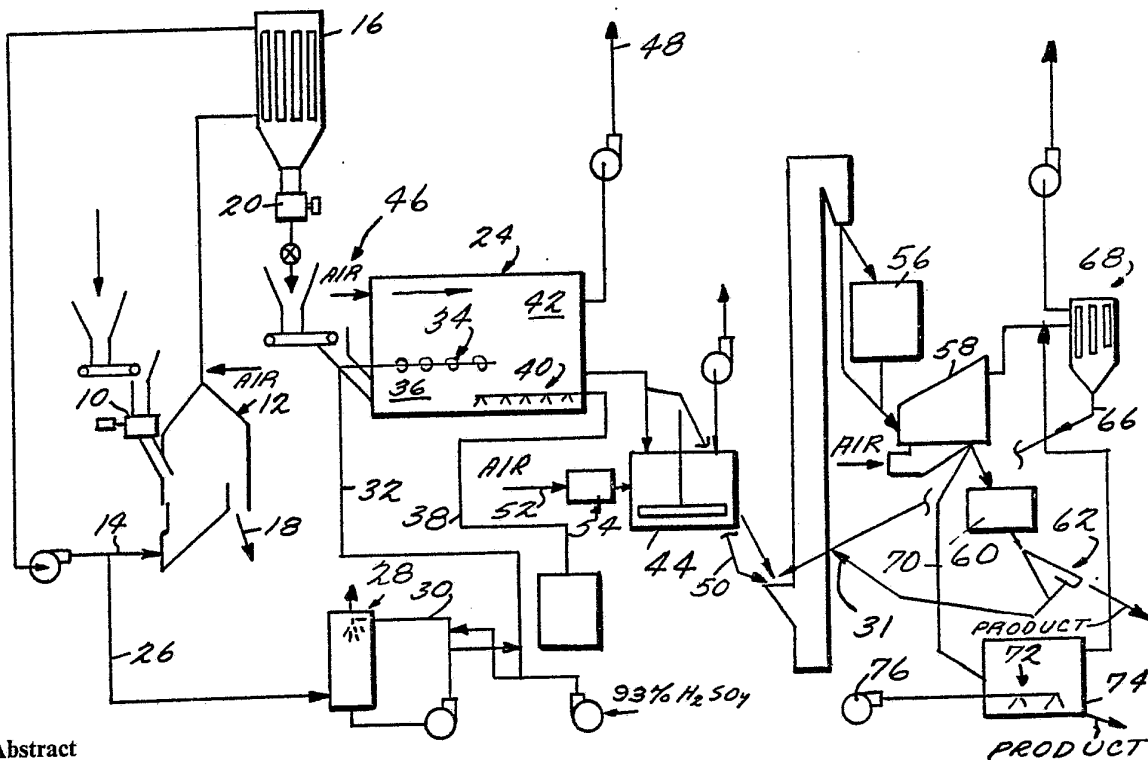




INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<p>(51) International Patent Classification³ : A23K 1/12, 1/22</p>	<p>A1</p>	<p>(11) International Publication Number: WO 84/ 03204 (43) International Publication Date: 30 August 1984 (30.08.84)</p>
<p>(21) International Application Number: PCT/US84/00252 (22) International Filing Date: 23 February 1984 (23.02.84) (31) Priority Application Number: 469,132 (32) Priority Date: 23 February 1983 (23.02.83) (33) Priority Country: US (71) Applicant: AGRO-SYSTEMS INC. [US/US]; 1108 Avalon Avenue, Muscle Shoals, AL 35660 (US). (72) Inventors: ANTHONY, Wilson, Brady ; Route 1, Box 409, Riesel, TX 76682 (US). SMITH, Anthony, James ; 710 Prospect Street, Florence, AL 35630 (US). SHIRLEY, Arthur, Ray, Jr. ; 202 Shirley Drive, Florence, AL 35630 (US). (74) Agents: DAVIS, Akin, T. et al.; Cushman, Darby & Cushman, 1801 K Street, N.W., Washington, DC 20006 (US).</p>		<p>(81) Designated States: AT (European patent), AU, BE (European patent), BR, CH (European patent), DE (European patent), DK, FI, FR (European patent), GB (European patent), JP, LU (European patent), NL (European patent), NO, SE (European patent). Published <i>With international search report.</i></p>

(54) Title: PROCESSING OF POULTRY LITTER



(57) Abstract

A process for treating particulate raw poultry litter includes the steps of reacting the litter with acid to reduce the pH of the litter and stabilize the volatile or potentially volatile nitrogen compounds in the litter, thereafter reacting the acidified litter with ammonia to increase the pH. The acid-ammonia reaction generates heat which may be utilized to vaporise moisture and/or reduce the pathogen content of the litter. Odorants in the off-gases can be removed by contacting the off-gases with acid.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	KR	Republic of Korea
AU	Australia	LI	Liechtenstein
BE	Belgium	LK	Sri Lanka
BG	Bulgaria	LU	Luxembourg
BR	Brazil	MC	Monaco
CF	Central African Republic	MG	Madagascar
CG	Congo	MR	Mauritania
CH	Switzerland	MW	Malawi
CM	Cameroon	NL	Netherlands
DE	Germany, Federal Republic of	NO	Norway
DK	Denmark	RO	Romania
FI	Finland	SD	Sudan
FR	France	SE	Sweden
GA	Gabon	SN	Senegal
GB	United Kingdom	SU	Soviet Union
HU	Hungary	TD	Chad
JP	Japan	TG	Togo
KP	Democratic People's Republic of Korea	US	United States of America

PROCESSING OF POULTRY LITTER

The present invention relates to a new and improved method for the conversion of raw poultry litter into a high protein feed supplement for ruminant animals such that the final product is more completely digested, has inoffensive physical characteristics (i.e., odor, appearance, and consistency), exhibits good storage and handling qualities (i.e., resistant to mold, decomposition, caking, and bridging, and with limited tendency for moisture absorption and dust generation), has safe levels of drug and bacteria contamination, and has an enhanced crude protein content.

