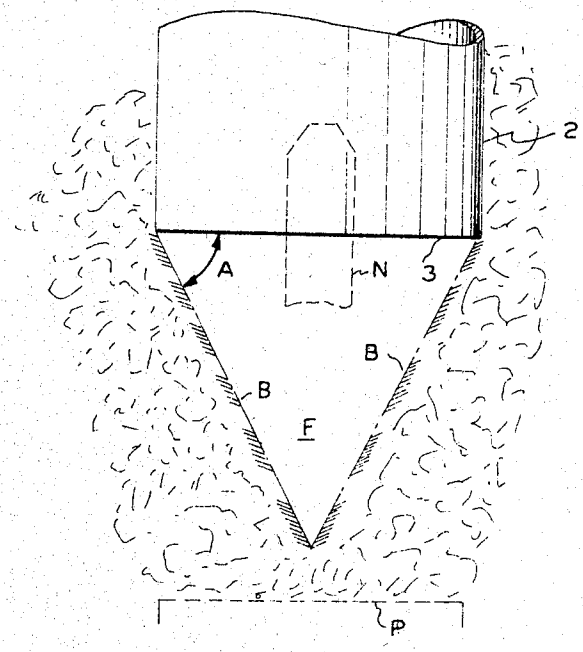

FIG. 3

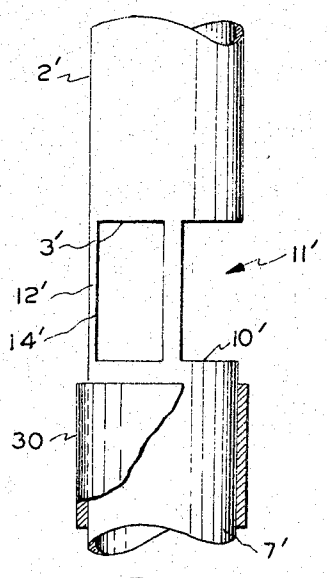

FIG. 4

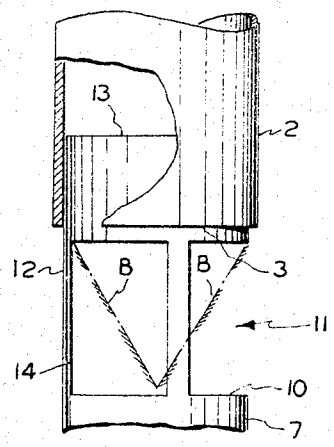

FIG. 2

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United States Patent Office

3,276,753
Patented Oct. 4, 1966

3,276,753

APPARATUS FOR LIFTING AND BLENDING LOOSE SOLIDS

Paul E. Solt, Allentown, and Willard F. Francis, Slatington, Pa., assignors to Fuller Company

Filed Aug. 17, 1964, Ser. No. 390,070
18 Claims. (Cl. 259—95)

The present invention relates to the lifting and blending of loose, discrete solids and is concerned more particularly with such handling of particulate materials, for example, pelleted plastics.

Lift-blending systems are known which use high-pressure blasts or jets of air or gas to suck aspirate material into and through the lift tubes. Other versions have used split streams of gas which combine additional carrying gas with the gas from the material-feeding nozzle.

Such systems use a great amount of horsepower, to produce the required high gas pressure, as well as excessive volumes of gas released in the lift tubes because of the high initial compression at the aspirating nozzle. The result is a high cost, extra-velocity system.

The present invention provides a system which avoids such extremes and which provides additional advantages previously either unavailable or impractical.

Most surprisingly, a form of the present invention enables the use of pressures in the order of a few inches of water-column as a vacuum, or induced draft differential, in contrast to the forced draft or positive pressure differentials—measured in pounds per square inch—which were previously considered necessary.

In general, the preferred form of the present invention comprises at least one lift tube with means for maintaining a supply of material adjacent the intake of the lift tube, and with a lifting gas-flow means including a gas port at least partially within the static respose zone of the material supply and spaced from the intake of the lift tube to form a gravity material intake between the intake and the gas port.

The upper end of each lift tube is positioned to discharge the gas material system into an upper zone, preferably in conjunction with scattering means to provide for scatter-mixing of several streams.

A better understanding for the invention may be derived from the following description and accompanying drawings in which:

FIG. 1 is a view of a preferred form of blender of the present invention;

FIG. 2 is a view of a portion of FIG. 1, on an enlarged scale, showing further detail of the lift-tube intake area;

FIG. 3 is a view similar to FIG. 2, showing a lift tube and gas port of the invention in relation to the characteristic angle of repose of the material; and

FIG. 4 is a view similar to FIG. 2, showing a modified form of the invention.

