# EXHIBIT R

**UNITED STATES DISTRICT COURT**
**FOR THE NORTHERN DISTRICT OF ALABAMA**
**EASTERN DIVISION**

| | | |
|---|---|---|
| DAVIS PRODUCT CREATION AND CONSULTING, LLC d/b/a BEESNTHINGS<br><br>Plaintiff,<br><br>v.<br><br>BRIAN BLAZER d/b/a CARPENTER BEE SOLUTIONS<br><br>Defendant. | ) | Case No.: 1:19-cv-00848-CLM |

**DECLARATION OF DR. GEORGE L. ROTRAMEL**

I, George L. Rotramel, declare and state:

1. My name is George L. Rotramel and I am over the age of nineteen years and reside in Chicago, Illinois. I have personal knowledge of the facts in this affidavit.

2. The following is a brief summary of my background and qualifications. My background and qualifications are more fully set out in my curriculum vitae (CV), attached as Tab 1.

3. I earned a Bachelor's of Science in Zoology from The University of Illinois at Urbana Champaign in 1964. While completing my Bachelor's of Science degree I conducted independent research on carpenter ants and wood-boring beetles.

4. I earned a Master's of Science in Entomology from The University of Illinois at Urbana Champaign in 1966, during which time I was employed as a systematic entomologist and researcher at the Illinois Natural History. My role as a systematic entomologist included identifying carpenter bees, carpenter ants and other wood-destroying insects.

5. I earned my Ph.D. from the University of California at Berkeley in 1971 wherein I conducted my thesis research on carpenter ants and other wood boring arthropods. I also assisted my major professor, Howell Daly, in his research on the nesting behavior and ecology of small carpenter bees.

6. I have served as a Pest management consultant since 1988 and worked as a Visiting Associate Professor at the University of Illinois in Chicago from 1999-2003.

7. I am very familiar with carpenter bees and their habits.

8. I am being compensated for my time spent on this matter at my usual and customary rate. My compensation is not related to this action's outcome and I have no financial interest in this case.

9. In preparing this declaration, I considered the following materials: U.S. Patent No. 46,421 (the "'421 Patent"), Plaintiff's Preliminary Invalidity Contentions and the prior art cited therein, Plaintiff's Amended and/or Supplemental Invalidity Contentions and the prior art cited therein, The Court of Appeals for the Federal Circuit's Opinion in *Blazer v. Best Bee Brothers, LLC et al.* and the Markman Order entered in this matter.

10. In this section, I describe my understanding of certain legal standards. Based on my professional experience, I am familiar with the patent system and the process of applying for and obtaining patents. I am not an attorney; I have been informed of these legal standards by Davis Product Creation and Consulting, LLC's attorneys generally.

11. I understand that, in order to receive a valid patent, an inventor must invent or discover a new and useful process, machine, manufacture, or composition of matter.

12. However, for an invention to be patentable, it must also be a non-obvious improvement over the prior art, as viewed by a person of ordinary skill in the art at the time the patent application was filed.

13. I expect to offer testimony regarding the level of ordinary skill in the art relevant to at least the '421 Patent (and possibly certain patents owned by DPCC). I understand that factors such as 1) the education level of those working in the field, including the inventor, 2) the sophistication of the technology, 3) the types of problems encountered in the art, 4) the prior art solutions to those problems, and 5) the speed at which innovations are made may help establish the level of skill in the art. Of course other factors may be considered. I believe that I am a person having ordinary skill in the art, or a PHOSITA given my background, education and experience.

14. I understand that, under 35 U.S.C. § 282, a patent is presumed valid. I understand that a patent cannot be invalidated based on one person's testimony alone without corroborating evidence, particularly without documentary evidence. I further understand that patent claims can be determined to be invalid only if shown by clear and convincing evidence. I understand that challenges to the validity of a patent are considered on a claim-by-claim basis.

15. I understand that determination of validity/invalidity, like infringement/non-infringement, requires a two-step analysis. I understand that the first step in determining validity is to properly construe the claims to determine claim scope and meaning. I further understand that the purpose of claim construction is to illustrate how one skilled in the art would have understood the claim terms at the time of the purported invention. I have been instructed by counsel that claim construction is for the Court to decide as a matter of law.

16. I understand that a patent may include two types of claims, independent claims and dependent claims. An independent claim stands alone and includes only the limitations it recites.

A dependent claim can depend from an independent claim or another dependent claim. I understand that a dependent claim includes all the limitations that it recites in addition to all of the limitations recited in the claim(s) from which it depends.

17. I understand that the claims of a patent define the scope of the rights conferred by the patent. I further understand that the claims particularly point out and distinctly claim the subject matter which the patentee regards as his/her invention and because the patentee is required to define precisely what he/she claims his/her invention(s) is/are. I further understand that construction of claims in a manner different from the plain import of the terms used consistent with the specification is improper. Accordingly, I understand that a claim construction analysis must begin and remain centered on the claim language itself.

18. As to claim terms that were previously considered and construed by the Court or the Court of Appeals for the Federal Circuit, I have relied on and adopted the claim construction therefrom.

19. I understand that a patent or other publication must first qualify as prior art before it can be used to invalidate a patent claim. I further understand that documents and materials that qualify as prior art can be used to invalidate a patent claim as anticipated or as obvious.

20. I understand that invalidity must be shown by clear and convincing evidence.

21. I have been instructed by counsel on the law regarding obviousness, and understand that, even if a patent is not anticipated, a claim is invalid if the differences between the claimed subject matter and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person of ordinary skill in the pertinent art. I further understand that the obviousness analysis requires a comparison of the properly construed claim to the alleged obviousness combination on a limitation-by-limitation basis.

22. I understand that a reference qualifies as prior art for an obviousness determination when it is analogous to the claimed invention; meaning that it is in the field of the inventor's endeavor, or if a person of ordinary skill would reasonably have consulted the reference and applied its teachings in seeking a solution to the problem that the inventor was attempting to solve.

23. I understand that the obviousness inquiry is based on the reference point of a person of ordinary skill in the art at the time of the invention. I also understand that this reference point prevents one from using insight or hindsight in deciding whether a claim is obvious. Thus, I understand that "hindsight reconstruction" cannot be used to combine references together to reach a conclusion of obviousness.

24. I also understand that an obviousness determination includes the consideration of factors (commonly referred to as the Graham factors), such as (1) the scope and content of the prior art, (2) the differences between the prior art and the asserted claims, (3) the level of ordinary skill in the pertinent art at the time of the invention, and (4) the existence of secondary considerations, objective evidence (secondary indicia) of non-obviousness, to the extent such exists.

25. I understand that an obviousness evaluation can also be based on a combination of multiple prior art references. I further understand that the prior art references themselves may provide a suggestion, motivation, or reason to combine, but other times the nexus linking two or more prior art references is simple common sense.

26. I also understand that practical and common sense considerations should guide a proper obviousness analysis, because familiar items may have obvious uses beyond their primary purposes. I further understand that a person of ordinary skill in the art looking to overcome a problem will often be able to fit the teachings of multiple publications together like pieces of a

puzzle. Therefore, I understand that obviousness analysis takes into account the inferences and creative steps that a person of ordinary skill in the art would employ under the circumstances.

27. I understand that a particular combination may be proven obvious merely by showing that it was obvious to try the combination. For example, when there is a design need or market pressure to solve a problem and there are a finite number of identified, predictable solutions, a person of ordinary skill has good reason to pursue the known options within his or her technical grasp because the result is likely the product not of innovation but of ordinary skill and common sense which led to a reasonable expectation of success.

28. I understand that the combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results. For example, when a work is available in one field of endeavor, design incentives and other market forces can prompt variations of it, either in the same field or a different one. Therefore, I understand that if a person of ordinary skill can implement a predictable variation, § 103 of the Patent Act likely bars its patentability.

29. I understand that when a patent simply arranges old elements with each performing the same function it had been known to perform and yields no more than one of ordinary skill in the art would reasonably expect from such an arrangement, the combination is obvious. It is further my understanding that a proper obviousness analysis focuses on what was known or obvious to a person of ordinary skill in the art, not just the patentee. Accordingly, I understand that any need or problem known in the field of endeavor at the time of invention and addressed by the patent can provide a reason for combining the elements in the manner claimed.

30. In sum, my understanding is that prior art teachings are properly combined where a person of ordinary skill in the art, having the understanding and knowledge reflected in the prior

art and motivated by the general problem facing the inventor, would have been led to make the combination of elements recited in the claims. Under this analysis, the prior art references, or any need or problem known in the relevant field at the time of the invention, can provide a reason for combining the elements of multiple prior art references in the claimed manner.

31. I have also been informed and understand that secondary indicia of non-obviousness must be addressed in the obviousness analysis and, to be relevant to the obviousness analysis, must have a nexus to the claimed invention. Furthermore, I understand that certain secondary considerations may be examined to determine whether a certain invention would have been obvious to one of ordinary skill in the art and could be used to overcome an obviousness rejection or challenge under § 103 of the Patent Act. Examples of secondary considerations include: any long-felt and unmet need in the art that was satisfied by the invention of the patent; any failure of others to achieve the results of the invention; any commercial success or lack thereof of the products and processes covered by the invention; any deliberate copying of the invention by others in the field; any taking of licenses under the patent by others; whether the invention was contrary to the accepted wisdom of the prior art; any expression of disbelief or skepticism by those skilled in the art upon learning of the invention; any unexpected results achieved by the invention; any praise of the invention by others skilled in the art; and any lack of contemporaneous and independent invention by others.

32. I understand that the factfinder must determine whether potential evidence of secondary considerations is relevant. In particular, I understand that the factfinder must ascertain whether a nexus connects, e.g., commercial success to a claimed invention and determine the probative value of secondary considerations evidence for rebutting a *prima facie* case of obviousness.

33. I have reviewed the prior art cited/discussed in DPCC's Preliminary Invalidity Contentions as well as DPCC's Amended and/or Supplemental Invalidity Contentions, namely U.S. Patent No. 5,231,792 to Warner ("Warner") attached hereto at Tab 2; U.S. Patent Pub. No. 2004/0231228 to Pazik ("Pazik") attached hereto as Tab 3;U.S. Patent Pub. No. 2008/0052982 to Windsor ("Windsor") attached hereto as Tab 4; Development and Evolution of Division of Labor and Foraging Specialization in a Social Insect, Page et al., Current Topics in Developmental Biology, 2006:74:253-86, Elsevier ("Page") attached hereto as Tab 5, U.S. Patent No. 6,766,611 to Prince ("Prince") attached hereto as Tab 6; and U.S. Patent No. 7,757,432 to Gunderman, Jr. ("Gunderman") attached hereto as Tab 7.

34. For ease of reference, I am adopting the shorthand references to each of the prior art references cited/discussed in DPCC's Preliminary Invalidity Contentions as well as DPCC's Amended and/or Supplemental Invalidity Contentions.

35. Pazik teaches and discloses a trap for flying insects.

36. Windsor teaches and discloses a carpenter bee trap.

37. Page teaches and discloses certain information about the natural instincts of bees.

38. Warner discloses an insect trap.

39. Prince discloses a carpenter bee trap.

40. Gunderman discloses an electronic carpenter bee trap.

41. The following claims have been asserted from the '421 Patent, 1, 2, 4, 7, 8, 13-17 (the "Asserted Claims") in this case. Each and every one of the Asserted Claims is invalid as obvious under Section 103 of the Patent Act.

42. In summary, it is my opinion that the Asserted Claims are invalid as obvious over the combinations of (i) Windsor, Pazik, Warner and Page, (ii) Prince, Pazik, Windsor and Warner,

(iii) Gunderman, Pazik, Windsor and Warner, (iv) Windsor, Pazik and Warner and (v) Prince, Pazik, Windsor, Warner and Page.

43. It is my opinion that the Asserted Claims are invalid over the combination of Windsor, Pazik, Warner and Page as a PHOSITA would have been motivated to look to the teachings of Windsor, Warner and Page to improve the trap of Pazik. Furthermore, it is my opinion that a PHOSITA would have been motivated to combine the teachings of these prior art references as they all relate to the same field —namely insect traps— and the elements to be combined would have been expected to maintain their respective properties/functions after they have been combined, a PHOSITA would have recognized the value of combining the elements of each prior art reference and would have known how to do so.

44. It is my opinion that the Asserted Claims are invalid over the combination of Prince, Pazik, Windsor and Warner as a PHOSITA would have been motivated to look to the teachings of Pazik, Windsor and Warner to improve the trap of Prince. Furthermore, it is my opinion that a PHOSITA would have been motivated to combine the teachings of these prior art references as they all relate to the same field—namely insect traps— and the elements to be combined would have been expected to maintain their respective properties/functions after they have been combined, a PHOSITA would have recognized the value of combining the elements of each prior art reference and would have known how to do so.

45. It is my opinion that the Asserted Claims are invalid over the combination of Gunderman, Pazik, Windsor and Warner as a PHOSITA would have been motivated to look to the teachings of Pazik, Windsor and Warner to improve the trap of Gunderman. Furthermore, it is my opinion that a PHOSITA would have been motivated to combine the teachings of these prior art references as they all relate to the same field —namely insect traps— and the elements to be

combined would have been expected to maintain their respective properties/functions after they have been combined, a PHOSITA would have recognized the value of combining the elements of each prior art reference and would have known how to do so. A PHOSITA would have been motivated to combine the teachings of these prior art references as they all relate to the same field —namely insect traps— and the elements to be combined would have been expected to maintain their respective properties/functions after they have been combined, a PHOSITA would have recognized the value of combining the elements of each prior art reference and would have known how to do so.

46. The Asserted Claims are invalid over the combination of Windsor, Pazik and Warner as a PHOSITA would have been motivated to look to the teachings of Windsor and Warner to improve the trap of Pazik. A PHOSITA would have been motivated to combine the teachings of these prior art references as they all relate to the same field —namely insect traps— and the elements to be combined would have been expected to maintain their respective properties/functions after they have been combined, a PHOSITA would have recognized the value of combining the elements of each prior art reference and would have known how to do so.

47. The Asserted Claims are invalid over the combination of Prince, Pazik, Windsor, Warner and Page as a PHOSITA would have been motivated to look to the teachings of Pazik, Windsor, Warner and Page to improve the trap of Prince. A PHOSITA would have been

motivated to combine the teachings of these prior art references as they all relate to the same field —namely insect traps— and the elements to be combined would have been expected to maintain their respective properties/functions after they have been combined, a PHOSITA would have recognized the value of combining the elements of each prior art reference and would have known how to do so.

48. To avoid unnecessary duplication herein, the claim charts attached hereto at Tab 8 show and/or explain where each of the elements of the Asserted Claims can be found in the prior art references discussed herein. I have reviewed these claim charts and found them to be accurate and hereby incorporate them into this declaration as if fully set forth herein.

49. I declare under penalty of perjury that the foregoing statements are true and correct.

JANUARY 30, 2023
Date

[signature]
George L. Rotramel

# Tab 1

# CURRICULUM VITAE

**George L. Rotramel**

**Education**

- BS in Zoology with Chemistry/Physics minor.
  University of Illinois at Urbana Champaign. 1964. (Assigned laboratory space in Department of Entomology for independent research on wood borers.)
- MS in Entomology with Plant Ecology minor.
  University of Illinois at Urbana Champaign. 1966.
- PhD in Entomology. (Thesis research on wood borers.)
  University of California at Berkeley. 1971.

**Work History**

- Pest Management Consultant, 1988 - present
- Visiting Professor, UI at Chicago, 1999-2003
- Technical Services Director, Velsicol 1986-1988
- Ag Products R&D, Union Carbide, 1975-1986
- Vector Control, Calif. DPH & CDC 1971-1975

**Licenses and Certifications**

- Licensed to apply restricted and general use pesticides for vector and pest control in/around buildings, institutions and food facilities.
- State approved recertification class instructor for structural pest control in Illinois.

**Relevant Technical Experience and Publications**

- Field and laboratory experience with small carpenter bees (*Ceratina* spp) at U.C. Berkeley.
- US Patent 5,275,125. Animal Harborages. Device with entrances “sized for the pest” was selected as new product of the year at the national hardware show.
- Deposed as defense expert in litigation involving traps for bed bugs.

**Expert Testimony Since June 2016**

- Epich v Duran. (termites). Case # 2012CH005784. Retained by John Norton.
- Yosemite National Park Hantavirus Litigation. (rodents) Case # 3:14-md-02532-MMC. Retained by U.S. Department of Justice.
- Bed Bug Patent Litigation (bed bugs). Retained by Foley & Lardner.
- Jones and Dayer v Terminix Int. (termites). Case # 16-1068-111. Retained by
- Hinshaw and Culbertson.
- Thomas v Dollar Rent A Car (rodents). Case # 4:17-cv-586-JM. Retained by Watts Donovan and Tilley.
- Collins v Terminix Int. (termites). Case # 01-18-0004-3723. Retained by Hinshaw and Culbertson.
- Rogers v Terminix Int. (termites) Case # 48-CV-2018-102-1. Retained by Hinshaw and Culbertson.

# Tab 2

US005231792A

# United States Patent [19]

Warner

[11] Patent Number: 5,231,792

[45] Date of Patent: Aug. 3, 1993

[54] **DOUBLE CONE INSECT TRAP**

[75] Inventor: **William B. Warner**, Chandler, Ariz.

[73] Assignee: **Farnam Companies, Inc.**, Phoenix, Ariz.

[21] Appl. No.: **915,253**

[22] Filed: **Jul. 20, 1992**

[51] **Int. Cl.**[5] .................................... **A01M 1/00**

[52] **U.S. Cl.** .................................... **43/122**

[58] **Field of Search** .................................... 43/122, 121

[56] **References Cited**

U.S. PATENT DOCUMENTS

1,107,091 8/1914 Mielke .................................... 43/122
4,121,372 10/1978 [illegible] .................................... 43/122

FOREIGN PATENT DOCUMENTS

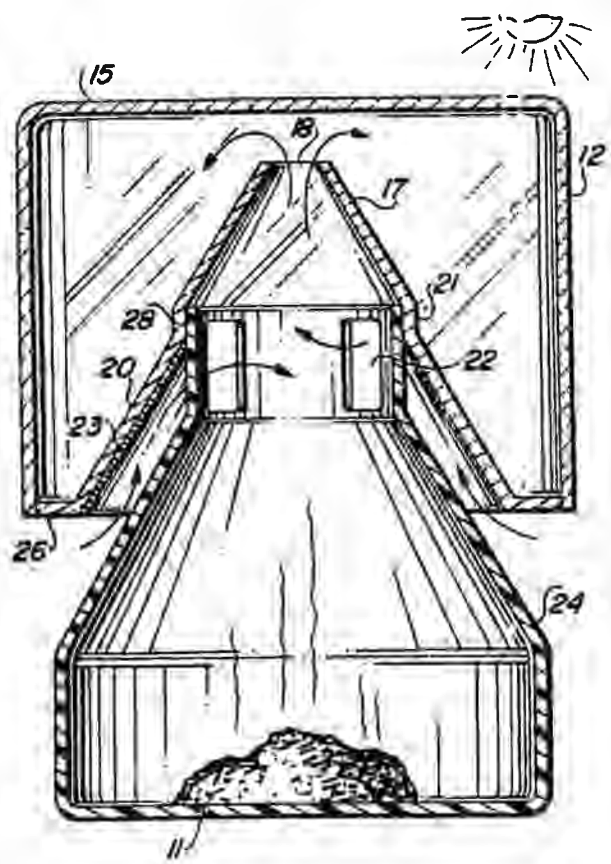
1228 of 1866 United Kingdom .................... 43/122

*Primary Examiner*—Mark Rosenbaum
*Assistant Examiner*—Jeanne M. Elpel
*Attorney, Agent, or Firm*—Joseph H. Roediger

[57] **ABSTRACT**

An insect trap is disclosed which includes a double-cone structure having a receiving chamber for an attractive composition with a tapered surface and a retaining chamber for placement thereon. A conical indentation formed in the bottom of the retaining chamber provides a tapered surface which is spaced from that of the receiving chamber thus forming the first cone. The central portion of the indentation provides the second cone which is light-transmissive and has a central opening. The tapered surfaces of the chambers are opaque. An insect passageway is formed in the receiving chamber and communicates with the central opening. Thus, as insect entering the chamber through the tapered surfaces experiences light from above through the second cone and is drawn upward through the central opening into the retaining chamber where it is trapped.

**9 Claims, 2 Drawing Sheets**



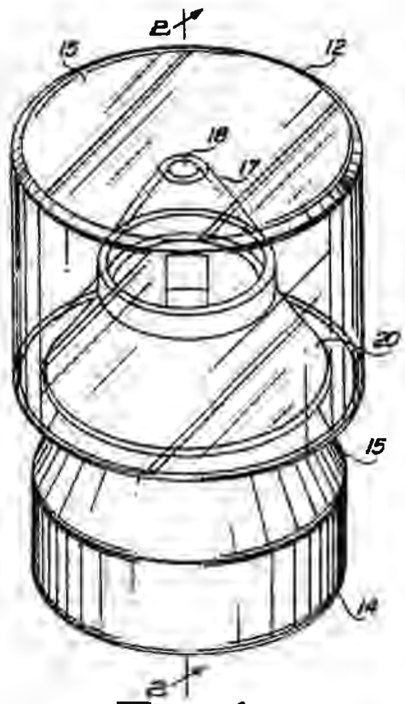


FIG. 1

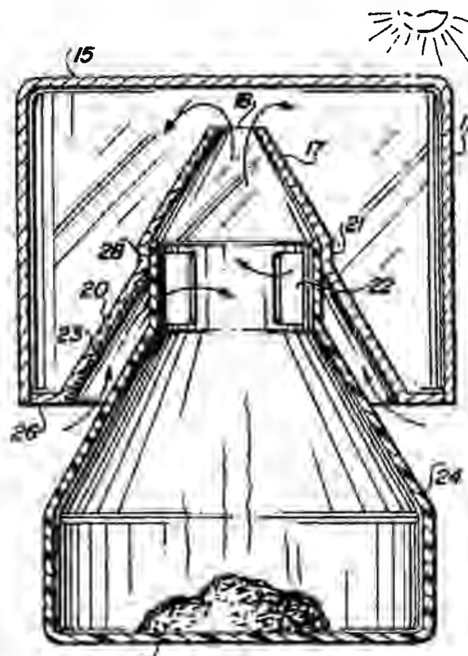


FIG. 2

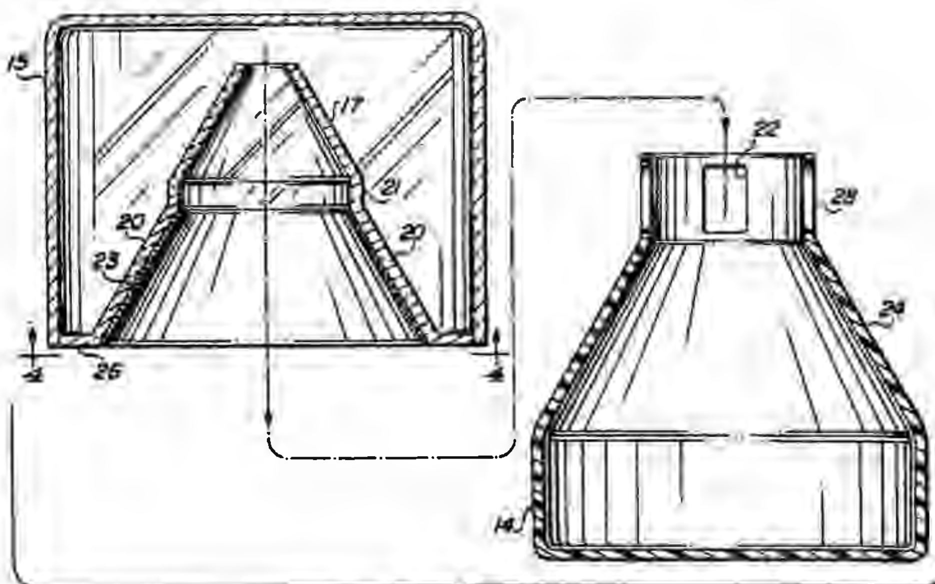


FIG. 3

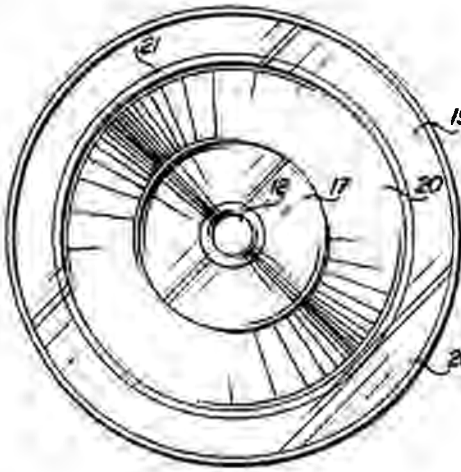



FIG. 4

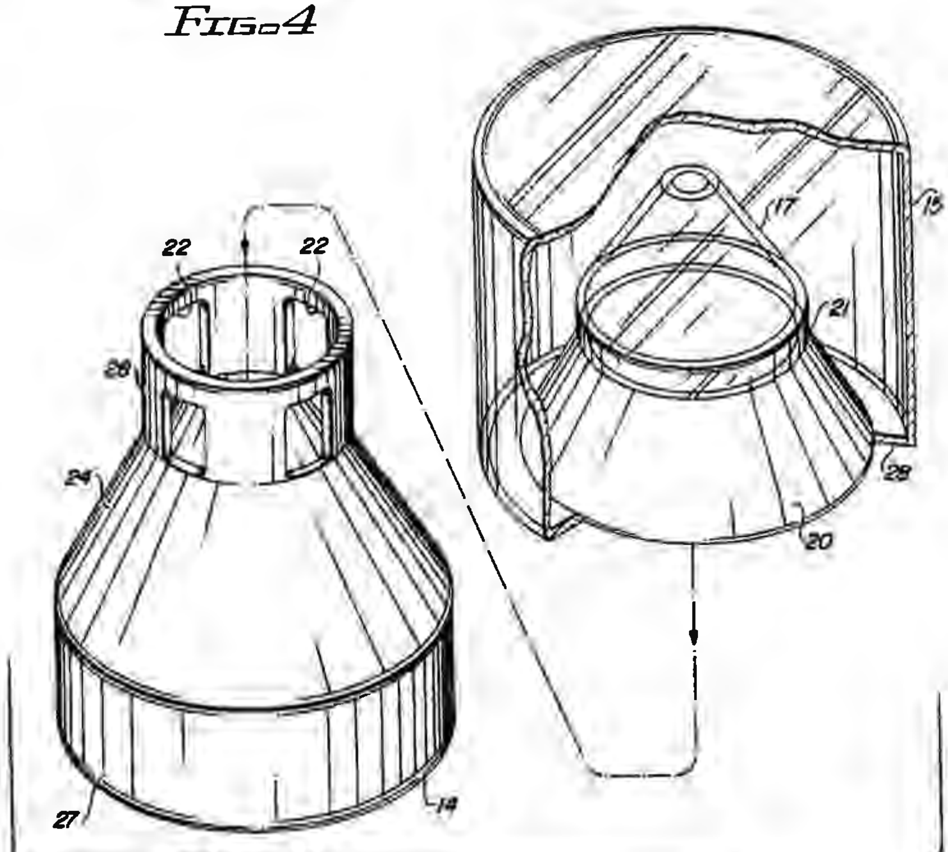



FIG. 5

## DOUBLE CONE INSECT TRAP

### BACKGROUND OF THE INVENTION

This invention relates to an improved insect trap and, in particular, to a trap having a double cone structure for use in combination with an insect attractant composition.

Throughout history, insects have distinguished themselves as persistent pests and health threats to both man and animals. Studies have been made documenting various insects as carriers of disease. The synanthropic fly is of particular concern to the public since it thrives and reproduces actively in both farm and home environments. As a result, substantial effort has been expended to develop trapping structures and chemical compositions for controlling the propagation of insects.

In the past, trapping structures utilizing wide mouth entry passages coupled with narrow exits in the shape of a cone have been employed to retain insects in a surrounding envelope which confines the insect for the rest of its life. The early trapping structures were designed to orient the entry and exit openings to take advantage of the insects tendency to favor travel in an upward direction toward the sun. Most of these devices relied upon natural attractants such as various food products, animal manure, putrifying meats, etc. to induce them to enter the wide opening. As a result, the number of flies and other insects entering the trap tended to be only a minor portion of the local insect population.

In the more recent past, sticky tapes, fly paper and hanging cylindrical traps with adhesive coatings on the exterior have been used to lower insect populations. Initially, these unsightly traps relied on the insect encountering these adhesive surfaces in their normal travels. The efficacy of the adhesive-based trap was enhanced by coloration studies which showed that insects favored certain colors, particularly the orange-yellow portion of the visible spectrum, as a preferred site to land on. In addition, studies showed that insects tended to land where other insects were already in place. This brought about the placement of simulated insects on the adhesive surfaces. All of these techniques enhanced the efficacy of the adhesive trap. Since these insect traps rely on an insect encountering the adhesive surface in its normal travels, the traps had to be publicly displayed and created an uncomfortable feeling especially when used in or viewed from a living environment.

Following the adhesive-based traps, the wide spread use of insecticides became favored to shorten the life of insects. However, recent studies have shown that use of insecticides in an indiscriminate manner has far greater ramifications than originally thought when the impact on man and his environment is examined. This has generated increasing interest in localized trapping of insects by the use of attractants. The attractants appeal to one or more of the senses of the insect to draw them to a central location. This central location need not be directly located in the normal living environment since the attractant causes the insects to travel to the attractant source. One such attractant used to draw synanthropic flies to a central location is the composition described and claimed in my U.S. Pat. No. 5,008,107, and used in the product marketed and sold by the Farnam Companies, Inc. Phoenix, Ariz. under the trademark APACHE.

Attractants of this type often utilize pheromones as sex attractants in combination with nitrogenous matter serving as feeding attractants. In the past few years, the use of attractants has proven to be a successful way to assist in controlling the insect population. The use of an attractant in combination with an insecticide is found to produce a rapid reduction in insect population, particularly in connection with flies. It is now possible to obtain attractants which through the use of pheromones result in a marked reduction in the female portion of the fly population thereby having an even greater impact on successive generations. The combination of attractant and insecticide has a possible drawback in that the insecticide is still being used to control the insect population. The insect ingesting a fly bait which contains an attractant and an insecticide is not confined at the distribution point. The insect tends to travel for a period after ingestion and die at a different location. This can create problems that reduces the desirability of using this type of control in many locations.

The combination of an improved insect trap which is designed to receive an attractant combination that assist in luring the insects to its interior is a highly desirable product. The absence of an insecticide coupled with the trapping or confining of the attracted insects not only reduces the population in the surrounding region, but also gathers the expired insects in the container itself. Furthermore, any environmental contamination occurring from either the insecticide or the insect ingesting it is essentially eliminated.

Accordingly, it is an object of the present invention to provide an improved insect trap for use in combination with an attractant composition to reduce insect populations. Furthermore, a major objective is to provide a structure which not only permits the attractant to exert its influence over the surrounding region, but also utilizes a novel double cone structure to draw the insects into the retaining chamber. In addition, the invention provides a structure which takes advantage of the tendency of insects to favor movement in an upward direction and toward an overlying light source. An important feature is the provision of a structure which shields a portion of the entering pathway from ambient light thereby permitting light from above to draw the insect into the trap.

### SUMMARY OF THE INVENTION

This invention relates to an improved insect trap having a double cone structure designed to utilize ambient light to draw insects to the trap. The present trap is designed to contain an attractant composition thereby increasing its efficacy beyond that exhibited by traps relying on insects encountering them during their normal travels. The present trap is constructed so that entering insects find it difficult to leave and are retained therein for the remainder of their life.

The present insect trap includes a receiving chamber which contains the insect attractant, supports an overlying retaining chamber and defines in part the means of entry into the trap. The receiving chamber has a base member adapted to rest on a support surface and an enclosing wall which extends upwardly therefrom to provide a relatively large area opening for the addition of the attractant composition. A portion of the enclosing wall is preferably tapered inwardly and provides one surface of the entry passage. In addition, at least one insect passageway is formed in the enclosing wall proximate to the end of the wall. This passageway serves also to permit the region of effectiveness of the attractant to extend outwardly beyond the confines of the trap.

A trapping chamber containing an indentation in the bottom surface thereof is provided for placement upon the enclosing wall. The indentation includes an entry member, conical in shape, having a central region containing an opening dimensioned to permit the passage of insects therethrough. The outer region of the indentation comprises an opaque skirt flared outwardly and depending from the central region. When the two parts are assembled, the outwardly flared skirt is spaced adjacent a portion of the enclosing wall to define the insect pathway to within the trap. A surrounding envelope is attached to the skirt and completes the enclosure of the trapping chamber by surrounding the skirt and entry member to form a bounded volume. The only entry for the insect into the trapping chamber is through the opening contained in the central region. Thus, the present insect trap has a double cone structure with the first conical pathway being bounded by both the receiving chamber and the trapping chamber. The upper or second cone is located in the indentation formed in the bottom surface of the trapping chamber. As a result, the second cone overlies the first cone and the trap thus takes advantage of an insects tendency to favor travel in the upward direction.

In addition, a portion of the envelope and the entry member formed in the indentation in the bottom of the trapping chamber are light-transmissive. As a consequence thereof, An insect entering the first conical pathway defined by the enclosing wall of the receiving chamber and the skirt experiences light from the passageway formed in the enclosing wall. The insect is influenced not only by the pheromones and olfactory attractants contained within the receiving chamber, but is also encouraged to migrate upwardly toward the light along the pathway defined by the double conical structure. Once the insect has entered the trapping chamber, its view of a possible escape route is obscured by the opaque and darkened entryway between the double cones, encouraging it to remain in the well lit trapping chamber.

In its simplest form, the present insect trap is comprised only of the receiving chamber and the trapping chamber. The two parts frictionally engage one another to form a unitary structure. To load the trap, the trapping chamber is removed, the attractant material added to the receiving chamber and the parts are then recombined. The combination of the upwardly inclined conical shape, the shielding of the ambient light by the opaque skirt to reduce distractions coupled with the effects of the attractant have been found to provide an effective trap useful with a variety of insects. Those insects that enter the trapping chamber are unable to leave since they are continually drawn upward away from the opening in the central region in the entry member and obscured escape route therein and spend the rest of their lives attempting to escape toward sunlight entering the transparent outer walls of the trapping chamber.

Further features and advantages will become more readily apparent from the following detailed description of a preferred embodiment of the invention when viewed in conjunction with the accompanying drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view in perspective of one embodiment of the invention.

FIG. 2 is a side view in section taken along line 2—2 of FIG. 1.

FIG. 3 shows the embodiment of FIG. 2 with the chambers separated.

FIG. 4 is a top view of the embodiment of FIG. 1.

FIG. 5 is an exploded view of the embodiment of FIG. 1 with the trapping chamber shown in partial section.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIGS. 1 and 2, the novel insect trap which is the subject of the present invention is shown in a cylindrical form and includes a trapping chamber 12 situated upon the receiving chamber 14. The trapping chamber is a bounded volume having a light-transmissive envelope 15 forming the exposed outer surface thereof. An indentation is formed in the bottom of the trapping chamber 12 and is surrounded by peripheral flange 26. The indentation includes skirt 20, a vertical engaging surface 21 and a central region 17. The central region is conical in shape and has an opening 16 centrally located therein which is dimensioned to provide a passage for insects.

The receiving chamber 14 has a basal surface with an enclosing wall 15 extending upwardly therefrom. The enclosing wall includes an inwardly tapered section 24 which terminates in a second engaging surface 28. The attractant composition 11 is added to the receiving chamber 14 through the central opening defined by the second engaging surface 28. A plurality of large area passageways 22 is formed about the circumference of the second engaging surface 28. The passageways are relatively large compared with the central opening 18 since they establish the airway through which the effects of the attractant 11 are outwardly disseminated. In addition, the light from above passes through the passageway 22 into the region between the skirt 20 and tapered section 24.

An opaque coating 23 is shown placed on the surface of the skirt 20. In addition, the receiving chamber 14 is made of moldable plastic with an opaque coating thereon. As a result, the inwardly and upwardly inclined pathway formed by the tapered section 24 and the skirt 20 is shielded from ambient light except that light transmitted through passageway 22. This structure capitalizes on the tendency of insects to favor travel paths which move upwardly toward a light source. Also, the attractant effects are experienced by the insects as they travel about beneath the pathway. As a result, the insect travels along the path of the arrows shown in FIG. 2.

Removal of the trapping chamber 12 from the receiving chamber 14 is shown in FIG. 3. This separation of parts permits the attractant composition to be readily placed in the receiving chamber when the device is placed in use. In addition, it permits a recharge of attractant composition if necessary. The engagement of the two parts to the present invention occurs by the dimensioning of the second engaging surface 28 and the mating engaging surface 21 provided between the central region 17 and skirt 20. The joining of the two parts is accomplished by placing the trapping chamber in position and rotating it gently while urging it downwardly so that the engaging surfaces 21 and 22 are in contact. The inward taper of the central region 17 provides the limiting means for vertical movement of the trapping chamber. It is recognized that threaded engagement can be provided by the formation of grooves in surfaces 21 and 28.

As shown in FIGS. 3, 4 and 5, the trapping chamber includes a clear plastic envelope 15. The envelope provides the external surface of the chamber and is supported by flange 26. The inwardly tapered section forming the skirt 20 is terminated by the vertical engaging surface 21 which is then followed by the tapered central region 17. In the manufacturing process, the trapping chamber 12 is preferably made as two parts with the envelope separately formed and joined to the outer surface of flange 26. The conical surfaces of the indentation and flange 26 are formed as a single piece by a molding process. The two pieces are made of a light-transmissive plastic with the opaque coating 23 applied to the surface of skirt 20. The preferred colors are black for the entryway between tapered section 24 and skirt 20 with the rest of the receiving chamber having bright yellow to orange coating with a high reflectance in 300–450 NM wavelength range. The preferred embodiment utilizes a yellowish-orange color residing in that portion of the spectrum known to especially appeal to flies. The receiving chamber 14 is formed as a single piece typically of a transparent plastic with a similar opaque coating applied to the entire receiving chamber. However, it is recognized that opaque plastics can be used for the receiving chamber and the preferred embodiment shown is of this type. Thus, no coating on the receiving chamber is shown in the drawings. The opaque portion of the receiving chamber should include the tapered section 24 and the second engaging surface 28 in order to most strongly influence the insect by the ambient light from above. However, the shielding of the attractant from view is highly desirably and thus it is recommended that the entire receiving chamber be made opaque.

The preferred attractant composition is the attractant set forth in my U.S. Pat. No. 5,008,107. However, it is to be noted that many different attractants can be used if desired. For example, for the trapping of wasps, a liver flavored attractant such as a commercial cat food can be employed as shown in FIG. 2.

In operation, the present insect trap employs a double cone construction with the initial pathway bounded by the opaque colored skirt 20 and the opaque tapered section 24. An insect traveling nearby encounters the effects of the attractant which pass through the passageways 22 and outwardly from the entering pathway. The insect is attracted to the structure, lands on or near the tapered surface 24 and crawls upwardly toward the light at the passageways. The attractancy of the composition 11 increases as the insect travels toward the light. When the insect passes through the passageway, the light-transmission central region 17 leads the insect to travel upwardly in the direction of the arrows shown in FIG. 2 and out through the opening 18. Since the light is present above from the device, and the insects tend to favor upward travel, the likelihood of an insect making a successful exit from the trap is minimal. One advantage of making the entire receiving chamber 14 opaque is that the insect does not see any light from the region containing the attractant composition and therefore has a reduced incentive to attempt to move downwardly as it passes through the passageway 22.



While the above description has referred to a preferred embodiment of the invention, it is to be noted that many modifications and variations may be made therein without departing from the scope of the invention as claimed.

I claim:

1. Apparatus for attracting and retaining insects which comprises:

a) a bottom enclosure having a base and a support wall extending therearound, said support wall forming a central opening above the base member;
b) an insect passage formed in said support wall;
c) a top enclosure having a bottom indentation for placement on the support wall, said indentation having a substantially conical surface with a central opening at the apex thereof, said central opening communicating with said passage, the placement of the top enclosure on the support wall forming a pathway therebetween, and
d) an opaque region located on the conical surface of the bottom indentation, said region limiting the light incident on the pathway whereby an insect entering said pathway primarily encounters light entering said pathway from the passage in said support wall.

2. Apparatus in accordance with claim 1 wherein said support wall includes a section having an inward taper.

3. Apparatus in accordance with claim 2 wherein the tapered section of the support wall is substantially parallel to the bottom indentation of the top enclosure.

4. An insect trap comprising:

a) a receiving chamber for containing an insect attractant, said chamber having a base member and an enclosing wall extending upwardly therefrom;
b) a passageway formed in the enclosing wall for the passage of insects therethrough;
c) a trapping chamber for placement upon the enclosing wall, said chamber including:
   i. an entry member having a central region containing an opening dimensioned to permit the passage of insects therethrough;
   ii. an opaque skirt depending from said central region and spaced adjacent the enclosing wall to define a pathway therebetween, and
   iii. an envelope attached to the skirt for surrounding the skirt and entry member to form a bounded volume, at least a portion of the envelope and the entry member being light-transmissive whereby an insect entering the pathway experiences light from above the pathway.

5. The invention in accordance with claim 4 wherein the enclosing wall of said receiving chamber includes a region having an inward taper spaced adjacent the opaque skirt.

6. The invention in accordance with claim 5 wherein the central region of the entry member is conical.

7. The invention in accordance with claim 6 wherein said entry member includes an attachment section for engaging the enclosing wall of the receiving chamber, said attachment section being positioned between the central region and the skirt.

8. The invention in accordance with claim 7 wherein the skirt of the trapping chamber extends below the passageway formed in the enclosing wall whereby the pathway is inclined upwardly into the envelope.

9. The invention in accordance with claim 8 wherein said receiving chamber is opaque.

* * * * *

# Tab 3

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(54) **TRAP AND METHOD FOR TRAPPING FLYING INSECTS**

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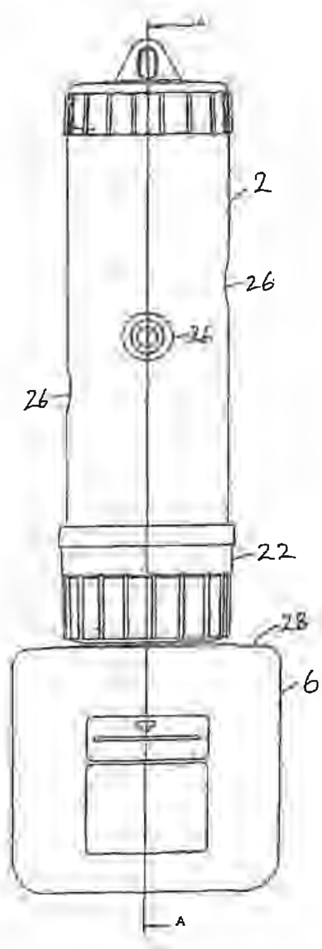
(52) **U.S. Cl.** ............ **43/107**

(57) **ABSTRACT**

A trap for insects, particularly for wasps, comprises a vapour chamber having at least one insect entrance defined in a wall of the vapour chamber, and a bait or collection chamber couplable to the vapour chamber at a restriction. The restriction is sized to control the movement of insects between these two chambers. In operation, attractant vapour from a bait source accumulates in the vapour chamber and is released through the entrance. Insects attracted by the attractant vapour enter the vapour chamber and are maintained in flight within it, the restriction delaying their entry into the collection chamber. Once tired, insects drop down into the collection chamber where, in a preferred embodiment, they are immersed in a fluid and drowned.