BACKGROUND

Many millions of tons of poultry litter are produced annually in the United States virtually all from intensive systems. Poultry litter is solid waste material composed primarily of bedding material (any of a variety of lignocellulose material) and poultry excreta, the litter having been removed from poultry houses. The relative proportion of bedding to excreta can vary widely, as can the chemical nature of the litter. There also may be present various pathogens and usually drug contaminants resulting from the drugs fed to the poultry. Litter is, of course, malodorous due to various odorants or precursors thereof. In addition to free ammonia gas there have been identified odorants such as mercaptans, sulfides, diketones, indole and skatole.

Poultry litter in the past has been used as fertilizer and more recently respected nutritionists



have promoted the use of poultry litter for ruminant feeds, because of all the animal litter, poultry litter is one of the highest in nutritional value. Poultry litter is high in crude protein, and the nitrogen and energy value can be efficiently utilized by ruminants. Although there are at this time several commercial operations in which poultry litter is dried and compressed into large and small pellets or otherwise processed, most poultry litter fed to ruminant animals appears to be through small on-farm type operations. Existing commercial processes are either too energy- and labor-intensive and thus are uneconomical, or they expose the litter to excessive heat and either char the litter destroying proteins or develop protein-carbohydrate complexes detrimental to effective digestion of the litter, or they do little to eliminate the offensive odorants and dangerous pathogens, thus making the feed undesirable and unsafe, or they possess more than one of these defections and usually others.

At the present time most poultry litter is prepared for feed to ruminants by deep stacking or ensiling (storage in a closed vessel in a low-oxygen environment) with or without corn or some other energy source in the presence of 35 to 40% moisture. Other processes include fumigation of the litter with ethylene oxide, heating it at high temperatures to try to deodorize the material and kill the pathogens, or just drying it in a rotary dryer. It is also known that use of acid to make litter slightly acidic can reduce the volatilization of ammonia during handling and drying and various acids are used. United States Patent 4,082,859 discloses a process for rendering lignocellulose material, including poultry litter, more digestible



to ruminants, the process including treatment of the litter with acid and then mixing the acidulated material to a further batch of litter which has been treated with a base such as ammonium hydroxide.

5 Further, it is known that autoclaving as well as various ensiling conditions can destroy pathogens and a variety of techniques have been proposed. However, all of the methods now used or previously employed for processing poultry litter are either
10 impractical, uneconomical, or ineffective when used on a large commercial scale.

The present invention, on the other hand, provides a process which is both practical and economical for the processing of poultry waste into
15 a desirable ruminant feed supplement.

BRIEF DESCRIPTION

The most important aspect of the present invention is a special treatment of poultry litter involving a strong-acid acidulation step followed by
20 a partial neutralizing and ammoniation step and at some point a heating step, the overall result of which is to produce a ruminant animal feed supplement which is free or essentially free of odor-producing compounds, pathogens and drug
25 contaminants and in which the nitrogen content of the excreta component of the litter is stabilized and in which the lignocellulose component of the litter has been partially hydrolyzed to render it more digestible to ruminants. By stabilization of
30 the nitrogen content is meant the conversion of volatile or potentially volatile nitrogen compounds in the excreta to a non-volatile form. In the preferred process the reaction conditions in both



steps are selected and controlled so that heat generated by the chemical reactions (heat of dilution of the acid, heat of reaction of the acid with the litter and heat of subsequent reaction of the ammonia with the acidulated litter) raises the temperature to levels at which most of the pathogens and drug contaminants are destroyed or rendered non-toxic and at which a substantial amount of water vapor is driven off so that under ideal conditions a dry or essentially dry product is obtained without direct input of heat. It may be necessary or desirable under some circumstances, however, to supply heat in addition to that generated by the reactions either for drying or pasteurizing purposes.

An important part of the invention is the realization that strong acids have the capability of preserving and stabilizing the nitrogen components of poultry excreta and rendering the excreta non-odorous even during storage of the fully treated litter in an environment which may become wet. The invention also contemplates the use of acid to scrub odorous components from the off-gases from the litter. It follows, therefore, that the present invention is only secondarily concerned with conversion of the lignocellulose content of poultry litter to ruminant-digestible form, even though this desirable reaction occurs at least to an extent during the acid treatment step. It is observed here that the aforesaid patent 4,082,859 discloses that poultry litter can be treated with acid for the purpose of partially hydrolyzing the lignocellulose content of the litter, there is no suggestion in the patent that this kind of treatment reduces odor, and in fact the second step of the disclosed process



adds base-treated, odor-producing litter to the acid-treated litter.

In the preferred process the acid is added to the poultry litter in a dry comminuted form, in which the particles are discrete, unagglomerated and free flowing, in a mixing operation such that wetting of each particle of litter takes place rapidly and uniformly. The amount of acid relative to the amount of litter is relatively low, e.g. 10% of H₂SO₄ to 90% litter, so that the mass of particles remains free flowing. Ammoniation of the free flowing particles is then carried out in a further mixing step using anhydrous ammonia in gas or liquid form. Aqueous ammonia can be used also but this results in adding water to the litter. The water must be removed later and this represents an additional energy input to the system. It is desirable to employ a special rotary drum reactor designed for carrying out the acidifying operation and the ammoniation operation. The rotary drum includes a first zone, having internal lifting flights which lift and drop the litter in a manner to form a continuous downwardly flowing stream or curtain of litter particles. The acid is sprayed in finely atomized form from stationary nozzles in the rotary drum onto the curtain of moving particles in a manner such that each particle becomes rapidly wetted and such that wetting of the mass is essentially uniform at any given axial point in the drum. Spraying in this manner protects the inner surface of the drum because there is no direct spraying of the acid onto the surface and because the acid penetrates into the particles of litter so that there is no free flowing acid to contact the surface. Ammoniation takes place in a second zone



of the drum downstream of the first zone. The second zone maintains the free-flow particles in a continuously rolling mass and to this end the second zone does not contain lifting flights although it
5 may contain anti-skid ribs. The anhydrous ammonia is injected into the rolling mass from stationary orifices located so as to be embedded in the rolling mass at all times. Under these conditions the ammonia reacts rapidly with the acidified particles
10 and no ammonia escapes into the atmosphere within the drum. At the downstream end of the second zone the litter, still free flowing, is discharged for further processing. The drum will usually include a central zone between the acidification zone and the
15 ammoniation zone; this central zone serves as a retention chamber for the acid reaction to progress as the litter moves toward the ammoniation zone.