A preferred form of blender according to the invention is shown in FIGS. 1 to 3. A blending vessel **1** is provided with a plurality of generally vertical gas lift tubes **2** each having its intake **3** within a lower region of the vessel and its discharge **4** within an upper region of the vessel. The lift tube discharges **4** are positioned at substantially the same level, which level is spaced from the top of the vessel **1** a substantial distance to provide a free space or disengaging zone **5**.

The intake **3** of each lift tube **2**, except the central tube **2***c*, is positioned at the same level, which is at substantially the same elevation as the junction or "spring line" between the cylindrical portion of the vessel and its conical hopper **6**. The desired angle of convergence of the hopper should be shown according to the static angle of repose of the material, which is discussed more fully hereinafter. The central lift tube **2***c* extends downwardly toward the apex of the hopper **6** and its intake **3** is positioned adjacent the lower point of the vessel interior.

Below each of the intakes **3** is positioned a conduit section **7**. Each conduit section **7** extends from a point of communication with the atmosphere, at which point it carries a suitable control valve such as a butterfly valve **8**, and passes through a positioning collar **9** in a wall of the vessel **1**. The conduit sections each terminate in a gas port **10** positioned adjacent one of the lift pipe intakes **3** and spaced therefrom to form a gravity material inlet **11**. An extension **12** of each conduit extends across each material inlet **11** and terminates in a sleeve portion **13** slidably engaging the lift tube **2**. The conduit extensions **12** are each provided with a plurality of material ports **14**.

The size and positioning of the gas ports in relation to the lift tubes is of particular importance. As best seen in FIG. 4, a material loosely filled into a zone about a lift tube will flow beneath the lower edge of the tube only to the extent permitted by its characteristic static angle of repose. Therefore, with the material flowing beneath the circular periphery of the tube, an inverted cone of space or free zone F is formed by the filled material when it reaches a static or rest position.

For convenience of description and definition, the zone occupied by a static load of material is hereinafter referred to as the "static repose zone," as opposed to the free zone F referred to above, and is represented by the material shown surrounding the free zone F in FIG. 3.

Of course, once material flow has started, the free zone F will be obliterated by the moving material, but it is the position of the material when at rest after initial filling, which is significant in the present inventon, since gravity will constantly seek to fill the static repose zone.

This position can be predicted sufficiently accurately, without an actual test within the vessel, by determination of the characteristic angle of repose of the particular material. There are several accepted methods for this determinaton, but as the term used here, the static angle of repose is measured angle of declination from the horizontal of the outer surface of a gently poured, conical pile of the material. The steepest angle of several tests preferably will be used, thereby ensuring proper flow into the material inlets as well as along the hopper wall.

The static angle of repose thus determined is then used as the base angle "A" (in FIG. 3) of the material surface line B forming the inverted cone which defines the free zone F. The intersection of diametrically opposite line B, with reference to the diameter of the lift tube **2**, fixes the general depth to which the free zone F will extend below the intake portion of the lift tube. The material-filled space surrounding each free zone F, then is the "static repose zone" referred to herein.

In FIG. 3, the dotted line P within the static repose zone represents the "opened" position of the gas supply port **10** of a conduit section **7** of FIG. 1, relative to the lift tube and its associated free zone F. (The conduit

extension 12 and its material ports 14 are not represented in this figure to avoid confusion of the drawing.)

For contrast, the dotted-line nozzle N shows an upper extreme position of a prior, aspirating high-pressure lift nozzle. Typically, such high pressure nozzles have been placed in various positions within the free zone F, up to and including the tube-penetrating position shown, in order to prevent their plugging with material when the gas flow is interrupted.

It is apparent that a considerable degree of aspirating effect, and therefore power, is required to draw the material across and up to the required position in front of the gas stream issuing from such prior art nozzles. On the other hand, it is apparent that, with a stream of gas issuing from the gas port at position P, or an intermediate position at which material can flow by gravity into the intervening material inlet and in front of at least a portion of the gas stream, only sufficient power is required for accelerating and lifting the material from its gravity-caused position. Also, the use of a single gas port of substantially the same size as the lift pipe not only avoids the need for higher compression, to overcome the pressure loss inherent in narrow nozzles, but also provides a positive-pickup gas stream with a frontal, material-entraining area which is exponentially greater than that available from the prior aspirating nozzles.