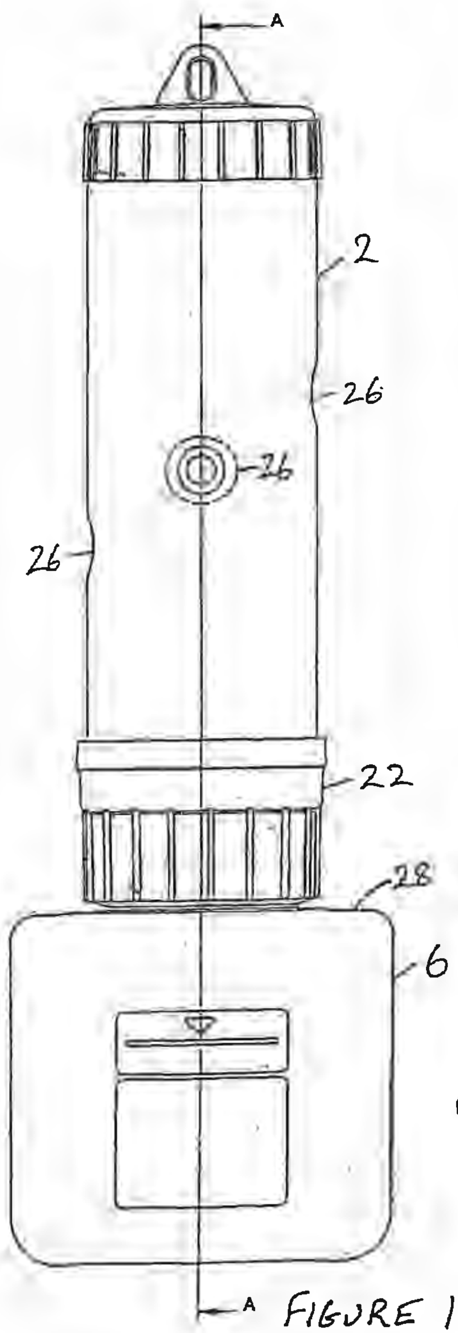



FIGURE 1

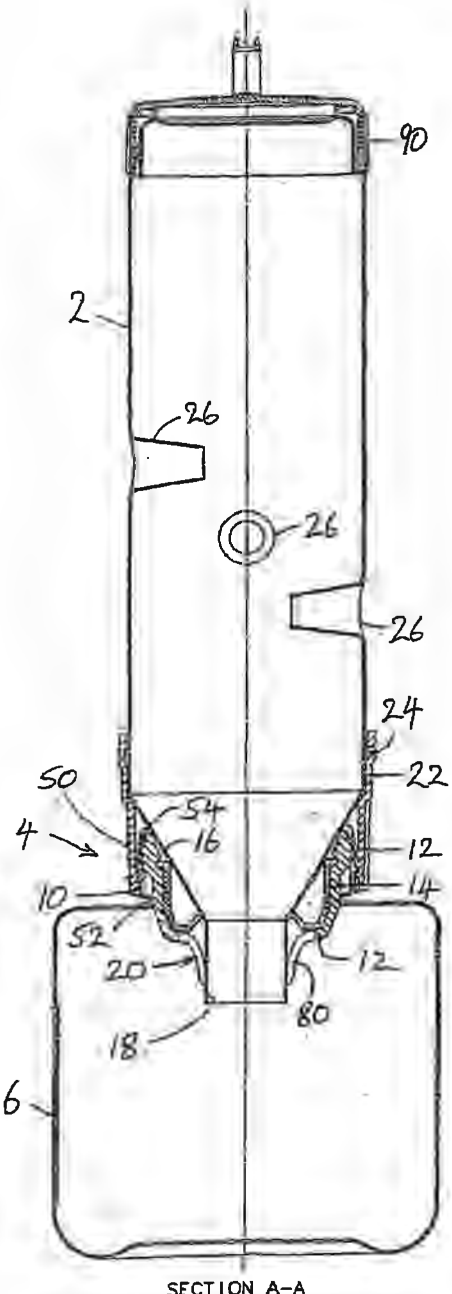



FIGURE 2

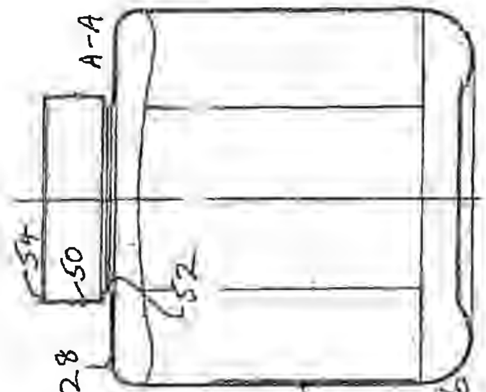



FIGURE 6

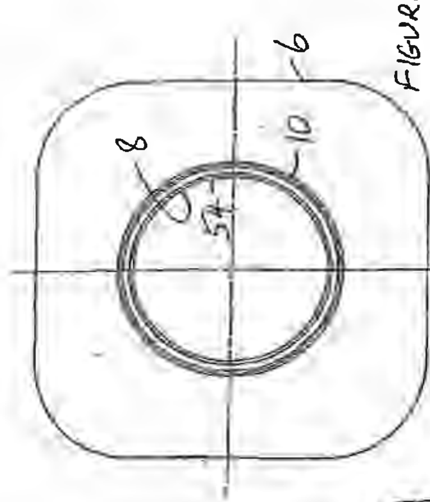



FIGURE 4

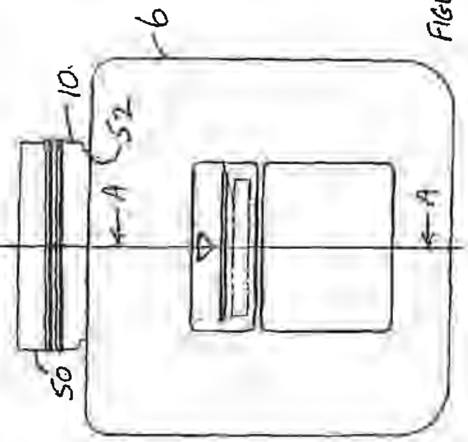



FIGURE 5

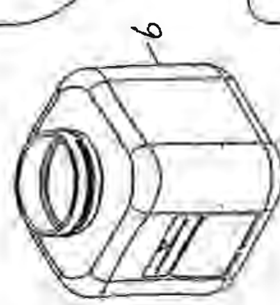



FIGURE 3

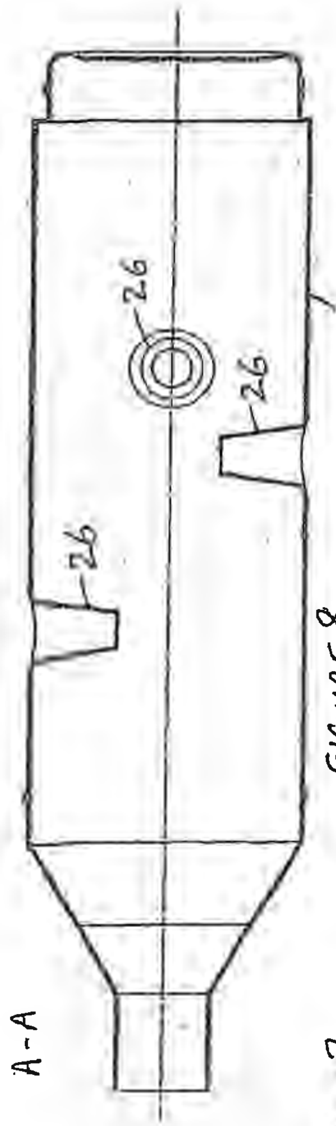


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FIGURE 8

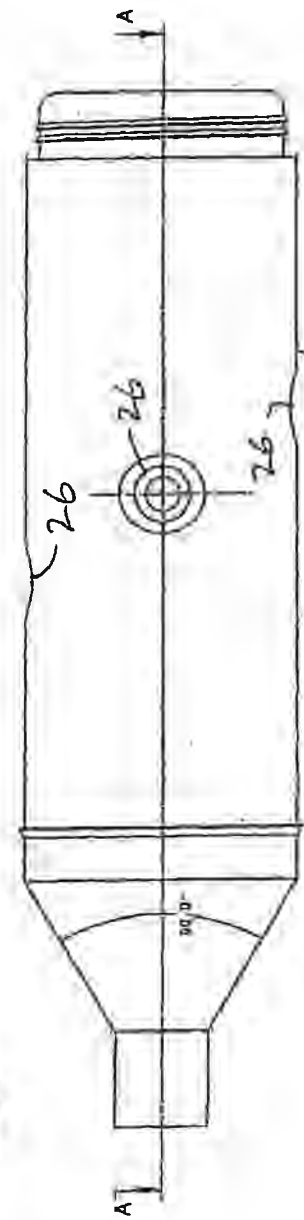

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FIGURE 9

FIGURE 7

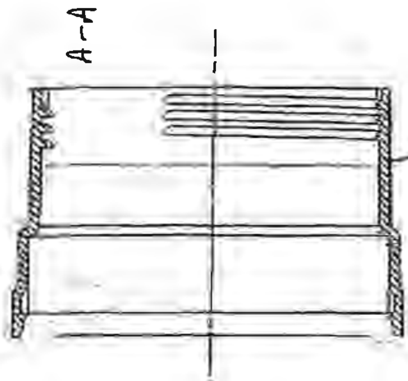


FIGURE 12

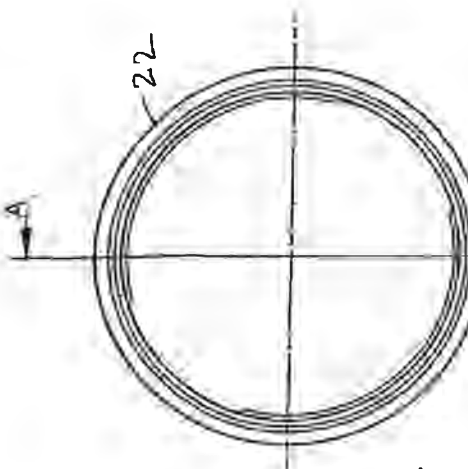


FIGURE 11

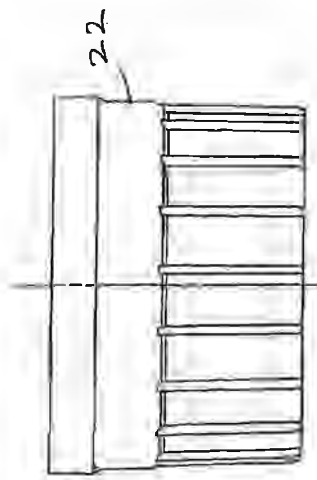


FIGURE 13

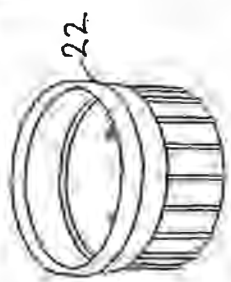
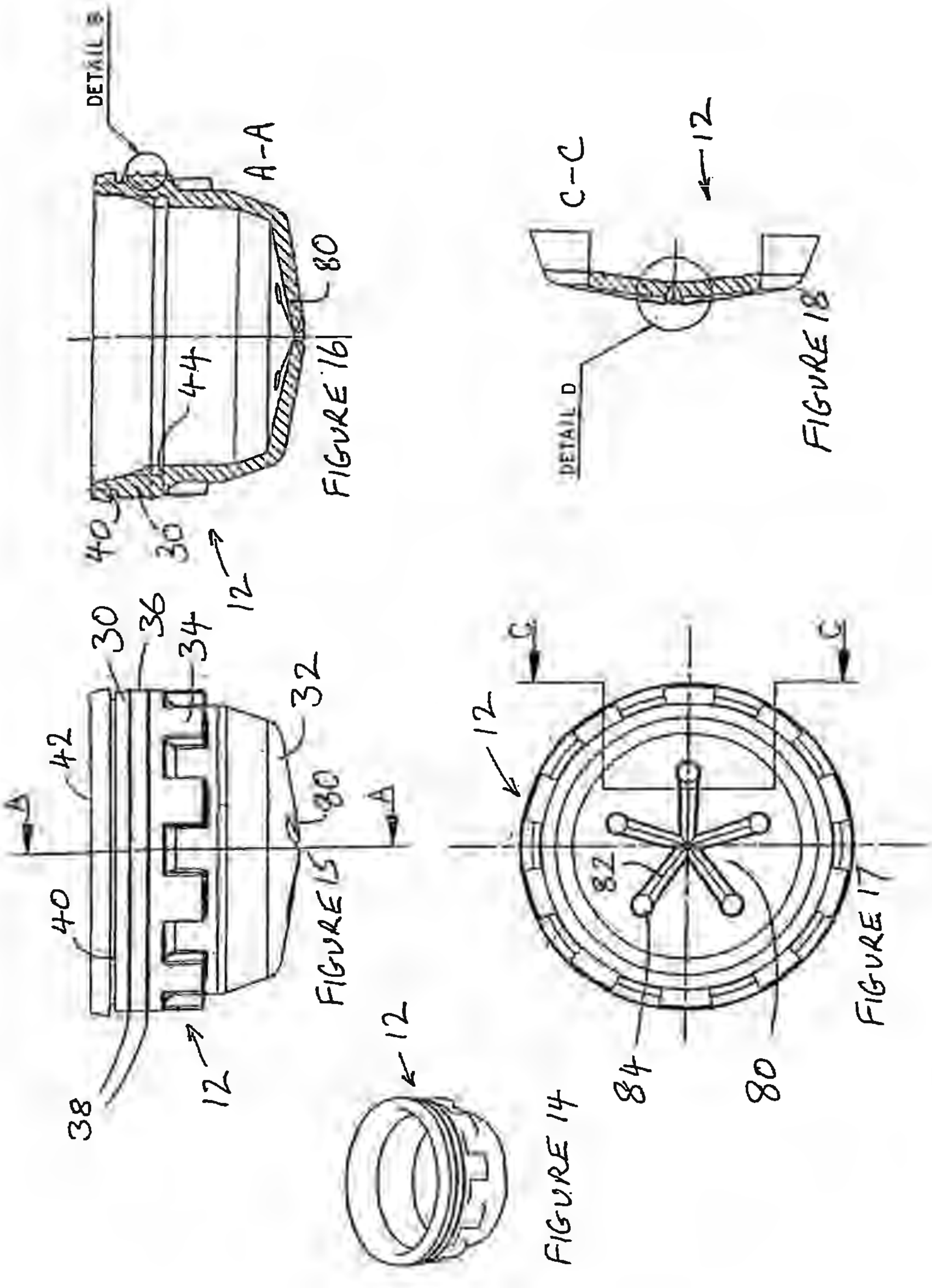


FIGURE 10


DETAIL B
A-A
FIGURE 16
C-C
DETAIL D
FIGURE 18
FIGURE 15
FIGURE 17
FIGURE 14

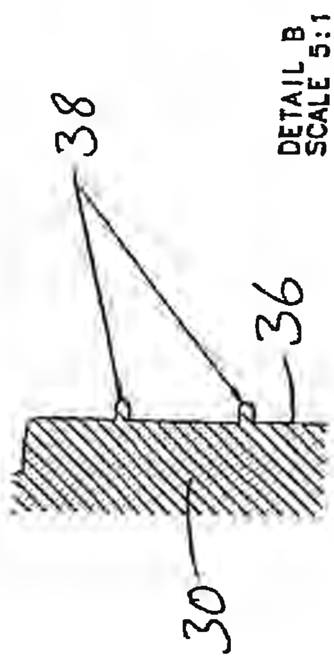



FIGURE 19

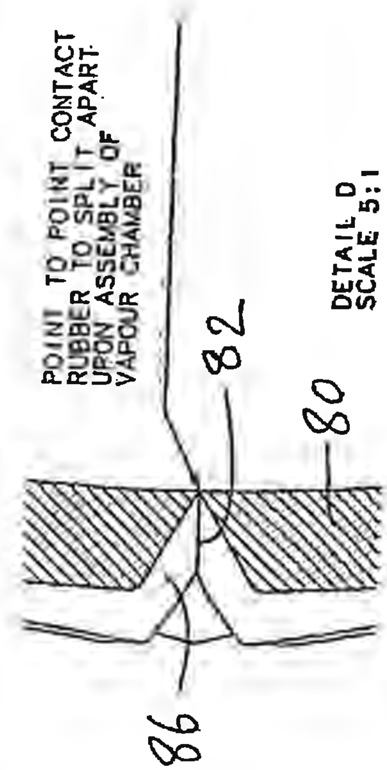
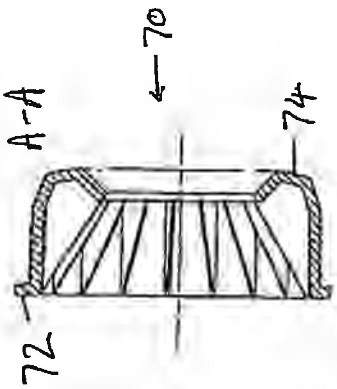



FIGURE 20



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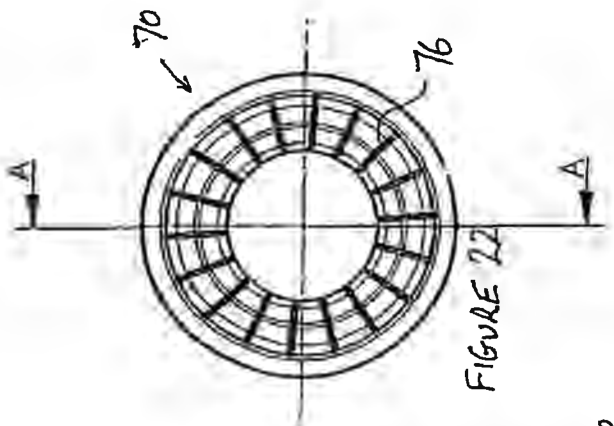

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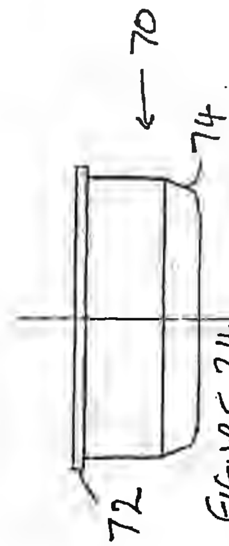


FIGURE 24

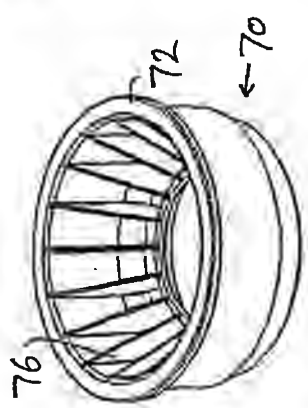


FIGURE 21

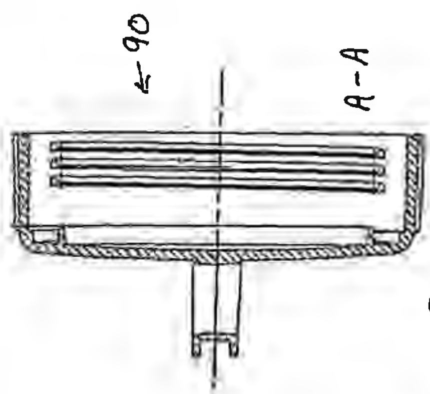


FIGURE 27

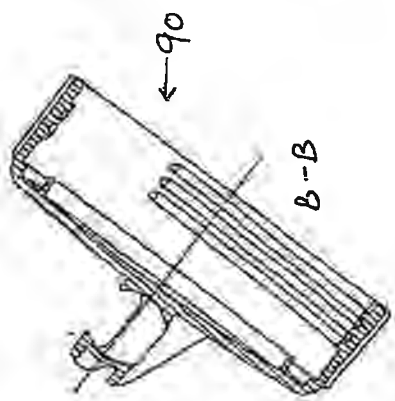


FIGURE 29

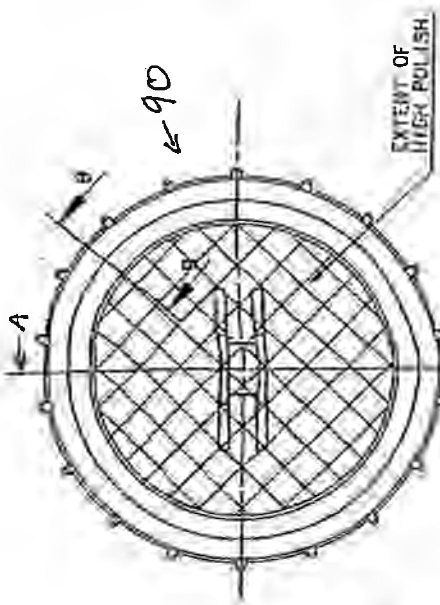


FIGURE 26

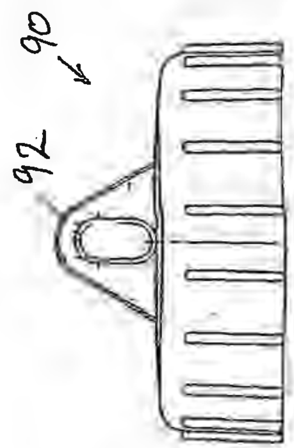


FIGURE 28

FIGURE 25

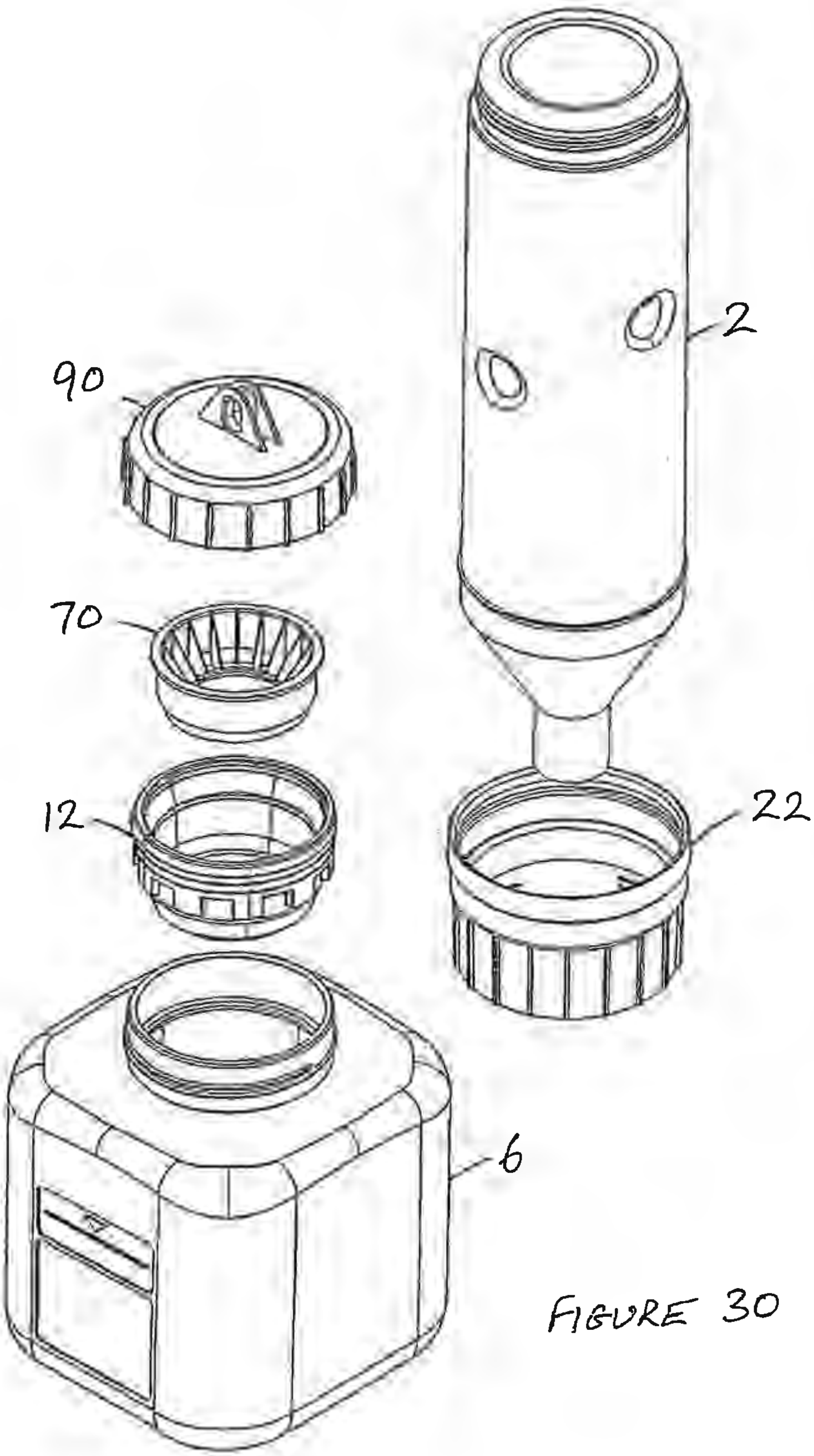



FIGURE 30

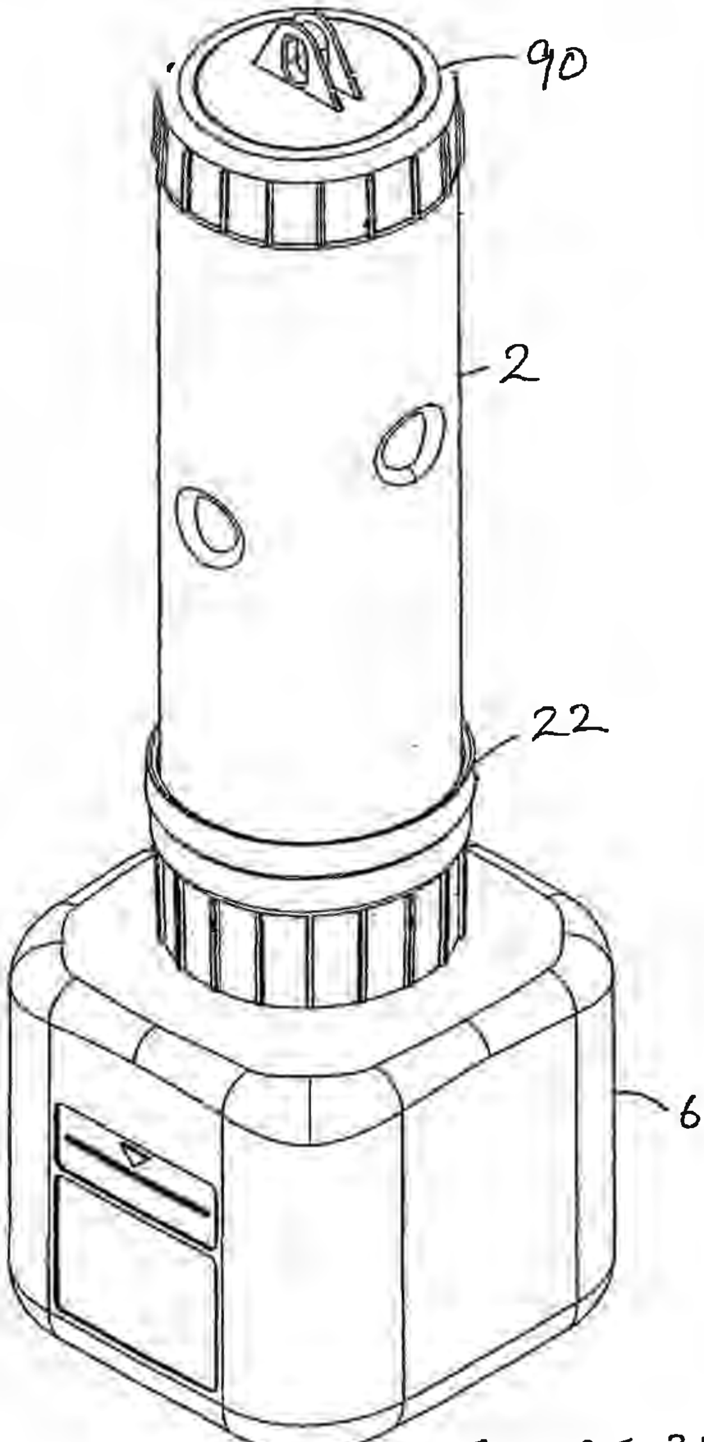
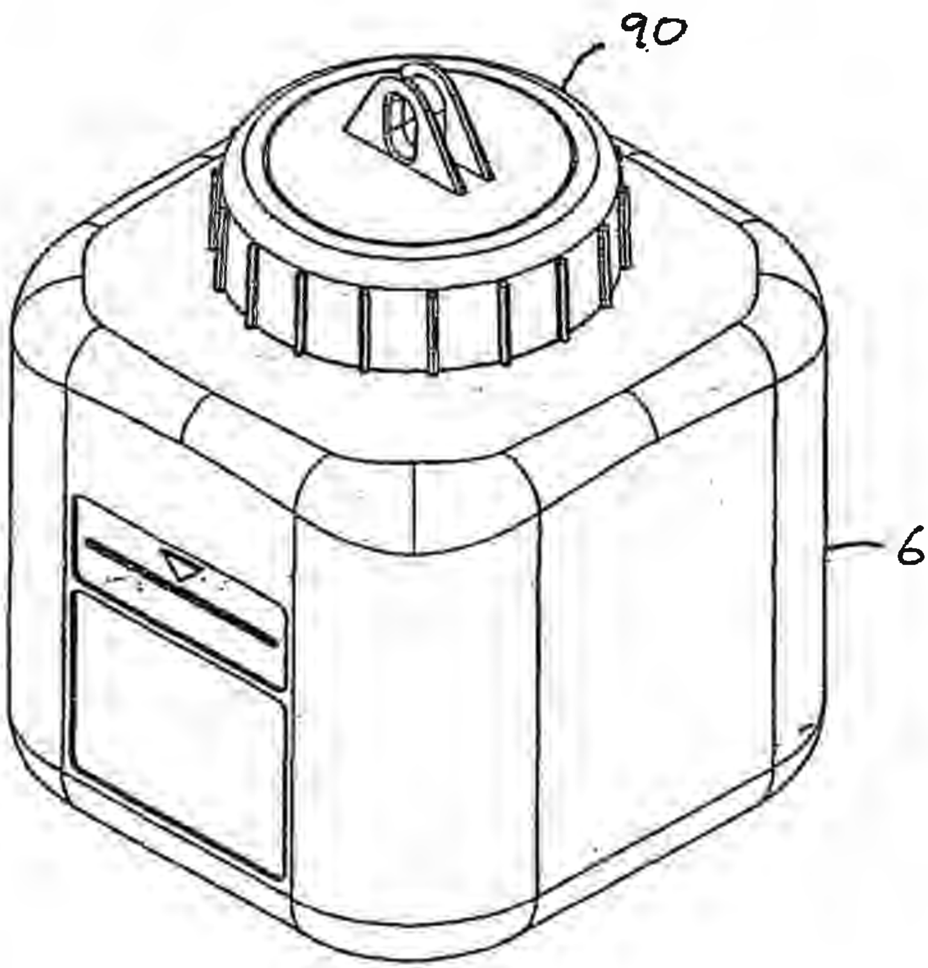



FIGURE 31

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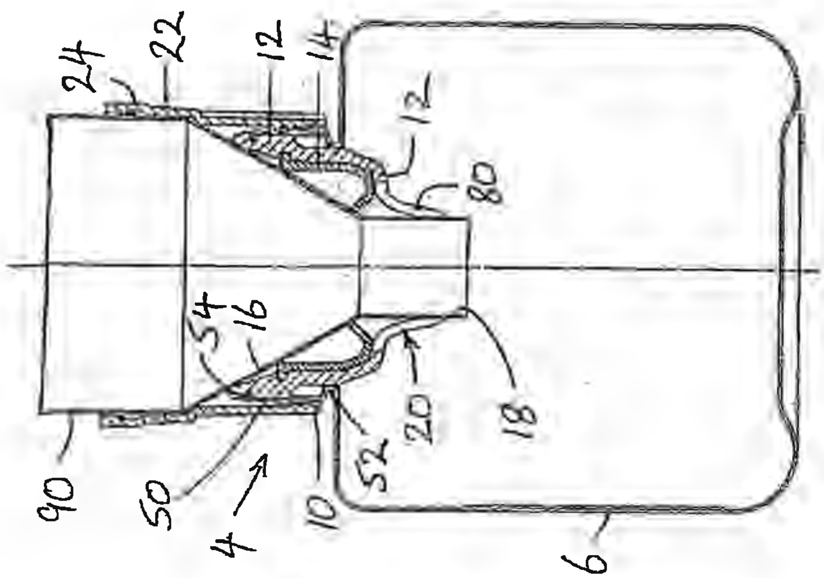
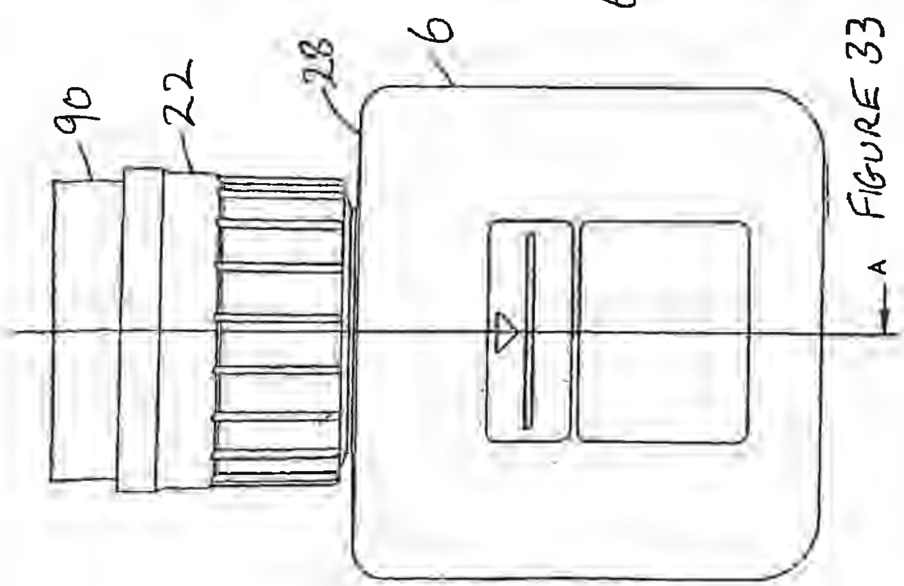



FIGURE 34

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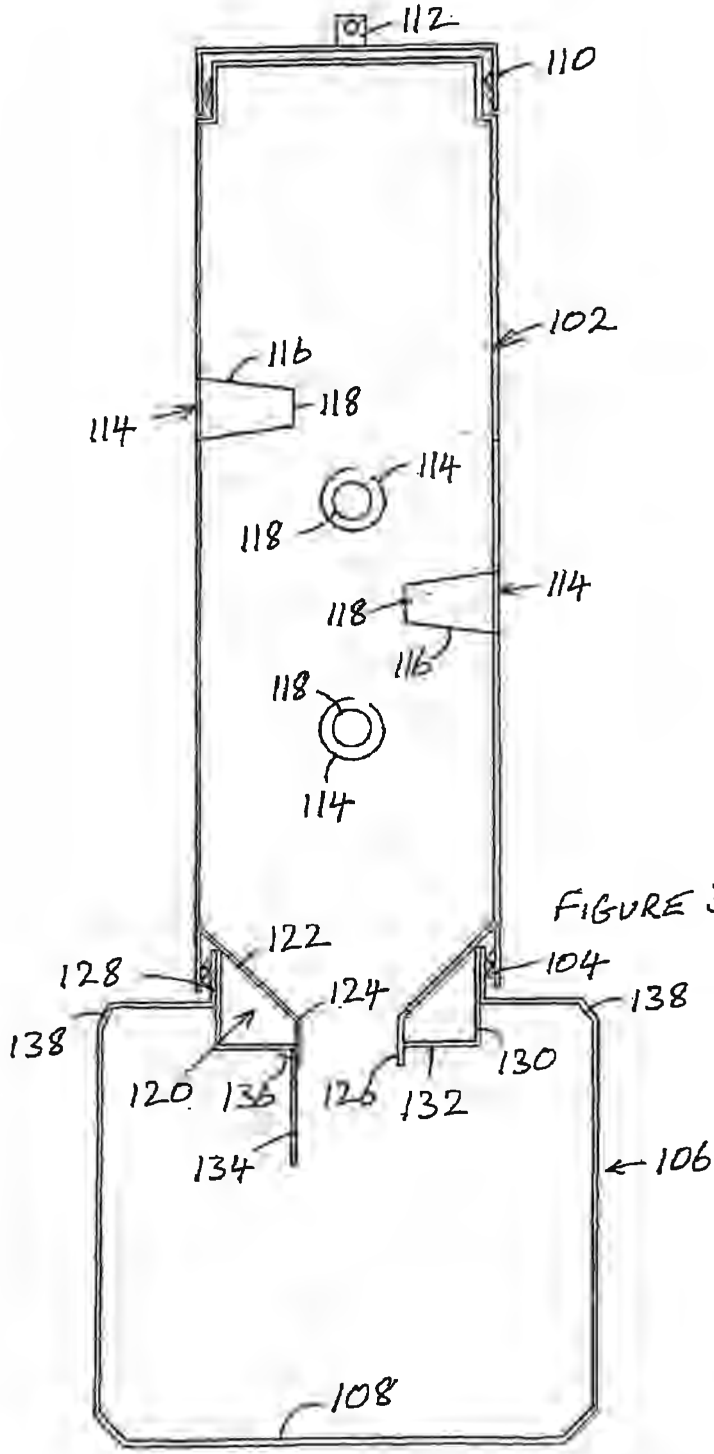

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FIGURE 35

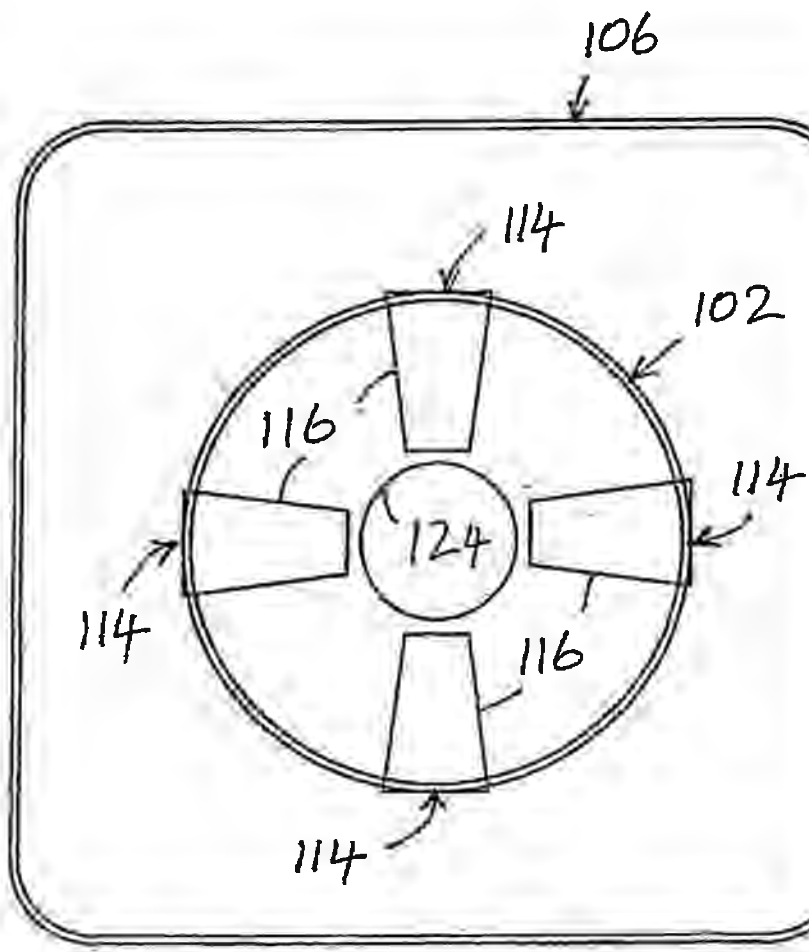


FIGURE 36

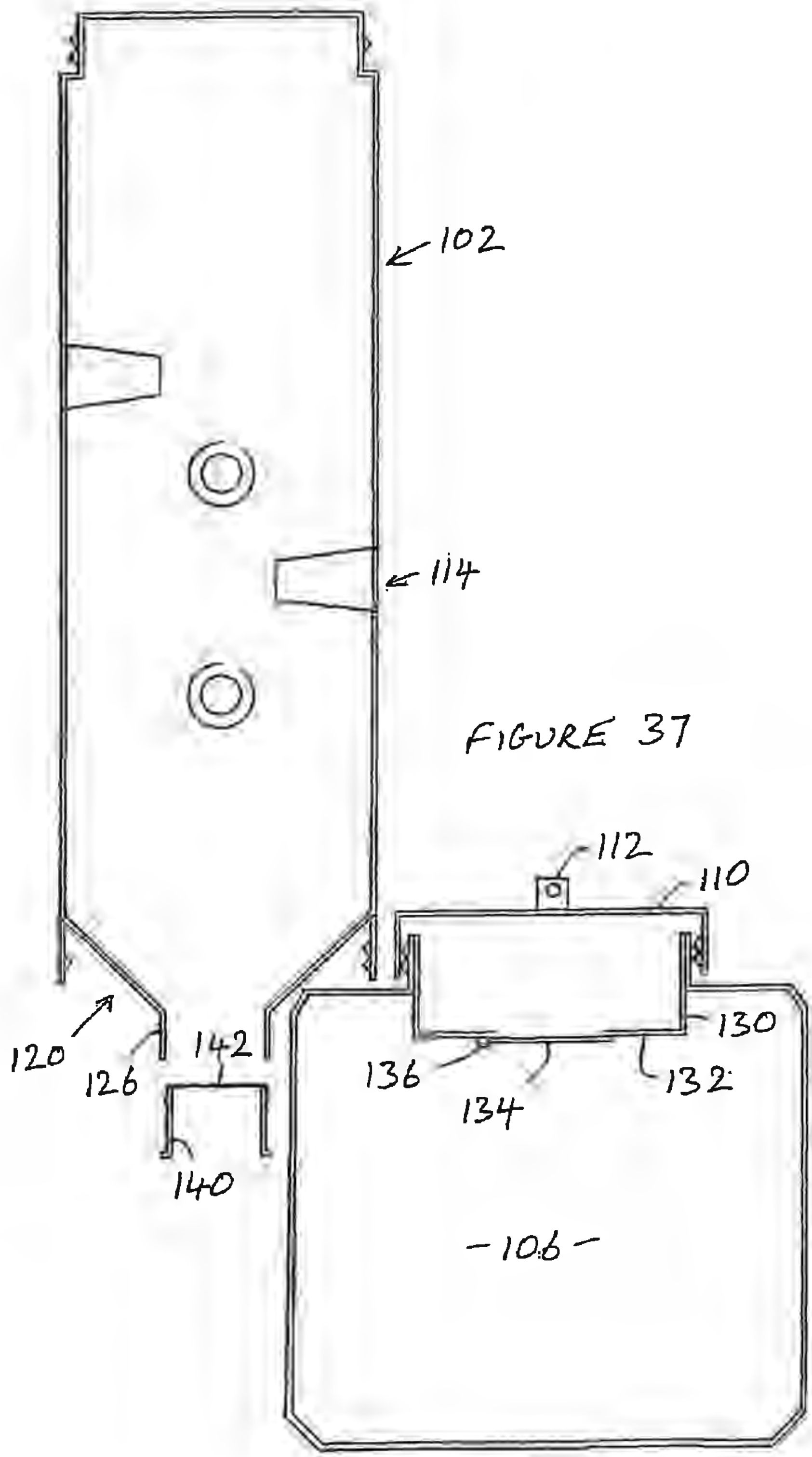


FIGURE 37

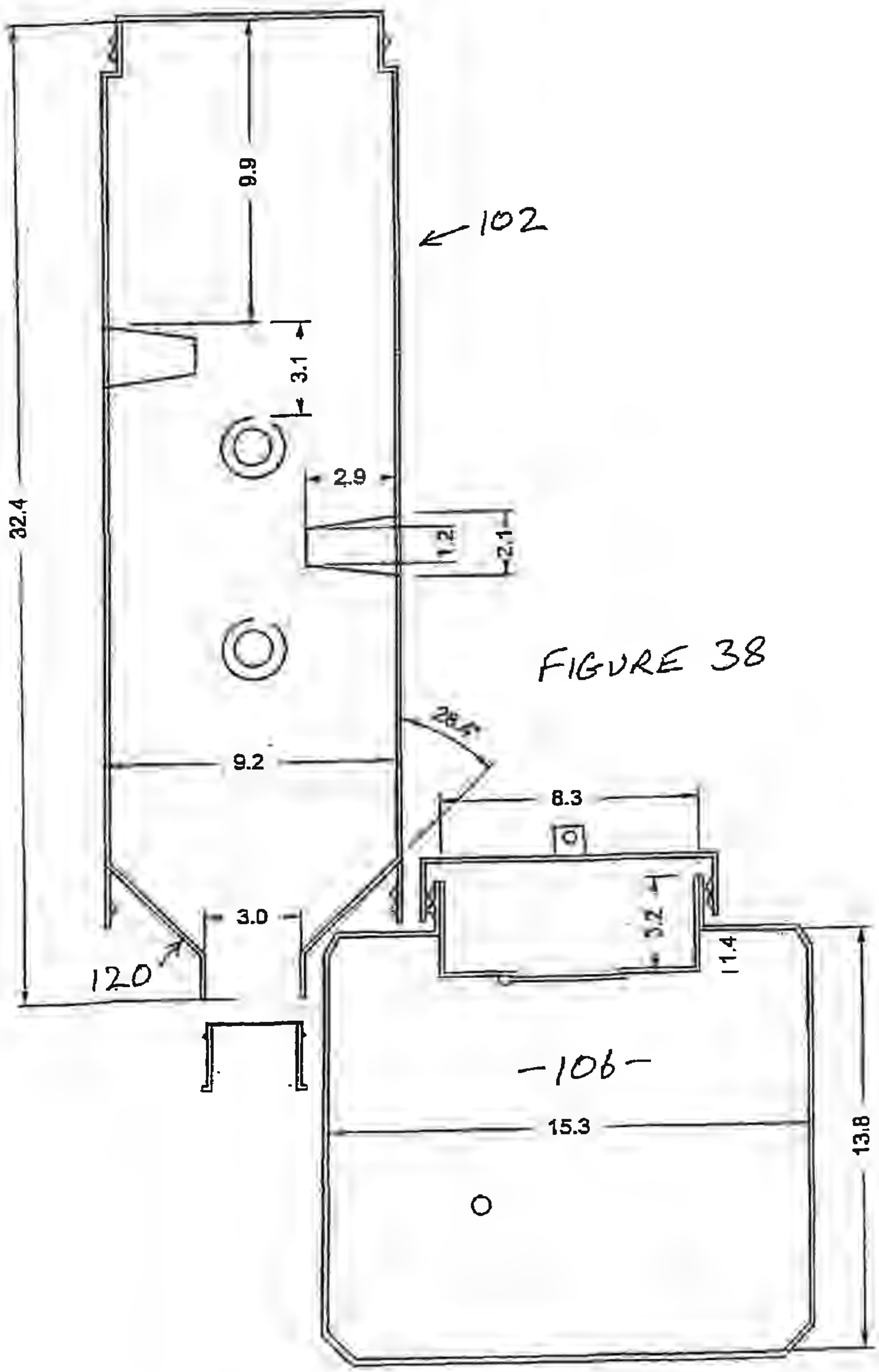


FIGURE 38

## TRAP AND METHOD FOR TRAPPING FLYING INSECTS

**[0001]** The invention relates to a trap and a method for trapping flying insects, in particular for trapping wasps, yellowjackets or the like.