The reaction within the acidification zone of the drum immediately traps the free ammonia
20 usually present in the poultry excreta component of the litter. As the litter progresses through the acidification zone and the retention zone the acidity of the litter increases chemically thereby rapidly altering the odorants or precursors thereof
25 and rendering them non-odor-producing. A pH of no greater than about 2.5 is required for this effect. In addition the acid reaction partially hydrolyzes the lignocellulose in the bedding
30 component of the litter thereby improving the digestibility of the final product to ruminant animals. The temperature of the acid reaction mass increases as the mass progresses through the acidification zone due to the heat of dilution of the acid as it becomes diluted by the moisture

35



content of the litter and due to the heat liberated by the chemical reactions which occur.

5 As the acidified litter moves into and through the ammoniation zone of the drum, the ammonia rapidly reacts with the acidified litter, causing its temperature and pH to rise. The temperature rise is highly desirable because it destroys pathogens and some drug components not already attacked by the acid and because it drives off moisture. It is preferred that the temperature increase to 190°F or even somewhat higher. The pH of the material discharged from the ammonization zone should be in the range 4.5 to 5 to be suitable as a feed supplement and to have a long storage life. It has been found that above a pH of about 5 the treated litter tends to develop objectionable odor during storage especially under damp or wet conditions.

20 Control of the temperature of the litter within the rotary drum is obtained primarily by pulling air through the drum so that the moisture released from the litter is taken up by the air.

25 The heat of dilution of the acid, the heat of reaction of the acid with the litter and the heat of subsequent reaction of ammonia with the acidified litter, together with proper retention time and proper control of air flow through the drum result in the following:

- 30
- (1) Chemical alteration of the very offensive odors to compounds having little or no odor
 - (2) Destruction of pathogens and harmful drugs without charring of the litter



or the development of protein-carbohydrate complexes within it

- (3) Hydrolytic destruction of drug contaminants
- 5 (4) Drying of the litter without additional energy
- (5) Enhancement and standardization of the crude protein content of the litter
- 10 (6) Attack of the lignocellulose bonds in the bedding component of the litter to improve its digestibility to ruminants.

The litter is subsequently discharged to an oven-dryer where the litter can be further dried if it was extremely wet initially, or it can be held for further pathogen and drug control if needed. The material is then fed to a pellet mill, such as a California Pellet Mill, for compaction before being cooled by evaporation and reduced in size to crumbles. Alternatively, the material can be cooled by evaporation without pelletizing and thence conditioned for dust control by the application of an edible oil. Off-gases are scrubbed with sulfuric acid to control odorants.

The preferred acid is sulfuric of a concentration in the range 50 to 100% by weight, with the higher concentrations being preferred. Other acids may be used, such as phosphoric acid, (45% or higher) alone or mixed with sulfuric acid, hydrochloric acid, HCl gas, SO₃ gas, chlorosulfonic



acid and other mineral acids. The term "reacting" the litter with an acid is intended to include reacting with an existing acid and reacting with an acid gas which forms the acid when it contacts the moisture in the litter.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a process diagram for a process of converting raw poultry litter into a high protein feed supplement for ruminant animals, employing the principles of the present invention;

Figure 2 is a schematic longitudinal cross-sectional view of the acidifier-ammoniator drum of Figure 1;

Figure 3 is a sectional view taken on the line 3-3 of Figure 2;

Figure 4 is a sectional view taken on the line 4-4 of Figure 2; and

Figure 5 is a pH profile of the material passing through the drum of Figure 2.

DETAILED DESCRIPTION OF THE INVENTION

Referring now more specifically to Figure 1, raw poultry litter is fed to the process where lumps of litter are shredded in a shredder mill 10 to allow subsequent fluidization of the litter in a fluid bed separator 12 which separates the heavy trash contaminants such as rock, glass, and metal from the litter. Recycled air 14



fluidizes and then conveys the entrained litter to a separation baghouse 16 and the heavy trash remains in the separator 12 and is ejected as waste 18. After separation from the air the litter passes
5 through a hammer mill 20 to grind it sufficient to pass a perforated plate screen with 1/2 inch diameter holes. It is subsequently collected and precisely metered at 22 to a rotating drum acidifier-ammoniator 24 of special construction.
10 Air bled at 26 from the fluid bed separator is very odorous and is scrubbed in a scrubber 28 with sulfuric acid delivered by a line 30 to deodorize the air before it is vented through a stack. Concentrated sulfuric acid between 50% and 100%
15 H₂SO₄ by weight, such as commercially available 78% and 96% acid, is metered through a line 32 to the acidifier-ammoniator 24 where it is sprayed through a plurality of stationary nozzles 34 onto the tumbling bed or curtain of poultry litter to effect
20 acidulation of the litter in a uniform and complete manner such that the pH of the material is lowered preferably below 2.5 as it leaves the acidulation section 36 of the rotary drum 24. The acidulated litter is then ammoniated by spraying gaseous
25 ammonia from pipe 38 through stationary orifices 40 into the litter such that the pH is raised preferably to between 4.5 and 5.0 before it leaves the ammoniation section 42 of the rotary drum 24 and thence flows to an oven-dryer 44. Air 46 is pulled
30 through and exhausted from the drum 24 at a controlled rate to maintain the proper temperature in the drum and to maximize the moisture given off by the litter as it is acidulated and ammoniated. The moisture leaves the process with the air which
35 is vented through the stack 48. The combination of



acidulation-ammoniation alters the odorants, acts to enhance the crude protein content in the product, and removes moisture. In most cases this step is acceptable to decontaminate the litter. However, 5 the process allows for continued heat treatment in an oven-dryer for the control of the more resistant pathogens if needed. In most cases, the oven-dryer is not needed and is by-passed as indicated by arrow 50. The oven-dryer can also be used to dry the 10 material further by passing air 52 through the unit and providing heat 54 to the unit. Processed litter discharged from or by-passing the oven-dryer passes to a pellet mill 56 for compaction into pellets which are subsequently cooled in an evaporative 15 cooler 58 and then are passed through a crumbler 60 to break the pellets into crumbles. Dust is separated from the crumbles by screening at 62. The material leaving the cooler and undersize 64 from the screening operation is sent along with dust 66 20 obtained in a baghouse 68 downstream of the pellet mill back to the pellet mill. When pelleting is not desired, the oven-dryer discharge or by-pass goes to cooler 58. The cooled product is discharged at 70 from the cooler and then sprayed at 72 in a rotary 25 drum 74 with an edible dust suppressant oil 76 such as acidulated soybean soap stock to control dusting.