At their upper ends, the discharges 4 of the lift tubes are each provided with a scattering means such as an inverted scattering cone 15 to deflect the discharging material stream. Preferably, an upright cone 16 is associated with the scattering cone 15 to prevent accumulation of material thereon and possible contamination of subsequent materials.

Each scattering cone 15 preferably is as light in weight as possible, and mounted on the lift tube 2 by means of rods 17 slidably retained by loops 18 mounted on the lift tube. Therefore, the cones 15 are free to rise into the position shown, in reaction to the flow of gas through the lift tube, and to drop toward and close off the lift tube when the flow is stopped. This is of particular advantage, as will be discussed more fully hereinafter. Other suitable closure means, responsive to gas flow through the lift tube, may be employed.

In the disengaging zone 5 of the vessel and preferably as far as is reasonable above the level of the lift tube discharges 4, an outlet 19 is provided in a vessel wall. The outlet 19 communicates via a conduit 20 with the intake of a fan 21. Preferably, a screen 22 is associated with the outlet 19 to trap any particles which might be deflected toward the outlet.

The embodiment of FIG. 1 discloses an induced draft, or "vacuum" system which incorporates all the advantages of the present invention. It is to be understood, however, that a forced draft system may be substituted, although this would be less advantageous and would require manifolding to the several butterfly valves 8 of conduit section 7.

An alternative of additinoal advantage with materials requiring inert or special gaseous atmospheres, is that of using a combined or closed system. For a closed system, the discharge of the fan 21 is diverted as indicated by the dotted line 23 of FIG. 1, and manifolded to supply each of the valves 8 of the several conduit sections 7.

A feature of especial advantage comprises a self-loading system including a conveying line, shown schematically at 24, connectable to the conduit section 7c of the central lift tube 2c and communicating with a storage bin, portable hopper, bulk truck, railway car or any suitable new material source shown schematically as a hopper 25. When an induced draft system is used, a simple air inlet 26 may be used in the line 24 near the hopper. For forced draft, however, a separate blower, or a remote piping system will be necessary to supply positive pressure air adjacent the hopper. The induced draft system is preferred since, with a flexible form of conduit 24, portable sources such as trucks need not be precisely spotted, and several separate sources—such as storage bins for different materials—may be served without complicated piping. This self-loading means may be used instead of, in conjunction with, or alternately with the usual valved inlet 27.

Preferably, the lift tubes 2 are roughened, such as by sandblasting, as disclosed in Schneider U.S. Patent No. 2,784,038 to inhibit the formation of "ribbons," "floss" or "streamers" when handling polyethylene or similar "smearing" material.

In operation of the system shown in FIGS. 1–3 the several conduit sections 7 are moved upwardly to close the material ports 14. Material, such as polyethylene pellets, is then filled through the inlet 27.

Alternatively, if the vessel is to be filled via the hopper 25, the fan 21 is started, after the material inlets have been closed and after all but the central butterfly valve 8c have also been closed. Air is then drawn by the fan through the conveying air inlet 26 and the conveying line 24 into the conduit section 7c of the central lift tube 2c, and upwardly therethrough to the outlet 19. Upon introduction of material via the hopper 25, the material is entrained through the conveying line 24 and upwardly through the central lift tube 2c. The scattering cone 15 scatters the material stream over the disengaging zone 5 to fall exterior the lift tubes and accumulate in the vessel hopper 6. The closure of the discharges 4 by the cone 15 prevents entrance of material to the remaining pipes. A significant blending may be achieved in filling the vessel via the conveying line 24, as will be discussed more fully hereinafter.

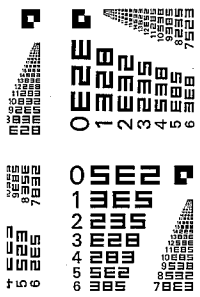
With an accumulation of material in the vessel, the fan 21 is started and at least one valve 8 is opened if filling was via the inlet 27. If filling was via the conveying line 24, the line is closed by any suitable means such as a valve, and at least one of the butterfly valves 8 is opened to supply lift air to the system.

With an air flow established in a given one of the lift tubes, the conduit section 7 of that tube is moved down to place its gas port 10 within the static repose zone, exposing the material ports 14 and permitting a gravity flow of material through the inlets to a position in front of the gas port 10. The wide stream of gas flowing from the gas port 10 to the lift tube intake 3 entrains the material thus presented in its flow path and carries it upwardly through the lift tube for dispersion through the disengaging zone 4 by the scattering cone 15.