**[0002]** Flying insects, including stinging insects such as wasps, are well known to be a nuisance in particular environments. For example, in soft fruit orchards wasps can cause considerable damage to fruit, rendering it unsaleable. It is clearly desirable in such environments to be able to reduce insect numbers. A variety of methods have been used to try to do this, including the use of pesticides and traps. In order to avoid environmental damage, particularly near human food crops such as fruit, it is desirable to avoid the use of pesticides. A number of trap designs exist but in tests the present inventor has found conventional designs to be unsatisfactory, primarily because they trap insufficient numbers of insects but also in terms of ease and safety of use.

**[0003]** The invention provides a trap and a method for trapping flying insects as defined in the appended independent claims. Preferred or advantageous features of the invention are set out in dependent sub-claims.

**[0004]** In its first aspect, the invention thus provides a trap comprising a vapour chamber, one or more entrances for insects defined in a wall of the vapour chamber, and a collection chamber coupled or couplable to the vapour chamber at a restriction. The collection chamber has no insect entrances, except at the restriction, which controls the movement of insects from the vapour chamber to the collection chamber.

**[0005]** In this and other aspects of the invention, the trap advantageously comprises a number of important design features to enhance its effectiveness and ease and safety of use. These design features are described below with particular reference to preferred embodiments of the invention for trapping wasps

**[0006]** 1. Valour Chamber

**[0007]** 1.1 The vapour chamber is preferably a distinct chamber from the collection chamber. The vapour chamber may advantageously be manufactured from a clear plastics material, such as PET (polyethylene terephthalate). There are three principal functions of this chamber:

**[0008]** 1.2 The vapour chamber is advantageously designed to maximise the lure of an attractant (bait), which may be provided in the collection chamber. In natural light, the vapour chamber behaves as a greenhouse raising internal temperatures within the chamber. This has the effect of pumping out attractant vapour through the process of gaseous expansion assisted by convection. Convection within the vapour chamber is also promoted in a preferred embodiment by having a controlled number of entrance flutes (funnels) which are positioned at angles to each other. It is particularly preferred to have four entrance flutes. Increasing the number of flutes tends to increase the chance of wasp escape and reduces the greenhouse effect within the chamber. Reducing the number of flutes tends to reduce the effect of drafts through the chamber dispersing attractant aroma or vapour.

**[0009]** 1.3 The vapour chamber is preferably designed to capture and retain wasps. The clear PET plastic encourages the wasps in the chamber to continue to fly against the wall of the chamber in a bid to escape rather than being guided to the entrance points. (In other words, were the chamber to be constructed of opaque or dark or coloured materials, light entering the chamber through the entrance flutes would illuminate an escape route for the wasps.)

**[0010]** 1.4 The preferred design of the vapour chamber and the trap may advantageously prevent or delay the entry of wasps into the collection chamber, and their immersion in attractant fluid if present in the collection chamber, preferably for as long as possible. The reason for this is that the vapour chamber of the trap provides an environment for wasps from different nests to interact aggressively, and the restriction between the vapour and collection chambers prevents the wasps from leaving the vapour chamber too easily Wasps from different nests become distressed when in close proximity and release chemical messengers to both warn and call more wasps for assistance. This sociological defence mechanism of the wasps is exploited by the vapour chamber as it promotes prolonged close proximity of the wasps and prolongs the period during which the wasps continue to emit the chemical messengers. Once the wasps are immersed in the attractant or bait (if present in the collection chamber), which is usually a liquid, then the release of these distress chemical messengers to the atmosphere is inhibited. The vapour chamber therefore advantageously has a tall cylindrical shape, which together with the restriction at the vapour chamber exit acts to retain wasps in this chamber for as long as possible. Furthermore, because the vapour chamber is saturated with attractant vapour, the wasps trapped inside tend to be unable to distinguish where the attractant vapour is coming from, and so are not led to the collection chamber by following an increasing vapour concentration. This is also an important design feature in retaining the wasps for as long as possible within the vapour chamber.

**[0011]** 1.5 The shape and size of the vapour chamber in the preferred wasp trap have been determined through a significant amount of experimentation. It is important to the efficiency of the wasp trap to have a tall vapour chamber of relatively narrow diameter. The reason for this is to give wasps trapped in the vapour chamber sufficient freedom of movement to allow for aerial manoeuvres in either attacking or escaping from other wasps also captured within the chamber whilst at the same time confining those movements so that the wasps within the trap are maintained in close enough proximity to propagate the distress response. A tall vapour chamber allows for considerable vertical freedom of flight and this is consistent with the flight behaviour of wasps for two reasons: firstly, wasps will drop vertically in a natural defensive manoeuvre to avoid predators or other wasps, and secondly, wasps then fly vertically to escape. A tall vapour chamber therefore advantageously reflects and accommodates this behaviour. Importantly, the tall design tends to increase the time that a wasp flies in s the vapour chamber before falling into the collection chamber and any attractant liquid therein. And also means that the wasps when having vertically congregate in the same vicinity.

**[0012]** 1.6 The vapour chamber is preferably designed such that the entrance flutes are sited at a predetermined distance from the top of the chamber. This is important because for the trap to work most efficiently the wasps should have a "flying zone" within the chamber in which to compete and interact with other wasps. The inventor has found that siting the entrance flutes too high up in the chamber results in more wasps escaping. This is believed to be because wasps have a tendency to fly vertically, so that they tend to congregate at the highest part of the chamber.

[0013] 1.7 The width of the vapour chamber may also be affected by the shape of the restriction leading to the collection chamber. For example, in a preferred restriction is a downward-sloping frusto-conical funnel, which is preferably sufficiently steep to prevent wasps from having a perch upon which they can rest.

[0014] 2. Entrance Flutes

[0015] 2.1 The entrance flutes (funnels) are preferably horizontal in orientation or should have only a shallow slope. The reason for this is to facilitate ease of access for the wasps. In particular on a smooth surface, such as a PET surface, wasps are unable to easily negotiate vertically-orientated or steeply-sloping flutes.

[0016] 2.2 The flutes are preferably tapered from a wider entrance to a narrower exit into the vapour chamber. The reason for this is to provide an easy landing platform for the wasps, and easy access into the vapour chamber, whilst the narrower exit means that the wasps find it more difficult to escape from the vapour chamber.

[0017] 2.3 The size of the flutes in the preferred embodiment for trapping wasps is carefully controlled to allow access for both British and European varieties of wasp (both foragers and queens) whilst minimising the size of the escape route.

[0018] 2.4 The flutes are preferably of a carefully predetermined length to reduce the chance of trapped wasps finding the exit. This length has been determined through experiment and by observing the flight behaviour of trapped wasps. Wasps flying against the walls of the trap periodically rebound from the walls but do so without rebounding by more than a given distance. The flutes are carefully controlled to this length. Longer flutes prevent rebounding wasps from escaping but disadvantageously reduce the space for flying inside the vapour chamber.

[0019] 2.5 The flutes are preferably of a number and positioned around the chamber so as to maximise drafts through the chamber to enhance the attractant lure of the trap whilst minimising the incidence of wasp escape and whilst protecting as far as possible the greenhouse conditions within the vapour chamber.

[0020] 2.6 The flutes are preferably staggered in vertical orientation (vertically spaced) to prevent wasps flying straight through the trap, and to increase the amount of convection within the trap so as to enhance the vaporisation of the attractant by continuously removing more vapour from the trap, so reducing the vapour density of the attractant in the head space of the trap (i.e. the vappur chamber), so promoting further evaporation of attractant.

[0021] 3. Restriction Between Vapour Chamber and Collection Chamber

[0022] 3.1 The restriction is preferably designed so as to allow wasps that are tired to pass or drop through into the collection chamber but to deter or delay the passage of more energetic wasps into the collection chamber. Advantageously, the restriction takes the form of a downward-sloping, frusto-conical funnel at the base of the vapour chamber, the collection chamber being positioned below the funnel opening.

[0023] 3.2 Wasps have a natural tendency to fly towards light. The restriction is preferably manufactured in an opaque material, such as black opaque PET, to guide wasps (which tend to fly towards light) towards the clear transparent walls of the wasp trap. Advantageously, both the vapour chamber and the collection chamber have transparent walls. This effectively helps delay the passage of wasps into the collection chamber and also helps to retain wasps in the collection chamber by encouraging them to fly consistently away from the exit (the restriction) towards the clear walls of the collection chamber.

[0024] 3.3 The restriction is preferably designed to fit sealingly into an aperture in a safety plug or closure which fits in an opening at the top of the collection chamber where the collection chamber couples to the vapour chamber. When the vapour chamber is assembled onto the collection chamber the restriction preferably prises or urges open a self-closing mechanism, such as a sprung flap. While the vapour chamber is disassembled from the collection chamber, the restriction continues to prevent the escape of wasps from the collection chamber because a seal between the two is maintained until such time as the flap or other self-closing mechanism closes. This is a safety feature of the trap designed to protect the operator from accidental wasp stings.

[0025] 3.4 When the restriction is implemented as a funnel, the slope of the funnel is preferably more than 50°, and particularly preferably at least 60°, from the horizontal. This preferably prevents tired wasps from gaining purchase and prevents them from, resting, and facilitates the eventual passage of wasps into the killing chamber once they have become too tired to continue flying in the vapour chamber. The minimum slope of the funnel may depend on the smoothness of the material from which it is made. A PET funnel preferably has a slope of at least 60°.

[0026] 3.5 When the restriction is embodied as a funnel, the size of the funnel opening has been assessed through experimentation and it has been found that it is preferably linked to the width of the vapour chamber and slope of the funnel. All of these parameters work together to provide optimum conditions for the efficacy of the wasp trap. If the funnel opening is too large, free falling wasps in defence flight are more prone to fall directly into the attractant liquid. The funnel helps to prevent this in those wasps that are not too tired. Furthermore, if the funnel opening is too large, then a larger and more robust self-closing mechanism may be required. For example, if a self-closing flap is used then if the funnel opening is large, the flap may need to be disadvantageously big and, more importantly, the required depth of the killing chamber may become impractically large in order to prevent snagging of the self-closing flap on captured and dead wasps once the chamber starts to fill.

[0027] 4. Collection Chamber Safety Plug or Closure Apparatus

[0028] 4.1 The collection chamber safety plug is a safety feature of preferred embodiments of the wasp trap, designed to prevent accidental wasp stings when the collection chamber is being replaced, for example during re-baiting. If the insects therein are then to be disposed of safely, it is desirable to be able to seal or close the container without permitting any insects to escape.

[0029] In a first embodiment, the safety plug or closure apparatus may advantageously comprise a tubular inlet extending from the vapour chamber funnel opening and a diaphragm, or septum, spanning the opening at the collection chamber entrance. At a central portion of the diaphragm three or more closure elements extend inwardly. The tubular inlet is insertable through the central portion of the diaphragm, resiliently deflecting the closure elements to open the opening into the collection chamber. Access from the vapour chamber to the collection chamber is then provided along the interior of the inlet. The inlet is removable from the diaphragm to allow the resilient closure elements to return to their undeflected position to close the opening.

[0030] Advantageously, the tubular inlet or inlet passage may be cylindrical or frusto-conical. In the latter case, the inlet may provide an entrance funnel. Advantageously, for example, the inlet may provide or comprise a part of the restriction between the vapour chamber and the collection chamber.

[0031] The closure apparatus advantageously comprises four or more closure elements and particularly preferably five closure elements. Advantageously, the closure elements are integral with the diaphragm, which is formed of a resiliently-deformable material, and bounded by slits, or cuts, radiating from a central point. Advantageously, each slit, or cut, terminates at a stress-relieving hole. This may prevent any tendency for the slits to extend or tear under the stress induced by passing the inlet between the closure elements.

[0032] In a preferred embodiment of the closure apparatus, the diaphragm is domed or otherwise asymmetrically formed (for example conically-formed). In this embodiment, the closure elements in their undeflected position are not coplanar. This has the effect that a lower force is required to separate the closure elements from one side of the diaphragm (the concave side) than from the other (the convex side). This embodiment may advantageously help to prevent egress or release of the contents from the collection chamber when the closure apparatus is in its closed condition. This embodiment is particularly advantageous when the collection chamber may contain live wasps.

[0033] A further advantage of this embodiment of the closure apparatus is that it decreases the angle of deflection of the closure elements when the inlet is inserted through the diaphragm, by comparison with a flat diaphragm in which the closure elements are coplanar in their undeflected position. The reduction in opening force and closure element deflection both reduce the stresses and strains applied to the closure elements and advantageously ease the demands on the material of the closure elements.

[0034] Advantageously, the diaphragm and the closure elements may be moulded from a resilient material, such as a rubber. Preferably, they may also be formed as a single component.

[0035] In a further aspect of the closure element, at its periphery the diaphragm may comprise a grommet, or an edge region of enlarged cross-section.

[0036] Advantageously, these may be moulded or formed from the same material. The grommet may be shaped for fitting into the entrance of the collection chamber.

[0037] Advantageously, an annular insert may also be provided, which fits within the grommet on one side of the diaphragm. The annular insert may advantageously retain the grommet within the entrance.

[0038] An inner surface of the annular insert may advantageously be shaped so as to receive or guide the inlet of the closure apparatus. Thus, to open the opening, the inlet may be inserted through the annular insert and thus guided to the central portion of the diaphragm. Further, the annular insert may locate the inlet in position while the opening is open.

[0039] The action of the insert in retaining the grommet within the entrance and guiding the inlet is important because, as the inlet is inserted through the diaphragm or is withdrawn, forces are applied to the diaphragm which may tend to dislodge it from the entrance. The insert advantageously helps to prevent this.

[0040] In summary, therefore, in use of this type of trap insects are attracted into the vapour chamber and eventually fall into the collection chamber. When trapping stinging insects, such as wasps, it is important that the collection chamber can be sealed without wasps escaping. The closure apparatus is used to couple the vapour chamber to the collection chamber; the diaphragm spanning an entrance to the collection chamber and the inlet protruding at a lower end of the vapour chamber. To set up the trap, the vapour chamber is mounted on the collection chamber by forcing the inlet between the closure elements of the diaphragm. After insects have been collected in the collection chamber, the vapour chamber can be removed, withdrawing the inlet of the closure apparatus and allowing the closure elements to close the opening from the collection chamber. The automatic closure of the collection chamber entrance may advantageously prevent the escape of insects from the collection chamber.

[0041] In a second closure embodiment, the collection chamber safety plug or closure has a self-closing hinged flap which closes automatically as the vapour chamber is removed. The safety plug of the second embodiment is preferably manufactured from black opaque PET. Preferably, the depth of the safety plug is lower than an upper shoulder of the collection chamber, in order to retain free flying wasps within the collection chamber by encouraging them to continue to fly towards the light which is maximised in the transparent shoulder of the collection chamber.

[0042] 5. Bait, Collection, or Killing Chamber

[0043] In a preferred embodiment, as described below, the collection chamber contains a liquid bait. Vapour from the liquid passes into the vapour chamber to attract insects such as wasps. When wasps fall from the vapour chamber into the collection chamber they may fall into the liquid bait and be killed, by drowning. Thus, while the collection chamber may be referred to as a bait chamber or killing chamber, its primary function is to collect insects entering the collection chamber from the vapour chamber. The terms collection chamber, bait chamber and killing chamber may therefore be taken, with reference to various embodiments of the invention, to refer to the same general component of the trap.

[0044] Bait could mean any attractant or lure and may advantageously, but not exclusively, be located in the collection chamber. Alternatively, bait could be located in a further chamber, also connected to the vapour chamber, or within the vapour chamber itself.

[0045] In the insect trap it may be advantageous to use a liquid bait. The closure apparatus may then advantageously provide a sealing effect to prevent bait spillage when the closure elements are in their undeflected position.

[0046] 5.1 The collection chamber is preferably manufactured from a clear plastics material, such as PET. This allows visual inspection of the amount of wasps which have been captured and killed.

[0047] 5.2 The clear design allows examination of the safety closure or flap (if fitted) to ensure that it is unhindered and capable of closing during rebaiting.

[0048] 5.3 The clear design of the collection chamber advantageously encourages wasps to continue to fly towards the light and away from the opening in the restriction.

[0049] 5.4 The collection chamber preferably has a line etched onto the wall of the chamber as a guide beyond which it is not recommended to capture more wasps. This is a safety feature designed to prevent the closure apparatus from becoming hindered by the sheer volume of caught wasps. This may be a problem particularly if the closure apparatus utilises a self-closing flap.

[0050] 5.5 The collection chamber is preferably square or triangular in horizontal cross section and significantly wider than the vapour chamber. This is so that once affixed to the vapour chamber, the collection chamber also acts as a counter weight and stable base. This may advantageously allow the trap to be used either free standing or hanging from a support.

[0051] 6. Collection Chamber Lid

[0052] 6.1 To provide a more permanent closure, a lid, such as a screw-on lid, may be applied to cover the closure apparatus, or the portion of the closure apparatus (such as a diaphragm or septum) spanning the collection chamber opening. This may also advantageously provide a substantially liquid-tight seal.

[0053] The lid to the collection chamber may advantageously be designed to screw onto an upper end of the vapour chamber to provide a fixture for hanging the wasp trap. The lid would then preferably be transparent.

[0054] 6.2 The collection chamber lid is preferably designed to be screwed onto the vapour chamber for safekeeping whilst the trap is in use. The collection chamber may then be re-lidded when it is ready for replacement and disposal.

[0055] 7. Mesh Baffle

[0056] 7.1 The mesh baffle is an optional feature of the wasp trap which when fitted to the restriction, will keep trapped wasps or other insects in the vapour chamber and prevent them from entering the collection chamber and potentially being killed in the bait (if present in the collection chamber). This allows the trap to be used as a humane means of capturing insects during field studies where there is no intention or need to kill them.

## DESCRIPTION OF SPECIFIC EMBODIMENTS AND BEST MODE OF THE INVENTION

[0057] Specific embodiments of the invention will now be described by way of example, with reference to the drawings in which:

[0058] **FIG. 1** is a side view of an insect trap according to a first embodiment of the invention;

[0059] **FIG. 2** is a cross-section of the insect trap of **FIG. 1**;

[0060] **FIG. 3** is an isometric view of the bait chamber of the insect trap of the first embodiment:

[0061] **FIG. 4** is a plan view of the bait chamber of **FIG. 3**;

[0062] **FIG. 5** is a side view of the bait chamber of **FIG. 3**;

[0063] **FIG. 6** is a cross-section of the bait chamber of **FIG. 3**;

[0064] **FIG. 7** is an isometric view of the vapour chamber of the trap of **FIG. 1**;

[0065] **FIG. 8** is a longitudinal section of the vapour is chamber of **FIG. 7**;

[0066] **FIG. 9** is a side view of the vapour chamber of **FIG. 7**;

[0067] **FIG. 10** is an isometric view of a coupling ring of the trap of **FIG. 1**;

[0068] **FIG. 11** is a plan view of the coupling ring of **FIG. 10**;

[0069] **FIG. 12** is a longitudinal section of the coupling ring of **FIG. 10**;

[0070] **FIG. 13** is a side view of the coupling ring of **FIG. 10**;

[0071] **FIG. 14** is an isometric view of the closure diaphragm of the trap of **FIG. 1**;

[0072] **FIG. 15** is a side view of the diaphragm of **FIG. 14**;

[0073] **FIG. 16** is a longitudinal section of the diaphragm of **FIG. 14**;

[0074] **FIG. 17** is a view from beneath the diaphragm of **FIG. 14**;

[0075] **FIG. 18** is a sectional view of the diaphragm of **FIG. 14**, on C-C as shown in **FIG. 17**;

[0076] **FIG. 19** is a section of a detail B of the diaphragm of **FIG. 14**, with reference to **FIG. 16**;

[0077] **FIG. 20** is a section of a detail D of the diaphragm of **FIG. 14**, with reference to **FIG. 18**;

[0078] **FIG. 21** is an isometric view of the annular insert of the trap of **FIG. 1**;

[0079] **FIG. 22** is a plan view of the insert of **FIG. 21**;

[0080] **FIG. 23** is a longitudinal section of the insert of **FIG. 21**;

[0081] **FIG. 24** is a side view of the insert of **FIG. 21**;

[0082] **FIG. 25** is an isometric view of the screw-on lid of the trap of **FIG. 1**;

[0083] **FIG. 26** is a plan view of the lid of **FIG. 25**;

[0084] **FIG. 27** is a longitudinal section of the lid of **FIG. 25**;

[0085] **FIG. 28** is a side view of the lid of **FIG. 25**;

[0086] **FIG. 29** is a partial section of the lid of **FIG. 25** on B-B as shown in **FIG. 26**;

[0087] **FIG. 30** is an exploded view of the insect trap of **FIG. 1**;

[0088] **FIG. 31** is an isometric view of the insect trap of **FIG. 1**;

[0089] **FIG. 32** is an isometric view of the screw-on lid of **FIG. 25** attached to the bait chamber of **FIG. 3**;

[0090] **FIG. 33** shows a wasp trap according to a second embodiment of the invention, assembled for use;

[0091] **FIG. 34** is a partial plan view of the wasp trap of **FIG. 33**;

[0092] **FIG. 35** shows-the wasp trap of **FIG. 33** after removal of the bait chamber; and

[0093] **FIG. 36** is a reproduction of **FIG. 35** incorporating dimensions, in centimetres, of a particularly preferred embodiment of the invention.

[0094] A first embodiment of the invention will be illustrated with reference to a trap for wasps, as illustrated in **FIG. 1**, and shown in section in **FIG. 2**. The trap comprises a vapour chamber **2** coupled by means of a closure apparatus **4** to a collection chamber **6**. The collection chamber contains liquid bait in this embodiment, and so forms a bait chamber, or killing chamber, **6**. The bait chamber is illustrated in more detail in FIGS. **3** to **6** and the vapour chamber in FIGS. **7** to **9**. The bait chamber has an opening **8** in its upper surface, surrounded by a substantially cylindrical neck **10**. The outer surface of the neck is threaded.

[0095] A moulded rubber diaphragm, or septum, **12** fits within the neck as described in more detail below. An annular insert **14** fits within the diaphragm.

[0096] The vapour chamber is substantially cylindrical in shape and at its lower end (when oriented for use) terminates in a narrowing frusto-conical funnel **16** leading to a tubular inlet **18**. To assemble the trap for use, the tubular inlet is inserted through the annular insert **14** and then through a central portion of the diaphragm comprising five inwardly-extending closure elements **20**. When fully inserted, the tubular inlet extends into the bait chamber and the funnel **16** is supported on inner surfaces of the annular insert and the diaphragm. A substantially cylindrical collar **22** encircles the lower end of the vapour chamber, being retained by engagement with a circumferential lip **24** protruding from the outer wall of the cylindrical portion of the vapour chamber. A lower end of the collar is internally threaded for engagement with the externally-threaded neck of the bait chamber. Screwing the collar onto the neck securely retains the vapour chamber in position on the bait chamber. The structure of the collar is shown in more detail in FIGS. **10** to **13**.

[0097] In use of the trap, bait is placed in the bait chamber and the vapour chamber attached to the top of the bait chamber. Vapour from the bait enters the vapour chamber and wasps attracted by the vapour enter the vapour chamber through entrances **26** in its side wall.

[0098] The trapped wasps fly within the vapour chamber, emitting distress pheromones which in turn attract further wasps, until they tire and fall into the funnel at the base of the vapour chamber. The wasps then fall into the bait chamber from which they are unlikely to escape. This is because wasps tend to fly towards light and at least the upper shoulder **28** of the bait is chamber is fabricated from a transparent material, attracting the wasps to fly into the corners of the bait chamber and away from the inlet **18** through which they could return to the vapour chamber.

[0099] After the trap has operated for a period of time, the bait chamber typically contains a very large number of wasps and so it is important to be able to seal the bait chamber reliably for disposal. This is achieved by unscrewing the collar **22** and removing the vapour chamber from the bait chamber, whereupon the closure elements **20** resiliently move together to close the bait chamber entrance. This procedure and the structure of the closure apparatus at the bait chamber entrance will now be described in more detail.

[0100] The Closure Apparatus

[0101] The closure apparatus comprises the diaphragm **12**, which is moulded from a resilient material such as a rubber, and the inlet **18** extending from the vapour chamber. The diaphragm is illustrated in more detail in FIGS. **14** to **20**.

[0102] The diaphragm comprises a substantially annular grommet **30** and a domed, or conical, section **32** spanning the interior of the annular grommet.

[0103] The neck **10** of the bait chamber primarily comprises a cylindrical wall **50**, which carries on its outer surface the thread for engagement with the collar **22**. The cylindrical wall is joined to the container portion of the bait chamber at a narrower, waisted portion **52**. At its outer end, distant from the container portion of the bait chamber, the neck terminates at a flange **54** which extends inwardly from the cylindrical wall.

[0104] The grommet portion of the diaphragm is moulded to be a press fit within the neck **10**. At its lower edge, the grommet comprises castellations **34** which bear on an upper edge of the waisted portion **52** of the neck **10**. The castellated structure is used to reduce the volume of rubber required to mould the diaphragm. Above the castellations, the grommet is shaped with a substantially cylindrical external wall, to fit against the internal wall of the cylindrical portion **50** of the neck. Two circumferential ribs **38** extend outwardly from the cylindrical wall of the grommet and bear against the internal wall of the cylindrical portion to improve sealing. At its upper end, the cylindrical wall terminates at an inwardly-extending circumferential groove **40**, which matches the inwardly-extending flange **54** of the neck **10**. Above the groove, the grommet terminates at an annular ridge **42**, which protrudes above the neck of the bait chamber when the grommet is in position within the neck.

[0105] The domed portion **32** of the diaphragm extends (in use) downwardly from the castellations of the grommet and, when the diaphragm is in place in the neck of the bait chamber, into the bait chamber itself.

**[0106]** The annular insert **14**, for insertion within the grommet, is illustrated in more detail in FIGS. **21** to **24**. The insert is moulded from a substantially rigid plastics material. From the upper edge of the insert a flange **72** extends outwardly, being shaped to fit into a circumferential groove **44** defined in the inner-wall of the grommet. The outer surface of the insert extends downwardly from the flange **72**. Adjacent the flange this surface is substantially cylindrical, to match the internal surface of the grommet, but at its lower end **74**, the insert tapers progressively to match the internal profile of the domed portion of diaphragm. The internal profile of the insert is substantially frusto-conical, tapering inwardly from the flange **72** at its upper edge. The inner surface of the insert is defined by a plurality of fins **76**; these reduce the volume of material required to mould the insert. The frusto-conical profile is shaped to match the exterior of the funnel **16** at the base of the vapour chamber. The frusto-conical interior of the insert terminates at its narrow end at an opening which is large enough to guide the tubular inlet **18** at the end of the vapour chamber into contact with the central portion of the diaphragm beneath, where the closure elements are located.

**[0107]** In summary, therefore, the diaphragm is fitted into the neck of the bait chamber as follows. As the diaphragm is pressed into the neck, the castellations **34** engage the waisted portion **52** at the base of the neck **10** to prevent the diaphragm from falling into the bait chamber. When the diaphragm is seated in the neck, the flange **54** extending inwardly at the upper edge of the neck seats in the external groove **40** of the diaphragm. The insert is then press fitted within the diaphragm, until the external flange **72** at the upper edge of the insert enters the internal groove **44** within the diaphragm. The upper edge of the grommet is chamfered to guide the insert into this position. When the insert is in position, it acts to prevent the rubber grommet from deforming and coming free from the flange **54** surrounding the neck of the bait chamber. In addition, the insert is sized such that, when press fitted within the grommet, it urges the grommet against the internal surface of the neck. This helps to ensure a liquid-tight seal, particular between the ribs **38** and the cylindrical surface of the neck.

**[0108]** The Closure Elements

**[0109]** At the central portion of the diaphragm, five substantially triangular closure elements **80** extend inwards, as shown in **FIG. 17**. These are divided by slits **82** extending outwardly from a common point at the centre of the diaphragm. Each slit terminates at a circular, stress-relieving hole **84**. The closure elements are moulded from the same resilient material as the remainder of the diaphragm and, when the inlet **18** is inserted through the central portion of the diaphragm, resiliently deflect outwards, as shown in **FIG. 2**. As the closure elements deflect, the stress-relieving holes **84** prevent tearing of the diaphragm.

**[0110]** When the diaphragm is initially moulded, the slits **82** are defined by chamfered grooves **86** but these do not penetrate entirely through the diaphragm and so the slits themselves are not formed. The slits are formed by tearing of the rubber at the base of each groove **86** as the inlet is first inserted through the diaphragm. Details of this construction are shown in **FIG. 20**. This enables the diaphragm to provide a completely liquid-tight seal before the first assembly of the trap. For this purpose, the stress-relieving holes **84** may not comprise holes through the entire thickness of the diaphragm, but regions in which the thickness of the diaphragm is substantially reduced. These aspects of the diaphragm construction enable bait to be provided, sealed within the bait chamber, and vapour only released when the trap is assembled and ready for use.

**[0111]** The domed or conical shape of the portion of the diaphragm comprising the closure elements provides a number of advantages. First, it reduces the angle through which the closure elements are deflected as the inlet is forced between them. This advantageously reduces the loading on the rubber material of the closure elements. Further, the reduced deflection of the closure elements helps the closure elements to lie close to or in contact with the external surface of the tubular inlet when inserted. This advantageously reduces the possibility that wasps may find their way out of the bait chamber between the closure elements and the inlet.

**[0112]** As the vapour chamber and the bait chamber are assembled and the inlet is inserted through the diaphragm, a force is applied to the diaphragm tending to push it into the bait chamber. Contact between the castellations of the grommets and the waisted portion of the neck prevent this. In this area of the diaphragm, the insert also prevents the grommet from distorting and falling into the bait chamber.

**[0113]** When the vapour chamber is removed from the bait chamber, the bait chamber may be filled with wasps As the inlet is withdrawn from the closure elements, a force is applied to the diaphragm tending to pull it out of the neck of the bait chamber, which is undesirable as it would release the wasps. This is prevented by the interaction of the grommet with the flange **54** at the upper end of the neck. This is assisted by the action of the insert. As the inlet is withdrawn, the closure elements are pulled upwards towards and against the rigid insert. This force is transferred through the insert to the grommet and thus to the flange at the upper end of the neck of the bait chamber preventing removal or distortion of the grommet portion of the diaphragm

**[0114]** As the inlet is withdrawn, there may be a tendency for one or more of the closure elements to adhere to the inlet. The profile of the lower edge of the insert is rounded, and the inner opening of the insert is sufficiently large, to prevent any closure elements adhering to the inlet from jamming within the insert (between the inlet and the insert) as the inlet is withdrawn. The opening in the insert is, however, sufficiently small to prevent any wasps escaping as the inlet is withdrawn as a result of being caught between a closure element and the inlet.

**[0115]** When the vapour chamber has been removed from the bait chamber, the closure elements resiliently recover into contact with each other, closing the bait chamber and preventing the escape of any trapped wasps. A further advantage of the domed, or conical, shape of the central portion of the diaphragm is that a greater force is required to press the closure elements open from within the bait chamber than from outside the bait chamber. Thus, even if the bait chamber is accidentally inverted after the diaphragm is closed, no insects should escape.

**[0116]** Finally, a screw-on lid **90** is provided for the bait chamber. This is shown in FIGS. **25** to **29**. After the vapour chamber has been removed, the lid is simply screwed onto the bait chamber to provide a permanent seal. The annular ridge 42 at the upper edge of the grommet extends beyond the flange 54 at the upper edge of the neck in order to provide a rubber seal against which the lid can close, to provide a liquid-tight seal.

[0117] When the vapour chamber is coupled to the bait chamber, the lid 90 can conveniently be stored at an upper end of the vapour chamber as shown in FIGS. 1, 2 and 31. A hook or eye 92 is moulded on an upper surface of the lid, from which the trap can be suspended if desired when the lid is in this position.

[0118] FIGS. 33 to 36 illustrate a wasp trap according to a second embodiment, comprising a vapour chamber 102 coupled at a screw thread 104 to an opening in the top of a collection chamber 106. As in the first embodiment, the collection chamber is suited to contain liquid bait and so may be termed a bait or killing chamber. The vapour chamber is positioned vertically above the bait chamber and the assembled trap can stand on the flat base 108 of the bait chamber. The bait chamber can be unscrewed to remove it from the vapour chamber and can then be sealed using a threaded lid 110. When the bait chamber is coupled to the vapour chamber the lid can be screwed onto a thread at the upper end of the vapour chamber for safe keeping. The lid is also provided with a protruding tab, or eye, 112 to which a string can be attached, so that the trap may be suspended during use, for example from the branch of a tree.

[0119] The vapour chamber 102, the bait chamber 106 and the lid 110 are all advantageously moulded from a transparent plastics material, such as PET.

[0120] The vapour chamber is circular in cross section as shown in FIG. 34, and four insect entrances 114 are formed in its vertical side wall. Each entrance is surrounded by a frusto-conical flange 116 which extends into the vapour chamber, ending at a narrow opening 118. The entrances are substantially horizontally oriented so that wasps can easily crawl or fly into the vapour chamber. The length of each flange is predetermined so that wasps flying within the vapour chamber and rebounding from its walls do not rebound beyond the flanges.

[0121] In use, a bait is placed in the bait chamber to release an aroma, which passes into the vapour chamber and out of the insect entrances, to lure insects into the trap.

[0122] The bait is typically liquid and wasps entering the bait chamber are likely to drown in this liquid.

[0123] None of the insect entrances are aligned with each other and all four entrances are at different heights. The inventor has found that avoiding alignment of the entrances reduces the number of wasps which escape from the vapour chamber and that vertically spacing the entrances enhances the release of bait aroma from the vapour chamber. In addition, the entrances are circumferentially spaced around the vapour chamber, so that wind from any direction passes through the vapour chamber to distribute bait aroma.

[0124] At the lower end of the vapour chamber a restriction 120 comprises a frusto-conical flange, or funnel, 122 extending downwardly from the wall of the vapour chamber to a narrower circular opening 124, from which a cylindrical tube 126 extends into the bait chamber. The restriction is opaque, either being coloured or moulded from an opaque plastics material.

[0125] Wasps tend to fly towards light, and in the vapour chamber will therefore tend to fly away from the restriction towards upper portions of the vapour chamber. When a wasp is tired, however, it is desirable that it should enter the bait chamber without delay, and so the angle of the sloping portion of the restriction is chosen to be too steep to allow wasps to rest on it.

[0126] The bait chamber has a circular opening surrounded by a cylindrical wall 128, which is externally threaded to engage either the lower end of the vapour chamber or the bait chamber lid. A safety plug 130 is a push fit within the cylindrical wall and includes a flange 132 which extends radially inwards to a central opening, which fits snugly around an outer surface of the cylindrical tube 126 of the restriction when the bait chamber is threaded onto the vapour chamber. The safety plug also comprises a self-closing flap 134 which is biassed by a spring 136 towards a closed position, in which it seals the central opening of the safety plug. As the bait chamber is threaded onto the vapour chamber, an end of the cylindrical tube 126 urges the flap 134 into an open position as shown in FIG. 33. As the bait chamber is unscrewed from the vapour chamber, the cylindrical tube is withdrawn, allowing the flap to seal the opening in the safety plug before the bait chamber is fully unscrewed.

[0127] FIG. 35 shows the bait chamber removed from the vapour chamber, with the flap closing the opening in the safety plug and the bait chamber lid in place.

[0128] The safety plug is moulded from an opaque material. Since wasps within the trap tend to fly towards light, this reduces the tendency for wasps to fly out of the bait chamber back into the vapour chamber. It should be noted that transparent shoulders 138 of the bait chamber extend outside and above the bottom of the safety plug. Wasps flying in the bait chamber tend to fly into these shoulders and away from the opening into the vapour chamber.

[0129] In an alternative embodiment, the trap may be used for collecting insects alive. In this case, as illustrated in FIG. 35, a cylindrical insert 140 carrying a mesh baffle 142 can be pressed into the cylindrical extension 126 of the restriction. The insert is shaped so that the cylindrical tube can still open the flap in the safety plug. However, the baffle covers the opening between the vapour chamber and the bait chamber so that bait aroma can still be released by the trap but wasps in the vapour chamber cannot enter the bait chamber. Wasps can then be caught alive in the vapour chamber.

[0130] FIG. 36 is a reproduction of FIG. 35 and shows the dimensions of an embodiment of the trap, in centimetres. It also shows the preferred angle for the sloping portion of the restriction 120. Although these dimensions have been found by the inventor to produce a highly effective wasp trap, the skilled person would readily appreciate that the design factors described in this patent application would provide guidance to allow effective traps of different dimensions to be designed, and that such traps therefore fall within the scope of the present invention.

[0131] Further Aspects

[0132] It has been noted that trapped insects, such as wasps, may tend to fly towards light. After trapping such insects it may be desirable to ensure that all have entered the collection chamber, and that the vapour chamber is empty, before removing the collection chamber from the vapour chamber. To do this it may be advantageous to cover the vapour chamber, but not the collection chamber, with an opaque or substantially opaque cloth or sleeve for a predetermined time. This closes the insect entrances into the vapour chamber to prevent entry of further insects and encourages those in the vapour chamber to enter the collection chamber, which is still lit through its transparent walls. The inventor has found that covering the vapour chamber in this way for about one minute is sufficient to clear the vapour chamber.

[0133] It has also been noted above that trapped insects can be sealed in the collection chamber for disposal. The vapour chamber is then available for reuse. In a preferred embodiment, therefore, new collection chambers containing bait can be advantageously supplied for fitting to the reusable vapour chamber. It may be undesirable to reuse collection chambers as it is safer, particularly when trapping stinging. insects, to dispose of the trapped insects sealed within the collection chamber.

[0134] A further advantage found by the inventor is that traps embodying the invention may selectively trap certain types of insect. A particularly beneficial example is that a trap set up in an apiary may selectively trap wasps and not bees. It is believed that this may be due to the emission of stress pheromones by trapped wasps attracting only further wasps and not bees.

1. A trap for flying insects, comprising;

a vapour chamber;

an insect entrance defined in a wall of the vapour chamber; and

a collection chamber couplable to the vapour chamber at a restriction which controls the movement of insects from the vapour chamber to the collection chamber.

2. A trap according to claim 1, in which the restriction defines an opening through which insects can pass from the vapour chamber to the collection chamber, the area of the opening being smaller than a cross-sectional area of the vapour chamber adjacent the restriction.

3. A trap according to claim 2, in which the area of the opening is less than half, and preferably between 0.25 and 0.05, of the cross-sectional area of the vapour chamber adjacent to the restriction.

4. A trap according to claim 2, in which the opening is substantially circular and has a diameter of between 1 cm and 8 cm, preferably between 2 cm and 5 cm, and particularly preferably between 2.5 cm and 4 cm.

5. A trap according to claim 1, in which the restriction is at the bottom of the vapour chamber during use.

6. A trap according to claim 1 in which the restriction comprises, during use, a surface sloping downwardly towards an opening into the collection chamber.

7. A trap according to claim 1, in which the restriction is substantially more opaque than a wall of the vapour chamber.

8. A trap according to claim 1, in which the wall of the vapour chamber is substantially transparent.

9. A trap according to claim 1, in which, during use, the height of the vapour chamber is greater than its width, preferably greater than twice its width, and particularly preferably about three times its width.

10. A trap according to claim 1, in which the insect entrance is defined in the wall of the vapour chamber such that, during use, an insect enters the vapour chamber in a substantially horizontal direction.

11. A trap according to claim 1, in which the insect entrance is surrounded by a flange which extends into the vapour chamber from its wall, the flange preferably being frusto-conical, and preferably having a length equal to or slightly greater than the distance that an insect flying within the vapour chamber typically rebounds on colliding with the wall.

12. A trap according to claim 1, comprising a plurality of insect entrances defined in the wall of the vapour chamber, the entrances all being at different heights during use.

13. A trap according to claim 1, comprising a plurality of insect entrances defined in the wall of the vapour chamber, none of the entrances being coaxial with each other.