It is clear that the process equipment can be altered and the same end achieved within the scope of the invention. The acidulation-ammoniation 30 step of the process can take place in two or more mixers if desired, or sequenced in the same or more mixers or partial ammoniation can occur concurrently with acidulation provided the pH of the litter is allowed to fall sufficiently to alter the organic 35 odorants before complete ammoniation is achieved.



It is further conceived that a substantial retention time may be desirable between acidulation and ammoniation for an extremely woody bedding material. For example, extended retention times up to 28 days are suitable. This is within the teaching of the invention, as the longer retention time will enhance the breakdown of lignocellulose bonds. However, some energy for drying the litter will obviously be lost by extended retention time and/or separation of the operation into separate vessels. Drying potential come from the heat of dilution of sulfuric acid coupled with the heat of reaction between acid and litter and ammonia and acidulated litter. Partial ammoniation and/or recycle of already processed litter is possible, but will result in excessive losses of ammonia which will then require scrubbing vessels. Liquid anhydrous ammonia can be used in ammoniation instead of gaseous ammonia, but (1) it is less safe due to the danger of trapping liquid ammonia in a heated enclosed space such as a pipe, and (2) it entails the loss of the heat of vaporization which helps evaporate moisture from the litter.

More specifically referring to Figure 2 acidulation and ammoniation are due in the rotary drum 24 which is divided into two chambers and most desirably into three chambers such that litter is fed into the acidulation chamber 36. Lifting flights 78 are installed herein which are canted approximately 45 degrees opposite the direction of rotation of the drum 24 so as to lift the litter such that it falls and cascades as a stream or curtain 80 in front of the nozzles 34 spraying the sulfuric acid such that litter is uniformly and lightly sprayed with acid substantially throughout



the length of this chamber 36. The bulk of the litter rolls as a mass 82 on the inner surface of the chamber 36. The manner in which the flights 78 are canted insures good mixing of the litter without build-up or reverse flow problems associated with many drum designs. The width of the flights 78 should be between 10 and 20% of the drum's diameter, causing them to effectively decrease the retention time in that chamber with respect to the subsequent chambers because a lot of the space underneath the flights remains essentially empty during operation. By maintaining a highly active but thin bed, good mixing of litter occurs, resulting in extremely uniform acidulation. A retention chamber 84 is a short space between the acidulation chamber and the subsequent ammoniation chamber and serves to give the litter some retention time in its most acid condition.

It has been found that two minutes in this condition is sufficient when the pH is below 2.5 and the temperature of the litter is over 100°F which it is normally expected to exceed at this point. However, it should be understood that poultry litters with various concentration of ingredients and bedding materials may require more or less retention time before ammoniation for proper control of odorants, and the breakdown of lignocellulose bonds for acceptable improvement in the digestibility of the product.

In the ammoniation chamber 42 anhydrous ammonia is injected underneath the bed 86 to effect ammoniation of the product to a pH between 4.5 and 5.0. Increasing pH above, this level leads to loss of ammonia both in the ammoniator section of the acidifier and in further processing. Also tests

have shown that at higher pH levels processed litter can give off an offensive sulfide-type odor when inadvertently subjected for an extended period of time to anaerobic conditions while wet. Although no special problems occur at lower pH levels they are not recommended because they result in excessive use of sulfuric acid and could result, in extreme cases, in too much acid in the rumen of the animal.

Figure 5 shows a typical pH profile for the material passing through the drum 24.

Now referring more specifically to Figure 3, the orientation of the nozzles 34 spraying sulfuric acid is seen to be such that the nozzles will spray onto material falling down from between the 10 to 11 o'clock position of the drum. A hollow stationary support member 88 for the nozzles 34 or truss extends through the drum and is supported on each end independent of the rotary drum. A shallow retaining ring 90 is positioned at the end of the discharge end of the flights 78 as support for the flights 78 and provides some additional mixing action to the litter leaving the acidulation chamber 36. The flights 78 are seen extending further towards the center of the drum than the retaining ring.

Now more specifically referring to Figure 4, the orientation of the ammonia spargers 40 can be seen located in the bed 86 of litter near the low end of the bed so that ammonia has the maximum time to disperse and react with the acidulated litter before being exposed to the surface of the bed or being brought near the surface of the bed. The distance of the spargers 40 from the wall of the drum 24 should not be greater than 1/2 the depth of the bed 86. The discharge retaining ring 92 is such



that approximately 10 inches of bed depth is maintained in the ammoniation section. The section also contains some small anti-slip strips 94 of metal approximately 1/4 to 1/2 inch in height to prevent the bed 86 from slipping inside the chamber. Between the acidulation chamber 36 and the start of the ammoniation sparge pipe 40 is about 25% of the capacity of the drum to serve as a reaction zone for the acidulation to come to completion. This is actually a part of the ammoniation chamber being without lifting flights but contains no means of ammoniation. In some cases this section might need to be expanded, but in most cases it can be reduced.

It is obvious to those knowledgeable in the arts of mixing, spraying, heat transfer, and chemical reaction that the reactions of this process can take place in other types of vessels, but probably at somewhat of a disadvantage to that described herein.