One or more of the lift tubes may be started at a time, but it is thought best to start less than the full number, when there are several in a large installation, to avoid possible stalling or plugging of some by too abrupt a transition from simple gas flow to the greater loading of multiple gas material streams. When all lift tubes are on stream, the operation is continued for the duration necessary to effect the desired degree of blend. This duration will vary, as in any blender, according to the original variation between the materials and the degree of uniformity required.

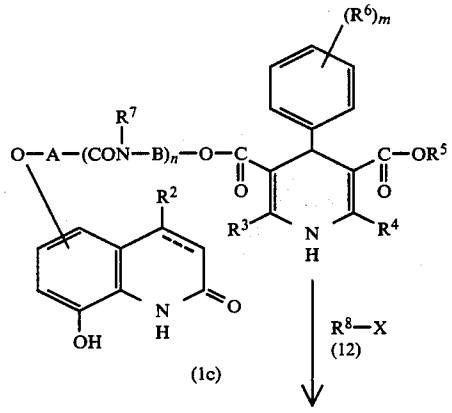
If one of the lift tubes becomes plugged, for any reason, the unit of FIGS. 1 to 3 provides for a particularly effective recovery of the system. The material inlet of the plugged tube is closed. The closing of a material inlet, and then the air-control butterfly valve 8 of another of the lift tubes is then effected, thus applying a greater pressure differential on the plugged pipe. If the shut-down of one of the lift tubes is not adequate, more tubes may be shut off, in succession, until sufficient pressure drop is imposed on the plug to cause it to break loose. When the clogged pipe is cleared, the shut-down lift tubes are re-started.

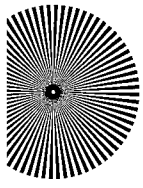
Alternatively, in installations employing induced draft and where the value of the material is not prohibitive,



8 PT.

Carbostyril derivative or a pharmaceutically acceptable acid addition salt thereof, having excellent platelate aggregation inhibitory effect, calcium antagonism, hypotensive effect and phosphodiesterase inhibitory effect are useful as prophylactic or treating agents for thrombosis, circulation improving agents for coronary blood flow such as coronary vasodilators, hypotensive agents and phosphodiesterase inhibitors. Furthermore, the carbostyril derivatives are weak in heart rate increasing activity and also in cardiac muscle contraction increasing activity, and the carbostyril derivatives are useful





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$$\cos\beta^* = \frac{K_2 - n\frac{T''}{v''}}{\sqrt{K_1^2 + \left(K_2 - n\frac{T''}{v''}\right)^2 + K_3^2}}$$

$$v'_{refl}(t) = K\,r\,\delta\left(t - \frac{2L - 2d_s}{v_w}\right) + K(1 - r^2)e^{-2\alpha_s d_s}$$

4 PT.

Carbostyril derivative or a pharmaceutically acceptable acid addition salt thereof, having excellent platelate aggregation inhibitory effect, calcium antagonism, hypotensive effect and phosphodiesterase inhibitory effect are useful as prophylactic or treating agents for thrombosis, circulation improving agents for coronary blood flow such as coronary vasodilators, hypotensive agents and phosphodiesterase inhibitors. Furthermore, the carbostyril derivatives are weak in heart rate increasing activity and also in cardiac muscle contraction increasing activity, and the carbostyril derivatives are useful

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$$(K_1x+K_2y+K_3z+T)+n(K''_1x+K'_2y+K''_3z+T'')=0$$