14. A trap according to claim 1, in which the or each insect entrance is spaced from the top of the vapour chamber during use, to allow space for insects to fly within the vapour chamber above the entrance.

15. A trap according to claim 1, in which the or each insect entrance is spaced from the top of the vapour chamber by at least a third of the height of the vapour chamber.

16. A trap according to claim 1, in which the collection chamber is detachably coupled to the vapour chamber.

17. A trap according to claim 16, comprising a self-closing mechanism or closure apparatus for automatically sealing the collection chamber as it is detached from the vapour chamber, in order to prevent insects escaping from the collection chamber.

18. A trap according to claim 1, in which a wall of the collection chamber is substantially transparent.

19. A trap according to claim 1, in which a wall of the collection chamber adjacent to the restriction is transparent.

20. A trap according to claim 1, in which the restriction defines an opening into the collection chamber and, during use, a substantially transparent wall of the collection chamber extends above the level of the opening.

21. A trap according to claim 1, in which, during use, the collection chamber is below the vapour chamber and the trap can either stand on a base portion of the collection chamber or be suspended from an upper portion of the vapour chamber.

22. A trap according to claim 1, in which a baffle can be positioned adjacent the restriction to prevent insects from entering the collection chamber, so that the trap can be used to collect insects alive in the vapour chamber.

23. A trap according to claim 1, in which the collection chamber is a bait chamber.

24. A trap according to claim 1, in which the collection chamber is a killing chamber for killing at least some of the insects collected therein.

25. A trap according to claim 1 in which bait is located other than in the collection chamber.

26. A trap according to claim 17, in which the self-closing mechanism, or closure apparatus, comprises;

a tubular inlet extending from the vapour chamber; and

a diaphragm spanning an opening at an entrance to the collection chamber and comprising at a central portion three or more inwardly-extending closure elements;

in which the tubular inlet is insertable through the central portion of the diaphragm, resiliently deflecting the closure elements to open the opening, and is removable to allow the resilient closure elements to return to their undeflected position to close the opening.

**27**. A trap according to claim 26, in which the inlet is cylindrical or frusto-conical.

**28**. A trap according to claim 26, comprising five closure elements.

**29**. A trap according to claim 26, in which the closure elements are bounded by slits in the diaphragm extending radially outward from a common point.

**30**. A trap according to claim 29, in which each slit terminates at its end distant from the common point in a stress-relieving hole or region of reduced diaphragm thickness.

**31**. A trap according to claim 26, in which the diaphragm is domed or is asymmetrically shaped so that the closure elements are more easily deflected to open the closure apparatus in one direction than in the other.

**32**. A trap according to claim 26, in which the closure elements are integrally formed with the diaphragm.

**33**. A trap according to claim 26, in which a circumferential ridge extends from an outer surface of a portion of the inlet which passes through the central portion of the diaphragm and beyond the closure elements on opening the closure apparatus, so that when the inlet is withdrawn from the central portion to close the closure apparatus, the ridge engages an end portion of each closure element and urges each closure element into its closed position.

**34**. A trap according to claim 26, in which the diaphragm comprises at its periphery a grommet or region of enlarged section for fitting within an entrance, such as an entrance to a container.

**35**. A trap according to claim 34, in which an outwardly-facing surface of the grommet forms a liquid-tight seal when fitted within the entrance.

**36**. A trap according to claim 34, further comprising an annular insert for fitting within an inwardly-facing surface of the grommet when inserted within the entrance to urge the grommet against an inwardly-facing surface of the entrance or to lock the grommet in place within the entrance.

**37**. A trap according to claim 36, in which an inwardly-facing surface of the insert guides the inlet into contact with the central portion of the diaphragm in order to open the closure apparatus.

**38**. A collection chamber for a trap as defined claim 1.

**39**. A method for trapping flying insects comprising the steps of:

luring insects through one or more entrances into a vapour chamber containing an aroma emitted by bait in a collection chamber;

allowing insects to fly within the vapour chamber;

restricting the rate at which insects enter the collection chamber from the vapour chamber; and

trapping or collecting insects in the collection chamber.

**40**. A method according to claim 39, comprising the step of removing the collection chamber to dispose of trapped or collected insects.

**41**. A method according to claim 39, in which the step of allowing insects to fly within the vapour chamber causes the insects to emit signals, such as visual, aural or olfactory signals, which attract further insects into the vapour chamber.

**42**. An insect trap comprising a removable collection chamber for collecting trapped insects and a self-closing mechanism operable to seal the collection chamber when the collection chamber is removed.

**43**. An insect trap according to claim 42, further comprising a second chamber couplable to the collection chamber by means of the self closing mechanism or closure apparatus, the self-closing mechanism or closure apparatus comprising;

a tubular inlet extending from the vapour chamber; and

a diaphragm spanning an opening at an entrance to the collection chamber and comprising at a central portion three or more inwardly-extending closure elements;

in which the tubular inlet is insertable through the central portion of the diaphragm, resiliently deflecting the closure elements to open the opening, and is removable to allow the resilient closure elements to return to their undeflected position to close the opening, such that insects collected in the collection chamber while the second chamber is coupled thereto can be retained in the collection chamber by removing the inlet from the central portion of the diaphragm and closing the opening.

**44**. A trap for flying insects, comprising a plurality of insect entrances each having an axis defining an insect entrance direction, in which all of the axes are vertically spaced from one another when the trap is in use.

**45**. A trap according to claim 44, in which all of the axes are angularly spaced from each other.

**46**. A trap for flying insects, comprising a chamber in which insects can fly, an insect entrance defined in a wall of the chamber and a flange encircling the entrance and extending into the chamber, in which insects flying in the chamber rebound from the wall and the flange length is equal to or greater than the distance to which insects rebound.

**47**. A trap for flying insects, comprising a chamber and a plurality of horizontal entrances defined in a side wall of the chamber, the chamber having, during use, an upper portion which is transparent and in which insects can fly substantially above the level of the entrances.

**48-50**. (Cancelled)

* * * * *

# Tab 4

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(54) WOOD-BORING INSECT TRAP

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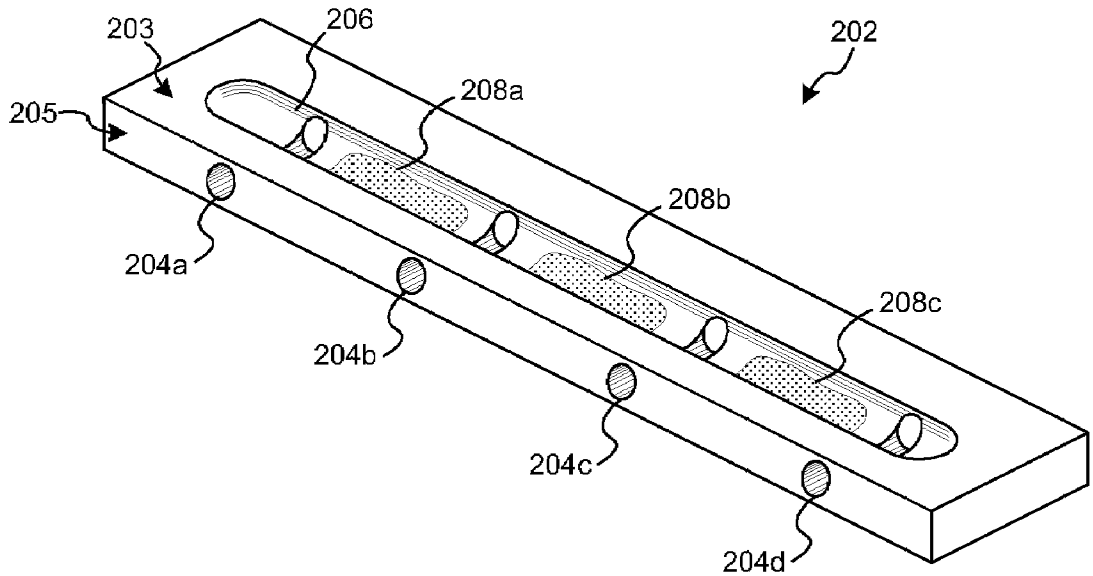
*A01M 1/14* (2006.01)
*A01M 1/20* (2006.01)

(52) **U.S. Cl.** ........................................... **43/114**; 43/107

(57) **ABSTRACT**

Apparatus, methods, and systems provide for the trapping and disablement of wood-boring insects such as carpenter bees. According to various embodiments described herein, a wood-boring insect trap includes a trap body, at least one longitudinal passage, and at least one insect entryway. The longitudinal passage is positioned within the trap body so that it is exposed when the wood-boring insect trap is not installed on a structure to be protected and enclosed when the trap is installed on the structure. The entryway intersects the longitudinal passage and allows wood-boring insects to enter the trap, proceed to the passage, where the insect will encounter an insect disabling substance. According to embodiments, the insect disabling substance may be a poison, glue, or a combination thereof.



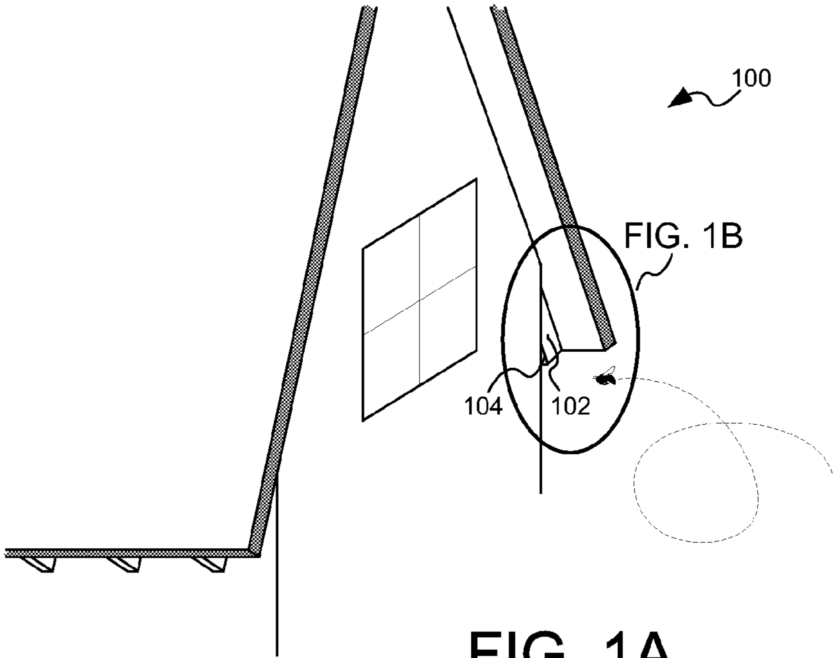



FIG. 1A
PRIOR ART

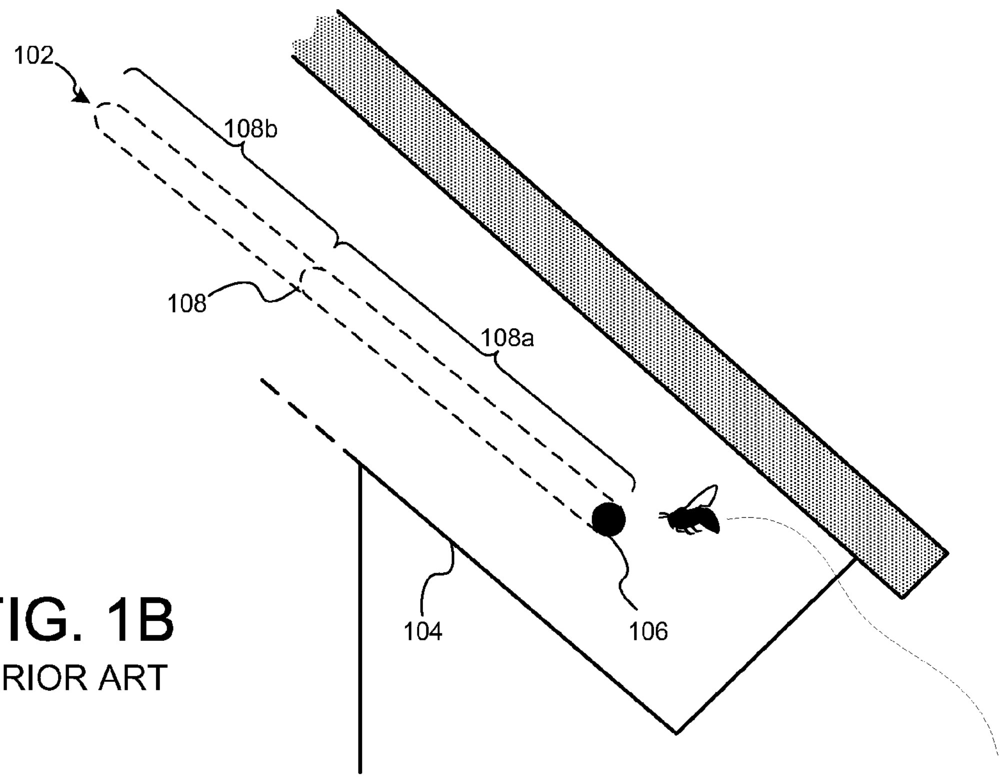



FIG. 1B
PRIOR ART

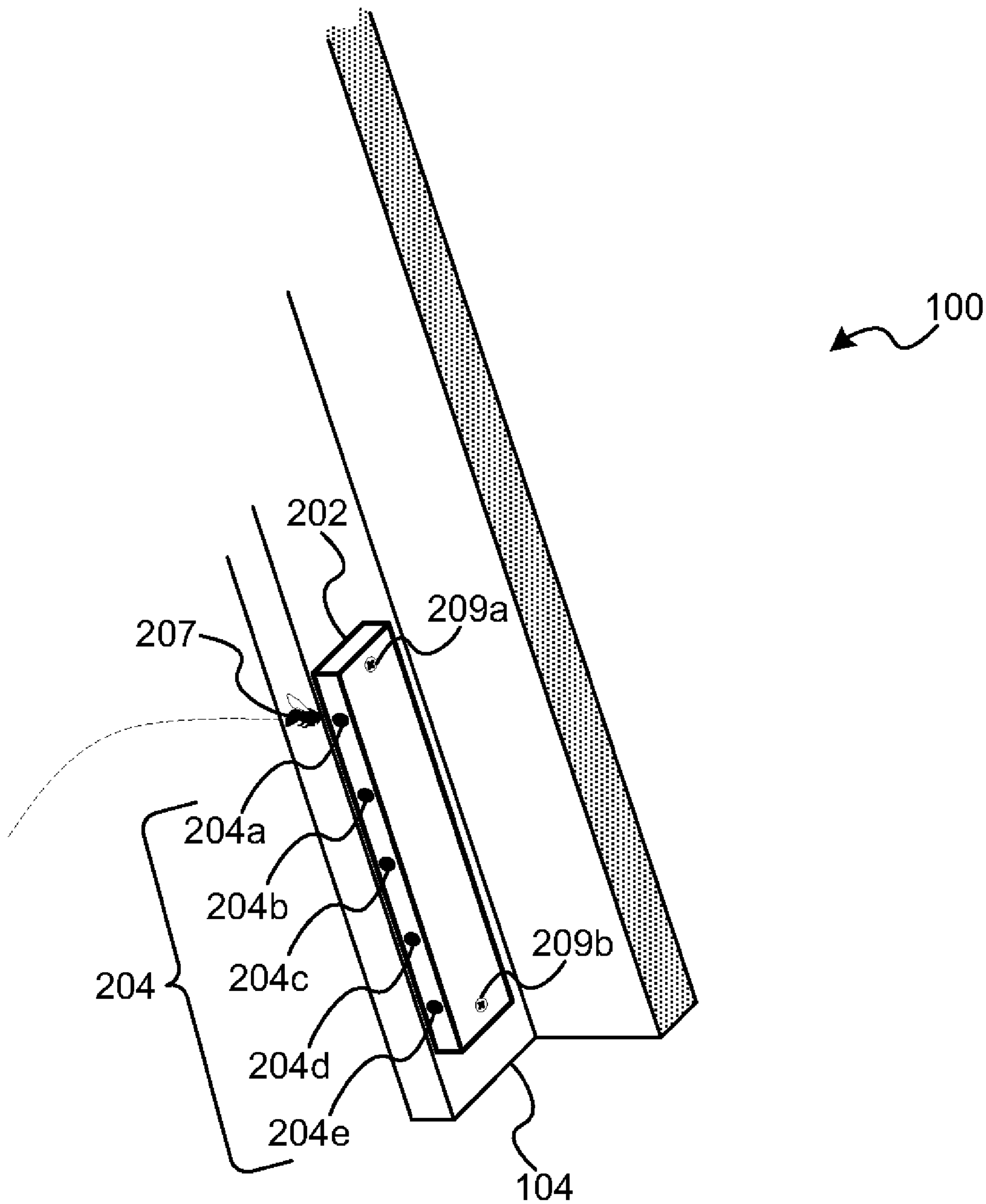



FIG. 2

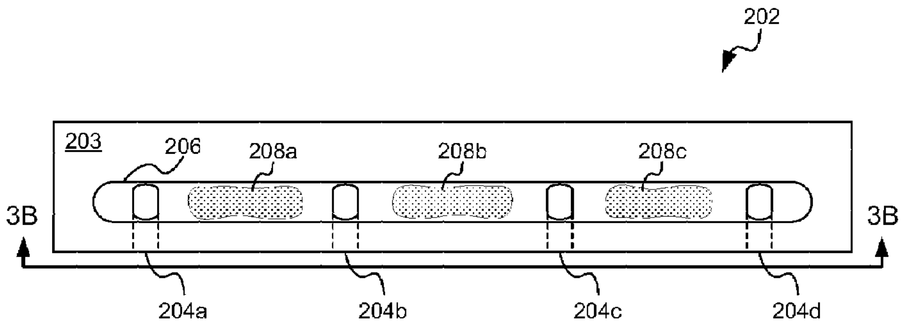



FIG. 3A

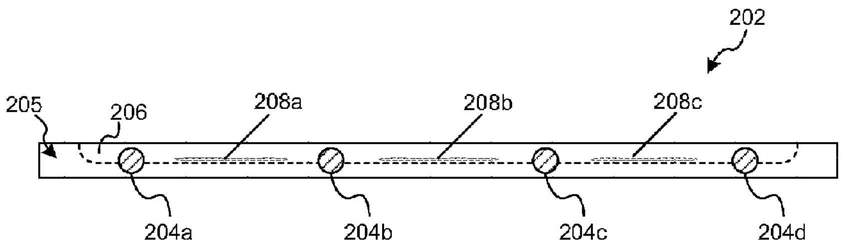



FIG. 3B

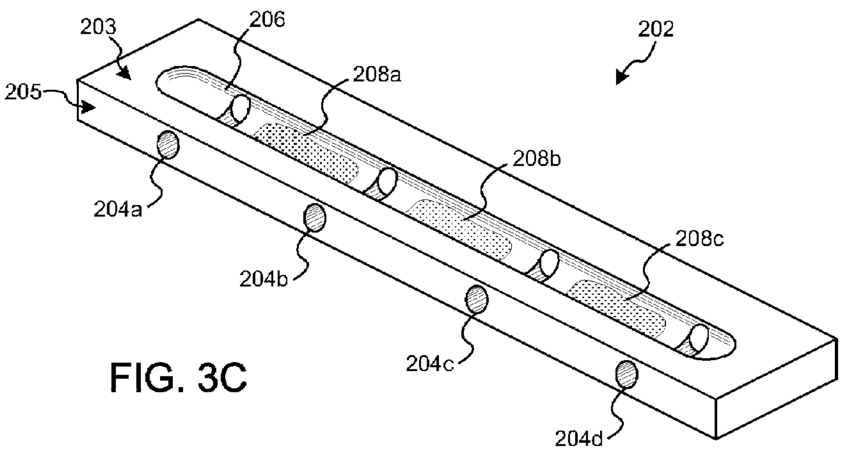



FIG. 3C

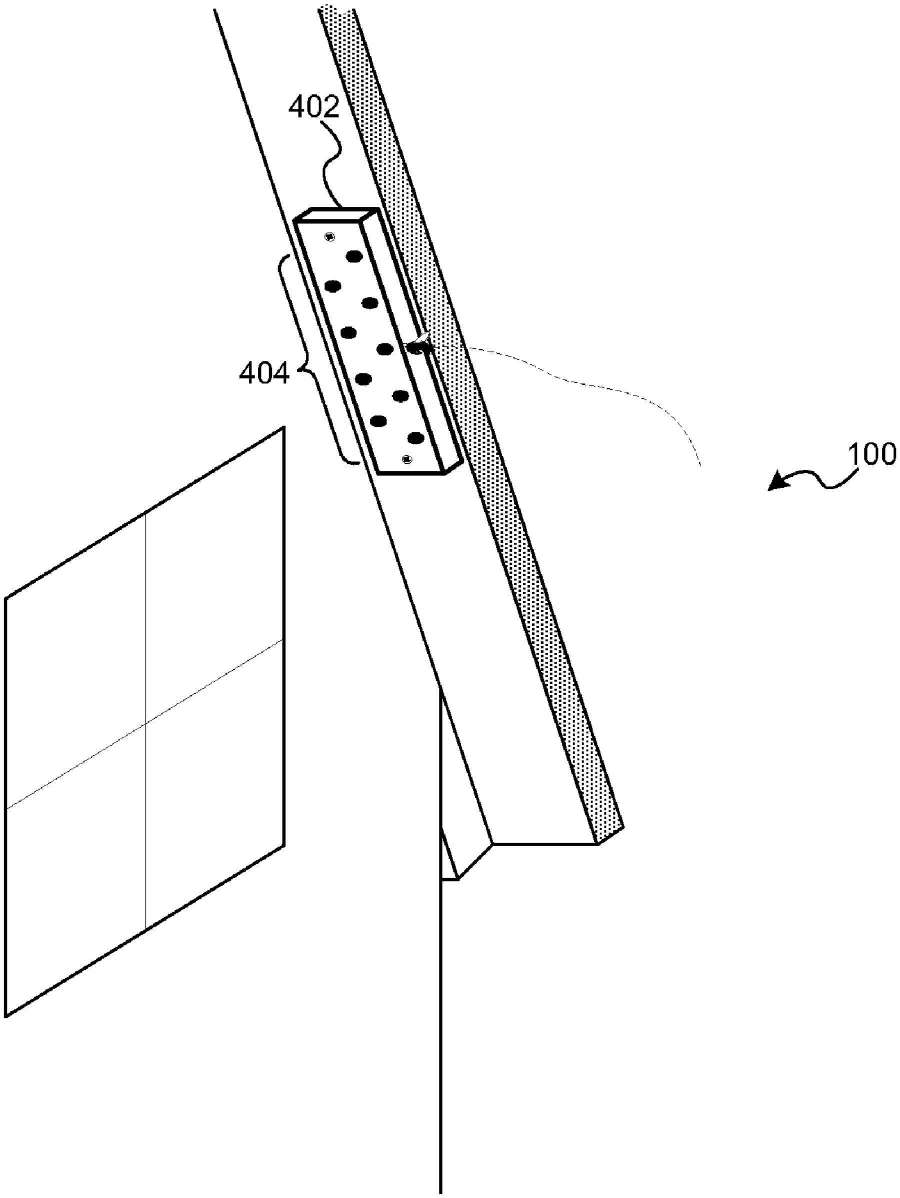



FIG. 4

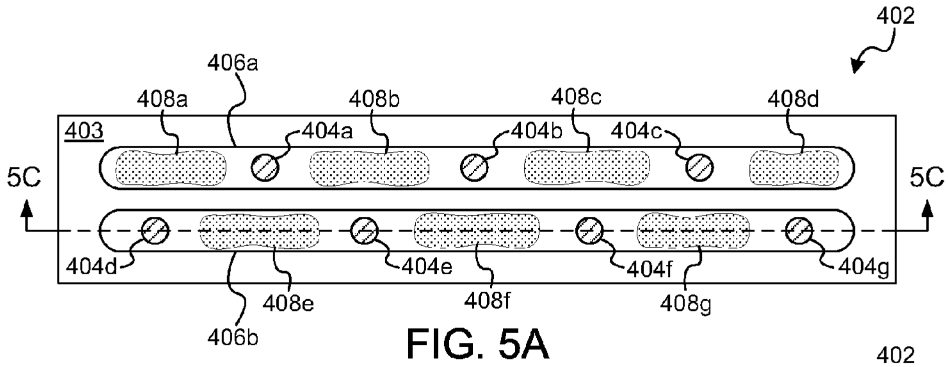



FIG. 5A

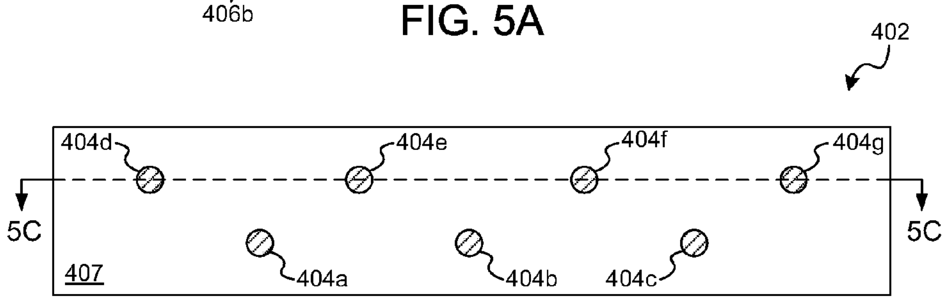



FIG. 5B

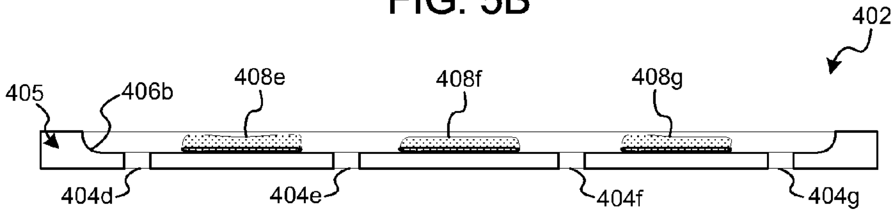



FIG. 5C

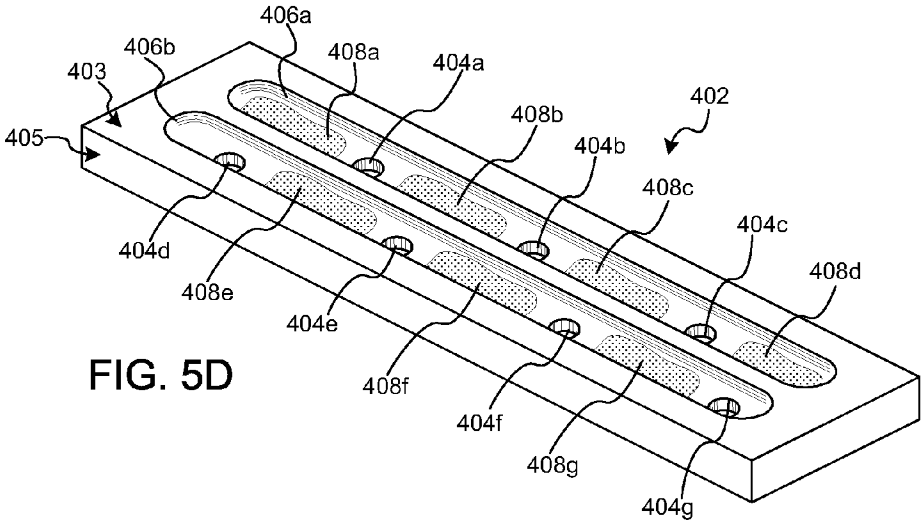



FIG. 5D

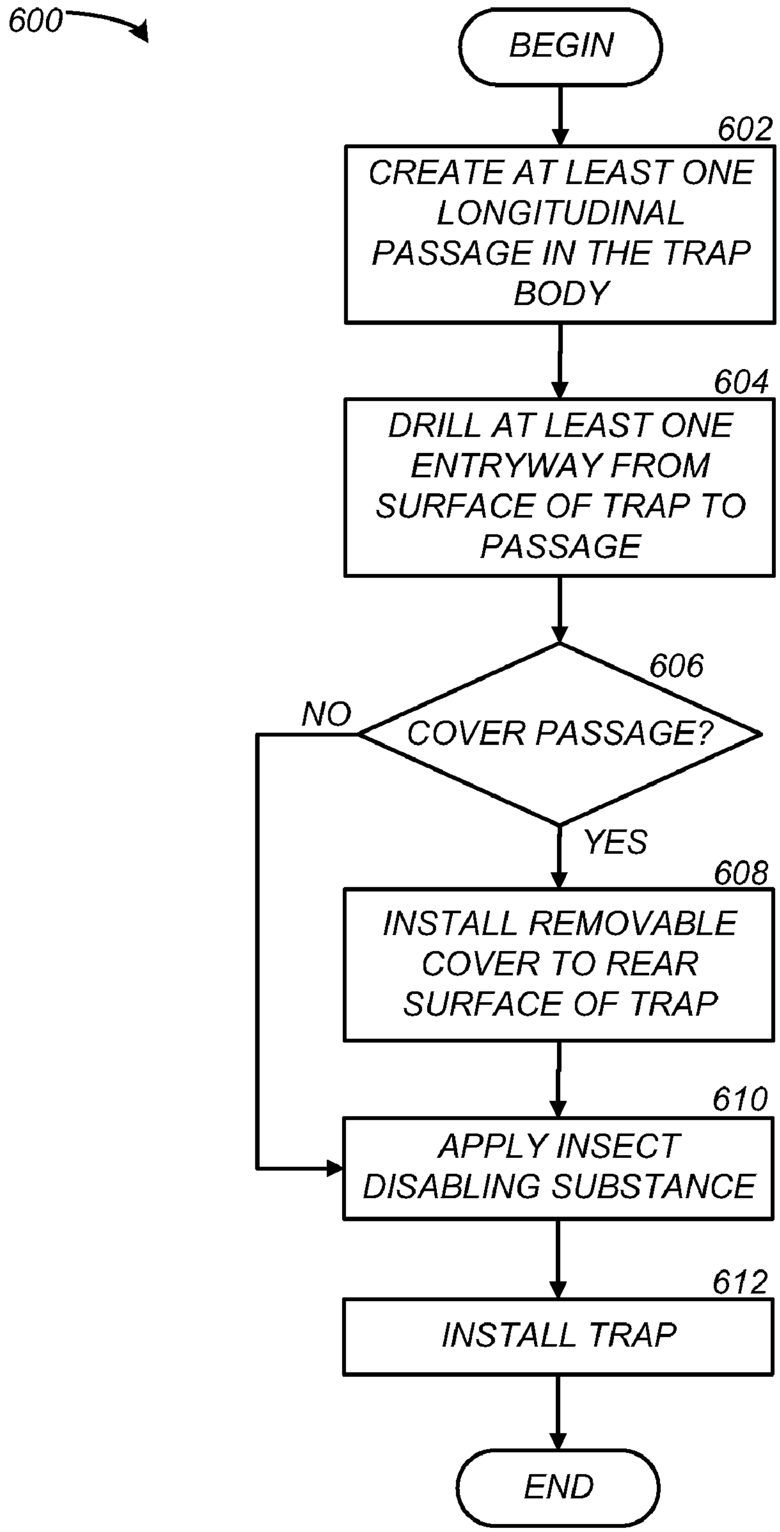

600
BEGIN
602
CREATE AT LEAST ONE LONGITUDINAL PASSAGE IN THE TRAP BODY
604
DRILL AT LEAST ONE ENTRYWAY FROM SURFACE OF TRAP TO PASSAGE
606
COVER PASSAGE?
NO
YES
608
INSTALL REMOVABLE COVER TO REAR SURFACE OF TRAP
610
APPLY INSECT DISABLING SUBSTANCE
612
INSTALL TRAP
END

Fig.6.

# WOOD-BORING INSECT TRAP

## CROSS REFERENCE TO RELATED APPLICATIONS

**[0001]** The present application claims priority under 35 U.S.C. §119 to co-pending U.S. provisional application No. 60/841,248 entitled "Carpenter Bee Trap" filed on Aug. 30, 2006, which is expressly incorporated in its entirety herein by reference.

## BACKGROUND

**[0002]** In North America, and in other parts of the world, certain flying insects can damage wood structures by boring through the wood to nest. Carpenter bees, for example, are known to bore into wood structures, and can drill tunnels ten to twelve inches long in a year. Carpenter bees are typically of the family *Xylocopa,* and in North America are primarily comprised of the species *Xylocopa virginica.* Over the course of many years, as carpenter bees continue to use the same nest, bored tunnels can reach six feet or more in length. Multiple tunnels may eventually weaken a wood structure. In addition, the sawdust and exterior holes created may be unsightly.

**[0003]** FIG. **1**A depicts an example of carpenter bee damage **102** to an exposed rafter **104** of a wooden structure **100**. FIG. **1**B depicts a detailed view of the rafter **104** and the carpenter bee damage **102**. Here, the carpenter bee damage **102** consists of an external opening **106** in the rafter **104** and an internal tunnel **108** extending from the opening **106** through an interior portion of the rafter **104**. The tunnel **108** consists of a first tunnel portion **108***a* and a second tunnel portion **108***b*. The first tunnel portion **108***a* may represent the extent of the carpenter bee damage **102** after a first year of occupying the rafter **104**. After a second year of use, the second tunnel portion **108***b* may result as an extension of the first tunnel portion **108***a*. Eventually, structural damage to the wooden structure **100** may result, especially if multiple tunnels **108** are created in close proximity to one another. The tunnel **108** is angled, primarily because carpenter bees may prefer to angle the tunnel **108** so that sawdust and debris created during construction and nesting will be removed from the tunnel **108** with the assistance of gravity.

**[0004]** Among the available preventatives for carpenter bee damage is the use of a thick coat of paint or some other wood treatment. However, these sometimes do not prevent infestation, due to thin spots, or to determined insects. Once a nest is established, carpenter bees may keep coming back to the same nests year after year. Poisons and wood fillers can be used to kill a nest and fill in the holes, but these are not always the safest or most effective forms of treatment.

## SUMMARY

**[0005]** It should be appreciated that this Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used to limit the scope of the claimed subject matter.

**[0006]** According to embodiments presented herein, apparatus, methods, and systems provide for the trapping and disablement of wood-boring insects such as carpenter bees. According to various embodiments, a wood-boring insect trap includes a trap body, at least one longitudinal passage, and at least one insect entryway. The longitudinal passage is positioned within the trap body so that it is exposed when the wood-boring insect trap is not installed on a structure to be protected and enclosed when the trap is installed on the structure. The entryway intersects the longitudinal passage and allows wood-boring insects to enter the trap, and to proceed to the passage.

**[0007]** Embodiments provide for a wood-boring insect trap system that includes an insect disabling substance applied to a surface of the longitudinal passage. The disabling substance may include a poison, a glue or other binding agent, or a combination thereof. A method for creating the wood-boring insect trap according to various embodiments include creating the longitudinal passage in the trap body by fabricating a channel within a rear surface of the trap body that is mounted against a surface of the structure to be protected. In this manner, the channel is exposed for application of an insect disabling substance when the wood-boring insect trap is not installed on the structure to be protected, but concealed to create the longitudinal passage when the wood-boring insect trap is installed on the structure. Entryways for the insects are created that extend from either a side surface or front surface of the wood-boring insect trap to the longitudinal passage.

**[0008]** Other apparatus, systems, and/or methods according to embodiments will be or become apparent to one with skill in the art upon review of the following drawings and Detailed Description. It is intended that all such additional apparatus, systems, and/or methods be included within this description, be within the scope of the present invention, and be protected by the accompanying claims.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0009]** FIG. **1**A is a pictorial diagram showing a perspective view of typical carpenter bee damage in a wooden structure;

**[0010]** FIG. **1**B is a pictorial diagram showing an enlarged view of the carpenter bee damage to the wooden structure shown in FIG. **1**A;

**[0011]** FIG. **2** is a pictorial diagram showing a perspective view of a wood-boring insect trap according to one embodiment presented herein;

**[0012]** FIGS. **3**A-**3**C are pictorial diagrams showing rear, side, and rear perspective views, respectively, of the wood-boring insect trap according to the embodiment shown in FIG. **2**;

**[0013]** FIG. **4** is a pictorial diagram showing a perspective view of a wood-boring insect trap according to another embodiment presented herein;

**[0014]** FIGS. **5**A-**5**D are pictorial diagrams showing rear, top, cross-sectional, and rear perspective views respectively of the wood-boring insect trap according to the embodiment shown in FIG. **4**; and

**[0015]** FIG. **6** is a flow diagram illustrating a method for creating a wood-boring insect trap according to one embodiment presented herein.

## DETAILED DESCRIPTION

**[0016]** The following detailed description is directed to an apparatus, method, and system for preventing wood-boring insect damage. In the following detailed description, references are made to the accompanying drawings that form a part hereof, and which are shown, by way of illustration, using specific embodiments or examples. Referring now to the drawings, in which like numerals represent like elements through the several figures, aspects of the apparatus provided herein will be described. Throughout this disclosure, embodiments are discussed with respect to trapping carpenter bees. However, it should be appreciated that the described embodiments are equally applicable to any type of wood-boring insect and is not limited to use with carpenter bees. The dimensions of the devices described below, as well as the quantities and dimensions of any openings or channels within the disclosed devices may be altered to target a specific wood-boring insect.

**[0017]** FIG. **2** depicts an example of a carpenter bee trap **202** as it may be utilized to trap carpenter bees and prevent the bees from damaging the wooden structure **100**. The wooden structure **100** may include a house or other building, a deck, a tower, or any other structure having any exterior surface made of wood. The carpenter bee trap **202** may be affixed to the exterior of the wooden structure **100**. The carpenter bee trap **202** may be comprised of cedar, redwood, fir, spruce, pine, cypress, and/or any other soft wood preferred by adult carpenter bees. It should be noted that the carpenter bee trap **202** need not necessarily be created of wood. However, if the surfaces surrounding the entryways **204** are wooden, this may serve to attract the insects. The carpenter bee trap **202** may be painted or otherwise treated in order to camouflage or advertise the trap's presence, or may include exposed wood in an effort to attract more carpenter bees. The carpenter bee trap **202** may be affixed to the wooden structure **100** using screws **209***a* and **209***b*. Other methods for affixing the trap to the structure may be utilized, including the use of VELCRO, or nails. It is useful to use a method of affixing which allows easy removal of the carpenter bee trap **202** so that captured insects can be disposed of.

**[0018]** The carpenter bee trap **202** includes the entryways **204**. Here, the carpenter bee trap **202** includes five entryways **204***a*-**204***e*, but other quantities may be used. According to one embodiment, the entryways **204** may be located along a narrow longitudinal surface of the carpenter bee trap **202**. The entryways **204** may be drilled at an angle perpendicular to the longitudinal axis of the carpenter bee trap **202**, where the longitudinal axis may be situated at an upward angle, so as to approximate how a carpenter bee constructs its own nest. The angle of an entryway **204** relative to the longitudinal axis need not necessarily be perpendicular, and other angles may suffice. A carpenter bee **207** is attracted to the exposed entryway **204***a*, which is due to a preference of such insects to use existing holes and nests, a preference for exposed and/or untreated or unpainted wood, and/or a preference for an attractant rubbed on the entryway **204***a* or located proximate the entryway **204***a*. Upon entry, the carpenter bee **207** may be immobilized, poisoned, or otherwise disabled, thereby preventing future damage to wooden structure **100** by the carpenter bee **207**. The interior structure of the carpenter bee trap **202** may include additional holes, tunnels, devices, and substances so as to assist in luring and disabling the carpenter bee **207**, as will be described in greater detail below.

**[0019]** FIGS. **3**A-**3**C depict rear, side, and rear perspective views, respectively, of the uninstalled carpenter bee trap **202** that is shown installed on the rafter **104** in FIG. **2**. The rear surface **203** of the carpenter bee trap **202** abuts the rafter **104** of the wooden structure **100** when the carpenter bee trap **202** is installed. According to one embodiment, the side surface **205** of the carpenter bee trap **202** includes four entryways **204***a*-**204***d*. As stated above, any number of entryways **204** may be included in the side surface **205** of the carpenter bee trap **202** without departing from the scope of this disclosure.

**[0020]** The entryways **204***a*-**204***d*, intersect a longitudinal passage **206**. The longitudinal passage **206** runs parallel to the longitudinal axis of the carpenter bee trap **202**. The longitudinal passage **206** may be a groove or routed passage that is open when the carpenter bee trap **202** is not installed, as shown in FIGS. **3**A-**3**C. Having an open longitudinal passage **206** allows for ease of access for cleaning and for applying the disabling substance **208**. When the carpenter bee trap **202** is installed, the rear surface **203** of the carpenter bee trap **202** abuts a surface of the rafter **104**, enclosing the longitudinal passage **206**. Alternatively, the longitudinal passage **206** may be enclosed using a method other than affixing surface to the wooden structure **100**. For example, the longitudinal passage **206** may be enclosed using a cover or a symmetrical hinged block. As stated above, the entryways **204** intersect the longitudinal passage **206**, creating a pathway that approximates the nest of the carpenter bee **207**. Although depicted using the single longitudinal passage **206**, it should be appreciated that any number of longitudinal passages **206** may be utilized. The entryways **204** may be spaced apart at any distance, regular or irregular. However, each entryway **204** should have at least enough clearance between at least one other hole to allow placement of the disabling substance **208**.

**[0021]** The disabling substance **208** may be placed in the interior of the longitudinal passage **206**. The disabling substance **208** may be placed at any location between the entryways **204**. The disabling substance **208** may be a form of poison, preferably without an odor that would deter the advancing carpenter bee **207**. The disabling substance **208** may also be a form of insect glue, which is sticky enough to prevent further movement by the carpenter bee **207** when crawling over it. If insect glue is utilized as the disabling substance **208**, it should be made not to dry and should retain its sticking qualities over a period of time, such as months or years. Combinations of disabling substances **208** may be available, such as, for example, insect glue that includes a poison. In addition to poison or insect glue, the disabling substance **208** may also be comprised of other substances that disable or kill an encroaching insect.

**[0022]** When placing the disabling substance **208**, there may need to be a set back from the intersection of the entryway **204** and the longitudinal passage **206**. By keeping the disabling substance **208** away from the entryway **204**, the approaching carpenter bee **207** will more likely turn the corner and come into contact with the disabling substance **208**, ultimately being immobilized, injured, killed, or otherwise disabled. A set back of approximately one inch may be necessary to ensnare the carpenter bee **207**, but any amount of set back may be used. It should be understood that although FIGS. **3**A-**3**C show the disabling substance **208** disposed between each adjacent entryway **204**, the disabling substance may be placed in a single location or at any number of locations within the longitudinal passage **206**.

**[0023]** The longitudinal passage **206** may be any shape or width, so long as the body of the carpenter bee **207** or other targeted insect can freely negotiate the passage. Here, the longitudinal passage **206** may be a concave channel that is three-quarters (¾) of one inch wide and one-half (⅜) inch deep and may be created using a router or other wood working tool. The entryways **204** similarly may be any shape or width, so long as the body of the carpenter bee **207** can pass through. For example, the entryways **204** may vary between three-eighths (⅜) and five-eighths (⅝) of an inch in diameter. Here, the entryways **204** may be circular and be one-half (½) inch in diameter. The entryway **204** may be any depth before encountering an intersection with the longitudinal passage **206**, especially a depth that approximates an actual carpenter bee nest. Here, the depth of the entryway **204** is approximately five-eighths (⅝) of an inch. The entryways **204** may be spaced apart any distance from each other, allowing for room for the disabling substance **208**. Here, the entryways **204** vary between four and seven inches apart. The wood or structure utilized to create the carpenter bee trap **202** may be any thickness that accommodates the entryways **204** and the longitudinal passage **206**. The wood here is approximately three-quarters (¾) of an inch thick.