The heats of reaction and of dilution provide the heat to effect the vaporization of moisture from the products. It can readily be seen however that should excessive air flow be pulled through the drum there will be a loss in energy available for evaporation of water which may instead go to heat up the excessive air flow, further material temperature within the drum may fall and pathogen elimination may be affected, since moisture will vaporize more freely, lowering temperature of materials. We have found it best to control air flow to keep the temperature of the material discharging from the rotary drum between 170 degrees F and 190 degrees F. It is clear that preheating air by any means in part eliminates the problem.

Material discharging from the acidifier-ammoniator 24 at 190°F has the potential of losing over 2% moisture on cooling if said cooling is done under controlled evaporative conditions. It is
5 important to cool the material to below approximately 130°F to prevent further reactions from occurring with subsequent charring of some of the product. The above step, however, is taken
10 following the last step of the process for which the material needs to remain hot, and would normally follow the pelletizing step or the oven-dryer or the ammoniation step if pelletizing is not done.

It has been found that an edible oil can be added to a dusty product at about 1% by weight to
15 suppress the dust. Many mixing devices work well although a rotary drum as used to condition fertilizers works very well.

The off-gases of poultry litter are successfully scrubbed with sulfuric acid to alter
20 the odorants and render the gases inoffensive.

It is clear to those skilled in the art that the process will work with hydrochloric acid or hydrogen chloride gas through containment of this
25 fuming acid or its gas can be a problem as can be the use of sulfur trioxide gas, chlorosulfonic acid and other mineral acids and acid gases.

The litter can be processed into a suitable feed or fertilizer by using phosphoric acid or a
mixture of phosphoric and sulfuric acids.

30 Less attractive, organic acids can be used in combination with mineral acids and acid gases for acidification but all combinations are seriously affected by the economic impact of the much higher cost of organic acids and all other acid
35 combinations. An added problem with the use of



organic acids is their odors. Some of them are already contained in poultry litter and are in part responsible for the offensive odor hence, their use is less effective and less desirable than sulfuric and hydrochloric acids.

Although weak acid solutions can be used as acidulation means this will require the evaporation of moisture contained in the acid solution from the final product by using energy obtained external of the process. The inventors of this unique process recognize that under special and unusual situations the use of a weak acid for acidulation might be desirable, but teach this as an undesirable alternative for most cases.

15

EXAMPLE 1

Chicken litter with a wheat straw bedding was processed by the previously described process in a large pilot plant built for that purpose. The litter which contained 22% moisture and 20% crude protein was continuously fed to a hammer mill approximating the subsequent rate of feed to the acidifier-ammoniator where it was ground to pass through a perforated plate containing holes 1/2 inch in diameter. After milling, and with the heavy trash removed, the material was conveyed by air entrainment to a belt feeder from where it was precisely metered to the acidifier-ammoniator rotary drum along with 93.2% sulfuric acid and gaseous anhydrous ammonia. The chicken litter feed rate to the acidifier-ammoniator was 1660 lb/hr while the feed rate of the 93.2% sulfuric acid and the anhydrous ammonia were 206 lb/hr and 42 lb/hr respectively. The rotary drum which was 3 ft. in



diameter and 8 ft. long rotated at 17 rpm. The acid chamber contained 12 flights, 5 1/2 inches wide and 3 feet long, canted 45 degrees opposite from the direction of rotation such that litter was cascaded in free fall in front of five atomizing nozzles mounted approximately 8 inches from the cascading bed. The retention time was about 2 minutes in the acidulation portion of the vessel. The material was cascaded for about three minutes before reaching the ammoniation section of the drum where the gaseous ammonia was admitted approximately 8 inches below the bed to ammoniate the product in a continuous and uniform manner through a pipe containing 35 small apertures. Retention time during ammoniation was about 3 minutes. A continuous air purge through the rotary drum was maintained such that air leaving the drum was essentially saturated with moisture and at a temperature of 122°F. Processed litter was discharged from the rotary drum at a temperature of 190°F. Moisture content of the material leaving the acidifier-ammoniator was approximately 17%. The pH of the final product was adjusted by slight variation in the feed rates of the three reactants to maintain a level of 4.5 to 5.0 pH. The pH of the litter leaving the acidifier portion of the drum was maintained at about 1.5. The material discharged from the acidifier-ammoniator was sent to an oven-dryer for slight additional drying with retention of about 45 minutes before discharge at approximately 14% moisture. This material was then subjected to evaporation cooling lowering the temperature down to 100°F and lowering moisture to about 12%. During cooling the product was sprayed with soybean oil equal to 1% of the product weight. Plant operation was continuous without interruption for a period of



24 hours. Analysis of a composite of the product by three independent laboratories as well as ours showed average crude protein content of the final product enhanced to 32%, moisture content 12%, and an absence of pathogens. The odor of the material leaving the rotary drum and that of the final product was similar to that of processed tobacco. Analysis showed no harmful drug residues. On a thorough chemical analysis of the product the concentration for all chemicals was found safe for process litter to be used as a substantial and desirable feed supplement in the ration of most ruminant animals. Consistency and appearance of the product was excellent and after general storage of the product for several months there was no indication of mold formation, change in odor, loss of nutrient, or any undesirable change in other physical or chemical characteristics. A decrease in the neutral detergent fiber content from 32% in the raw litter to 26% in the processed litter along with an increase in C₅ and C₆ sugars from 1% in the raw litter to 2% in the final product shows increased digestibility of the product because of breakdown of the lignocellulose bonds.

25

EXAMPLE II

Chicken litter with a wheat straw bedding was processed as in Example I with the exception that following discharge of the processed litter from the acidifier-ammoniator, the processed litter was fed directly to a California Pellet Mill with the addition of steam to increase the moisture content to improve pelleting. The processed litter leaving the pellet mill was subsequently cooled by



5 evaporative cooling and without further addition of
heat to effect evaporation. The pelletized,
processed litter was crumbled and screened. It had
essentially the same chemical characteristics as in
10 Example I with moisture content between 12 and
13%. However, physical characteristics were better
as the material had better flow properties and no
dust suppressant was needed. The odorants were
altered in the rotary drum, therefore, the pellet
15 mill did not give off the offensive odor which has
caused substantial operation and marketing problems
with poultry litter processed by other means.