4 PT.

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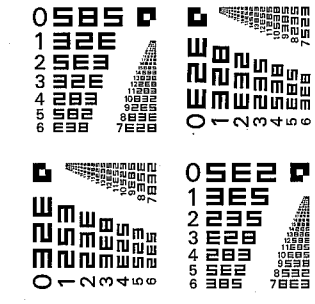
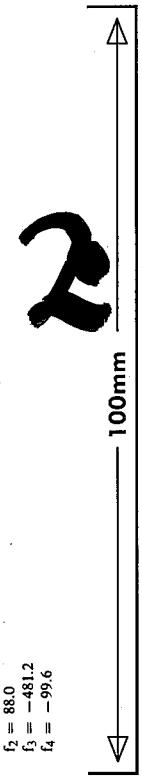
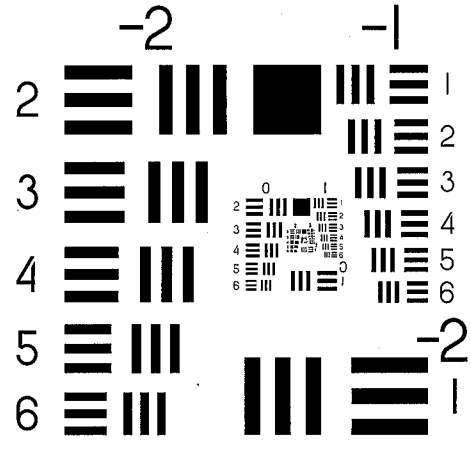
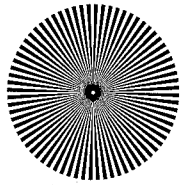


= 101.2 Aperture ratio:		1:1.10	
agnification of projection:		−7.997×	
alf angle of view:		28.56°	
43.454	$d_1 = 11.0$	$n_1 = 1.49380$	L_1
−1542.254	$d_2 = 68$		
16.976	$d_3 = 20.0$	$n_2 = 1.62286$	L_2
10.914	$d_4 = 2.87$		
−89.375	$d_5 = 5.0$	$n_3 = 1.59501$	L_3
−127.071	$d_6 = 58.8$		
−48.609	$d_7 = 5$	$n_4 = 1.49380$	L_4
∘			
∘	$d_8 = 5$	$n_5 = 1.45000$	S
∞	$d_9 = 8$	$n_6 = 1.51872$	G

r_1 (L_1)	r_6 (L_3)	r_7 (L_4)
K = 1.0	K = 1.0	K = 0.0
$C_2 = 0.0$	$C_2 = 0.0$	$C_2 = 0.0$
$C_4 = -0.15691 \times 10^{-6}$	$C_4 = +0.95381 \times 10^{-7}$	$C_4 = -0.22891 \times 10^{-5}$
$C_6 = -0.40068 \times 10^{-10}$	$C_6 = -0.73871 \times 10^{-10}$	$C_6 = +0.12283 \times 10^{-9}$
$C_8 = +0.21016 \times 10^{-13}$	$C_8 = +0.12280 \times 10^{-13}$	$C_8 = +0.84230 \times 10^{-13}$
$C_{10} = -0.37685 \times 10^{-17}$	$C_{10} = -0.33177 \times 10^{-17}$	$C_{10} = -0.20592 \times 10^{-16}$
$f_1 = 314.6$		
$f_2 = 88.0$		
$f_3 = -481.2$		
$f_4 = -99.6$		







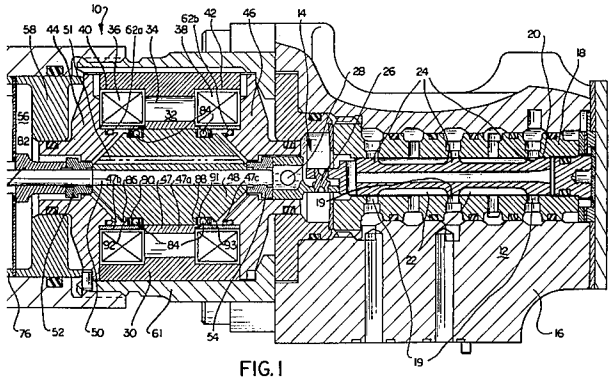
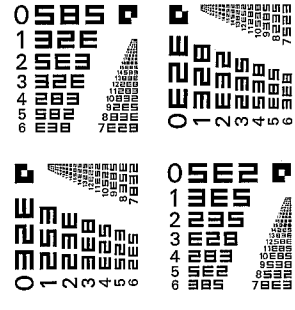