**[0024]** As described above, when the rear surface **203** of the carpenter bee trap **202** is affixed to a structure, the longitudinal passage **206** becomes an enclosed tunnel. The approaching carpenter bee **207** may enter through entryway **204** and proceed towards longitudinal passage **206**. At the intersection, the carpenter bee **207** may believe that it is in a nest and enter the longitudinal passage **206** towards the disabling substance **208**. Once coming into contact with the disabling substance **208**, the carpenter bee **207** may be disabled, stuck, injured, and/or killed. Subsequent carpenter bees **207** may enter the same or other entryways **204** and be disabled themselves. It may be necessary to provide multiple entryways **204** to accommodate multiple carpenter bees **207**, although one may be sufficient.

**[0025]** Turning now to FIG. **4**, a carpenter bee trap **402** according to an alternative embodiment will be described. The carpenter bee trap **402** includes multiple entryways **404**. The entryways **404** are located along a wider longitudinal surface, and are again drilled in a direction mostly perpendicular to the longitudinal axis of the carpenter bee trap **402**. Here, the carpenter bee trap **402** is affixed along the underside of a surface of the wooden structure **100**, although the carpenter bee trap may be placed on a vertical surface of the wooden structure **100** as well. The specific location for placement need not be specific, but the location should be exterior to the structure and able to be sensed by the insects. Locating the carpenter bee trap **402** near existing carpenter bee damage may be an attractive location. Again, the longitudinal axis of the carpenter bee trap **402** is oriented at an upward angle.

**[0026]** FIGS. **5**A-**5**D depict rear, top, cross-sectional, and rear perspective views, respectively, of the carpenter bee trap **402** according to the embodiment shown in FIG. **4**. As with the carpenter bee trap **202** of FIGS. **2**-**3**C, the carpenter bee trap **402** is affixed to the wooden structure **100** such that the rear surface **403** of the carpenter bee trap **402** abuts the rafter **104** of the wooden structure **100** when the carpenter bee trap **402** is installed. Longitudinal passages **406**, including longitudinal passages **406***a* and **406***b*, run parallel to the longitudinal axis of the carpenter bee trap **402**. Entryways **404**, rather than entering through a narrow side such as side surface **205** of the carpenter bee trap **202** shown in FIG. **3**B, enter through the top surface **407** of the carpenter bee trap **402**, which is wide surface opposite the rear surface **403** that abuts the wooden structure **100**. As before, the entryways **404***a*-**404***g* intersect with the longitudinal passages **406***a* and **406***b*, creating a 90-degree path for carpenter bees to follow. In between the entryways **404** and along the longitudinal passages **406**, a disabling substance **408** has again been placed, allowing for a set back from each of the entryways **404**. The entryways **404** may extend any to any depth before intersecting the longitudinal passages **406**. Here, the entryways **404** extend approximately one-quarter (¼) inch into the carpenter bee trap **402**.

**[0027]** It should be appreciated that the carpenter bee traps **202** and **402** may be installed and removed as needed. They can be left up year-round, or merely during the season when carpenter bees **207** create their nests (i.e. the springtime). The carpenter bee traps **202** and **402** may need to be removed periodically in order to remove disabled carpenter bees **207**. The length of each carpenter bee trap **202** and **402** is not essential to the disclosure herein, although thirty (30) inches in length may be used. The width of each carpenter bee trap **202** and **402** is also not essential to the disclosure herein, although a width of three and one-half (3½) inches may be used. Any number of carpenter bee traps **202** and **402** may be installed around the wooden structure **100**, depending on, for example, the size of an anticipated infestation, the cost, and the desired frequency of cleaning.

**[0028]** Although the term "longitudinal" is used throughout, meaning in the direction of the longest dimension, longitudinal passages need not necessarily be oriented along the longest axis of a particular trap. The longitudinal passages **206** and **406** may be parallel to each other or oriented at any angle with respect to one another. The longitudinal passages **206** and **406** may be configured perpendicular to the entryways **204** and **404** or at any angle with respect to the entryways **204** and **404**. Additionally, the longitudinal passages **206** and **406** may be oriented at an upward angle, or any desired angle, once installed.

**[0029]** Turning now to FIG. **6**, an illustrative routine **600** will be described for creating the carpenter bee trap **202** according to various embodiments presented herein. The routine **600** will be described with respect to the carpenter bee trap **202** shown in FIGS. **2**-**3**C. However, it should be appreciated that the routine **600** is equally applicable to the creation of the carpenter bee trap **402** shown in FIGS. **4**-**5**D. The routine **600** begins at operation **602**, where at least one longitudinal passage **206** is created by routing a channel into the rear surface **203** of a trap body, which may be a piece of wood. The routine **600** continues from operation **602** to operation **604**, where at least one entryway **204** is created by drilling a hole from the side surface **205** of the trap body to a depth within the trap body in which the entryway intersects the longitudinal passage **206**.

**[0030]** From operation **604**, the routine **600** continues to operation **606**, where a determination is made as to whether the carpenter bee trap **202** will have a cover over the longitudinal passage **206** when the carpenter bee trap **202** is not installed on the wooden structure **100**. As mentioned above, the longitudinal passage **206** may be exposed when the carpenter bee trap **202** is not installed, as is shown in FIGS. **3**A-**3**C. Alternatively, the carpenter bee trap **202** may include a cover that is hinged, slidably removed, or otherwise engaged to the rear surface **203** of the trap body. In this alternative embodiment, the cover may provide the mounting surface, which is mechanically attached to the wooden structure **100** when the carpenter bee trap **202** is installed.

**[0031]** If at operation **606**, it is determined that a cover is not to be utilized, then the routine **600** proceeds to operation **610** and continues as described below. However, if at operation **606**, it is determined that a cover is to be utilized, then the routine **600** proceeds to operation **608**, where a removable cover is installed on the rear surface **203** of the carpenter bee trap **202**. The routine **600** continues from operation **608** to operation **610**, where the insect disabling substance **208** is applied to one or more locations on the longitudinal passage **206**. From operation **610**, the routine **600** continues to operation **612**, where the trap is installed on the wooden structure **100** using the screws **209** or other fasteners and the routine **600** ends.

**[0032]** Although the subject matter presented herein has been described in conjunction with one or more particular embodiments and implementations, it is to be understood that the invention is not necessarily limited to the specific structure, configuration, or functionality described herein. Rather, the specific structure, configuration, and functionality are disclosed as example forms of the invention. The subject matter described above is provided by way of illustration only and should not be construed as limiting. Various modifications and changes may be made to the subject matter described herein without following the example embodiments and applications illustrated and described, and without departing from the true spirit and scope of the present invention.

What is claimed is:

**1**. A wood-boring insect trap, comprising:

a trap body;

a longitudinal passage within the trap body configured such that the longitudinal passage may be exposed for application of an insect disabling substance on a surface of the longitudinal passage when the wood-boring insect trap is in an uninstalled configuration and concealed when the wood-boring insect trap is in an installed configuration; and

an insect entryway into the trap body configured to intersect the longitudinal passage at a first end of the entryway and exit an exposed surface of the trap body at an opposing second end of the entryway.

**2**. The wood-boring insect trap of claim **1**, wherein the trap body comprises wood.

**3**. The wood-boring insect trap of claim **1**, wherein the insect entryway is one of a plurality of insect entryways, and wherein the first end of each entryway is spaced apart from an adjacent entryway by a distance that allows for a quantity of a disabling substance that is sufficient to disable a targeted wood-boring insect.

**4**. The wood-boring insect trap of claim **1**, wherein configured such that the longitudinal passage may be exposed for application of the insect disabling substance on the surface of the longitudinal passage when the wood-boring insect trap is in the uninstalled configuration and concealed when the wood-boring insect trap is in the installed configuration comprises configured as a channel in a rear surface of the wood-boring insect trap such that the channel is exposed with the wood-boring insect trap is not attached to a structure and is concealed when the rear surface of the wood-boring insect trap abuts the structure.

**5**. The wood-boring insect trap of claim **1**, wherein configured such that the longitudinal passage may be exposed for application of the insect disabling substance on the surface of the longitudinal passage when the wood-boring insect trap is in the uninstalled configuration and concealed when the wood-boring insect trap is in the installed configuration comprises a cover attached to the trap body and configured to expose the longitudinal passage to create the uninstalled configuration and to conceal the longitudinal passage to create the installed configuration.

**6**. The wood-boring insect trap of claim **1**, wherein the longitudinal passage is one of a plurality of parallel longitudinal passages and wherein the insect entryway is one of a plurality of insect entryways intersecting the plurality of parallel longitudinal passages.

**7**. The wood-boring insect trap of claim **1**, further comprising the insect disabling substance disposed on the surface of the longitudinal passage.

**8**. The wood-boring insect trap of claim **7**, wherein the insect disabling substance comprises an insect poison.

**9**. The wood-boring insect trap of claim **7**, wherein the insect disabling substance comprises a glue.

**10**. The wood-boring insect trap of claim **1**, further comprising a mounting surface configured for attachment to a structure to be protected, wherein a longitudinal axis of the insect entryway is coplanar with the mounting surface.

**11**. The wood-boring insect trap of claim **1**, further comprising a mounting surface configured for attachment to a structure to be protected, wherein a longitudinal axis of the insect entryway is perpendicular to the mounting surface.

**12**. A method for creating a wood-boring insect trap, comprising:

creating a longitudinal passage within a surface of a trap body such that the longitudinal passage is exposed for application of an insect disabling substance on a surface of the longitudinal passage when the wood-boring insect trap is in an uninstalled configuration and concealed when the wood-boring insect trap is in an installed configuration; and

creating an insect entryway in the trap body, wherein the entryway is configured to intersect the longitudinal passage at one end of the entryway and exit an exposed surface of the trap body at an opposing end of the entryway.

**13**. The method of claim **12**, wherein the trap body comprises wood and wherein creating the longitudinal passage within the trap body comprises routing a channel into a rear surface of the trap body.

**14**. The method of claim **13**, wherein the trap body comprises wood and wherein creating the insect entryway comprises drilling an aperture from the exposed surface of the trap body to the longitudinal passage.

**15**. The method of claim **12**, wherein the exposed surface of the trap body comprising the entryway is substantially perpendicular to a mounting surface of the trap body that is configured for attachment to a structure to be protected from wood-boring insects.

**16**. The method of claim **12**, wherein the exposed surface of the trap body comprising the entryway is substantially parallel to a mounting surface of the trap body that is configured for attachment to a structure to be protected from wood-boring insects.

**17**. The method of claim **12**, further comprising applying an insect disabling substance on a surface of the longitudinal passage.

**18**. A wood-boring insect trap system, comprising:

a trap body;

a longitudinal passage within the trap body configured such that the longitudinal passage may be exposed for application of an insect disabling substance on a surface of the longitudinal passage when the wood-boring insect trap is in an uninstalled configuration and concealed when the wood-boring insect trap is in an installed configuration;

an insect entryway into the trap body configured to intersect the longitudinal passage at a first end of the entryway and exit an exposed surface of the trap body at an opposing second end of the entryway; and

the insect disabling substance applied on the surface of the longitudinal passage.

**19**. The wood-boring insect trap system of claim **18**, wherein when the wood-boring insect trap system is in an installed configuration, the longitudinal passage is enclosed by the trap body on a first side of the longitudinal passage and by a structure to which the wood-boring trap system is installed on a second side of the longitudinal passage.

**20**. The wood-boring insect trap system of claim **18**, wherein the trap body is wood, wherein the longitudinal passage is one of a plurality of longitudinal passages, wherein the insect entryway is one of a plurality of insect entryways, and wherein a longitudinal axis of each of the plurality of insect entryways is substantially perpendicular to a mounting surface of the trap body that is configured for attachment to a structure to be protected from wood-boring insects.

* * * * *

# Tab 5

# 8

# The Development and Evolution of Division of Labor and Foraging Specialization in a Social Insect (*Apis mellifera* L.)

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How does complex social behavior evolve? What are the developmental building blocks of division of labor and specialization, the hallmarks of insect societies? Studies have revealed the developmental origins in the evolution of division of labor and specialization in foraging worker honeybees, the hallmarks of complex insect societies. Selective breeding for a single social trait, the amount of surplus pollen stored in the nest (pollen hoarding) revealed a phenotypic architecture of correlated traits at multiple levels of biological organization in facultatively sterile female worker honeybees. Verification of this phenotypic architecture in "wild-type" bees provided strong support for a "pollen foraging syndrome" that involves increased sensomotor responses, motor activity, associative learning, reproductive status, and rates of behavioral development, as well as foraging behavior. This set of traits guided further research into reproductive regulatory systems that were co-opted by natural selection during the evolution of social behavior. Division

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of labor, characterized by changes in the tasks performed by bees, as they age, is controlled by hormones linked to ovary development. Foraging specialization on nectar and pollen results also from different reproductive states of bees where nectar foragers engage in prereproductive behavior, foraging for nectar for self-maintenance, while pollen foragers perform foraging tasks associated with reproduction and maternal care, collecting protein. 

## I. Introduction

Advanced societies of insects display marked patterns of behavior where reproduction is restricted to elite individuals (queens) who are often anatomically differentiated from nonreproductive individuals (the workers) (Wheeler, 1928). Workers are often further differentiated into anatomically and/or behaviorally differentiated individuals that specialize on the performance of specific behavioral tasks for at least some part of their adult lives. In the honeybee, this differentiation is behavioral without any obvious anatomical differences and expressed by changes in behavior associated with age and change of location in the nest, an age-related polyethism (Seeley, 1982). Typically, bees perform tasks in the center of the brood nest soon after emergence including cleaning brood cells and feeding larvae. After about 1 week they make a transition to performing tasks outside the brood nest area such as comb construction and food processing. When they are in about their third week of life, they make a final transition to foraging outside the nest after which they are seldom observed performing tasks within the nest other than those directly related to foraging, such as unloading pollen and nectar, and performing recruitment dances.

When a worker honeybee makes the transition to foraging, she usually collects pollen (a source of protein) and nectar (a carbohydrate source), though a minority of workers collect water and propolis, a resinous substance collected from plants and used in nest construction. Most food foragers collect both pollen and nectar on a single foraging trip, however, many collect only a single substance (Hunt *et al.*, 1995; Page *et al.*, 2000). The total load collected by a forager is constrained. A maximum nectar load is about 60 mg, while a maximum load of pollen is about 30 mg. So, each 1 mg of pollen "costs" about 2 mg of nectar. Nectar is carried inside the crop, the first chamber of the alimentary canal (Snodgrass, 1956), while pollen is carried on the hind legs and may impose aerodynamic drag, perhaps explaining the differences in maximum load sizes.

Returning nectar foragers pass their nectar loads to younger bees in the nest through trophallaxis. The younger bees then distribute the nectar to other bees, or deposit it in open cells in the comb where it is eventually processed by other bees into honey. Returning pollen foragers deposit their loads directly into empty cells or cells containing pollen close to the area of the nest where young larvae are raised (Dreller and Tarpy, 2000). Stored pollen is consumed by young bees (Crailsheim *et al.*, 1992). The pollen proteins are converted into glandular secretions that are fed directly to larvae (Crailsheim, 1990). Stored pollen inhibits pollen foraging in colonies (Dreller *et al.*, 1999) while pheromones produced by larvae stimulate pollen foraging (Pankiw *et al.*, 1998). Colonies regulate the amount of stored pollen (Fewell and Winston, 1992), probably through a combination of the inhibiting effects of pollen and stimulating effects of brood. At "equilibrium" pollen intake into the colony should equal pollen consumption, and meet the protein demands of developing larvae.

The brood nest is organized spatially with the brood (eggs, larvae, and pupae) located centrally (Winston, 1987). Pollen is stored close to the brood, and honey is stored at the periphery of the nest (Fig. 1). The amount of pollen stored in the comb represents a complex colony-level trait that is a consequence of the interactions of thousands of individual colony members. Younger workers consume pollen and feed the protein to larvae, older workers respond to the foraging stimuli, forage, and recruit other foragers to their resources. The stored pollen phenotype can be selected by artificial selection and is assumed to be under natural selection (Page and Fondrk, 1995).

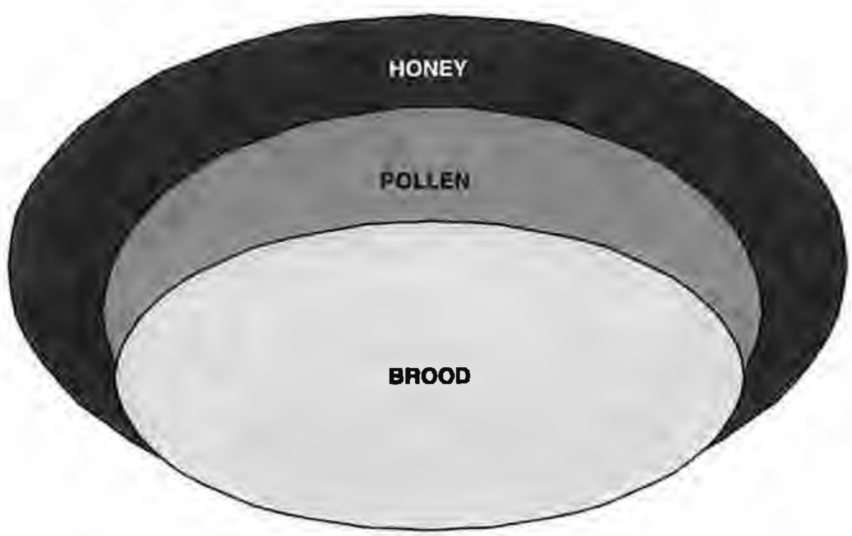


**Figure 1** A diagram of a comb drawn from near the center of a honeybee nest showing the spatial orientation of honey, pollen, and brood.

## II. Effects of Selection on Pollen Hoarding

### A. Colony Level Selection

Hellmich *et al.* (1985) conducted two-way selection for the amount of pollen stored in the comb (pollen hoarding) and demonstrated a strong selective response. Subsequent studies showed that when fostered in the same colony, workers from the high-pollen hoarding strain were more likely to forage for pollen than were bees from the low strain (Calderone and Page, 1988, 1992). Bees from the high strain also foraged about 1 day earlier in life (Calderone and Page, 1988). Page and Fondrk (1995) repeated the selection from a different commercial population and also demonstrated a strong response to selection. After just three generations, colonies of the high strain contained about six times more pollen. Like Hellmich *et al.* (1985), they selected for a single trait, pollen hoarding, however, they also looked at other individual behavioral and physiological traits that might have changed as a consequence of selection on the colony-level phenotype. This enabled them to look for mechanisms at different levels of biological organization that causally underlie the differences in the colony-level phenotype (Page and Erber, 2002).

### B. Foraging Behavior of High- and Low-Strain Bees

High-strain bees initiate foraging earlier in life than low-strain bees. Pankiw and Page (2001) demonstrated an average difference of about 10 days in a study of 12 host colonies. High-strain bees are more likely to specialize on pollen, while low-strain bees are more likely to specialize on nectar (Fewell and Page, 2000; Page and Fondrk, 1995; Pankiw and Page, 2001). High- and low-strain bees were raised together in "wild-type" colonies (commercial colonies not derived from the pollen hoarding strains). Workers of each strain were marked with paint on the thorax to identify their strain origins and then were placed into the same wild type test colonies, a type of "common garden," experiment. Colony entrances were examined daily. Marked, returning foragers were captured, and their nectar and pollen loads analyzed. High-strain bees were more likely to collect pollen and collected larger pollen loads and smaller nectar loads than low-strain bees. High-strain bees were also more likely to collect water, and when they collected nectar, accepted nectar with lower sugar content than did bees of the low strain. Low-strain bees were much more likely to return empty from foraging trips (Page *et al.*, 1998).

Differences in pollen load sizes were expected and represented by differences between the strains in their responses to pollen foraging stimuli. Fewell and Winston (1992) showed that colonies respond to changes in quantities of stored pollen by changing the allocation of foraging effort between collecting nectar and pollen. When colonies were presented with additional stored pollen beyond what they had already stored, they responded by reducing the number of pollen foragers and the sizes of the pollen loads. The opposite effect on foraging behavior was observed when stored pollen was removed. Colonies regulate the amount of stored pollen around a homeorhetic set point. Studies by Dreller *et al.* (1999) and Dreller and Tarpy (2000) demonstrated that foragers directly assess the amount of pollen stored in the combs and adjust their foraging behavior accordingly. The mechanism appears to involve the assessment of empty cells near the areas of the nest where larvae and pupae are located. Therefore, the regulatory mechanism involves individual assessment of stored pollen and individual "decisions" with respect to what to collect on a foraging trip (Fewell and Page, 2000). High-strain colonies reach a regulated set point with much larger quantities of stored pollen than do low-strain colonies. Therefore, high-strain bees have a threshold for stored pollen (or empty cells near the brood) that is different from low-strain bees. When cofostered in a wild-type colony, where high- and low-strain bees are much fewer than the resident bees, high-strain bees perceive the amount of stored pollen below their optimal set point, while the low-strain bees perceive it above theirs. As a result, high-strain bees are much more likely to forage for pollen, and low-strain bees are much more likely to forage for nectar.

Young larvae and hexane rinses of young larvae stimulate pollen-specific foraging behavior (Pankiw *et al.*, 1998). Increasing the numbers of larvae in a nest, or augmenting the larvae with larval rinses, results in the recruitment of new pollen foragers and larger pollen loads but does not affect nectar foraging (Dreller *et al.*, 1999; Pankiw *et al.*, 1998). When foragers are not allowed direct contact with larvae, they do not change their foraging behavior with changes in larval quantities (Dreller *et al.*, 1999). Selection for high- and low-pollen hoarding could have resulted in differences in quantities of brood, differences in brood pheromone levels in colonies, or differences in the perception/response systems coupled to pollen foraging stimuli. High- and low-strain bees do not differ in quantities of brood except under space-limited conditions where brood areas are reduced by excess pollen hoarding (Page and Fondrk, 1995).

High- and low-strain bees respond differently to changes in the pollen and brood stimuli in colonies. Pankiw and Page (2001) cofostered high- and low-strain bees in colonies with high- and low-pollen hoarding stimuli. High-stimulus colonies were experimentally manipulated to contain more larvae and less stored pollen than the low-stimulus colonies. Foragers in the high-stimulus colonies were more likely to collect pollen, collected larger loads of pollen, and smaller loads of nectar. High-strain bees demonstrated a larger difference in foraging behavior between treatments, demonstrating a genotype x–environment interaction where high-strain bees are more sensitive to the foraging stimulus environment. In summary, selection for the colony-level trait—the amount of pollen stored in the comb—resulted in changes in behavior at the individual level. Workers from colonies selected for storing more pollen initiated foraging earlier in life, foraged more successfully, were more likely to collect pollen, collected larger pollen loads and smaller nectar loads, and were more likely to collect water and nectar with lower concentrations of sugar. High- and low-strain bees respond to changes in foraging stimuli. Based on what we know about the regulation of stored pollen, a pollen foraging inhibiting stimulus, and the effects of brood on the release of pollen foraging behavior, it seems likely that high- and low-strain bees differ in their responsiveness to these important stimuli.

### C. Sensory Responses

Changes in foraging behavior related to collecting pollen were expected of selection for pollen hoarding. However, high-strain bees are also more likely to forage for water than low-strain bees (Page *et al.*, 1998). When high-strain bees forage for nectar, they accept nectar with lower concentrations of sugar than low-strain bees. There was no obvious physiological or behavioral mechanism to explain these relationships until Page *et al.* (1998) looked at the responses of pollen and nectar foragers to sucrose solutions under controlled laboratory conditions. Bees can respond to antennal stimulation with sucrose by extending the proboscis (Kunze, 1933; Marshall, 1935). Page *et al.* (1998) used an increasing concentration series of sucrose solutions to determine the sucrose responsiveness of wild type pollen and nectar foragers. Bees were placed into small tubes to restrict their movement. Then they were sequentially tested at each antenna with a droplet of sucrose solution (Fig. 2A). Sucrose concentrations increased with a logarithmic sequence of 0.1%, 0.3%, 1%, 3%, 10%, and 30%. Their response was recorded as "yes" (proboscis extension response, PER) or "no" (no PER) for each of the trials, which provided a measure of responsiveness to sucrose. The average proboscis responses of several bees to different sucrose concentrations are represented by the concentration–response curve (Fig. 2B). This curve can be used to estimate bees' sucrose response threshold or their sensitivity for sucrose (Page *et al.*, 1998). Bees that are more responsive have lower thresholds and are more sensitive. The results were surprising: pollen foragers were more likely than nectar foragers to respond to water and lower

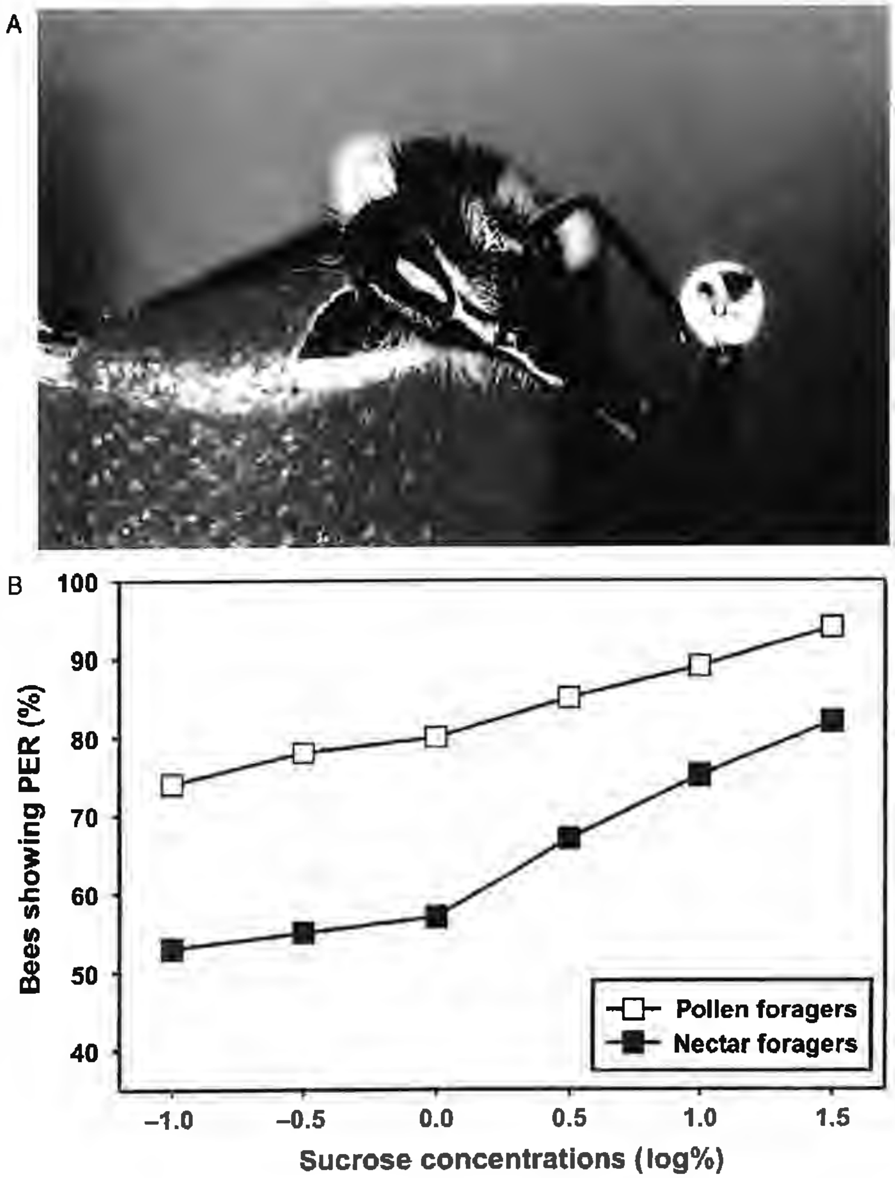


**Figure 2** Measuring of sucrose responsiveness in honeybee foragers. (A) Fixed honeybee showing the proboscis extension response (PER). When the antenna of a bee is touched with a droplet of sucrose solution of sufficient concentration, the bee extends her proboscis in expectation of food. This response can be used to measure responsiveness to different sucrose concentrations. (B) Sucrose-concentration response curve of pollen and nectar foragers. The $x$-axis presents the log(%) of the sucrose concentrations tested. The $y$-axis displays the percentage of bees showing the PER. Pollen foragers are more responsive to all sucrose concentrations tested than nectar foragers (Scheiner *et al.*, 2003a).

concentrations of sucrose (Fig. 2B). Apparently, pollen foragers have lower thresholds for water and sucrose and are, therefore, more sensitive for these stimuli.

Responsiveness to sucrose depends on a number of external and internal parameters. Feeding bees, under laboratory conditions with sucrose, generally reduces responsiveness, but the differences between pollen and nectar foragers remain (Page *et al.*, 1998). In free flying bees, responsiveness to sucrose is modulated by feeding and foraging experience (Pankiw *et al.*, 2001). Even the sucrose responsiveness of hive bees changes with changing concentrations of nectar brought back by returning foragers (Pankiw *et al.*, 2004). Sucrose responsiveness varies during the foraging season in pollen and nectar foragers. Nevertheless, pollen foragers consistently show higher sensitivity than nectar foragers (Scheiner *et al.*, 2003a). The effects of genotype on sucrose responsiveness were shown by testing young bees of the high- and low-strain before they initiated foraging (Pankiw and Page, 1999; Pankiw *et al.*, 2002; Scheiner *et al.*, 2001a). In all age groups high-strain bees were more responsive to sucrose solutions and water than low-strains bees. This finding suggests that selection for pollen hoarding behavior had resulted in selection for the gustatory response system, which correlates with foraging behavior. These experiments demonstrate that gustatory sensitivity and foraging behavior are closely related.

If water and sucrose responses are related to nectar and pollen foraging, we should be able to test wild type bees before they start to forage and predict their foraging behavior 2–3 weeks later. Pankiw and Page (2000) tested wild type bees for their responses to water and sucrose within their first week of adult life, before they initiated foraging. Bees were marked for individual identification and placed back into their colony. Colony entrances were observed, returning foragers were collected, and their foraging loads were analyzed. Bees displaying the highest responsiveness to water and sucrose solutions when they were up to 7 days old were most likely to collect water on a foraging trip. The next most responsive group was very likely to collect pollen. Bees with lower responsiveness would later collect nectar or both nectar and pollen. The group with the lowest responsiveness would later in life return empty to the hive (Fig. 3).

The function of gustatory responsiveness for the division of foraging labor is not clear a priori. Why should a pollen forager be very sensitive to sucrose when she is mainly collecting pollen? Why is a water collector simply sensitive to water and insensitive to sucrose stimuli? A number of studies have clarified these questions. Bees who are sensitive to sucrose are also sensitive to stimuli of other modalities, and they show higher stimulus-related motor activity.

Bees that are highly responsive to sucrose are also highly responsive to pollen stimuli (Scheiner *et al.*, 2004a). In these experiments, the gustatory

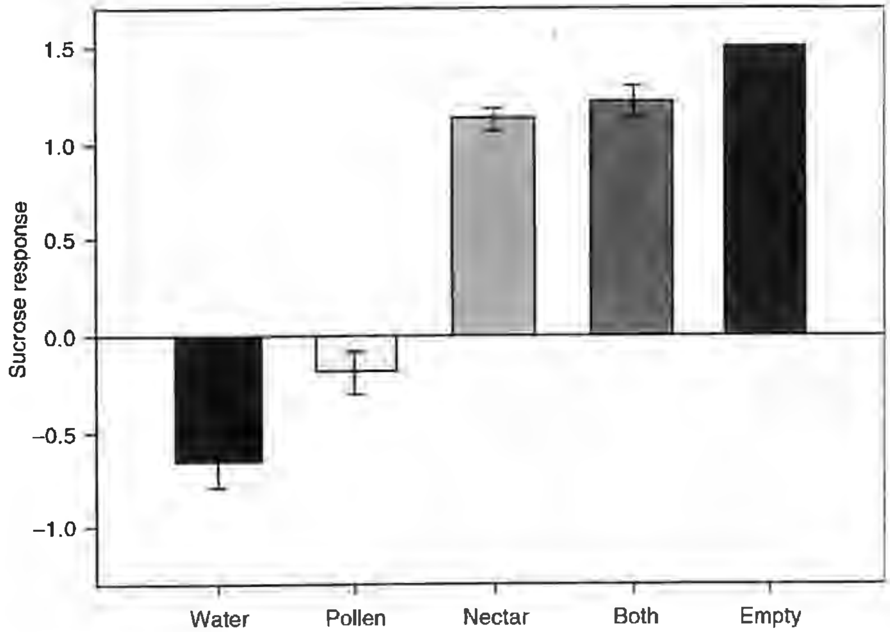


**Figure 3** Sucrose responses of 1-week-old bees predict their foraging behavior later in life. The *x*-axis shows the foraging material of the bees tested for their sucrose responses at the age of 1 week, brought back by them when they reached foraging age. The *y*-axis shows the lowest sucrose concentrations ($\log_{10}$) at which 1-week-old bees responded with proboscis extension. Bees with the highest sucrose responsiveness (i.e., the lowest threshold) at young age will later forage for water or pollen. Individuals with low-sucrose responsiveness (i.e., a high threshold) perhaps collect nectar, nectar and pollen, or return empty. From Fig. 1 Pankiw and Page (2000) with the kind permission of Springer Science and Business Media.

responsiveness of bees was measured first. Then the same bees were stimulated with different pollen concentrations, which were produced by mixing pollen with cellulose grains of the same size. Bees that were highly responsive to sucrose, also responded with proboscis extension to the pollen stimulus, provided the concentration of pollen was higher than 6.3%, while bees with low responsiveness to sucrose did not respond to the same pollen concentration. Over 40% of the sensitive animals showed the proboscis response when stimulated with pure pollen, while less than 10% of the sucrose-insensitive bees responded to pure pollen. In another experiment, bees were tested in an olfactometer after measuring their sucrose responsiveness (Scheiner *et al.*, 2004a). Again, bees that were sensitive to sucrose were also more sensitive to olfactory stimuli than were animals that were relatively insensitive to sucrose. Phototactic behavior of bees was tested in a round arena that allowed stimulation of a single bee with small monochromatic light sources (520 nm) of relative intensities between 3% and 100%. Stimulated bees walked toward the light. Walking behavior was recorded by an infrared camera that was mounted above the arena. Bees with high responsiveness to sucrose were also more sensitive to light stimuli in the arena. All these experiments demonstrate that sucrose responsiveness correlates with sensitivities for other stimulus modalities. Pollen foraging bees are not only sensitive to sucrose but also to pollen, odors, and light stimuli.

The behavioral responses to stimuli that can be measured in honeybees are the result of complex neuronal processes that integrate sensory information and produce motor output. Motor patterns of the proboscis, the antennae, or the legs are controlled by specific motor systems consisting of different types of neurons and often different types of muscles. Therefore, it is important to ask whether the motor system is tuned differently in bees that differ in their sensory responses. Several experiments have shown that sensory input can influence motor output in honeybees. Bees whose eyes are covered by paint scan an object within the range of the antennae with rapid antennal movements. The mechanical stimuli produced during antennal contact with an object initiate motor activity that even shows motor learning (Erber *et al.*, 1997). Antennal scanning activity is significantly higher in bees that are responsive to sucrose compared to animals that are not responsive (Scheiner *et al.*, 2005). This experiment demonstrates that there is a correlation between gustatory responsiveness and stimulus-evoked motor activity.

Responsiveness to sucrose correlates with locomotor activity under ambient light conditions when bees first emerge as adults. Humphries *et al.* (2005) tested locomotion in newly emerged wild type bees by measuring their walking activity in an enclosed arena under ambient light. They then determined their response to sucrose using the proboscis extension response protocols. Bees that were more responsive to sucrose were also more active in the light. A number of independent experiments with wild type nectar foragers have shown that the velocity of walking in the dark is not correlated with gustatory responsiveness but with foraging role (independent unpublished experiments by Hoormann, Erber, and Franz). Pollen foragers walk faster than nectar foragers. High-strain workers were more active than low-strain workers, consistent with the results from wild-type bees (Humphries *et al.*, 2005). Rueppell *et al.*, 2005 tested high- and low-strain males (drones) for locomotor activity under light and dark conditions. High-strain drones were more active under both conditions, which is consistent with the results from workers. Thus, these experiments suggest that wild type pollen and nectar foragers differ in locomotor activity and that the same relations are found in high- and low-strain bees.

In summary, the gustatory responses of bees to sucrose solutions are related to foraging behavior and to sensory responses to odor, pollen, and light. Pollen forages are more sensitive to sensory stimuli than nectar foragers. As a consequence of sensory sensitivities, stimulus evoked motor patterns are different in sensitive and insensitive animals. Locomotor activity differs between pollen and nectar foragers and also between high- and low-strain bees. Sucrose responsiveness can be used as a robust indicator for general differences of processing sensory information in the central nervous system.

## D. Learning and Memory in Wild-Type Bees and Selected Strains

Division of foraging labor correlates with associative learning performance. In different laboratory learning paradigms, pollen foragers were shown to perform better than nectar foragers (Scheiner *et al.*, 1999, 2001b, 2003a). In the tactile learning assay which was employed by Scheiner *et al.* (1999) to compare the learning performance of pollen and nectar foragers, bees were trained to associate the characteristics of a small metal plate with a sucrose reward. Returning pollen and nectar foragers were constrained in small tubes and their eyes were occluded with black paint to block visual inputs. The tactile object was brought into the scanning range of a bee. After the bees began scanning the target plate (the conditioned stimulus, CS) a droplet of sucrose solution was touched to one antenna (the unconditioned stimulus, US), eliciting the proboscis extension response (PER). A droplet of sucrose solution was then presented briefly to the tip of the proboscis as a reward (Erber *et al.*, 1998). After few trials, most bees learned to respond to the plate without the US (Fig. 4). Pollen foragers learned faster than nectar foragers and reached a higher plateau in their acquisition function. These findings were later also demonstrated for olfactory learning, in which the bees have to associate an odor with a sucrose reward (Scheiner *et al.*, 2003a).

Learning differences were not only described for pollen and nectar foragers. High-strain bees perform better in tactile and olfactory learning tests than low-strain bees (Scheiner *et al.*, 2001a,b). Because this is true for bees that have not yet initiated foraging, it demonstrates that it is not a function of foraging experience but has genetic determinants.

In general, bees that are more responsive to sucrose learn faster and reach a higher asymptote of learning than bees that are less responsive (Scheiner *et al.*, 1999, 2001a,b,c, 2003a, 2004a, 2005). The probability of showing the conditioned response in retrieval tests 24 hours after conditioning is higher in bees that are more responsive to sucrose (Scheiner *et al.*, 2004a, 2005).

If bees with a similar responsiveness to sucrose are tested for tactile or olfactory learning, they do not differ in their learning performance, regardless of their genotype or foraging role (Scheiner *et al.*, 1999, 2001a,b, 2003a). These findings led to the hypothesis that learning performance is directly related to the evaluation of the sucrose stimulus used during conditioning. If this hypothesis is correct, it should be possible to induce an equal learning

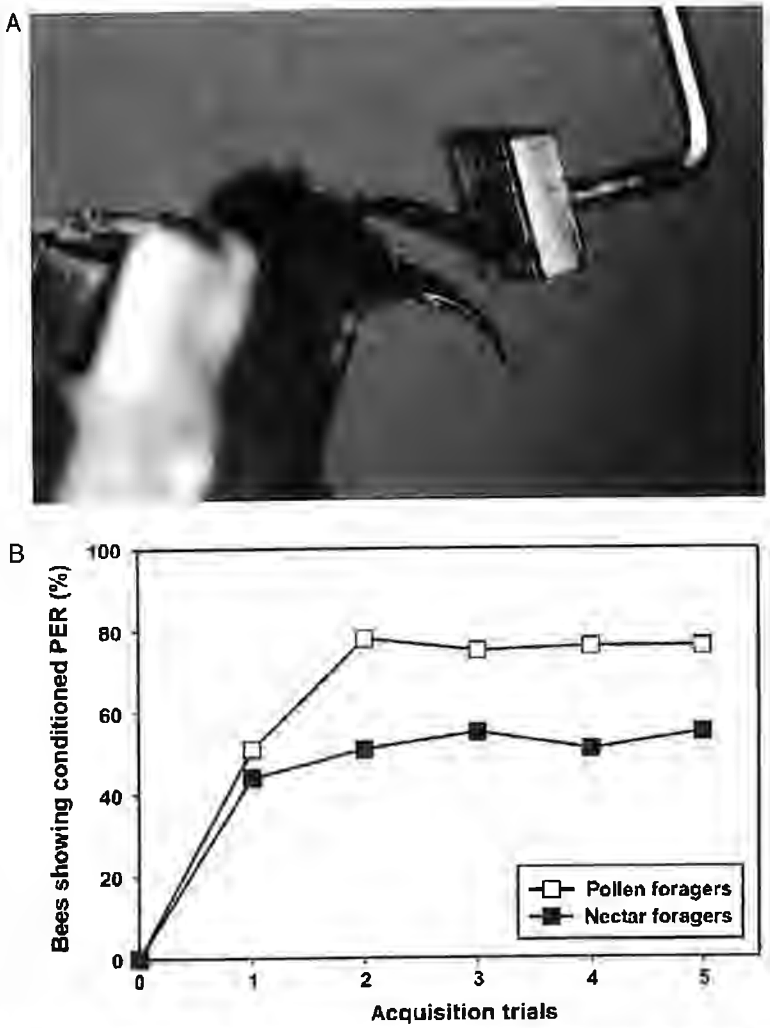


**Figure 4** Tactile learning. (A) Honeybee showing conditioned proboscis extension response during tactile antennal conditioning. In this learning paradigm, the bee is rewarded for scanning a tactile object. The sucrose reward is briefly presented to the antenna. When the bee extends her proboscis after antennal stimulation with sucrose, she can imbibe a droplet of sucrose solution. After few conditioning trials, the bee shows conditioned proboscis extension while scanning the tactile target plate. (B) Acquisition curves of pollen and nectar foragers in tactile antennal learning. The *x*-axis shows the acquisition trials. The *y*-axis shows the percentage of bees displaying the conditioned proboscis extension response (PER). Both groups have reached the plateau of their acquisition function after three acquisition trials. However, the level of acquisition is higher in pollen foragers than in nectar foragers.

performance in bees with very different responsiveness to sucrose by giving them equal *subjective* rewards, based on their individual sucrose responsiveness. For individuals with high-sucrose responsiveness, a low-sucrose concentration should have the same *subjective* reward value as a high-sucrose concentration would have for a bee with low-responsiveness. This hypothesis was tested by Scheiner *et al.* (2005). A mathematical model for the individual reward value of sucrose was developed for bees that differ in gustatory sensitivity. Individuals were placed in classes according to their sucrose responsiveness. Based on their sucrose responsiveness, equal *subjective* reward concentrations were estimated. The performance and memory of all bees during conditioning and in the retrieval tests was very similar.

The correlation between learning performance and individual evaluation of the reward explains why pollen foragers learn better than nectar foragers and why high-strain bees perform better than low-strain bees. Pollen foragers are more responsiveness to sucrose than are nectar foragers; and high-strains bees are more responsive than low-strain bees. Bees with higher responsiveness place a higher reward value on sucrose and, therefore, reach a higher performance level (Page *et al.*, 1998; Pankiw and Page, 2000; Scheiner *et al.*, 1999, 2001b, 2003a, 2005). A similar relationship has been shown for nonassociative learning. Individuals with high-sucrose responsiveness need more trials for habituation of the proboscis extension response and display stronger sensitization by a sucrose stimulus than bees with low-sucrose responsiveness. Because individual sucrose responsiveness increases with age, older bees need more trials for habituation than younger bees (Scheiner, 2004).