EXAMPLE III

15 Chicken litter with a wood shaving base was
processed by the previously described process. The
litter contained 20.5% moisture and 16% crude
protein. It was fed to the rotary drum acidifier-
ammoniator at the rate of 1160 lb/hr and reacted in
20 sequence with 186 lb/hr of 93.2% sulfuric acid and
49 lb/hr of gaseous anhydrous ammonia. After
complete acidulation the pH of the litter was 0.8.
Product pH was controlled at 4.5 to 5.0 to give a
product with an odor somewhat like that of processed
tobacco. The air flow through the acidifier-
25 ammoniator was controlled to remove essentially 6.5%
moisture from the litter which was subsequently
further dried by evaporative cooling to a moisture
of 12.5% giving the product a crude protein content
of 34%.

30



EXAMPLE IV

Turkey litter with a wheat straw base was processed by the previously described process. The litter contained 27% moisture and 17% crude protein. It was fed to the rotary drum acidifier-ammoniator at the rate of 1140 lb/hr and reacted in sequence with 198 lb/hr of 93.2% sulfuric acid and 36 lb/hr of gaseous ammonia. After complete acidulation the pH of the litter was less than 1.0. Product pH was controlled at 4.5 to 5.0 to give a product with an inoffensive odor. The air flow through the acidifier-ammoniator was controlled to remove essentially 6.5% moisture from the litter which had to be further dried in the oven-dryer to 12.5% before pelletizing because of its very high initial moisture content. The product had excellent chemical, physical, and biological properties and a crude protein content of 30%.

EXAMPLE V

Chicken litter was prepared for acidification ammoniation as in the other process. However, it was acidified in the laboratory with 32% hydrochloric acid to a pH below 2.5%, then ammoniated with ammonium hydroxide solution and dried. The litter protein content was enhanced to 32% and the odorants were sufficiently altered to be inoffensive.



WHAT IS CLAIMED IS:

1. A process for converting raw poultry litter to an essentially odor-free product of increased digestibility to ruminant animals comprising reacting the raw litter with acid at a pH of no greater than about 2.5 to thereby stabilize the volatile or potentially volatile nitrogen compounds in the litter and thereafter reacting the acidified litter with ammonia to raise the pH thereof to no greater than about 5.5 to enhance the crude protein content and at some point in the process raising the temperature of the litter to at least 160°F to reduce pathogens to safe levels.

2. A process as in claim 1 wherein the acid is sulfuric acid of a concentration of at least 50% by weight and wherein the ammonia is anhydrous ammonia.

3. A process as in claim 1 wherein the raw litter is dry, particulate free-flowing form is mixed with the acid in an amount that the particles become essentially saturated with acid yet remain free-flowing.

4. A process as in claim 3 wherein the litter is sprayed with an acid or an acid gas as it is being tumbled in a rotating drum having an axis inclined slightly from horizontal.

5. A process as in claim 1 wherein the raising of the temperature is effected primarily by heat generated within the litter by the acid reaction and the ammonia reaction.



6. A process for treating raw poultry litter in dry, particulate, free-flowing form comprising forming a stream of the free-flowing litter particles; spraying the stream with atomized acid or acid gas in an amount to reduce the pH of the particles to about 2.5; maintaining the acidified particles free-flowing and forming a tumbling bed of the acidified particles; introducing anhydrous ammonia into the acidified particles from at least one location within the bed to increase the pH of the particles to no greater than about 5.5 to enhance the crude protein content and to thereby generate heat and increase the temperature of the particles to at least 160°F to vaporize moisture and to reduce pathogen content.

7. A process as in claim 6 carried out in a rotary drum having an acidifying zone fitted with flights which lift the raw litter particles and drop them in the form of said stream, said drum having an ammoniating zone downstream of said acidifying zone which forms said tumbling bed.

8. A process as in claim 7 including the step of passing a stream of air through the drum to control the temperature of the litter.

9. In a process for treating poultry litter to render it suitable for use as a feed supplement for ruminant animals, during which process handling of the litter produces off-gases containing odorants, the step of removing odorants from the off-gases by intimately contacting the off-gases with an acid.



Fig. 1.