FIG. 1

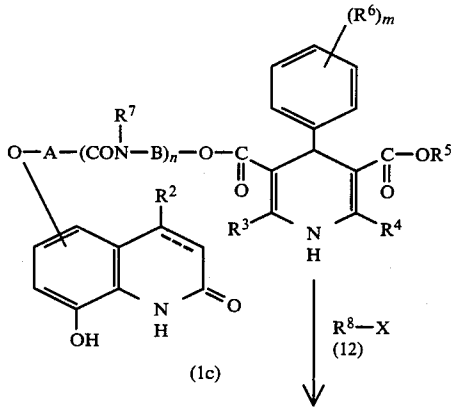
IMAGE SYSTEM
TEST TARGET
A

U.S. DEPARTMENT OF COMMERCE
PATENT AND TRADEMARK OFFICE



Carbostyril derivative or a pharmaceutically acceptable acid addition salt thereof, having excellent platelate aggregation inhibitory effect, calcium antagonism, hypotensive effect and phosphodiesterase inhibitory effect are useful as prophylactic or treating agents for thrombosis, circulation improving agents for coronary blood flow such as coronary vasodilators, hypotensive agents and phosphodiesterase inhibitors. Furthermore, the carbostyril derivatives are weak in heart rate increasing activity and also in cardiac muscle contraction increasing activity, and the carbostyril derivatives are useful

8 PT.



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6 PT.

$$\cos\beta^* = \frac{K_2 - n\frac{T''}{\nu''}}{\sqrt{K_1^2 + \left(K_2 - n\frac{T'}{\nu''}\right)^2 + K_3^2}}$$

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4 PT.

$$v'_{ref}(t) = K\,r\,\delta\left(t - \frac{2L - 2d_s}{v_w}\right) + K(1 - r^2)e^{-2\alpha s d_s}$$

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6 PT.

$$(K_1x+K_2y+K_3z+T)+n(K''_1x+K'_2y+K''_3z+T'')=0$$

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4 PT.

	r_1 (L_1)	r_6 (L_3)	r_7 (L_4)
K	1.0	1.0	0.0
C_2	0.0	0.0	0.0
C_4	-0.15691×10^{-6}	$+0.95381 \times 10^{-7}$	-0.22891×10^{-5}
C_6	-0.40068×10^{-10}	-0.73871×10^{-10}	$+0.12283 \times 10^{-9}$
C_8	$+0.21016 \times 10^{-13}$	$+0.12280 \times 10^{-13}$	$+0.84230 \times 10^{-13}$
C_{10}	-0.37685×10^{-17}	-0.33177×10^{-17}	-0.20592×10^{-16}
f_1	314.6		
f_2	88.0		
f_3	−481.2		
f_4	−99.6		

101.2	Aperture ratio:	1:1.10	
nification of projection:		-7.997^x	
angle of view:		28.56°	
454	$d_1 = 11.0$	$n_1 = 1.49380$	L_1
542.254	$d_2 = 68$		
976	$d_3 = 20.0$	$n_2 = 1.62286$	L_2
914	$d_4 = 2.87$		
9.375	$d_5 = 5.0$	$n_3 = 1.59501$	L_3
27.071	$d_6 = 58.8$		
3.609	$d_7 = 5$	$n_4 = 1.49380$	L_4
	$d_8 = 5$	$n_5 = 1.45000$	S
	$d_9 = 8$	$n_6 = 1.51872$	G

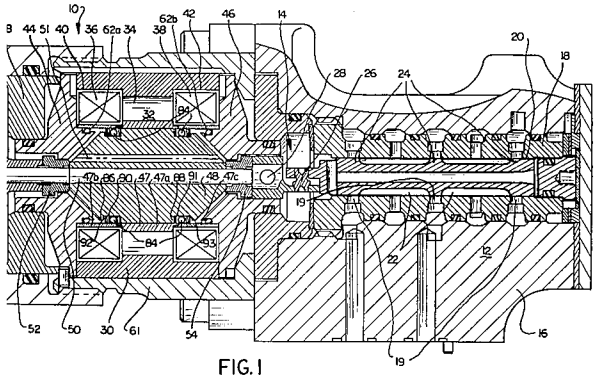

FIG. 1

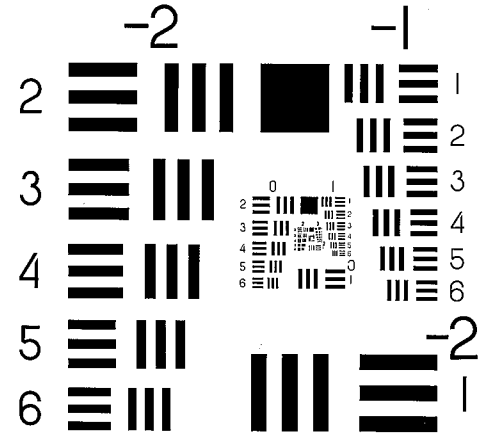

IMAGE SYSTEM
TEST TARGET
A
U.S. DEPARTMENT OF COMMERCE
PATENT AND TRADEMARK OFFICE