## E. Transmitter Systems and Neurochemical Signaling Cascades

### 1. Nervous System Signaling and Sensory Sensitivity

The set of variable correlated traits observed between pollen and nectar foragers, and between high- and low-strain bees, are centered on differences in sensory and motor response (see in an earlier section). As a consequence, differences in signaling cascades affecting sensory and motor response systems are prime candidates for understanding the neurobiochemical and genetic origin of variation in foraging behavior. Central components of nervous system signaling include biogenic amines, protein kinases, and second messengers that interact to affect sensory input, signal processing, and motor response.

**a. Biogenic Amines.** Biogenic amines modulate sensory and motor responses, traits that vary between pollen and nectar foragers, and bees from the high- and low-pollen hoarding strains. In honeybees, the four biogenic amines—dopamine, serotonin, octopamine, and tyramine have important functions in nervous system signaling (Blenau and Baumann, 2001, 2003). Their capability to modulate sensory sensitivity makes them candidates for the regulation of foraging behavior. Octopamine, which has been studied most extensively, generally increases sensitivity and related behavioral responses. Responsiveness to gustatory stimuli that are applied to the antenna, for example, is strongly increased after octopamine application (Braun and Bicker, 1992; Menzel *et al.*, 1988, 1990; Scheiner *et al.*, 2002). This amine also increases olfactory sensitivity (Menzel *et al.*, 1991, 1994). Octopamine can also act on the visual system. It enhances, for example, the direction-specific visual antennal reflex (Erber and Kloppenburg, 1995; Erber *et al.*, 1993a). Tyramine has a similar effect as octopamine on gustatory sensitivity (Scheiner *et al.*, 2002). Otherwise, the behavioral role of this amine is less clear because until recently it was mainly considered as the biochemical precursor of octopamine rather than being a neurotransmitter itself. But interest in this amine has been growing since the first tyramine receptor of the bee was cloned (Blenau *et al.*, 2000). Serotonin and dopamine often act antagonistically to octopamine in sensory systems. Dopamine, for example, reduces gustatory responsiveness (Scheiner *et al.*, 2002). Serotonin, which has no effect on gustatory responses, decreases the direction-specific visual antennal reflex (Erber and Kloppenburg, 1995; Erber *et al.*, 1993a,b).

Because sensory sensitivity correlates with different aspects of foraging behavior and because amines can modulate sensory sensitivity, we assume that biogenic amines are involved in division of foraging labor by modulating response-thresholds to foraging-related stimuli (see in a later section).

**b. Protein Kinases and Second Messengers.** Sensory responses involve complex signaling cascades of which the biogenic amines are only one part. Other important signaling molecules are second messengers, such as cAMP or cGMP, and protein kinases, which activate target proteins by phosphorylation of their threonine or serine residues. Stimulation of the antenna with sucrose, for example, increases the activity of cAMP-dependent protein kinase (PKA) (Hildebrandt and Müller, 1995). Octopamine injections can mimic antennal sucrose stimulation and lead to an increase in PKA activity. This suggests a close interaction of octopamine and PKA during sensing of gustatory stimuli presented to the antenna.

Responsiveness to sucrose correlates with activity of PKA in the antennal lobes (Scheiner *et al.*, 2003b). Bees with high responsiveness to sucrose stimuli applied to the antenna have a higher baseline PKA activity than bees with low-sucrose responsiveness. Activation of PKA by application of 8-Br-cAMP increases responsiveness to sucrose (Scheiner *et al.*, 2003b). High- and low-strain bees differ in their sucrose responsiveness and differ in brain titers for PKA, making cAMP activation of PKA a likely cause of this difference. Humphries *et al.* (2003) showed that bees selected for high-pollen hoarding have significantly higher titers of PKA than low-pollen hoarding bees at the time they emerge as adults and at 5 days of age. Whether high- and low-strain bees also differ in their PKA activity in the antennal lobes remains to be tested. Together, these findings imply a strong role of PKA in sensory responsiveness to gustatory stimuli applied to the antenna.

cGMP-dependent protein kinase (PKG) also appears to be involved in the perception of sucrose stimuli in insects. The two *Drosophila* variants—sitters and rovers, which differ in their PKG activity (Osborne *et al.*, 1997) also differ in their responsiveness to sucrose (Scheiner *et al.*, 2004b); and we have first indications that feeding of the PKG activator 8-Br-cGMP increases responsiveness to sucrose in honeybees (R. Scheiner and J. Erber, unpublished). Rueppell *et al.* (2004a,b), mapped a quantitative trait locus that affects responsiveness to sucrose close to *Amfor*, the honeybee gene for PKG, suggesting that variation in PKG between the high- and low-pollen hoarding strains may be affecting observed differences in sucrose responses. In addition, Ben-Shahar *et al.* (2003) showed that cGMP increases responsiveness to light. J. Tsuruda and R. E. Page (unpublished data) demonstrated that high-strain bees and wild-type bees with higher sucrose responsiveness are more responsive to light stimuli than low-strain bees and wild-type bees that are less responsive to sucrose. Differences in cGMP signaling provide a plausible explanation for these correlations. It is likely that significant cross talk occurs between the cAMP and cGMP pathways. PKA is activated by cGMP as well as by cAMP (Jiang *et al.*, 2002), and some proteins can act as substrates for both PKA and PKG (Wang and Robinson, 1997).

These examples show the important role of biogenic amines, protein kinases, and second messengers in the modulation of sensory response thresholds. Individual differences in behavioral response thresholds are assumed to be at the basis of division of labor in insect colonies (Beshers and Fewell, 2001; Beshers *et al.*, 1999; Page and Erber, 2002; Robinson, 1992; Theraulaz *et al.*, 1998). Therefore, we can hypothesize that changes in the division of labor profile of a colony are, to some extent, induced by a complex interaction of biogenic amines, second messengers, and protein kinases. A number of studies show how these neuromodulators change division of labor, although the exact mechanisms behind these changes are still poorly understood.

## 2. Nervous System Signaling and Learning

Pollen and nectar foragers, and bees of the high- and low-pollen hoarding strains, differ in associative learning performance (see in an earlier section).

Sensory system inputs are linked to motor-response systems through learning processes that alter behavior. Associative learning is an important part of honeybee behavior. Foragers, for example, have to remember the location of their hive and different food sources. Once they arrive at a flower, they have to remember how to find and handle the nectar and pollen that is presented. All bees of a colony must remember the odors of their hive and of their nest-mates. These are just a few examples. There are many more situations when bees perform associative learning tasks. Honeybees learn conditioned stimuli of different modalities very fast and establish long-lasting memories under free-flying conditions and in the laboratory (Bitterman *et al.*, 1983; Giurfa, 2003; Menzel and Müller, 1996).

Biogenic amines, especially octopamine (OA) are important modulators of associative learning. Application of this amine improves olfactory acquisition, memory formation, and retrieval traits that distinguish pollen and nectar foragers; and bees from the high- and low-pollen hoarding strains. Octopamine injections into the calyx or the alpha-lobe of the mushroom bodies, which are assumed to be the centers of olfactory learning, enhance memory formation (Menzel *et al.*, 1990), whereas injections of the octopamine-receptor antagonist mianserine into the antennal lobes or downregulation of the expression of the octopamine receptor AmOA1 strongly decrease acquisition and retrieval (Farooqui *et al.*, 2003). Octopamine has also an important function at the cellular level of associative learning. It was shown in associative learning under laboratory conditions that the ventral unpaired median neuron 1 of the maxillary neuromere ($VUM_{mx1}$ neuron; Hammer, 1993) depolarizes in response to the presentation of sucrose rewards to antennae and proboscis. Current injection into the $VUM_{mx1}$ neuron can substitute for the sucrose reward during olfactory conditioning (Hammer, 1993; Hammer and Menzel, 1998). $VUM_{mx1}$ belongs to a group of octopamine-immunoreactive neurons (Kreissl *et al.*, 1994), and it is assumed that VUM neurons release octopamine, which could mediate the reward in some forms of associative conditioning (Hammer, 1997; Hammer and Menzel, 1998).

In contrast to octopamine, dopamine inhibits retrieval of information without affecting acquisition (Bicker and Menzel, 1989; Macmillan and Mercer, 1987; Menzel *et al.*, 1988, 1990, 1994, 1999; Mercer and Menzel, 1982; Michelsen, 1988). Serotonin can reduce both acquisition and retrieval when injected prior to conditioning (Bicker and Menzel, 1989; Mercer and Menzel, 1982; Menzel *et al.*, 1990, 1994). The effect of tyramine on associative learning has not been studied.

These examples imply that biogenic amines are involved in different pathways of associative learning in honeybees. Among the different signaling cascades, the PKA and the PKC signaling pathways are involved in memory formation (Grünbaum and Müller, 1998; Müller, 2000). High- and low-strain bees differ both in their brain content of these protein kinases (Humphries *et al.*, 2003) and in their associative learning performance (Scheiner *et al.*, 2001a,b), suggesting that these pathways are involved in foraging division of labor.

It can be assumed that biogenic amines affect associative learning performance by changing the sensory sensitivity for the unconditioned and conditioned stimuli because sensory sensitivity correlates with learning performance (see earlier). However, direct experimental proof is still needed for this hypothesis.

### 3. Nervous System Signaling and Division of Labor

The titers of dopamine, octopamine, and 5-HT (serotonin) increase as bees' age, with the highest titers being found in foragers (Harris and Woodring, 1992; Schulz and Robinson, 1999; Schulz *et al.*, 2004; Taylor *et al.*, 1992; Wagener-Hulme *et al.*, 1999). Because bees of different ages normally perform different tasks, it is conceivable that biogenic amine titers are part of the regulatory network for age-dependent division of labor. Whether the differences in biogenic-amine titers between bees of different ages are related to age differences or whether they are related to the different tasks the bees perform is often difficult to test. Single-cohort colonies can be very helpful for distinguishing between these alternatives. Thus Schulz and Robinson (1999) showed that differences in the titers of dopamine, octopamine, and 5-HT in mushroom bodies of foragers and nurse bees were related to age, whereas in the antennal lobes the differences were related to different tasks. Another way of studying the role of biogenic amines in division of labor is to manipulate amine titers and to determine the behavioral effects. Thus it was shown that octopamine induced bees to forage precociously, whereas tyramine had the opposite effect (Schulz and Robinson, 2001).

There are also some examples of how biogenic amines affect division of labor among same-aged bees. Božic and Woodring (1998) showed that bees who perform waggle dances after they returned from a foraging bout have higher titers of dopamine, octopamine, and 5-HT throughout the season than bees who followed the dancers. Another example comes from Taylor *et al.* (1992). They showed that pollen foragers had higher titers of dopamine in the optic lobes than in nectar foragers. Whereas pollen foragers also had 5-HT in the optic lobes, no serotonin was found in the optic lobes of nectar foragers.

OA has also been shown to affect response thresholds to brood pheromone. When hive bees were fed with OA for several days, their responsiveness to brood pheromone increased, and the bees subsequently increased their foraging activity (Barron *et al.*, 2002). OA treatment did not increase responsiveness to queen mandibular pheromone, which would have resulted in a higher attendance in the queen's retinue (Barron and Robinson, 2005). This implies that OA can modulate specific olfactory thresholds in different individuals and could thus be a major modulator of division of labor (Schulz and Robinson, 2001; Schulz *et al.*, 2002a).

Because the selected high- and low-pollen hoarding strains of Page and Fondrk (1995) differ systematically in their responsiveness to sucrose and sensitivities for other stimulus modalities, it can be assumed that these strains differ in the titer of biogenic amines. However, Schulz *et al.* (2004) demonstrated that these strains do not differ in their brain titers of octopamine, dopamine, or 5-HT. Apparently, selection for increased pollen hoarding, which led to a suite of traits modulated by these amines, did not result in detectable differences in titers of amines. It is conceivable that different degrees of receptor activation or differences in the signaling cascades downstream the biogenic amines might be responsible for the observed differences in sucrose responsiveness. As discussed in an earlier section, high-strain bees do have higher brain titers of PKA and PKC than that of low-strain bees of equivalent age.

Experimental evidence of the role of second messengers in division of labor in honeybees is rare. Ben-Shahar *et al.* (2002) showed that cGMP-dependent protein kinase (PKG) is involved in the initiation of honeybee foraging behavior. This kinase is encoded by *Amfor*, the so-called "foraging gene". Expression of *Amfor* is higher in foragers than in bees that have not initiated foraging, and application of the PKG activator 8-Br-cGMP induced precocious foraging (Ben-Shahar *et al.*, 2002). Rueppell *et al.* (2004a) demonstrated that differences in *Amfor*, or a gene or genes nearby, explain differences in age of foraging onset between bees of the high- and low-pollen hoarding strains.

### F. Hormonal Signaling Cascades

The systemic hormones—ecdysone and juvenile hormone (JH)—are key modulators of insect behavior (Cayre *et al.*, 2000; Hartfelder, 2000). Ecdysone is produced by the prothoracic gland during larval and pupal development, and by the ovary during the adult stage. Putative effects of ecdysone in adult honeybees are currently elusive (Hartfelder *et al.*, 2002; Robinson *et al.*, 1991). JH is a growth hormone produced by the *corpora allata* of insects (Hagenguth and Rembold, 1978). JH has been hypothesized to play an important role in honeybee division of labor by pacing age-related changes in behavior, especially the transition to foraging (Robinson, 1992; Robinson and Vargo, 1997). Many studies have demonstrated elevated blood titers of JH in foragers relative to bees that perform tasks in the nest (Fahrbach *et al.*, 2003; Huang and Robinson, 1992, 1995, 1996; Huang *et al.*, 1994; Jassim *et al.*, 2000; Robinson, 1987; Robinson *et al.*, 1991; Sullivan *et al.*, 2000, 2003; Withers *et al.*, 1995). Treatment with the JH analog methoprene also results in bees initiating foraging behavior earlier in life (Bloch *et al.*, 2002). Other evidence suggests that JH affects aspects of adult maturation. Young bees normally do not show associative learning the first 5–6 days after emergence (Ray and Ferneyhough, 1999). When treated topically with JH within 1hour after emergence, however, they show associative olfactory learning when they are 3 days old (Maleszka and Helliwell, 2001). Application of methoprene increases sucrose responsiveness in young bees (Pankiw and Page, 2003), and also elevates responses to alarm pheromones (Robinson, 1987). These roles of JH appear to be closely linked to OA. It is has been suggested that OA and JH regulate each other, and thus modulate the onset of foraging behavior and changes in responsiveness (Kaatz *et al.*, 1994; Schulz *et al.*, 2002a,b). Foragers have high titers of both JH and OA, particularly in the antennal lobes (Schulz and Robinson, 1999; Spivak *et al.*, 2003). When 1-day-old bees are treated with methoprene, their levels of OA in the antennal lobes increase and they forage precociously (Schulz *et al.*, 2002b). When the *corpora allata* complex is surgically removed, workers are unable to produce JH. Such bees have been observed to initiate foraging later in life than sham treated controls (Sullivan *et al.*, 2000). When the allatectomized workers are treated with methoprene or OA, they forage at an earlier age. These experiments suggest that OA acts downstream of JH. However, OA has also been shown to increase JH release from the *corpora allata in vitro* in a dose-dependent manner (Kaatz *et al.*, 1994), suggesting that OA is upstream of JH in the regulatory cascade. Interactions between JH and OA are, therefore, not well understood.

Overall, JH correlates with age-based changes in honeybee behavior and sensory sensitivity, but is it pacing behavioral development? As mentioned in an earlier section, Sullivan *et al.* (2000) removed the *corpora allata* from newly emerged bees. The allatectomized workers initiated foraging, though slightly delayed in time relative to sham treated control bees. This result, which was obtained from observations of workers that returned from presumably successfully foraging flights of more than 15-min duration, was later called into question by data that included information on activities at the entrance of the nest. In this case, the allatectomized bees were observed initiating flight at the same time as controls (Sullivan *et al.*, 2003). Worker honeybees from the high- and low-pollen hoarding strains initiate foraging at different ages and also differ in JH titer at adult emergence, however, their JH titer is not different 12 days later (Schulz *et al.*, 2004). Thus, it is clear that JH is not necessary for behavioral development, but that treatments with JH and JH analog nonetheless have behavioral effects.

Insights that resolve this paradox emerged with the finding that *vitellogenin* gene activity suppresses the JH titer of worker bees (Guidugli *et al.*, 2005). Vitellogenin is a major yolk precursor in many insects (Babin *et al.*, 1999; Mann *et al.*, 1999) and is also the most abundant hemolymph protein in worker bees that perform tasks in the nest prior to foraging (Engels and Fahrenhorst, 1974; Fluri *et al.*, 1981, 1982). Juvenile hormone is known to suppress the synthesis of honeybee vitellogenin at onset of foraging (Pinto *et al.*, 2000), but the effect of *vitellogenin* gene expression on JH further suggests that these two compounds are linked in a positive feedback loop via a mutual ability to suppress each other. This regulatory relationship is uncommon in insects and was hypothesized by Amdam and Omholt (2003). They argued that the evolution of an unconventional role of honeybee vitellogenin in brood-food synthesis (Amdam *et al.*, 2003) selected for a mechanism that retains bees in the brood nest with high-vitellogenin levels. Foraging behavior, consequently, is triggered when the vitellogenin titer drops below a certain level. The feedback action of JH on vitellogenin is a reinforcing mechanism that causes the workers to become behaviorally and physiologically locked into the forager stage. In accordance with this hypothesis, M. Nelson, K. Ihle, G. Amdam, and R. Page (unpublished data) showed that reduction of *vitellogenin* gene activity by RNA interference (RNAi) causes bees to forage earlier in life. Amdam *et al.* (2006) demonstrated that vitellogenin RNAi increases the sucrose responsiveness of worker bees, and suggested that honeybee vitellogenin is a modulator of behavior and sensory sensitivity that acts via a signaling pathway that includes JH as a downstream feedback element.

Honeybee vitellogenin is produced by the abdominal fat body, but available evidence demonstrates that this protein triggers responses in other cell types (Guidugli *et al.*, 2005), implying that vitellogenin itself can be classified as a hormone. The documented effects of JH and JH analog treatments can be understood as direct results of suppressed vitellogenin action, and predicts that high-pollen–hoarding strain bees, which forage earlier in life than workers from the low-pollen–hoarding strain (see earlier), should demonstrate a precocious drop in vitellogenin hormone titer. Data support this prediction (Amdam *et al.*, unpublished data).

## III. Genetic and Phenotypic Architecture of Pollen Hoarding

### A. Genetic Architecture

Genetic mapping studies have revealed four major quantitative trait loci (QTL) that explain significant amounts of the phenotypic variance for pollen hoarding and foraging behavior between the high- and low-pollen hoarding strains (Hunt *et al.*, 1995; Page *et al.*, 2000; Rueppell *et al.*, 2004a,b). Three QTL (*pln1*, *pln2*, and *pln3*) were identified by directly mapping the pollen hoarding trait at the colony level. They were subsequently confirmed by marker association studies of individual foraging behavior. A fourth QTL—*pln4*—was revealed by marker association studies.

Ben-Shahar *et al.* (2002) demonstrated the effects of cGMP on the onset of foraging. They also demonstrated elevated titers of PKG (*Amfor*), a downstream target of cGMP in the signaling cascade in wild-type foragers relative to bees performing tasks in the nest. Genetic variants of PKG of *Drosophila*, the so-called *foraging* gene (*for*), affect the feeding behavior of *Drosophila* larvae and are manifested as variation in their movement (DeBelle *et al.*, 1989). The *for* gene also affects the responsiveness of *Drosophila* to sucrose solutions (Scheiner *et al.*, 2004b), therefore, it was a likely candidate gene for our studies. We found a polymorphism between our high- and low-strain bees in a non-coding region of *Amfor* and designed a marker (Rueppell *et al.*, 2004a). Subsequent studies of bees derived from crosses of the high- and low-pollen hoarding strains demonstrated significant differences in behavior segregating with marker alleles from the two strains; (Rueppell *et al.*, 2004a,b). This does not "prove" that *Amfor* itself is responsible for these effects, but it does demonstrate that *Amfor* or something close to it is having an effect. It is interesting that another important signaling gene—*Amtyr1*—

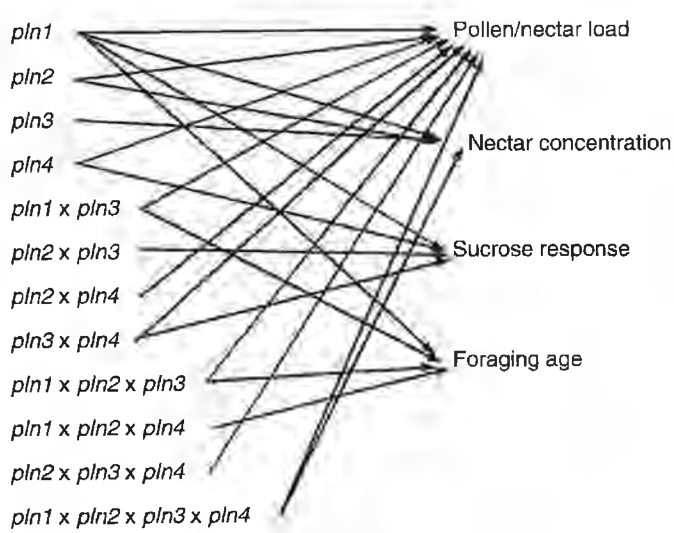


**Figure 5** Genetic architecture of traits associated with foraging behavioral differences between the high- and low-pollen hoarding strains (Page and Fondrk, 1995).

mapped to *pln2* (Humphries *et al.*, unpublished), making these two signaling genes prime candidates for further research (Fig. 5).

The genetic architecture of pollen hoarding and foraging behavior is complex (Fig. 4). All QTL demonstrate pleiotropy, providing an explanation for the association of this set of traits. They are also richly epistatic, which would be expected if they are involved in complex hormonal and neuronal signaling networks. All individual QTL and most of their interactions affect pollen and nectar load sizes. All individual QTL also affect concentration of nectar collected. *pln1* is central. It has a demonstrated direct effect on all behavioral traits. The combination of these QTL studies and the completed honeybee genome sequence and annotation should provide informed candidate genes for future studies of the underlying genetic basis for variation in pollen hoarding and foraging behavior.

## B. Phenotypic Architecture

Results discussed in an earlier section, reveal a suite of covarying and interacting phenotypic traits that span behavior to neurobiochemistry that

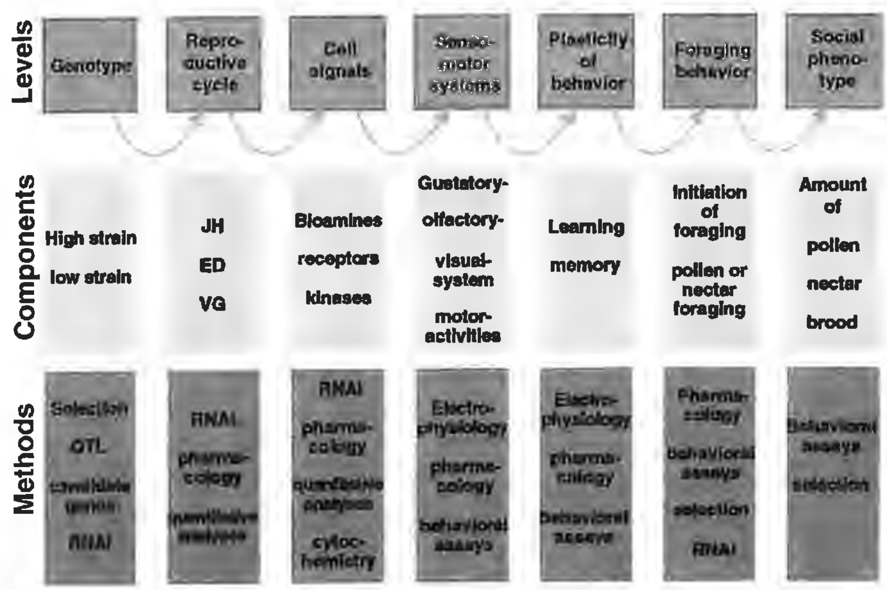


**Figure 6** The phenotypic architecture of pollen hoarding behavior in honeybees. Levels of biological organization are shown on the top row spanning genotype to complex social behavior. Phenotypic traits were studied at each level and are shown in the middle row. The bottom row shows the methods that were used to study phenotypic traits at each level.

define the architecture of the pollen hoarding trait (Fig. 6). The foraging behavioral traits themselves covary. Pollen and nectar load sizes are negatively correlated as a result of constraints on maximum load sizes (Page *et al.*, 2000). In addition, nectar load size correlates positively with nectar concentration (Page *et al.*, 2000). Bees collect larger loads of nectar and smaller loads of pollen if the nectar has a higher concentration of sugar. Pankiw and Page (2000) showed that newly emerged wild-type bees that are more responsive to sucrose solutions forage earlier in life, collect nectar with lower concentrations of sugar, and collect larger pollen loads than those that are less responsive. This robust result was true for wild-type bees of European origin and Africanized bees (Pankiw, 2003).

Key foci in this architecture are revealed by observed genotypic differences between the high- and low-strain bees, the rich set of correlations of gustatory sensitivity and response revealed by PER sucrose sensitivity assays, and the effects of biogenic amines on the suite of traits revealed by behavioral pharmacology. Collectively the results suggest the involvement of neuromodulatory networks involving cAMP signaling. These neuromodulatory networks affect correlated sensory response systems that include sensitivity to sugar, a central foraging stimulus for honeybees involved in foraging decision making, recruitment behavior, and associative learning. Findings that identify connections between pollen hoarding, vitellogenin hormone dynamics (Amdam *et al.*, 2004), and ovary development (Amdam *et al.*, 2006) suggest that pollen foraging behavior with the covarying suite of traits associated with it are modulated by a superior hierarchy of regulatory hormones involved in reproduction and reproductive behavior. It is likely that the neuromodulatory networks are themselves modulated by the reproductive hormones.

## C. Reproductive Ground Plan

Amdam *et al.* (2004) proposed that the suite of traits associated with foraging behavior and the underlying complex genetic architecture could be explained if foraging specialization was derived from a reproductive regulatory network (West-Eberhard, 1987, 1996). In solitary insects, different stages of the female reproductive cycle (previtellogenesis, vitellogenesis, oviposition, and brood care) are linked and involve coupled physiological and behavioral changes (Finch and Rose, 1995; Lin and Lee, 1998; Miyatake, 2002). Juvenile hormone and ecdysone are key hormones controlling vitellogenesis in many insect species (Brownes, 1994; Hiremath and Jones, 1992; Ismail *et al.*, 1998; Sankhon *et al.*, 1999; Socha *et al.*, 1991). In addition, they regulate behavioral transitions associated with changes in reproductive state such as the shift from foraging for nectar in previtellogenic females to protein foraging in vitellogenic individuals, as it occurs in the mosquito—*Culex nigripalpus* (Hancock and Foster, 2000). JH and ecdysone also modulate changes in sensory perception, locomotor activity, and reproductive physiology (Lin and Lee, 1998; Zera and Bottsford, 2001)—traits that have been shown to be different in workers from the high- and low-pollen–hoarding strains and in wild-type pollen and nectar foragers (see earlier).

In solitary insects, hormonal effects on reproductive traits typically act in mature adults (Fig. 7), following a prereproductive phase where the animals may enter diapause or aestivate and disperse (Hartfelder, 2000). In honeybees, however, these hormonal signals shifted in time (Amdam *et al.*, 2004), occurring in the late pupal stages where they activate the production of vitellogenin (Barchuk *et al.*, 2002). Differential amplitude of JH titers were observed in newly emerged high- and low-pollen–hoarding strain bees where high-strain workers had higher titers of JH (Schulz *et al.*, 2004). This elevated titer correlates with a higher level of vitellogenin mRNA and a higher vitellogenin hormone titer in the blood (Amdam *et al.*, 2004). Compared to the low-strain bees, workers of the high-pollen–hoarding strain

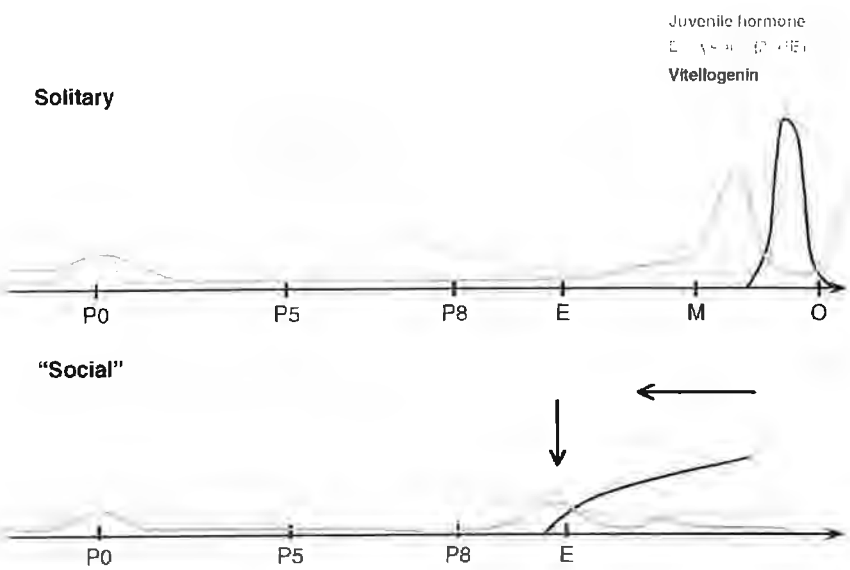


**Figure 7** A time course of blood hormone titers from early to late pupal stages (P0–P8) through emergence (E) and into mature prereproductive adults (M) to adults with activated ovaries (O) in solitary and social insects (Barchuk *et al.*, 2002; Pinto *et al.*, 2000). Amdam *et al.* (2006) hypothesized that the spikes of hormone titers seen between M and O in solitary insects have shifted with time in social insects and is homologous with the increases in titer observed just prior to adult emergence.

have larger ovaries (they have more ovary filaments) that can show an active previtellogenic ovarian phenotype already at adult emergence (Amdam *et al.*, 2006). It was proposed that if such documented markers of JH and ecdysone action are present early in honeybee adult life, then pleiotropic effects on behavior may have shifted from later life-stages as well (Amdam *et al.*, 2004), as demonstrated by the differences in sensory responses and locomotor activity of high- and low-strain bees and the correlation of locomotor and sensory responses in wild-type workers.

Reproductive signaling, early in life, can also explain the observed differences between newly emerged high- and low-strain bees in PKA and PKC titers (Humphries *et al.*, 2003). These kinases play key roles in sensory sensitivity and learning. In addition, observed differences in *Amtyr1* mRNA levels (Humphries, unpublished data) can be understood as a pleiotropic effect of a reproductive regulatory network because the tyramine pathway appears to be involved in reproductive tuning of queenless worker honeybees (Sasaki and Nagao, 2002). The finding that ovary size correlates with sensory responsiveness in 5-day-old bees (Tsuruda, unpublished data), and the known association between such sensory responses and foraging behavior 2–3 weeks later suggests that gonotrophic events in young bees have persistent effects on adult behavior. These insights are summarized in the "reproductive ground plan" hypothesis of social evolution (Amdam *et al.*, 2004). The hypothesis proposes that the genetic and hormonal networks that govern reproductive development, physiology, and behavior in solitary species represent one fundamental regulatory module with capacity to serve as basis for evolution of social phenotypes.

## IV. The Evolution of Division of Labor and Specialization

Division of labor between nest tasks and foraging activity, and foraging specialization on pollen and nectar, likely evolved from the gonotrophic cycle of solitary ancestors of the honeybee. The first step was a shift in the timing of reproductive hormonal signaling events from the mature adult stage into the late pupal stages (Amdam *et al.*, 2004). This shift turned on the production of vitellogenin and further caused behavioral traits interlinked with reproductive maturity to be expressed in young bees. These vitellogenic females bypassed the phases of dispersal, diapause, and aestivation that characterized the ancestral prereproductive period. Instead, they expressed a coordinated set of maternal reproductive behaviors, including larval care, nest defense, and foraging (West-Eberhard, 1987, 1996). The second step was the evolution of a feedback interaction between vitellogenin and JH (Guidugli *et al.*, 2005), apparently resulting in a regulatory mechanism that enabled vitellogenin to become a pace maker for division of labor. Higher blood titers of vitellogenin keep bees in the nest, performing maternal nonforaging tasks. Blood titers of vitellogenin decrease as a consequence of vitellogenin consumption in brood rearing (Amdam *et al.*, 2003), and workers with low-vitellogenin levels—a state presumably incompatible with ability to nourish larvae—are triggered to leave the nest to perform foraging tasks. During this transition, a rapid increase in JH strongly suppresses remaining expression of vitellogenin, thereby producing a robust and definite differentiation of the forager phenotype (Amdam and Omholt, 2003; Guidugli *et al.*, 2005). After the transition, bees with active ovaries preferentially forage for protein (pollen), as did their reproductively activated solitary ancestors that were provisioning their brood. Those with inactive ovaries forage primarily for nectar, as do nonreproductive solitary insect females (Dunn and Richards, 2003).

The early initiation of vitellogenesis is the necessary first step in social evolution via the subsocial route to sociality—staying and helping your mother raise siblings at the natal nest (Michener, 1974). Our model thus demystifies this first, essential step in social evolution and shows a simple, plausible mechanism by which it could have occurred. It also demonstrates that behavioral specialization can be an immediate emergent property, conferring a selective advantage to subsocial group living. Foraging specialization is, under our model, an immediate consequence of the ancestral interlinkage between reproductive tuning and foraging-preference for nectar or pollen. Temporal polyethism, furthermore, is an immediate consequence of variation in vitellogenin dynamics caused by developmental and nutritional factors. One factor that converges at the intersection between development and nutrition is worker ovary size: ovary size is determined during honeybee larval development and is influenced by nutrition (Hartfelder and Engels, 1998; Kaftanoglu *et al.*, unpublished). In adult worker bees, ovary size is a documented component of the reproductive network that regulates social behavior (Amdam *et al.*, 2006). Therefore, stochastic feeding events resulting in variation in ovary size could lead to differences in rates of onset of foraging behavior and foraging specialization. Finally, differences in stimulus–response sensitivities resulting from differences in reproductive states could result in a self-organized division of labor as described by Page and Mitchell, 1991, 1998; Fewell, 2003; Fewell and Page, 1999. Patterns of complex division of labor, thereby, emerged without explicit selection for task specialization.

By co-option and compartmentalization of the relationships between gonotrophic state and behavior, which was controlled originally by ancestral developmental programs, social insects evolved a division of labor and task specialization among functionally sterile individuals. Once in place, the social structure of colonies could be adapted by a fine-tuning of the pleiotropic hormonal and neuronal signaling networks that affected the behavior.

However, these richly epistatic and pleiotropic networks would impose initial constraints on evolution by decreasing or masking the additive genetic variance available for natural selection, and by correlated responses to selection for traits not under direct selection. Over two decades, a concerted effort has succeeded in making these correlations transparent for the set of traits observed for the pollen-hoarding syndrome of the honeybee—in sum providing the first direct evidence for an evolutionary origin of complex social behavior.

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# Tab 6

US006766611B2

(12) **United States Patent**
**Prince**

(10) **Patent No.: US 6,766,611 B2**
(45) **Date of Patent: Jul. 27, 2004**

(54) **CARPENTER BEE TRAP**

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(73) Assignee: **Bruce H. Prince**, Jasper, GA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/818,347**

(22) Filed: **Mar. 27, 2001**

(65) **Prior Publication Data**

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**Related U.S. Application Data**

(60) Provisional application No. 60/192,239, filed on Mar. 27, 2000.

(51) **Int. Cl.**[7] .................... **A01M 1/10**
(52) **U.S. Cl.** .................... **43/58**; 220/690; 220/6
(58) **Field of Search** .................... 43/66, 38, 65, 43/107, 122; 119/428; 229/117.01, 122.2, 149, 195; 220/6, 690

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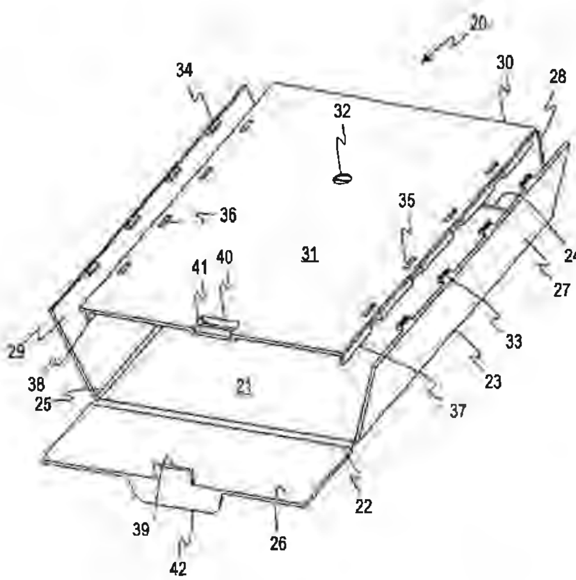
*Assistant Examiner*—Susan C. Alimenti
(74) *Attorney, Agent, or Firm*—Jenkens & Gilchrist

(57) **ABSTRACT**

A carpenter bee trap comprises a housing having a hollow interior and at least one solid wall having a hole formed therein to permit carpenter bees to enter the hollow interior of the housing, the hole having about the same size as holes normally made by carpenter bees so that the hole tends to attract such bees. The preferred hole size is in the range from about 5/16 inch to about ½ inch. The exterior surface of the solid wall around the hole preferably has a light color, and the walls of housing are preferably opaque so that the hole appears dark from outside the housing. The interior surface of the solid wall forming the interior edge of the hole is preferably substantially flat. The trap may be made of a single piece of molded plastic with molded hinges connecting selected pairs of adjacent walls, and including integral latching means for releasably latching selected pairs of adjacent walls.