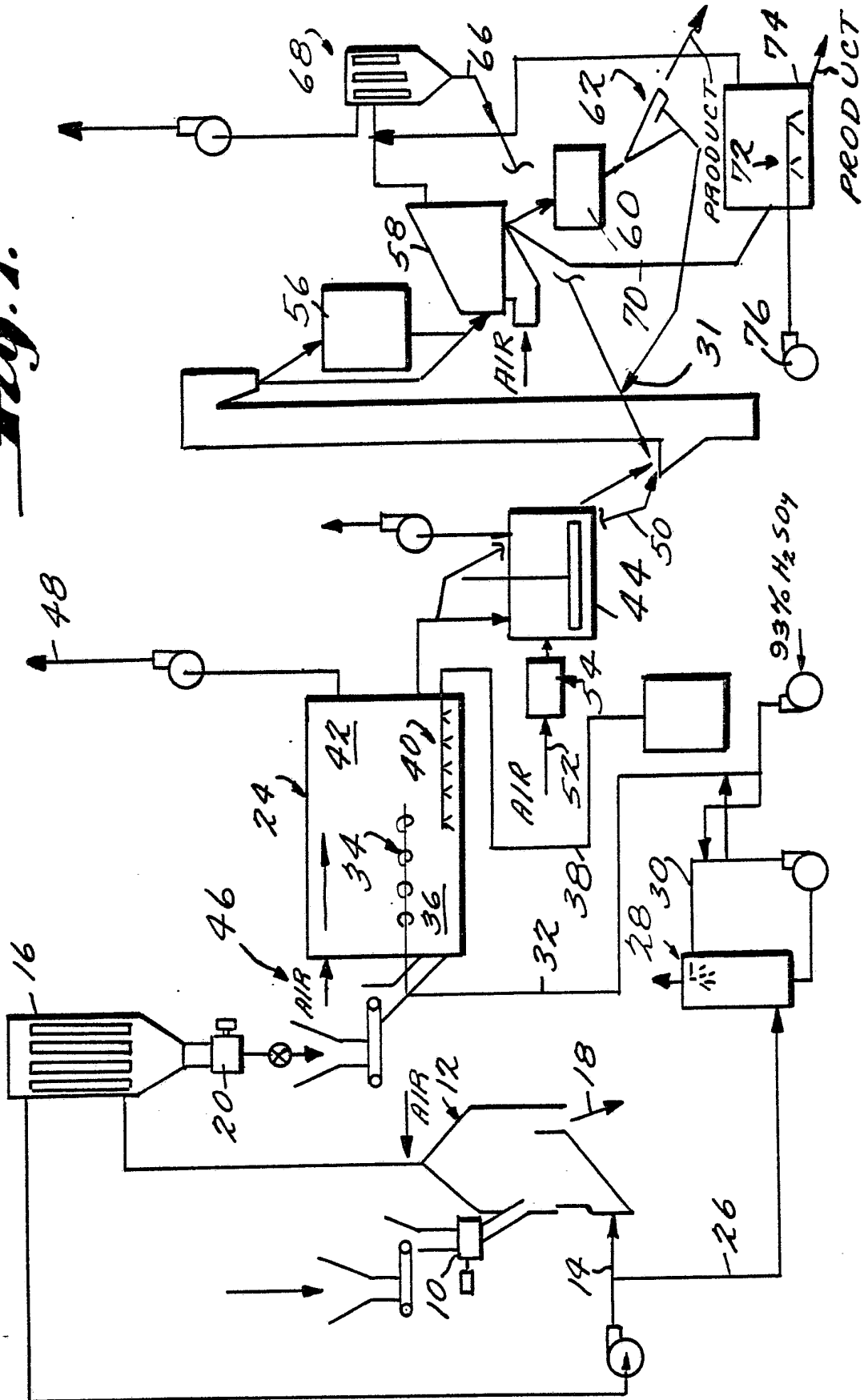


Fig. 2.

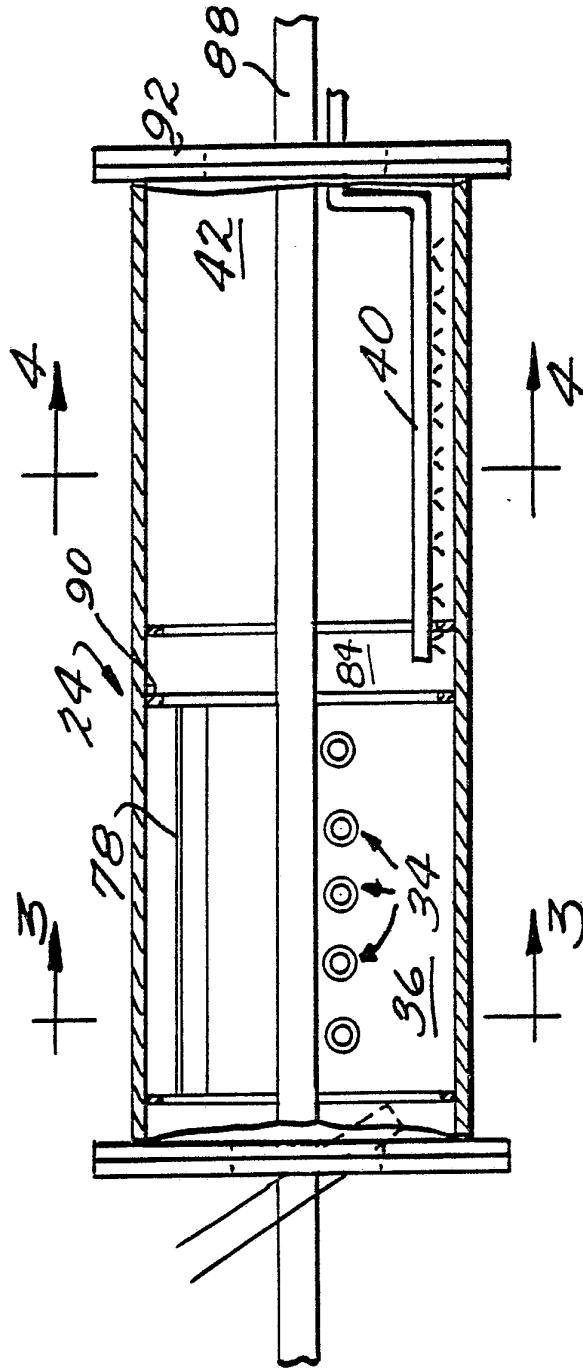


Fig. 3.

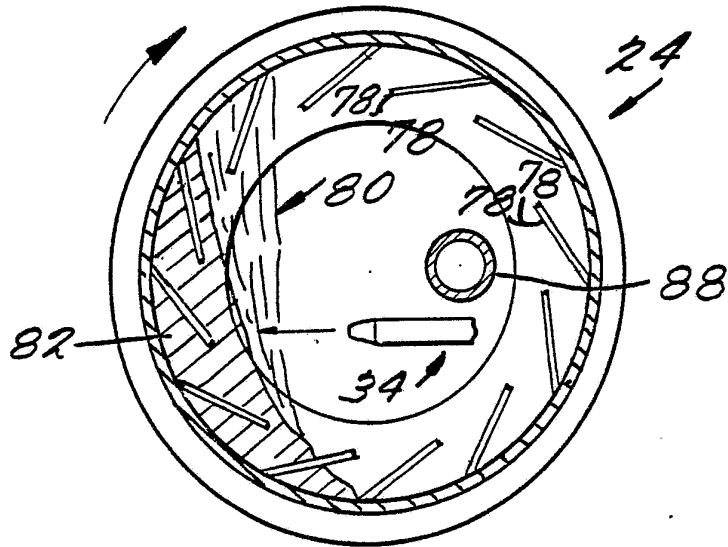
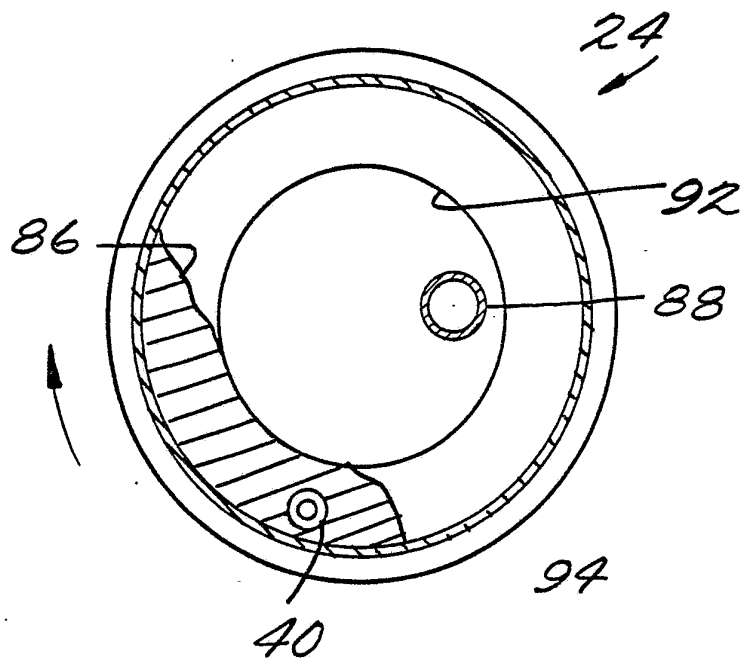


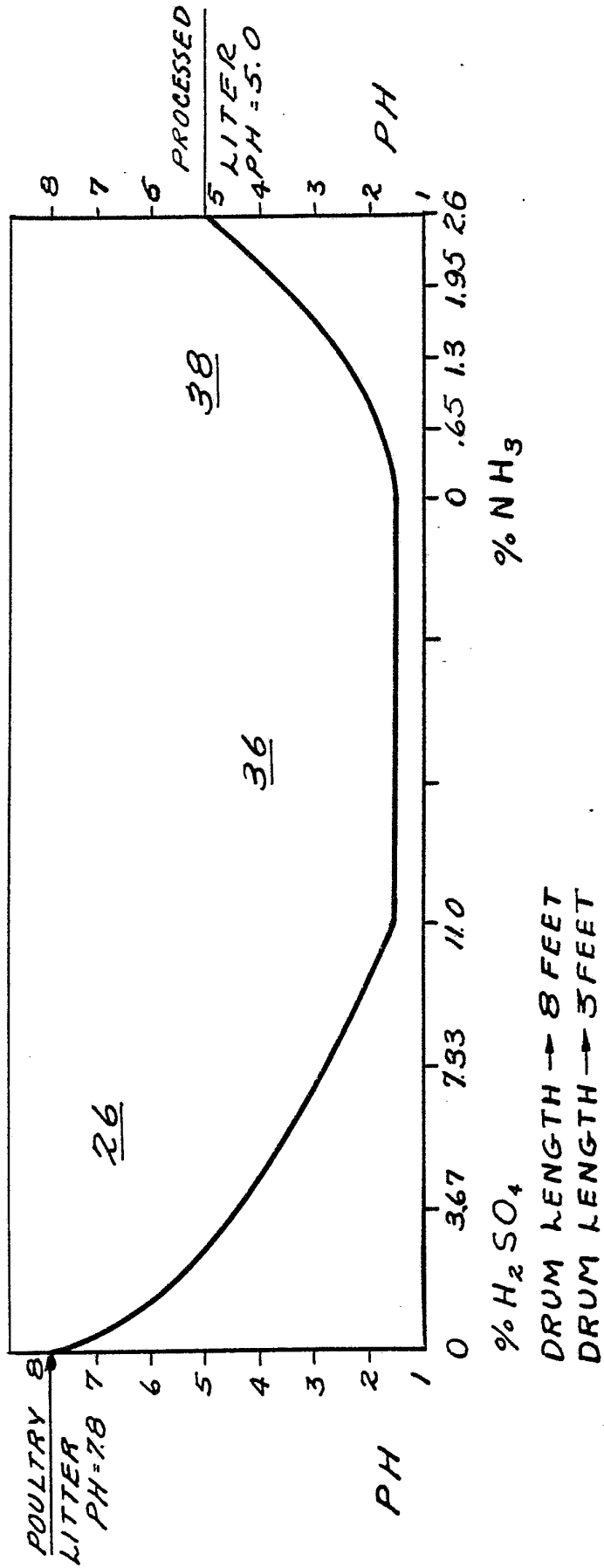
Fig. 4.



4/4

Fig. 5.

PH CURVE FOR PROCESS DRUM



CONTINUED ON SHEET



INTERNATIONAL SEARCH REPORT

International Application No PCT/US84/00252

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ³		
According to International Patent Classification (IPC) or to both National Classification and IPC		
INT. CL. ⁹	A23K 1/12 A 23 K 1/22	
U.S. CL.	426/69, 319, 486, 488, 626, 635, 636, 807	
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁴		
Classification System	Classification Symbols	
US	426/69, 319, 486, 488, 626, 635, 807	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁵		
III. DOCUMENTS CONSIDERED TO BE RELEVANT ¹⁴		
Category ⁶	Citation of Document, ¹⁶ with indication, where appropriate, of the relevant passages ¹⁷	Relevant to Claim No. ¹⁵
Y	US, A, 4,082,859 PUBLISHED 04 APRIL 1978 KATZEN.	
Y	US, A, 4,369,199 PUBLISHED 18 JANUARY 1983 KATZEN.	
Y	US, E, RE22,477 PUBLISHED 09 MAY 1944 MILLAR.	
A	US, A, 4,356,196 PUBLISHED 10 OCTOBER 1982 HULTQUIST.	
A	US, A, 4,064,276 PUBLISHED 20 DECEMBER 1977 CONRADSEN ET AL.	
A	US, A, 4,182,780 08 January 1980, Lagerstrom	
<p>⁸ Special categories of cited documents: ¹⁵</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&" document member of the same patent family</p>		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search ²	Date of Mailing of this International Search Report ²	
APRIL 30, 1984	24 MAY 1984	
International Searching Authority ¹	Signature of Authorized Officer ²⁰	
ISA/US	R. B. Penland	