**17 Claims, 5 Drawing Sheets**



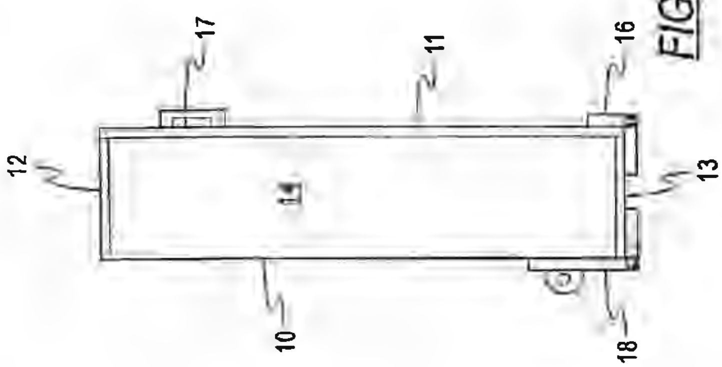



FIG. 3

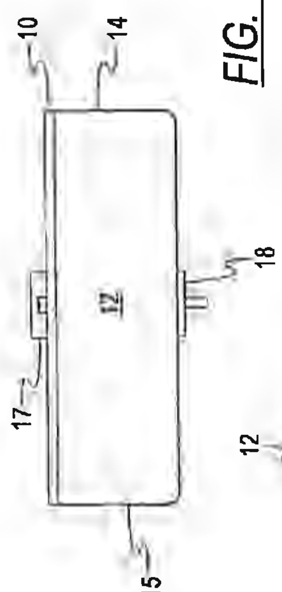



FIG. 1

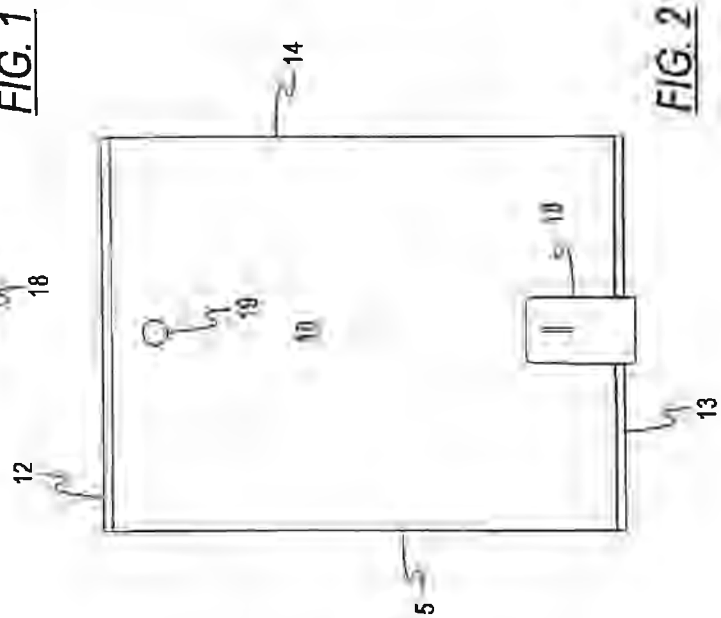



FIG. 2

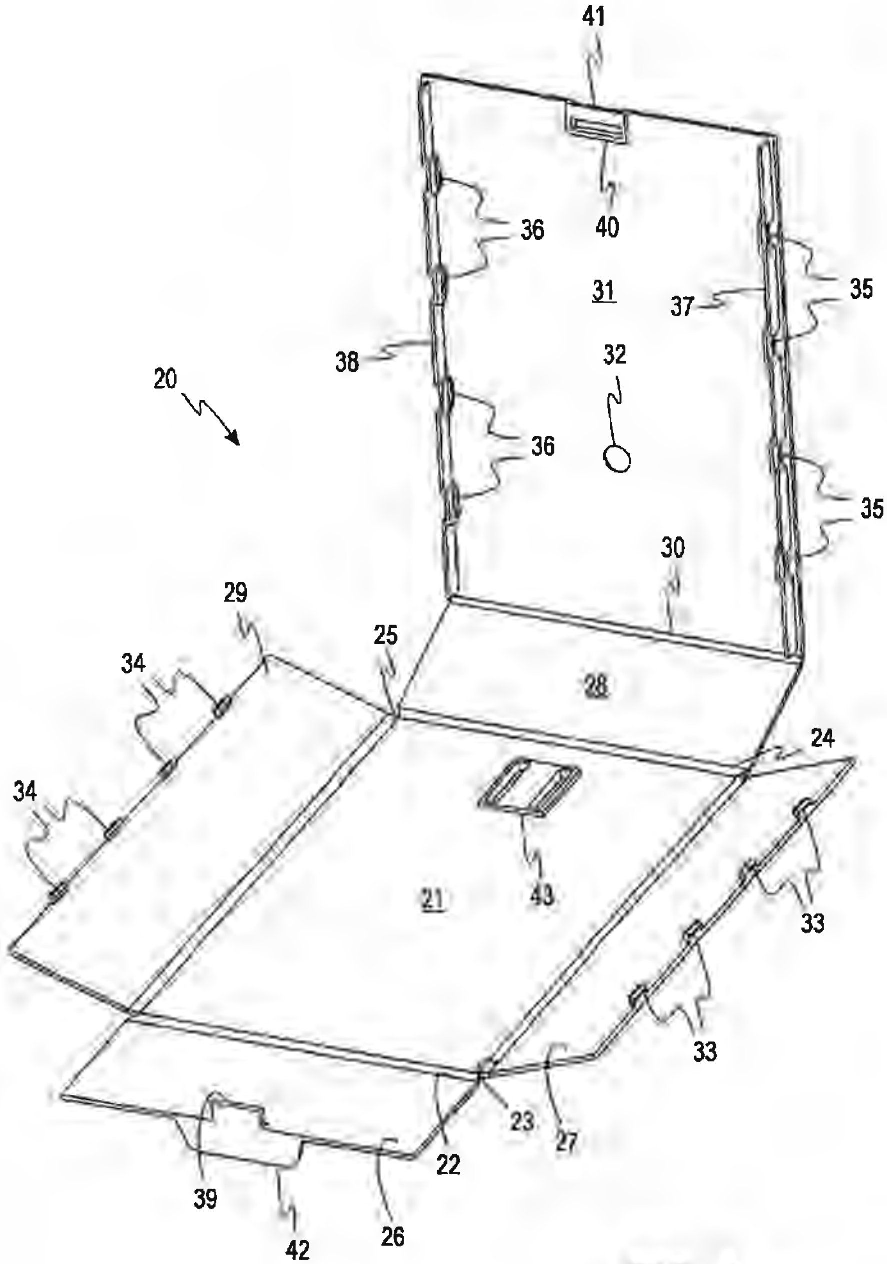

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FIG. 4

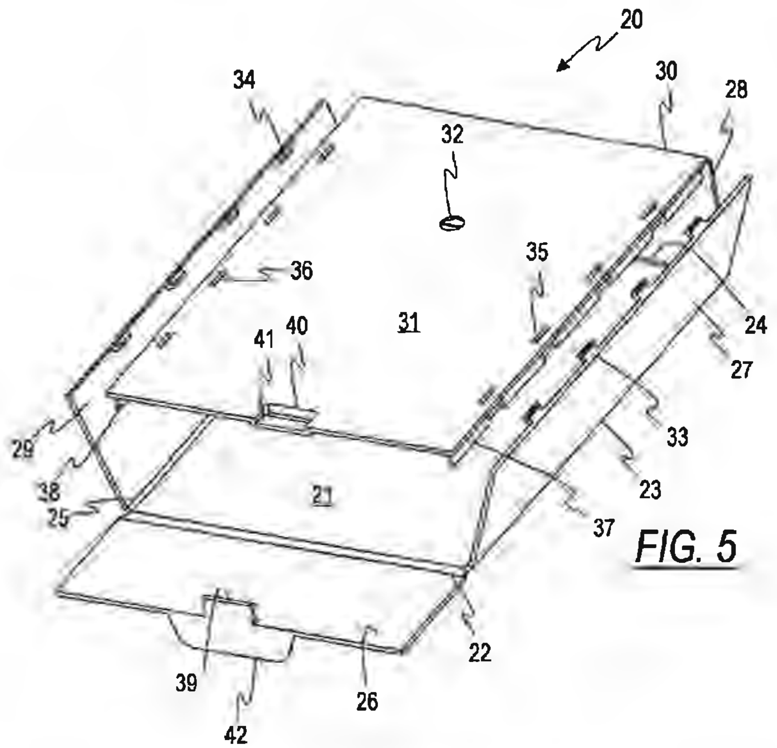
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FIG. 5

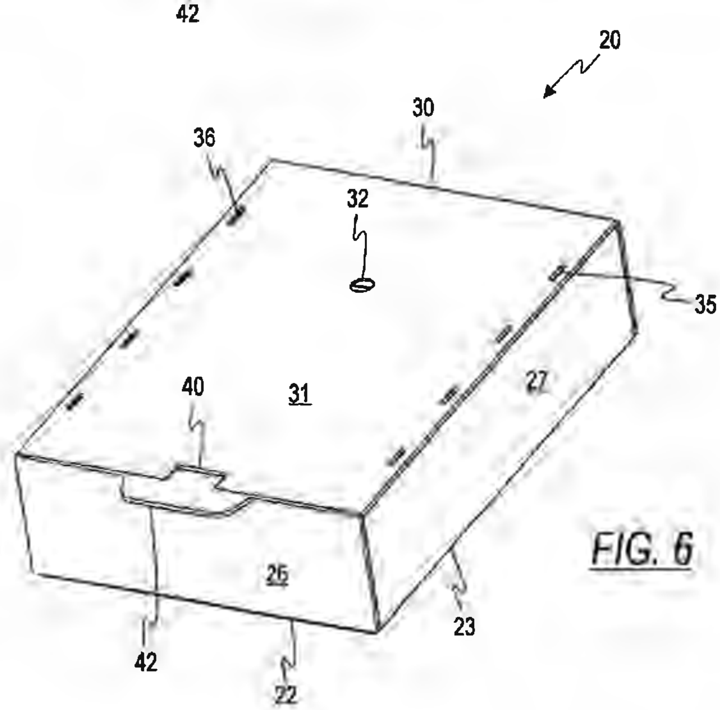
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FIG. 6

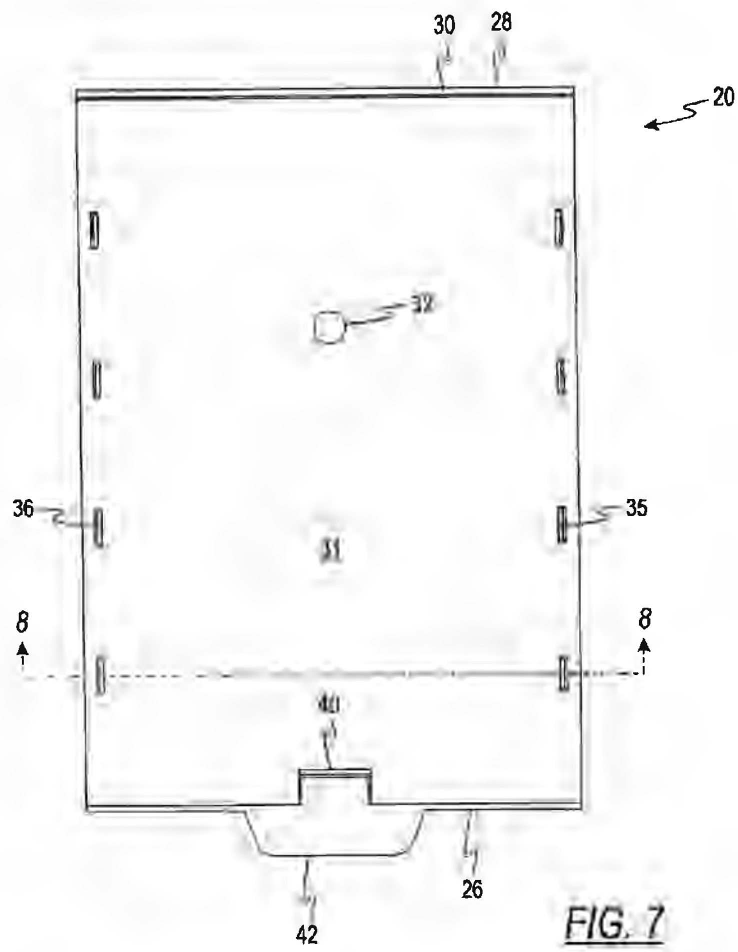


FIG. 7

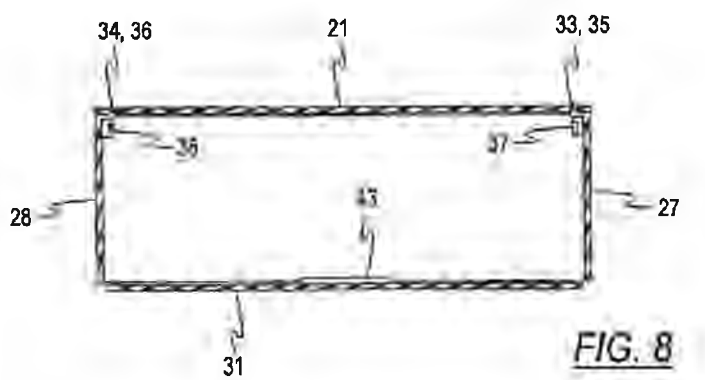


FIG. 8

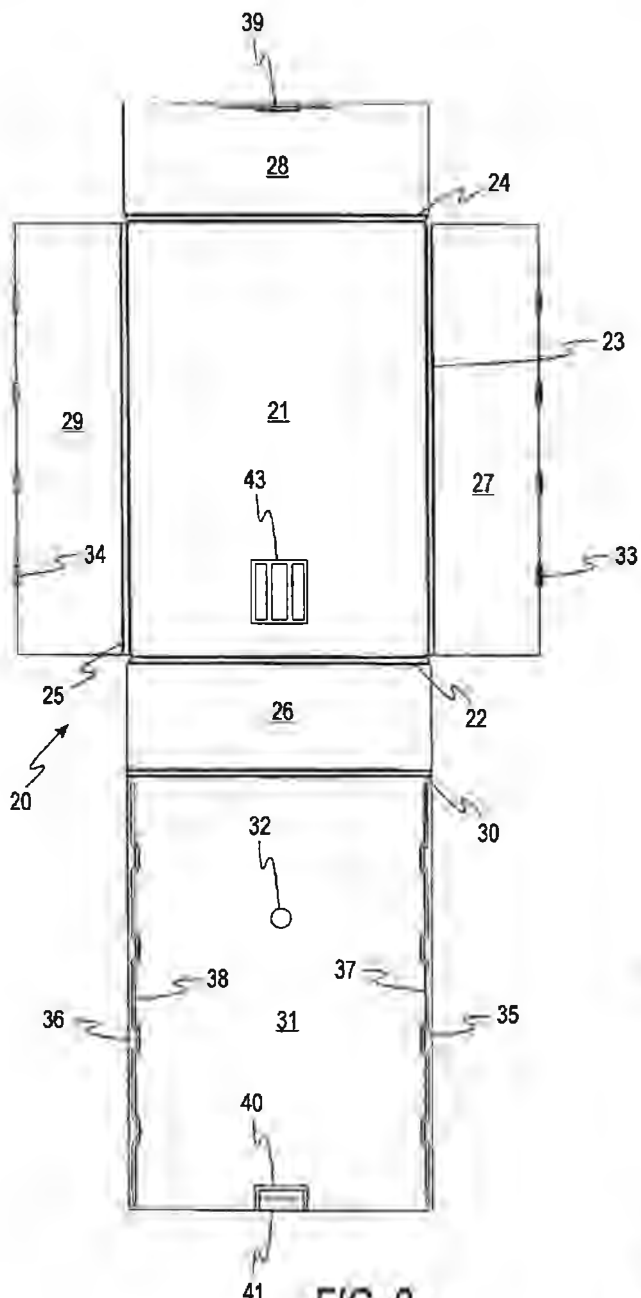
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FIG. 9

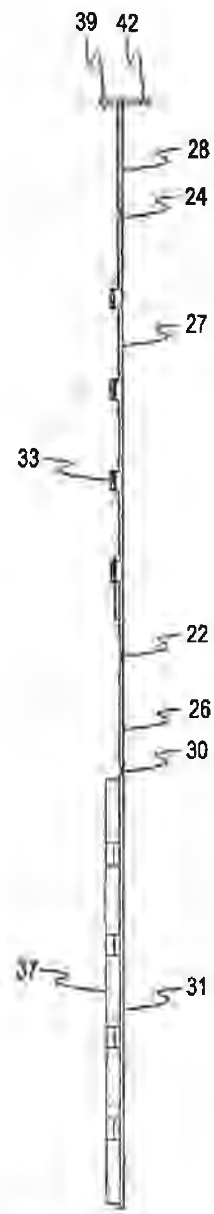
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FIG. 10

# CARPENTER BEE TRAP

## CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of priority of U.S. Provisional Patent Application Serial No. 60/192,239 filed on Mar. 27, 2000.

## FIELD OF THE INVENTION

This invention relates generally to insect traps and, more particularly, to a trap for carpenter bees.

## BACKGROUND OF THE INVENTION

Carpenter bees are a problem in certain geographical regions because they tend to bore holes in various wooden structures, including houses. Once the wooden facade of a house has been penetrated by these bees, they can spread through the interior of the house, becoming a nuisance and causing physical damage and sometimes even physical harm to occupants. Thus, there has been a need for a trap for these pests in the vicinity of wooden structures to be protected from them.

It is a primary object of the present invention to provide such a trap which is effective in trapping carpenter bees and can be efficiently and economically manufactured in large numbers.

## SUMMARY OF THE INVENTION

In accordance with the present invention, there is provided a carpenter bee trap comprising a housing having a hollow interior and at least one solid wall having a hole formed therein to permit carpenter bees to enter the hollow interior of the housing, the hole having about the same size as holes normally made by carpenter bees so that the hole tends to attract such bees. The preferred hole size is in the range from about 5/16 inch to about ½ inch. The interior surface of the solid wall forming the interior edge of said hole is substantially flat. The exterior surface of the solid wall around the hole preferably has a light color, and the walls of housing are preferably opaque so that the hole appears dark from outside the housing. The interior surface of the solid wall forming the interior edge of the hole is preferably substantially flat. In a particularly preferred embodiment, the trap is made of a single piece of molded plastic with molded hinges connecting selected pairs of adjacent walls, and including integral latching means for releasably latching selected pairs of adjacent walls.

## BRIEF DESCRIPTION OF THE DRAWINGS

The invention may best be understood by reference to the following description taken in conjunction with the accompanying drawings, in which:

FIG. **1** is a top plan view of a carpenter bee trap embodying the invention;

FIG. **2** is a front elevation of the carpenter bee trap shown in FIG. **1**;

FIG. **3** is a side elevation of the carpenter bee trap shown in FIGS. **1** and **2**;

FIG. **4** is an exploded perspective view of a modified carpenter bee trap embodying the invention;

FIG. **5** is a perspective view of the trap shown in FIG. **4** in a partially assembled form;

FIG. **6** is a perspective view of the trap shown in FIG. **4** in a fully assembled form;

FIG. **7** is an enlarged front elevation view of the trap shown in FIG. **6**;

FIG. **8** is a sectional view taken along line **8—8** in FIG. **7**;

FIG. **9** is a plan view of the trap shown in FIG. **4** with all the parts laid out flat in a common plane; and

FIG. **10** is side elevation of the parts shown in FIG. **9**.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Although the invention will be described next in connection with certain preferred embodiments, it will be understood that the invention is not limited to those particular embodiments. On the contrary, the description of the invention is intended to cover all alternatives, modifications, and equivalent arrangements as may be included within the spirit and scope of the invention as defined by the appended claims.

Turning now to the drawings, and referring first to FIGS. **1–3**, there is shown a carpenter bee trap that is essentially a rectangular plastic housing formed by six walls, including front and rear walls **10** and **11**, top and bottom walls **12** and **13**, and a pair of side walls **14** and **15**. The bottom and rear walls **13** and **14** are connected by a hinge **16** so that the bottom wall **13** can be pivoted downwardly away from the bottom edge of the front wall **10** to permit removal of bees trapped inside the housing. The exterior surface of the rear wall **14** is also equipped with a plastic hanger **17** to facilitate mounting of the trap on a supporting surface. The hinged bottom wall **13** also carries a hinged plastic hasp **18** which permits the bottom wall **13** to be latched to, and unlatched from, the front wall **10**.

It has been found that carpenter bees will enter an opening having a size similar to the size of the holes that carpenter bees normally form in wooden structures. The size of such holes is typically within the range from about 5/16 in. to about ½ inch in diameter. A hole **19** of this size is provided in the front wall **10**, near the top of the wall. To improve the visibility of the hole **19**, the exterior surface of the front wall **10** of the housing, at least the region surrounding the hole **19**, preferably has a light color such as light gray or tan to provide a sharp contrast with the dark hole. After a bee enters the housing through the hole **19**, it is difficult for the bee to re-enter the hole from inside the house and escape. Consequently, most bees that enter the hole **19** from outside the housing become trapped within the housing and eventually die from lack of nourishment and moisture. To make it even more difficult for the bee to escape from the housing once inside, the inside walls of the housing are preferably made with a smooth surface so that there is no frictional surface that the bee can use to crawl toward the hole through which it entered the housing.

FIGS. **4–10** illustrate a modified version of the trap comprising a single molded plastic part **20** forming multiple molded hinges that permit the trap to be packaged and shipped as a substantially flat sheet, and then quickly and easily assembled when removed from the package by a user. The molded plastic part **20** forms a rear panel **21** that has four molded hinges **22, 23, 24** and **25** extending along its four sides. These four hinges **22–25** join the rear panel **21** with a bottom panel **26**, a right side panel **27**, a top panel **28**, and a left side panel **29**, respectively. A fifth molded hinge **30** extends along the second elongated edge of the top panel and joins the top panel to a front panel **31** that forms a hole **32** through which bees enter the trap.

As can be seen in FIGS. **9** and **10**, the molded plastic part **20** can be flattened for packaging and shipping, so that a large number of traps can be efficiently packaged and shipped together in a package that contains little empty space by simply stacking multiple parts **20** on top of each other in their flattened condition. When it is desired to assemble the trap, the top panel **28** and the front panel **31** hinged thereto are folded toward the rear panel **21**, as illustrated in FIGS. **4** and **5**. When the front panel **31** is aligned with the rear panel **21**, the two side panels **27** and **29** are folded toward the front panel **31** and pressed against the side edges of the front panel **31** so that multiple lugs **33** and **34** on the front edges of the side panels **27** and **29**, respectively, snap into mating slots **35** and **36** formed in the front panel **31** along its two side edges. The lugs **33** and **34** have beveled leading edges that serve as cams to bend the lugs slightly as they engage the side edges of the front panel **31** and slide over the inside surface of that panel until they snap into the slots **35** and **36**. Engagement of the lugs **33**, **34** in the slots **35**, **36** locks the side panels **27** and **29** to the front panel **31**. The front panel **31** also forms a pair of integral flanges **37** and **38** that engage the inside surfaces of the side panels **27** and **29** when the panels are all locked together.

The final step in the assembly operation is to fold the bottom panel **26** toward the bottom edge of the front panel **31** until an integral latching lug **39** on the front edge of the bottom panel **26** engages a mating slot **40** in the front panel **31**. As can be seen in FIG. **5**, the leading edge of the latching lug **39** is beveled to serve as a cam that bends the latching lug slightly away from the front panel **31** as the lug engages the bottom edge of the front panel **31** and slides across the surface of a recess **41** leading from the bottom edge of the panel **31** to the slot **40**. When the lug **39** reaches the slot **40**, it snaps into the slot to latch the bottom panel **26** to the front panel **31**. When the user wishes to remove trapped bees from the trap, an integral flange **42** depending from the latching lug **39** is pressed to release the lug from the slot **40**, and then the bottom panel **26** can be pivoted downwardly to open the interior of the trap and remove the trapped bees.

As can be seen in FIGS. **4** and **9**, an integral hanger **43** is molded into the inside surface of the rear panel **21** to facilitate mounting of the trap. If desired, an attractant for the bees may also be placed in the interior of the trap.

What is claimed is:

**1**. A carpenter bee trap comprising a housing having a hollow interior and at least one solid wall having a hole formed therein to permit carpenter bees to enter the hollow interior of the housing, said hole having about the same size as holes normally made by carpenter bees so that the hole tends to attract such bees, said housing containing no bait, the interior surface of said solid wall forming the interior edge of said hole is substantially flat.

**2**. The carpenter bee trap of claim **1** in which said housing has only a single hole, and the exterior surface of said solid wall around said hole has a light color, and the walls of said housing are opaque so that said hole appears dark from outside the housing.

**3**. The carpenter bee trap of claim **1** in which at least one of the walls of said housing can be pivoted away from adjacent walls to permit the hollow interior of the housing to be opened for the removal of trapped bees.

**4**. The carpenter bee trap of claim **1** in which the interior surfaces of said housing are smooth.

**5**. The carpenter bee trap of claim **1** which is made of a single piece of molded plastic with molded hinges connecting selected pairs of adjacent walls, and including integral latching means for releasably latching selected pairs of adjacent walls.

**6**. The carpenter bee trap of claim **1** in which said hole as a diameter within the range of from about 5/16 inch to ½ inch.



**7**. A carpenter bee trap comprising a housing made of single piece of molded plastic with molded hinges connecting selected pairs of adjacent walls, and including integral latching means for releasably latching selected pairs of adjacent walls, said housing having a hollow interior and at least one solid wall having a hole formed therein to permit carpenter bees to enter the hollow interior of the housing, said hole having about the same size as holes normally made by carpenter bees so that the hole tends to attract such bees, said housing containing no bait, the exterior surface of said solid wall around said hole having a light color, and the walls of said housing being opaque so that said hole appears dark from outside the housing.

**8**. The carpenter bee trap of claim **7** in which at least one of the walls of said housing can be pivoted away from adjacent walls to permit the hollow interior of the housing to be opened for the removal of trapped bees.

**9**. The carpenter bee trap of claim **7** in which the interior surfaces of said housing are smooth.

**10**. The carpenter bee trap of claim **7** in which said hole a diameter within the range of from about 5/16 inch to ½ inch.

**11**. A carpenter bee trap comprising a housing made of single piece of molded plastic with molded hinges connecting selected pairs of adjacent walls, and including integral latching means for releasably latching selected pairs of adjacent walls, and housing having a hollow interior and at least one solid wall having a hole formed therein to permit carpenter bees to enter the hollow interior of the housing, said hole having about the same size as holes normally made by carpenter bees so that the hole tends to attract such bees, said housing containing no bait, the interior surface of said solid wall forming the interior edge of said hole is substantially flat.

**12**. A method of trapping carpenter bees without the use of bait or insecticide comprising providing a housing having a hollow interior and at least one solid wall having an exposed hole formed therein to permit carpenter bees to enter the hollow interior of the housing, said hole having about the same size as holes normally made by carpenter bees so that the hole tends to attract such bees, and said housing containing no bait, the exterior surface of said solid wall around said hole having a light color, and the walls of said housing being opaque so that said hole appears dark from outside the housing, and periodically removing trapped bees from said hollow interior of said housing.

**13**. The method of trapping carpenter bees as set forth in claim **12** in which at least one of the walls of said housing can be pivoted away from adjacent walls to permit the hollow interior of the housing to be opened for the removal from trapped bees.

**14**. The method of trapping carpenter bees as set forth in claim **12** in which the interior surfaces of said housing are smooth.

**15**. The method of trapping carpenter bees as set forth in claim **12** which is made of a single piece of molded plastic with molded hinges connecting selected pairs of adjacent walls, and including integral latching means for releasably latching selected pairs of adjacent walls.

**16**. The method of trapping carpenter bees as set forth in claim **12** in which said hole has a diameter within the range of from about 5/16 inch to ½ inch.

**17**. A method of trapping carpenter bees without the use of bait or insecticide comprising providing a housing having a hollow interior and at least one solid wall having an exposed hole formed therein to permit carpenter bees to enter the hollow interior of the housing, said hole having about the same size as holes normally made by carpenter bees so that the hole tends to attract such bees, and said housing containing no bait, and periodically removing trapped bees from said hollow interior of said housing, the



interior surface of said solid wall forming the interior edge of said hole is substantially flat.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

# CERTIFICATE OF CORRECTION

PATENT NO. : 6,766,611 B2
DATED : July 27, 2004
INVENTOR(S) : Bruce H. Prince

Page 1 of 1

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 4,
Line 1, after "of" add -- a --
Line 4, "on" should read -- one --
Line 20, after "hole" add -- has --
Line 22, after "of" add -- a --
Line 26, "and housing" should read -- said housing --
Line 50, "from" should read -- of --

Signed and Sealed this

First Day of February, 2005

Jon W. Dudas

JON W. DUDAS
*Director of the United States Patent and Trademark Office*

# Tab 7

US007757432B2

(12) **United States Patent**
**Gunderman, Jr.**

(10) **Patent No.:** **US 7,757,432 B2**
(45) **Date of Patent:** **Jul. 20, 2010**

(54) **ELECTRONIC CARPENTER BEE TRAP**

(76) Inventor: **Robert Dale Gunderman, Jr.**, 4149 Clover St., Honeoye Falls, NY (US) 14472

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 716 days.

(21) Appl. No.: **11/456,210**

(22) Filed: **Jul. 9, 2006**

(65) **Prior Publication Data**

US 2007/0006519 A1 Jan. 11, 2007

**Related U.S. Application Data**

(60) Provisional application No. 60/698,203, filed on Jul. 11, 2005.

(51) **Int. Cl.**
***A01M 1/22*** (2006.01)
***A01M 1/02*** (2006.01)
***A01M 1/10*** (2006.01)

(52) **U.S. Cl.** .......................................... **43/112**; 43/107

(58) **Field of Classification Search** .................. 43/112, 43/98, 113, 107
See application file for complete search history.

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*Primary Examiner*—Darren W Ark
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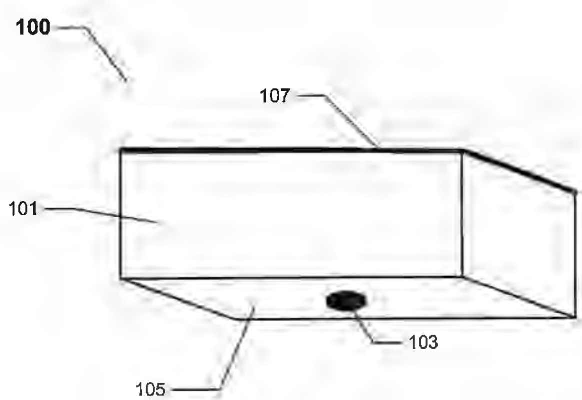
(57) **ABSTRACT**

A carpenter bee trap having a housing that contains a hole, an electrode in proximity to the hole, and a power source connected to the electrode. The hole is of a size similar to the size holes that carpenter bees normally make, thus attracting the carpenter bees to the hole. The carpenter bees will enter the hole, and make contact with an electrode. The electrode is energized through connection with a power source. In one embodiment, the power source includes a photovoltaic panel. Once the carpenter bee makes contact with the electrode, a high voltage discharge will take place through the body of the carpenter bee, thus killing the carpenter bee. The carpenter bee will then fall from the hole, and the trap will be ready for the next carpenter bee to enter.

**20 Claims, 7 Drawing Sheets**



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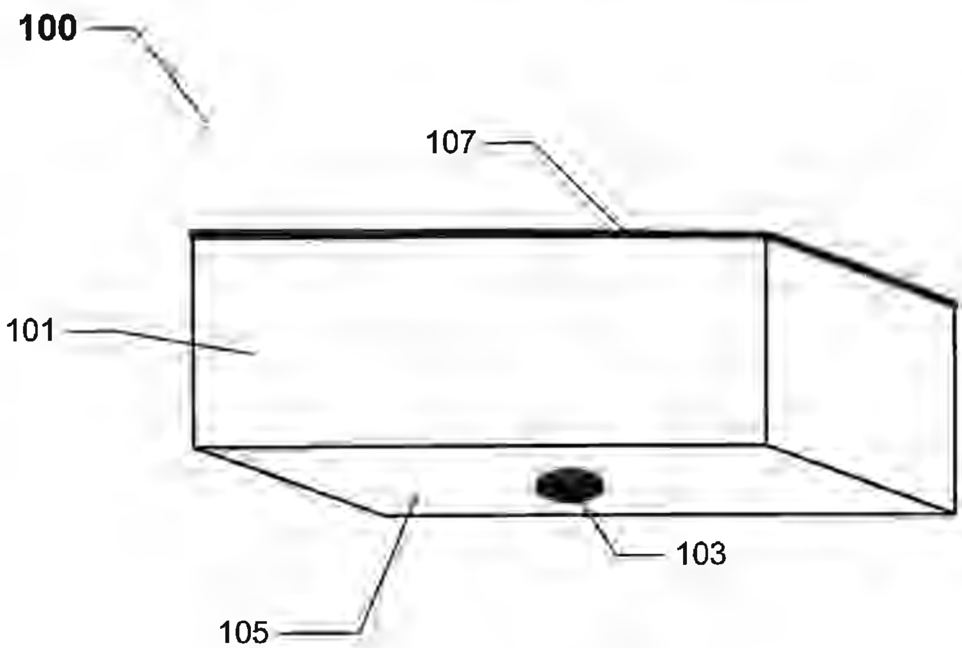


FIG. 1

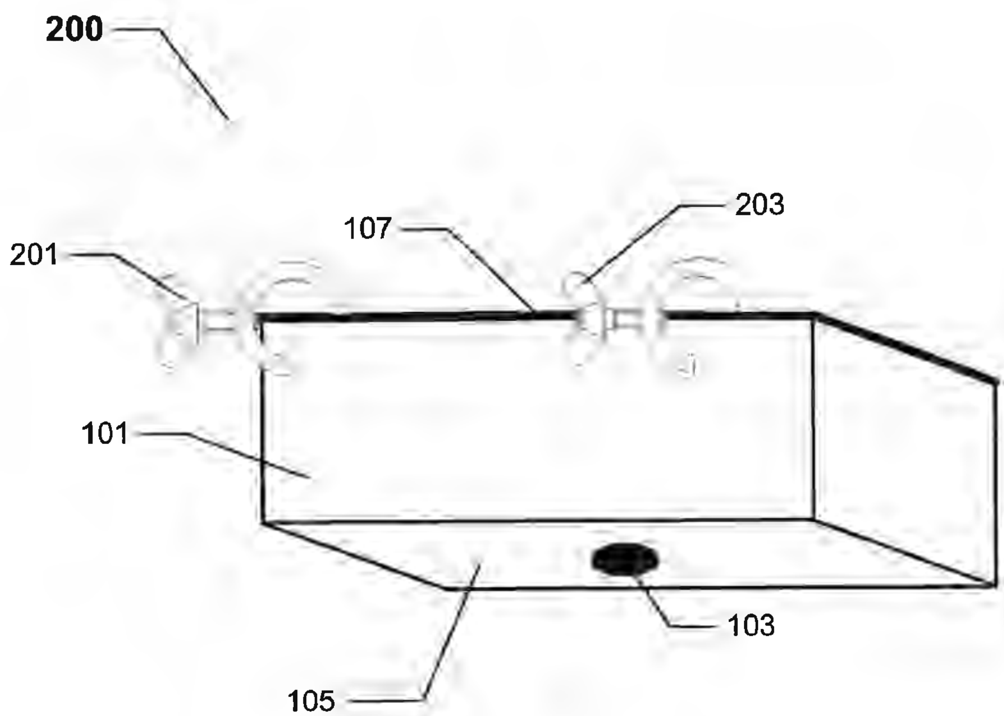


FIG. 2

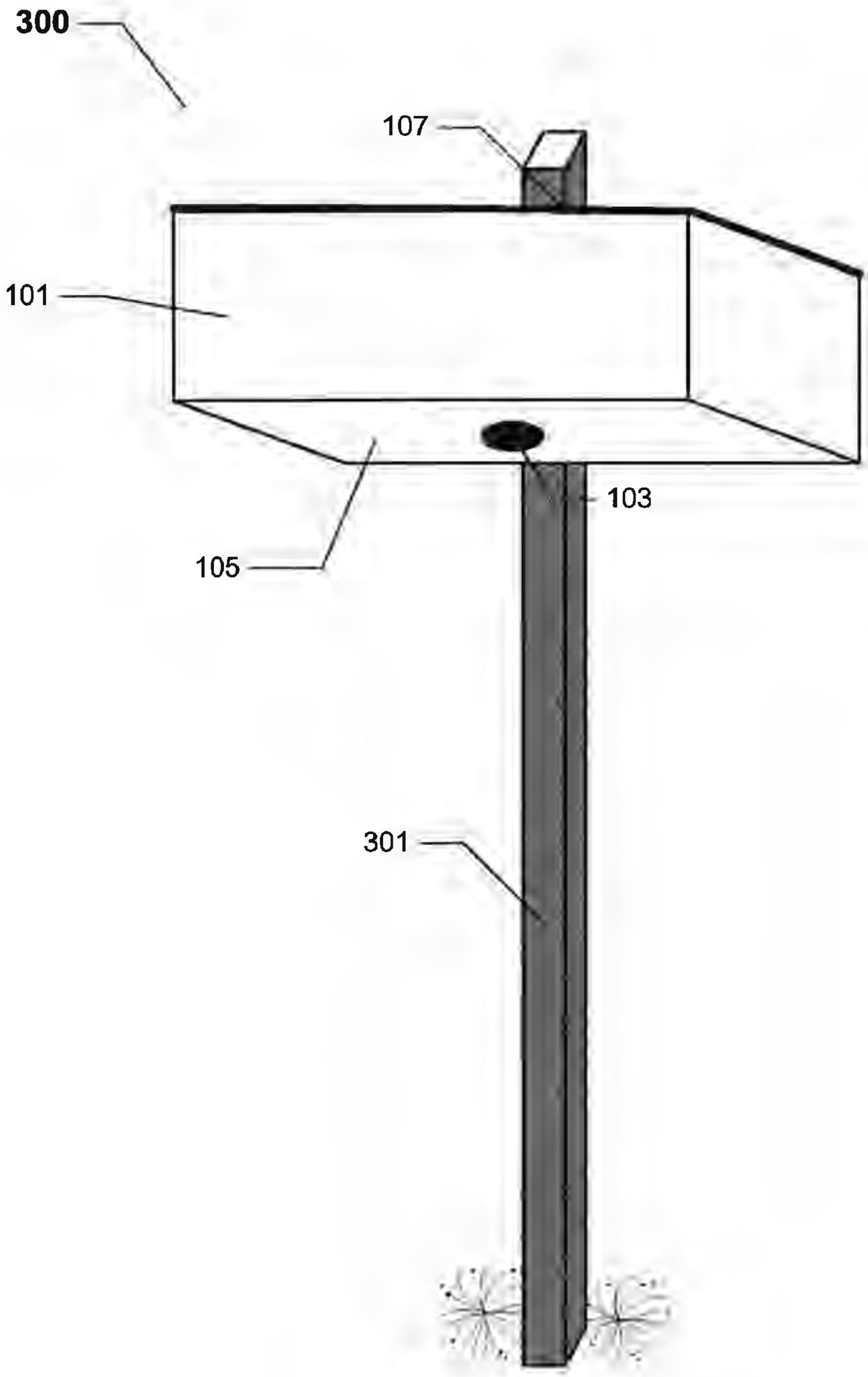


FIG. 3

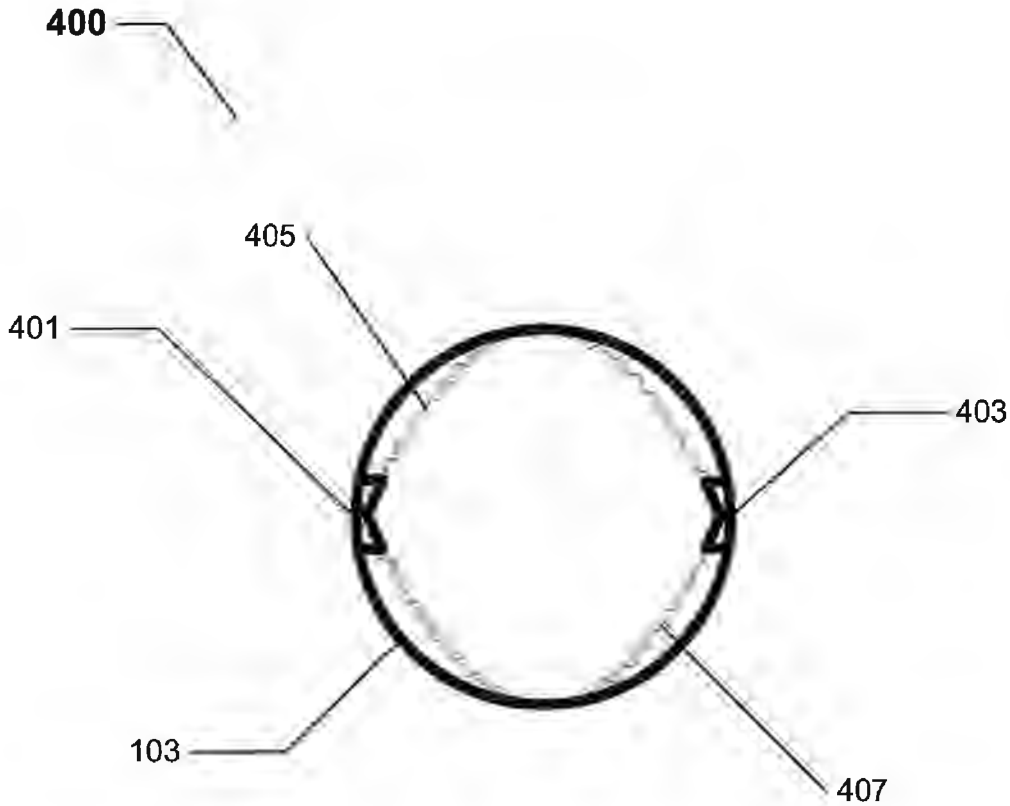


FIG. 4

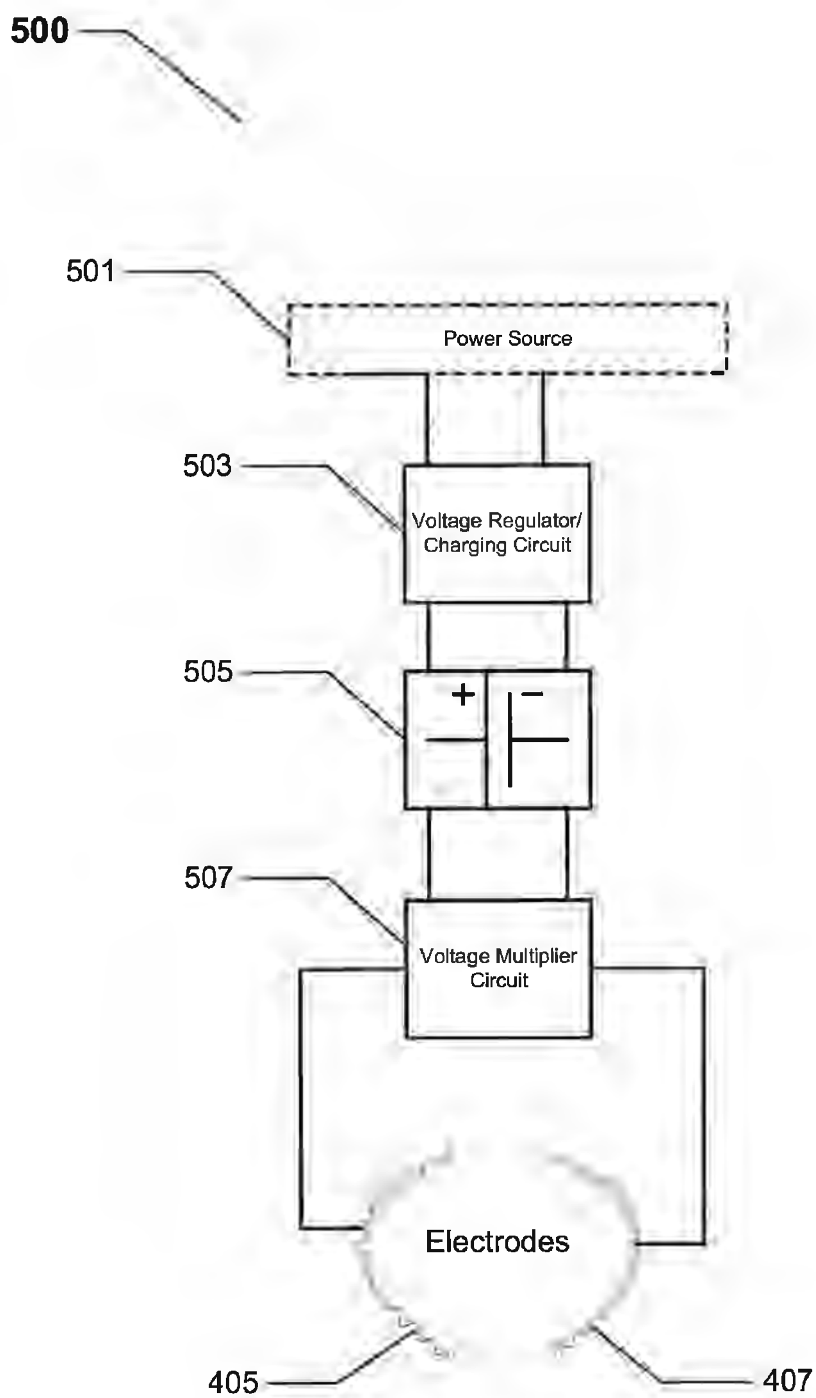
500
501
Power Source
503
Voltage Regulator/
Charging Circuit
505
+
−
507
Voltage Multiplier
Circuit
Electrodes
405
407

FIG. 5

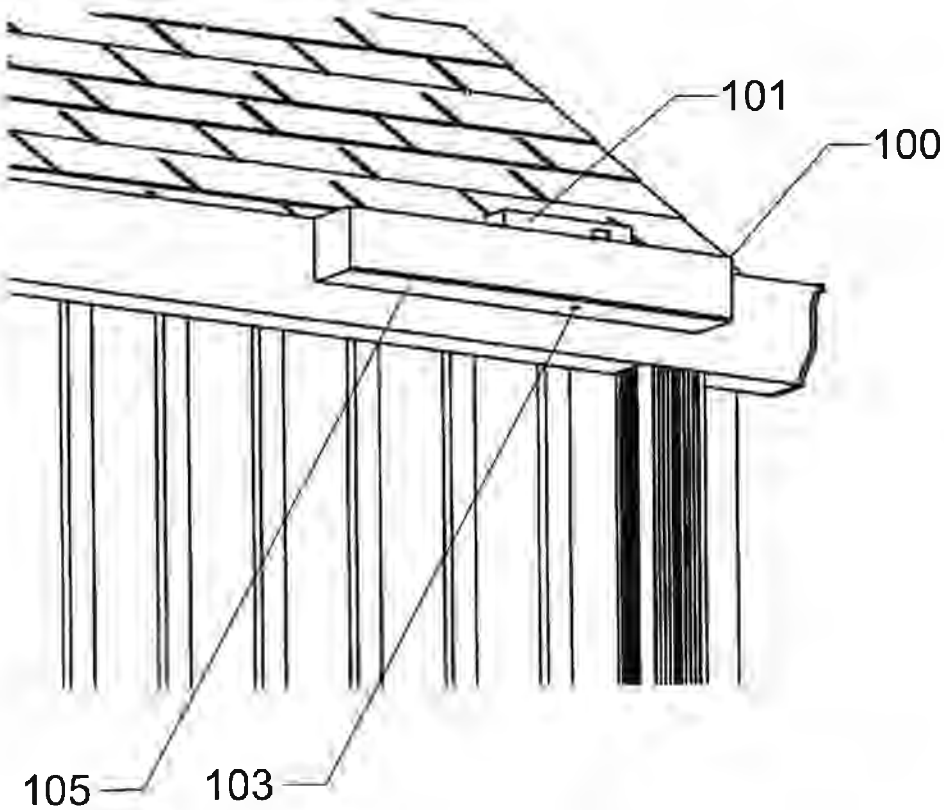


FIG. 6

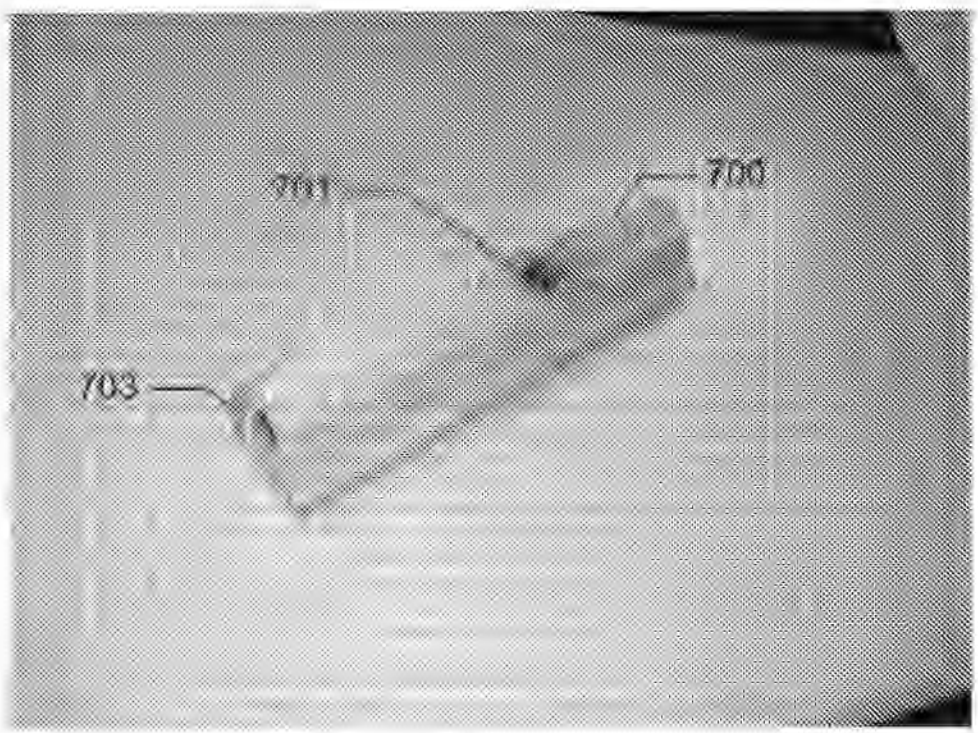


Fig. 7

# ELECTRONIC CARPENTER BEE TRAP

## CROSS-REFERENCE TO RELATED PATENT APPLICATIONS

This application claims the benefit of the filing date of U.S. provisional patent application No. 60/698,203 filed on Jul. 11, 2005.

## BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to an insect trap, and more particularly to an electronic trap for carpenter bees and other insects.

2. Description of the Related Art

Carpenter bees are common in many areas, and can cause extensive damage to wooden structures. Carpenter bees cause damage to homes and buildings that are clad with a wooden siding or are constructed entirely of wood, such as a log home or a timber framed building. The carpenter bees bore a hole of up to ¾ inch in diameter into an outside component of a building such as a wooden fascia. The carpenter bee creates a tunnel in the wood that makes an approximate right angle turn once inside the wood. The tunnel is used by the female carpenter bee to lay eggs. This unsightly hole creates not only cosmetic flaws in the building, but the hole will also weaken the wood and create a point at which water can enter, causing further damage to the building. In addition, the hole can be used by other insects that further damage the wood, such as carpenter ants, termites, and the like. The male carpenter bee does not sting, but is a highly aggressive and territorial insect, often times becoming a significant nuisance to humans that are in proximity to the carpenter bee's hole. Often times the carpenter bee holes are near an outside deck or patio, and can greatly annoy the occupants of such a deck or patio.

The related art has disclosed numerous forms of pesticides that are used to kill flying insects such as hornets, wasps, bees, and the like. Such pesticides are often contained in an aerosol can that is capable of spraying an intense stream of pesticide in excess of twenty feet, providing a sufficient trajectory to reach most carpenter bee holes. Many of these pesticides will knock down an airborne insect that contacts the spray. The carpenter bee is a highly agile flyer, and can avoid a jet stream of pesticide while flying. Carpenter bee holes are often times sprayed with a pesticide in an attempt to control their damage. Unfortunately, it is extremely difficult to spray the carpenter bee eggs with pesticide because the carpenter bee tunnels make a right angle turn from their point of entry. These difficulties make the use of pesticides ineffective, and result in unnecessary and ineffective application of pesticides, causing significant environmental damage.

U.S. Pat. No. 6,766,611 entitled "Carpenter Bee Trap" discloses a plastic box with a hole to trap carpenter bees. The premise of such a trap is that the carpenter bees will enter the hole in the plastic box, and will be unable to find their way back out of the plastic box. For the few carpenter bees that are not physically able to locate the hole and exit the box, this leaves a live carpenter bee in the box that requires disposal.

It is an object of the present invention to provide a carpenter bee trap that does not rely on the use of harmful pesticides. It is another object of the present invention to provide a carpenter bee trap that does not require the user to dispose of a live carpenter bee. It is another object of the present invention to provide a carpenter bee trap that, in one embodiment of the present invention, uses solar power to kill carpenter bees. It is



a further object of the present invention to provide a carpenter bee trap that is effective in eliminating carpenter bees from a dwelling or area.

## BRIEF SUMMARY OF THE INVENTION

In accordance with the present invention, there is provided an electronic carpenter bee trap comprising a housing having a hole to entice carpenter bees to enter the housing, said hole being of a size similar to the holes normally made by carpenter bees, an electrode assembly in proximity to said hole, and a power source connected to said electrode. The foregoing paragraph has been provided by way of introduction, and is not intended to limit the scope of the following claims.

## BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be described by reference to the following drawings, in which like numerals refer to like elements, and in which:

FIG. **1** is a perspective view of an electronic carpenter bee trap according to one embodiment of the present invention;

FIG. **2** is a perspective view of an electronic carpenter bee trap with mounting clamps;

FIG. **3** is a perspective view of an electronic carpenter bee trap attached to a post;

FIG. **4** is a plan view of an entry hole for an electronic carpenter bee trap showing electrodes that are used to kill carpenter bees; and

FIG. **5** is a block diagram of circuitry used to energize electrodes that are used to kill carpenter bees.

FIG. **6** illustrates one embodiment of the electronic carpenter bee trap in use protecting a cedar sided house.

FIG. **7** is a cross sectional view of a pine board that was damaged by a carpenter bee.

The present invention will be described in connection with a preferred embodiment, however, it will be understood that there is no intent to limit the invention to the embodiment described. On the contrary, the intent is to cover all alternatives, modifications, and equivalents as may be included within the spirit and scope of the invention as defined by the appended claims.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

For a better understanding of the present invention, a short preface describing one attribute of the behavior of carpenter bees is essential. It is well known that carpenter bees bore holes in wood to create nests. The carpenter bees do not eat the wood, but use it merely to create a nest for laying eggs and raising young. The hole that is made by the carpenter bee is commonly about 5/16 to about ½ inch in diameter. Through experimental observation and studies conducted by the inventor, he has observed that carpenter bees will often times be attracted to a pre-existing hole, and if the hole is of the size frequently made by carpenter bees, the carpenter bee will preferentially use a pre-existing hole, apparently avoiding the effort involved in boring a new hole. The carpenter bee, upon encountering a pre-existing hole, will be attracted to the pre-existing hole, and will enter the pre-existing hole to investigate its possible use as a nesting site. The applicant conducted experiments in the spring and summer of 2004 to determine what characteristics of a pre-existing hole are necessary to entice a carpenter bee to enter a manmade hole. It was noted that a manmade hole of from about 5/16 inch to about ⅞ inch, made in wood, would entice a carpenter bee to enter the hole.

Carpenter bees preferred soft species of wood such as pine to hardwood species such as oak, cherry, or walnut. The present invention uses this behavioral trait of carpenter bees to attract and kill the carpenter bees before they have a chance to bore new holes in a home or building. By destroying the carpenter bees before they have a chance to reproduce, the area surrounding a home or building is kept free of carpenter bees and their related damage without the use of toxic pesticides. If a carpenter bee population around a home or building is left unchecked, the population can grow over several years, creating ongoing structural and cosmetic damage to the home or building. The inventor attached the Electronic Carpenter Bee trap to a gutter of his home in the spring of 2006, and by late June of 2006 he had completely eliminated the carpenter bee infestation and resulting wood damage to his home.

For a general understanding of the present invention, reference is made to the drawings. In the drawings, like reference numerals have been used throughout to designate identical elements.

FIG. **1** is a perspective view of an electronic carpenter bee trap **100** according to one embodiment of the present invention. Referring to FIG. **1**, a housing **101** is shown. The housing may be rectangular in shape, or may be of any geometry that is convenient to produce. The shape of the housing **101** does not have as much of a bearing on the effectiveness of the electronic carpenter bee trap as the shape of the entry hole **103** does. The housing **101** may be made of wood, a preferred nesting material for carpenter bees. The housing **101** may also be made from recycled wood composite, plastic, aluminum, masonry, or any other material that is not repugnant to carpenter bees. The housing **101** contains an entry hole **103** with a diameter of from about ¼ inch to about 1 inch. In a preferred embodiment of the present invention, the diameter of the entry hole **103** is from about 5/16 inch to about ¾ inch. In proximity to the entry hole **103** are electrodes that will be more clearly illustrated and described by way of FIG. **4**. The entry hole **103** may be located at any point on the surface of the housing **101**. In one embodiment of the present invention, the entry hole **103** is located on the bottom **105** of the housing **101**. As will be more clearly illustrated by way of FIGS. **4** and **5**, the housing **101** contains electronics (not shown in FIG. **1**) that energize electrodes that are located in proximity to the entry hole **103**. The electronics are powered, in one embodiment of the present invention, by a solar panel **107** that is attached to the housing **101**. The housing **101** may, in some embodiments of the present invention, be machined from wood or a metal to accommodate the electronics. The housing **101** may also be molded from a plastic. The electronics are contained within the housing **101**, and are made weather resistant through the use of gaskets, sealants, and other techniques that are well known to those skilled in the art.

To use the electronic carpenter bee trap, the trap is placed in an area where carpenter bees are known to be a problem, often times near a house or building, or physically attached to a house or building. The electronic carpenter bee trap is left undisturbed, and over time, carpenter bees that are investigating suitable nesting locations will come upon the electronic carpenter bee trap, observe the entry hole, and upon entering the entry hole, will make contact with energized electrodes and be destroyed. The dead carpenter bee will then drop from the entry hole, and the electronic carpenter bee trap will be ready to destroy the next carpenter bee that enters the entry hole. The electronic carpenter bee trap will eliminate carpenter bees before they have a chance to infest and damage a house or building. Several traps may be placed at various locations near a building or house to increase the area of protection.

FIG. **2** shows a perspective view of an electronic carpenter bee trap with mounting clamps **200**. A first clamp **201**, and in some embodiments of the present invention, a second clamp **203**, are attached to the housing **101**. The clamps can be c-clamps, ratchet clamps, pressure clamps, hose clamps, or another style clamp that allows the electronic carpenter bee trap to be mounted to a house or a building. An example of a mounting location for the electronic carpenter bee trap is on the gutter of a building. A gutter provides an open lip upon which the electronic carpenter bee trap with clamps **200** can be safely mounted. For added safety, the electronic carpenter bee trap with clamps **200** can also be fitted with a wire or string (not shown) and attached to a gutter nail or gutter bracket as an added safety measure.

In some embodiments of the present invention, the electronic carpenter bee trap may be attached to a tree using screws, nails, wire, or other fastening techniques known to those skilled in the art.

Turning now to FIG. **3**, a perspective view of an electronic carpenter bee trap attached to a post is shown. For situations where attaching an electronic carpenter bee trap to a house or a building is not practical or desired, the electronic carpenter bee trap may be attached to a post **301** and driven into the ground. The post **301** may be made of wood, metal, plastic, or the like.

FIG. **4** shows a plan view of an entry hole assembly **400**. The entry hole **103** that is illustrated by way of FIG. **4** does not show the surrounding housing of the electronic carpenter bee trap **100** for the purpose of clarity. Within the entry hole **103**, a first electrode **405** and a second electrode **407** are attached. In some embodiments of the present invention, additional electrodes may be added. The first electrode **405** and the second electrode **407** are made of a conductive metal such as copper, brass, steel, stainless steel, gold, silver, aluminum, or the like. The first electrode **405** and the second electrode **407** may, in some embodiments of the present invention, be curved, spiral, or contain an irregular surface to increase the probability of electrical contact between the electrode and the carpenter bee. The electrodes may be placed at any point along the entry hole. In some embodiments of the present invention, the entry hole may make a right angle turn, similar to the hole structure made by a carpenter bee (see FIG. **7**), and the electrodes may be placed at any point along this right angle hole structure. The electrodes are retained in proximity of the entry hole by a first retainer **401** and a second retainer **403**. In some embodiments of the present invention, additional retainers may be added. The first retainer **401** and the second retainer **403** are made from an insulating material such as a plastic, ceramic, rubber, or the like. Upon entering the entry hole **103**, the carpenter bee will make physical contact with the first electrode **405** and the second electrode **407**, thus completing an electrical circuit where electrical charge is transferred through the carpenter bee, causing the carpenter bee to die. The carpenter bee will fall from the entry hole **103**, readying the electronic carpenter bee trap for the next carpenter bee.

FIG. **5** is a block diagram **500** of circuitry used to energize electrodes that are used to kill carpenter bees. A power source **501** is used to charge a charge storage device **505** such as a battery or an ultracapacitor. The power source **501**, in one embodiment of the present invention, is a photovoltaic panel such as the solar panel **107** illustrated in FIGS. **1**, **2** and **3**. The solar panel **107** provides the electronic carpenter bee trap with a source of renewable and clean power, and does not require wires, extension cords, or electrical outlets. In addition, carpenter bees are most active during periods of bright sunshine, making this form of energy highly practical. To provide for an instantaneous burst of energy sufficient to kill a carpenter bee, the power source **501** is connected to a voltage regulator/charging circuit **503** that is in turn connected to a charge storage device **505** such as a battery or an ultracapacitor. Batteries include sealed lead acid batteries, Nickel Metal Hydride batteries, Nickel Cadmium Batteries, Lithium Ion batteries, and other batteries that are capable of being charged and discharged repeatedly. The charge storage device **505** is in turn connected to a voltage multiplier circuit **507**. Voltage multiplier circuits are well known to those skilled in the art, and may include capacitors and rectifiers. The voltage multiplier circuit **507** is connected to a first electrode **405** and a second electrode **407**. The first electrode **405** and the second electrode **407** are located in proximity to the entry hole **103**, as has been clearly illustrated and described by way of FIG. **4**.

Turning now to FIG. **6**, there is shown an electronic carpenter bee trap **100** according to one embodiment of the present invention, in use protecting a cedar sided house. The electronic carpenter bee trap **100**, as shown in FIG. **6**, is attached to the gutter of a house by way of clamps (not shown), such as the clamps previously depicted in FIG. **2**. The bottom **105** of the electronic carpenter bee trap, in the embodiment depicted, is wood. Other materials that resemble wood, such as various plastics, may also be used. The entry hole **103** is shown projecting downward from the bottom **105** of the electronic carpenter bee trap. The entry hole contains electrodes, as described previously in this specification. The electrodes are not visible in FIG. **6**. The housing **101** is a weathertight enclosure that contains the electronics that have been previously described in this specification and by way of FIG. **5**. Carpenter bees looking for suitable infestation sites were observed to preferentially enter the entry hole **103** of the carpenter bee trap **100**, where they encountered energized electrodes and were electrocuted. The unit depicted in FIG. **6** was installed on gutters of the inventor's cedar sided house in the spring of 2006, and it was noted that by early July of 2006 there were no remaining carpenter bees or their associated structural damage evident in or around the cedar sided house.

Lastly, FIG. **7** is a cross sectional view of a pine board **700** that was damaged by a carpenter bee. The carpenter bee bored a hole **701** in the board, and made a right angle turn in the board. The board was cut at the ends to show the burrow **703** that was made by the carpenter bee.

It is, therefore, apparent that there has been provided, in accordance with the various objects of the present invention, an apparatus for trapping and killing carpenter bees. While the various objects of this invention have been described in conjunction with preferred embodiments thereof, it is evident that many alternatives, modifications, and variations will be apparent to those skilled in the art. Accordingly, it is intended to embrace all such alternatives, modifications and variations that fall within the spirit and broad scope of this specification and the claims appended herein.

What is claimed is:

**1**. An electronic insect trap comprising a housing having a top, a bottom extending within a horizontal plane, and a generally round hole that extends through the bottom of said housing for the entry of insects, said hole being open to and communicating with the ambient environment and of a size similar to the holes normally made by carpenter bees, an entry hole area constituting less than 25% of an area of a lower exterior surface of the housing, an electrode assembly within the housing and in proximity to said hole, and a power source electronically connected to said electrode assembly; and wherein light cannot pass through any other part of the insect trap except for the entry hole.



**2**. The electronic insect trap of claim **1**, wherein the hole has a diameter within the range of from about 5/16 inch to about 3/4 inch.

**3**. The electronic insect trap of claim **1**, wherein the housing is made from wood.

**4**. The electronic insect trap of claim **1**, wherein the housing is made from a plastic.

**5**. The electronic insect trap of claim **1**, wherein the power source is a battery.

**6**. The electronic insect trap of claim **1**, wherein the power source is an ultracapacitor.

**7**. The electronic insect trap of claim **1**, further including a solar panel operatively connected to the power source.

**8**. The electronic insect trap of claim **1**, wherein the power source is a solar panel.

**9**. The electronic insect trap of claim **1**, further including mounting clamps attached to said housing for attaching the carpenter bee trap to a structure.

**10**. A carpenter bee trap comprising a housing having a top, a bottom extending within a horizontal plane, and a generally round entry hole that extends through the bottom of the housing to entice carpenter bees to enter the housing, said entry hole being open to and communicating with the ambient environment and of a size similar to the holes normally made by carpenter bees, an entry hole area constituting less than 25% of an area of a lower exterior surface of the housing, an electrode assembly within the housing and in proximity to said hole, and a power source electronically connected to said electrode assembly; and wherein light cannot pass through any other part of the carpenter bee trap except for the entry hole.

**11**. A carpenter bee trap comprising a housing having a top, a bottom extending within a horizontal plane, and a generally round entry hole that extends through the bottom of the housing to entice carpenter bees to enter the housing, said entry hole being open to and communicating with the ambient environment and of a size similar to the holes normally made by carpenter bees, an entry hole area constituting less than 25% of an area of the bottom of the housing, an electrode assembly within the housing and in proximity to said hole, and a power source electronically connected to said electrode assembly; and wherein light cannot pass through any other part of the carpenter bee trap except for the entry hole.

**12**. The carpenter bee trap of claim **1**, wherein the hole has a diameter within the range of from about 5/16 inch to about 3/4 inch.

**13**. The carpenter bee trap of claim **1**, wherein the housing is made from wood.

**14**. The carpenter bee trap of claim **1**, wherein the housing is made from a plastic.

**15**. The carpenter bee trap of claim **1**, wherein the power source is a battery.

**16**. The carpenter bee trap of claim **1**, wherein the power source is an ultracapacitor.

**17**. The carpenter bee trap of claim **1**, further including a solar panel operatively connected to the power source.

**18**. The carpenter bee trap of claim **1**, wherein the power source is a solar panel.

**19**. The carpenter bee trap of claim **1**, further including mounting clamps attached to said housing for attaching the carpenter bee trap to a structure.

**20**. The carpenter bee trap of claim **19**, wherein the mounting clamps are gutter clamps.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

# CERTIFICATE OF CORRECTION

PATENT NO. : 7,757,432 B2
APPLICATION NO. : 11/456210
DATED : July 20, 2010
INVENTOR(S) : Robert Dale Gunderman, Jr

Page 1 of 1

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 6, lines 44-61, in claims 12-19, for the claim reference numeral '1', each occurrence, should read -10-. (dependent claims 12-19 should refer back to claim 10, not claim 1).

Signed and Sealed this
Fifteenth Day of May, 2012

David J. Kappos

David J. Kappos
*Director of the United States Patent and Trademark Office*

# Tab 8

*Pazik, Windsor, Warner & Page*

| Claim Element | Prior Art Citation |
|---|---|
| 1. A carpenter bee trap comprising: | Pazik discloses a flying insect trap. Para. 0001.<br><br>Windsor discloses a carpenter bee trap. Para. 0006. |
| a trap entrance unit forming a plenum being made of wood or a wood substitute; | The trap of Pazik forms a plenum and is manufactured from a wood substitute. Para. 0007.<br><br>Windsor teaches that a carpenter bee trap is preferably made of wood. Para. 0017. |
| said trap entrance unit having at least one hole drilled there-through and sized to mimic a natural carpenter bee nest tunnel so as to provide a primary attractant; | Pazik teaches at least one hole in a trap entrance unit that extends from outside of the trap entrance unit to the inside. Fig. 2; paras. 0014-0020, 0097.<br><br>Windsor also at least one hole forming a trap entrance that extends from outside of the trap to the inside of the trap. Fig. 3C. Windsor discloses that its entrances are sized for and to attract carpenter bees. Paras. 0018 and 0023. |
| said hole extending from the outside of the trap unit to a plenum interior; | Pazik teaches at least one hole that extends from outside of the trap unit to the inside of the trap. Fig. 2; paras. 0015-0023.<br><br>Windsor also at least one hole forming a trap entrance that extends from outside of the trap to the inside of the trap. Fig. 3C; para. 0007. |

| | |
|---|---|
| said hole being configured to extend substantially horizontally or at an upward angle; | Both Pazik and Windsor teach a hole that is substantially horizontal or at an upwards angle. *See* Pazik at Fig. 2; para. 0015 and Windsor para. 0018. |
| a means to shelter an entrance to said hole is provided to reduce the admittance of ambient light; | This is a means plus function pursuant to 35 USC § 112(f). Warner teaches a flange that provides shelter to the entrance hole. Fig. 1; col. 1, ll. 47-50.<br><br>Alternatively, Windsor teaches walls that would shelter an entrance hole. Figs. 2 and 4. |
| said trap unit further comprising a receptacle adapter being substantially located at the bottom of said trap unit and being configured to receive a clear or translucent receptacle; | Pazik teaches a clear receptacle received by a receptacle adapter at the bottom of the trap. Fig. 35; paras. 0046, 0096-0099, 0101 and 0188. |
| a receptacle received by said adapter situated to allow ambient light to enter through said bottom into said plenum interior, thereby providing a secondary attractant; said receptacle further being provided to receive trapped bees. | Pazik teaches a clear receptacle received by a receptacle adapter which receives and helps retain the receptacle that catches bees and provides a secondary attractant for bees as ambient light may enter through the bottom of the receptacle. Fig. 1; paras. 0046-0048.<br><br>Carpenter bee's phototactic behavior was well known in the prior art as early as 2006. Page, pg., 261; Pazik 0023. |
| | |
| 2. The carpenter bee trap of claim 1, wherein the receptacle is temporarily attached to the trap. | Pazik teaches a receptable that is removable and thus temporarily attached to the trap. Figs. 0033-0036; Para. 0118. |
| | |

| | |
|---|---|
| 4. The carpenter bee trap of claim 1, wherein the receptacle is configured to be screwed into said bottom of said plenum. | Pazik discloses a receptacle capable of being screwed into the plenum. Fig. 35; para. 0118. |
| | |
| 7. The carpenter bee trap of claim 1, wherein the diameter of the at least one hole is between ½ inch to ¾ inch. | Windsor teaches that the hole is between ½ and ¾ inches. Para. 0023. |
| | |
| 8. The carpenter bee trap of claim 1, wherein a back panel of the plenum is vertical and has a flat exterior to allow flush mounting. | Windsor discloses a plenum having a vertical back panel with a flat exterior allowing flush mounting. Figs. 4, 5A, 5B, 5C and para. 0026. |
| | |
| 13. A carpenter bee trap, comprising: | Pazik discloses a flying insect trap. Para. 0001.<br><br>Windsor discloses a carpenter bee trap. Para. 0006. |
| a trap entrance unit formed of wood or a wood substitute, wherein at least one side of the trap entrance unit has at least one entrance hole that extends from outside the trap entrance unit to an interior of the trap entrance unit, wherein the at least one entrance hole extends substantially horizontally or at an upward angle with a size and shape configured to provide a primary attractant for carpenter bees, and | The trap of Pazik is manufactured from a wood substitute. Para. 0007. Pazik teaches at least one hole forming that extends from outside of the trap to the inside of the trap. Fig. 2; paras. 0015-0020.<br><br>Windsor teaches that a carpenter bee trap is preferably made of wood. Para. 0017. Windsor also at least one hole forming a trap entrance that extends from outside of the trap to the inside of the trap. Fig. 3C. Windsor discloses that its entrances are sized for and to attract carpenter bees. Paras. 0018 and 0023. |

| | |
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| | Both Pazik and Windsor teach a hole that is substantially horizontal or at an upwards angle. *See* Pazik at Fig. 2; para. 0015 and Windsor para. 0018. |
| wherein the trap entrance unit further comprises an exit opening for providing an exit path from the interior of the trap entrance unit; and | Pazik discloses that the trap unit has an exit leading to the receptacle. Fig. 2; paras. 0096, 0098, 0101 and 0106. |
| a receptacle adapter located at the exit opening of the trap entrance unit, wherein the receptacle adapter is adapted to receive at least one receptacle and is adapted so as to allow at least some ambient light to enter the interior of the trap entrance unit via the exit opening, thereby providing a secondary attractant for carpenter bees. | Pazik discloses a receptacle adapter configured to receive a clear or translucent receptacle. Fig. 35; paras. 0046, 0096, 0101 and 0118. Pazik also teaches a clear receptacle that is received by a receptacle adapter which receives and helps retain the receptacle wherein the clear receptacle provides a secondary attractant to bees and allows some light to enter the exit opening. Fig. 1; paras. 0046, 0048 and 0132.<br><br>Carpenter bee's phototactic behavior was well known in the prior art as early as 2006. Page, pg., 261; Pazik 0023. |
| | |
| 14. The carpenter bee trap of claim 13, further comprising a receptacle removably attached to the receptacle adapter. | Pazik teaches a receptable that is removable and thus temporarily attached to the trap. Para. 0118. |
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| 15. The carpenter bee trap of claim 14, wherein the receptacle is clear or translucent. | Pazik also teaches a clear receptacle that is received by a receptacle adapter wherein the clear receptacle provides a secondary attractant to bees. Fig. 1; paras. 0046, 0048 and 0132. |
| | |
| 16. The carpenter bee trap of claim 13, wherein the trap entrance unit comprises at least one top panel that overhangs a side wall of the trap entrance unit. | Warner discloses a top panel that overhangs a side wall of the trap entrance unit. Fig. 1. |
| | |
| 17. The carpenter bee trap of claim 13, wherein the at least one entrance hole extends at an upward angle. | Both Pazik and Windsor teach a hole that is at an upwards angle. *See* Pazik at Fig. 2; para. 0015 and Windsor para. 0018. |

*Prince, Pazik, Windsor & Warner*

| Claim Element | Prior Art Citation |
|---|---|
| 1. A carpenter bee trap comprising: | Pazik discloses a flying insect trap. Para. 0001.<br><br>Prince discloses a carpenter bee trap. Col. 1, ll. 30-35. |
| a trap entrance unit forming a plenum being made of wood or a wood substitute; | Prince discloses a bee trap having a trap entrance unit with a plenum made of wood or a wood substitute. Col. 2, ll. 18-23.<br><br>Alternatively, the trap of Pazik forms a plenum and is manufactured from a wood substitute. Para. 0007.<br><br>Windsor teaches that a carpenter bee trap is preferably made of wood. Para. 0017. |
| said trap entrance unit having at least one hole drilled there-through and sized to mimic a natural carpenter bee nest tunnel so as to provide a primary attractant; | Prince teaches a trap entrance unit with multiple holes therein which are sized to attract carpenter bees. Col. 2, ll. 32-38. |
| said hole extending from the outside of the trap unit to a plenum interior; | The holes in the trap entrance unit taught by Prince extend from outside to the inside of the trap entrance unit. Figs. 1, 4, 5, 6 and 9. Col. 2, ll. 32-38. |
| said hole being configured to extend substantially horizontally or at an upward angle; | Both Pazik and Windsor teach a hole that is substantially horizontal or at an upwards angle. *See* Pazik at Fig. 2; para. 0015 and Windsor para. 0018.<br><br>The entrance holes of Prince are substantially horizontal. Figs. 1-7. |

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|---|---|
| a means to shelter an entrance to said hole is provided to reduce the admittance of ambient light; | This is a means plus function pursuant to 35 USC § 112(f).<br><br>Warner teaches a flange that provides shelter to the entrance hole. Fig. 1; col. 1, ll. 47-50.<br><br>Alternatively, Windsor teaches walls that would shelter an entrance hole. Figs. 2 and 4. |
| said trap unit further comprising a receptacle adapter being substantially located at the bottom of said trap unit and being configured to receive a clear or translucent receptacle; | Pazik teaches a clear receptacle received by a receptacle adapter which receives and helps retain the receptacle at the bottom of the trap. Fig. 35; paras. 0046, 0096-0099, 0101 and 0188. |
| a receptacle received by said adapter situated to allow ambient light to enter through said bottom into said plenum interior, thereby providing a secondary attractant; said receptacle further being provided to receive trapped bees. | Pazik teaches a clear receptacle received by a receptacle adapter that catches or receives bees and provides a secondary attractant for bees as ambient light may enter through the bottom of the receptacle. Fig. 1; paras. 0046-0048.<br><br>Carpenter bee's phototactic behavior was well known in the prior art as early as 2006. Pazik 0023. |
| | |
| 2. The carpenter bee trap of claim 1, wherein the receptacle is temporarily attached to the trap. | Pazik teaches a receptable that is removable. Fig. 0033-0036; Para. 0118. |
| | |

| | |
|---|---|
| 4. The carpenter bee trap of claim 1, wherein the receptacle is configured to be screwed into said bottom of said plenum. | Pazik discloses a receptacle capable of being screwed into the plenum. Fig. 35; para. 0118. |
| | |
| 7. The carpenter bee trap of claim 1, wherein the diameter of the at least one hole is between ½ inch to ¾ inch. | Windsor discloses that the entrance hole is between ½ and ¾ inch. Para. 0023. |
| | |
| 8. The carpenter bee trap of claim 1, wherein a back panel of the plenum is vertical and has a flat exterior to allow flush mounting. | Windsor discloses that the back panel of the plenum is vertical and has a flat exterior for mounting flush. Figs. 4, 5A, 5B, 5C and 5D; paras. 0019-0020. |
| | |
| 13. A carpenter bee trap, comprising: | Pazik discloses a flying insect trap. Para. 0001. Prince, col. 1, ll. 30-35. |
| a trap entrance unit formed of wood or a wood substitute, wherein at least one side of the trap entrance unit has at least one entrance hole that extends from outside the trap entrance unit to an interior of the trap entrance unit, wherein the at least one entrance hole extends substantially horizontally or at an upward angle with a size and shape configured to provide a primary attractant for carpenter bees, and | Prince discloses a bee trap having a trap entrance unit with a plenum made of wood or a wood substitute. Col. 2, ll. 18-23. Prince teaches a trap entrance unit with multiple holes therein which are sized to attract carpenter bees. Col. 2, ll. 32-38. The holes in the trap entrance unit taught by Prince extend from outside to the inside of the trap entrance unit. Figs. 1, 4, 5, 6 and 9. Col. 2, ll. 32-38.<br><br>Both Pazik and Windsor teach a hole that is substantially horizontal or at an upwards angle. See Pazik at Fig. 2; para. 0015 and Windsor para. 0018. The entrance holes of Prince are substantially horizontal. Figs. 1-7. |

| | |
|---|---|
| wherein the trap entrance unit further comprises an exit opening for providing an exit path from the interior of the trap entrance unit; and | Pazik discloses that the trap unit has an exit leading to the receptacle. Fig. 2; paras. 0096, 0098, 0101 and 0106. |
| a receptacle adapter located at the exit opening of the trap entrance unit, wherein the receptacle adapter is adapted to receive at least one receptacle and is adapted so as to allow at least some ambient light to enter the interior of the trap entrance unit via the exit opening, thereby providing a secondary attractant for carpenter bees. | Pazik discloses a receptacle adapter configured to receive and help retain a clear or translucent receptacle. Fig. 35; paras. 0046, 0096, 0101 and 0118.<br><br>Pazik also teaches a clear receptacle that is received by a receptacle adapter wherein the clear receptacle provides a secondary attractant to bees. Fig. 1; paras. 0046, 0048 and 0132.<br><br>Carpenter bee's phototactic behavior was well known in the prior art as early as 2006. Pazik 0023. |
| | |
| 14. The carpenter bee trap of claim 13, further comprising a receptacle removably attached to the receptacle adapter. | Pazik teaches a receptable that is removable and thus temporarily attached to the trap. Para. 0118. |
| | |
| 15. The carpenter bee trap of claim 14, wherein the receptacle is clear or translucent. | Pazik also teaches a clear receptacle. Fig. 1; paras. 0046, 0048 and 0132. |
| | |
| 16. The carpenter bee trap of claim 13, wherein the trap entrance unit comprises at least one top panel that overhangs a side wall of the trap entrance unit. | Warner discloses a top panel that overhangs a side wall of the trap entrance unit. Fig. 1. |
| | |

| | |
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| 17. The carpenter bee trap of claim 13, wherein the at least one entrance hole extends at an upward angle. | Both Pazik and Windsor teach a hole that is substantially horizontal or at an upwards angle. See Pazik at Fig. 2; para. 0015. |

*Gunderman, Pazik, Windsor & Warner*

| **Claim Element** | **Prior Art Citation** |
|---|---|
| 1. A carpenter bee trap comprising: | Pazik discloses a flying insect trap. Para. 0001.<br><br>Gunderman discloses a carpenter bee trap. Col. 3, ll. 20-22. |
| a trap entrance unit forming a plenum being made of wood or a wood substitute; | Gunderman discloses a housing made of wood or a wood substitute wherein said housing has a plenum. Col. 3, ll. 27-34. |
| said trap entrance unit having at least one hole drilled there-through and sized to mimic a natural carpenter bee nest tunnel so as to provide a primary attractant; | Gunderman teaches a housing having one or more entry holes of a diameter between 5/16 to ¾ of an inch.<br><br>Col. 3., ll. 27-34. Entry holes of that size are known to be an attractant to carpenter bees. Col. 2, ll. 52-67. |
| said hole extending from the outside of the trap unit to a plenum interior; | Pazik teaches at least one hole forming a trap entrance that extends from outside of the trap to the inside of the trap. Fig. 2; paras. 0015-0023. |
| said hole being configured to extend substantially horizontally or at an upward angle; | Both Pazik and Windsor teach a hole that is substantially horizontal or at an upwards angle. *See* Pazik at Fig. 2; para. 0015 and Windsor para. 0018. |
| a means to shelter an entrance to said hole is provided to reduce the admittance of ambient light; | This is a means plus function pursuant to 35 USC 112(f).<br><br>Warner teaches a flange that provides shelter to the entrance hole. Fig. 1; col. 1, ll. 47-50. Alternatively, Windsor teaches walls that would shelter an entrance hole. Figs. 2 and 4. |

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| said trap unit further comprising a receptacle adapter being substantially located at the bottom of said trap unit and being configured to receive a clear or translucent receptacle; | Pazik teaches a clear receptacle received by a receptacle adapter which receives and helps retain the receptacle at the bottom of the trap. Fig. 35; paras. 0046, 0096-0099, 0101 and 0188. |
| a receptacle received by said adapter situated to allow ambient light to enter through said bottom into said plenum interior, thereby providing a secondary attractant; said receptacle further being provided to receive trapped bees. | Pazik teaches a clear receptacle received by a receptacle adapter that catches bees and provides a secondary attractant for bees as ambient light may enter through the bottom of the receptacle. Fig. 1; paras. 0046-0048.<br><br>Carpenter bee's phototactic behavior was well known in the prior art as early as 2006. Pazik, para. 0023. |
| | |
| 2. The carpenter bee trap of claim 1, wherein the receptacle is temporarily attached to the trap. | Pazik teaches a receptable that is removable and thus temporarily attached to the trap. Figs. 0033-0036; Para. 0118 |
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| 4. The carpenter bee trap of claim 1, wherein the receptacle is configured to be screwed into said bottom of said plenum. | Pazik discloses a receptacle capable of being screwed into the plenum. Fig. 35; para. 0118. |
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| 7. The carpenter bee trap of claim 1, wherein the diameter of the at least one hole is between ½ inch to ¾ inch. | Gunderman teaches a housing having one or more entry holes of a diameter between 5/16 to ¾ of an inch. |
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| 8. The carpenter bee trap of claim 1, wherein a back panel of the plenum is vertical and has a flat exterior to allow flush mounting. | Gunderman discloses a plenum having a flat back panel that is vertical and allows for flush mounting. Figs. 1-3.<br><br>Windsor discloses that the back panel of the plenum is vertical and has a flat exterior for mounting flush. Figs. 4, 5A, 5B, 5C and 5D; paras. 0019-0020. |
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| 13. A carpenter bee trap, comprising: | |
| a trap entrance unit formed of wood or a wood substitute, wherein at least one side of the trap entrance unit has at least one entrance hole that extends from outside the trap entrance unit to an interior of the trap entrance unit, wherein the at least one entrance hole extends substantially horizontally or at an upward angle with a size and shape configured to provide a primary attractant for carpenter bees, and | Gunderman discloses a housing made of wood or a wood substitute wherein said housing has a plenum. Col. 3, ll. 27-34.<br><br>Gunderman teaches a housing having one or more entry holes of a diameter between 5/16 to ¾ of an inch. Col. 3., ll. 27-34. Entry holes of that size are known to be an attractant to carpenter bees. Col. 2, ll. 52-67.<br><br>Pazik teaches at least one hole forming a trap entrance that extends from outside of the trap to the inside of the trap. Fig. 2; paras. 0015-0023. |

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| wherein the trap entrance unit further comprises an exit opening for providing an exit path from the interior of the trap entrance unit; and | Pazik teaches a hole that is substantially horizontal or at an upwards angle. See Pazik at Fig. 2; para. 0015. |
| a receptacle adapter located at the exit opening of the trap entrance unit, wherein the receptacle adapter is adapted to receive at least one receptacle and is adapted so as to allow at least some ambient light to enter the interior of the trap entrance unit via the exit opening, thereby providing a secondary attractant for carpenter bees. | Pazik discloses a receptacle adapter configured to receive and help retain a clear or translucent receptacle. Fig. 35; paras. 0046, 0096, 0101 and 0118.<br><br>Pazik also teaches a clear receptacle that is received by a receptacle adapter wherein the clear receptacle provides a secondary attractant to bees. Fig. 1; paras. 0046, 0048 and 0132.<br><br>Carpenter bee's phototactic behavior was well known in the prior art as early as 2006. Pazik, para. 0023. |
| | |
| 14. The carpenter bee trap of claim 13, further comprising a receptacle removably attached to the receptacle adapter. | Pazik teaches a receptable that is removable and thus temporarily attached to the trap. Para. 0118. |
| | |
| 15. The carpenter bee trap of claim 14, wherein the receptacle is clear or translucent. | Pazik also teaches a clear receptacle that is received by a receptacle adapter wherein the clear receptacle provides a secondary attractant to bees. Fig. 1; paras. 0046, 0048 and 0132. |
| | |
| 16. The carpenter bee trap of claim 13, wherein the trap entrance unit comprises at least one top panel that overhangs a side wall of the trap entrance unit. | Warner discloses a top panel that overhangs a side wall of the trap entrance unit. Fig. 1. |

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| 17. The carpenter bee trap of claim 13, wherein the at least one entrance hole extends at an upward angle. | Both Pazik and Windsor teach a hole that is substantially horizontal or at an upwards angle. See Pazik at Fig. 2; para. 0015 and Windsor para. 0018. |

*Pazik, Windsor & Warner*

| Claim Element | Prior Art Citation |
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| 1. A carpenter bee trap comprising: | Pazik discloses a flying insect trap. Para. 0001.<br><br>Windsor discloses a carpenter bee trap. Para. 0006. |
| a trap entrance unit forming a plenum being made of wood or a wood substitute; | The trap of Pazik forms a plenum and is manufactured from a wood substitute. Para. 0007.<br><br>Windsor teaches that a carpenter bee trap is preferably made of wood. Para. 0017. |
| said trap entrance unit having at least one hole drilled there-through and sized to mimic a natural carpenter bee nest tunnel so as to provide a primary attractant; | Pazik teaches at least one hole forming a trap entrance that extends from outside of the trap to the inside of the trap. Fig. 2; paras. 0014-0020, 0097.<br><br>Windsor also at least one hole forming a trap entrance that extends from outside of the trap to the inside of the trap. Fig. 3C. Windsor discloses that its entrances are sized for and to attract carpenter bees. Paras. 0018 and 0023. |
| said hole extending from the outside of the trap unit to a plenum interior; | Pazik teaches at least one hole forming a trap entrance that extends from outside of the trap to the inside of the trap. Fig. 2; paras. 0015-0023.<br><br>Windsor also at least one hole forming a trap entrance that extends from outside of the trap to the inside of the trap. Fig. 3C; paras. 0007. |

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| said hole being configured to extend substantially horizontally or at an upward angle; | Both Pazik and Windsor teach a hole that is substantially horizontal or at an upwards angle. *See* Pazik at Fig. 2; para. 0015 and Windsor para. 0018. |
| a means to shelter an entrance to said hole is provided to reduce the admittance of ambient light; | This is a means plus function pursuant to 35 USC § 112(f). Warner teaches a flange that provides shelter to the entrance hole. Fig. 1; col. 1, ll. 47-50.<br><br>Alternatively, Windsor teaches walls that would shelter an entrance hole. Figs. 2 and 4. |
| said trap unit further comprising a receptacle adapter being substantially located at the bottom of said trap unit and being configured to receive a clear or translucent receptacle; | Pazik teaches a clear receptacle received by a receptacle adapter which receives and helps retain the receptacle at the bottom of the trap. Fig. 35; paras. 0046, 0096-0099, 0101 and 0188. |
| a receptacle received by said adapter situated to allow ambient light to enter through said bottom into said plenum interior, thereby providing a secondary attractant; said receptacle further being provided to receive trapped bees. | Pazik teaches a clear receptacle received by a receptacle adapter that catches bees and provides a secondary attractant for bees as ambient light may enter through the bottom of the receptacle. Fig. 1; paras. 0046-0048.<br><br>Carpenter bee's phototactic behavior was well known in the prior art as early as 2006. Pazik, para. 0023. |
| | |
| 2. The carpenter bee trap of claim 1, wherein the receptacle is temporarily attached to the trap. | Pazik teaches a receptable that is removable and thus temporarily attached to the trap. Fig. 0033-0036; Para. 0118. |
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| 4. The carpenter bee trap of claim 1, wherein the receptacle is configured to be screwed into said bottom of said plenum. | Pazik discloses a receptacle capable of being screwed into the plenum. Fig. 35; para. 0118. |
| | |
| 7. The carpenter bee trap of claim 1, wherein the diameter of the at least one hole is between ½ inch to ¾ inch. | Windsor teaches that the hole is between ½ and ¾ inches. Para. 0023. |
| | |
| 8. The carpenter bee trap of claim 1, wherein a back panel of the plenum is vertical and has a flat exterior to allow flush mounting. | Windsor discloses a plenum having a vertical back panel with a flat exterior. Figs. 4, 5A, 5B, 5C and para. 0026. |
| | |
| 13. A carpenter bee trap, comprising: | Pazik discloses a flying insect trap. Para. 0001.<br><br>Windsor discloses a carpenter bee trap. Para. 0006. |
| a trap entrance unit formed of wood or a wood substitute, wherein at least one side of the trap entrance unit has at least one entrance hole that extends from outside the trap entrance unit to an interior of the trap entrance unit, wherein the at least one entrance hole extends substantially horizontally or at an upward angle with a size and shape configured to provide a primary attractant for carpenter bees, and | The trap of Pazik forms a plenum and is manufactured from a wood substitute. Para. 0007. Pazik teaches at least one hole forming a trap entrance that extends from outside of the trap to the inside of the trap. Fig. 2. Pazik teaches at least one hole forming a trap entrance that extends from outside of the trap to the inside of the trap. Fig. 2; paras. 0015-0020.<br><br>Windsor teaches that a carpenter bee trap is preferably made of wood. Para. 0017. Windsor also at least one hole forming a trap entrance that extends from outside of the trap to the inside of the trap. Fig. 3C. Windsor discloses that its entrances are sized for and to attract carpenter bees. Paras. 0018 and 0023. |

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| | Both Pazik and Windsor teach a hole that is substantially horizontal or at an upwards angle. *See* Pazik at Fig. 2; para. 0015 and Windsor para. 0018. |
| wherein the trap entrance unit further comprises an exit opening for providing an exit path from the interior of the trap entrance unit; and | Pazik discloses that the trap unit has an exit leading to the receptacle. Fig. 2; paras. 0096, 0098, 0101 and 0106. |
| a receptacle adapter located at the exit opening of the trap entrance unit, wherein the receptacle adapter is adapted to receive at least one receptacle and is adapted so as to allow at least some ambient light to enter the interior of the trap entrance unit via the exit opening, thereby providing a secondary attractant for carpenter bees. | Pazik discloses a receptacle adapter configured to receive and help retain a clear or translucent receptacle. Fig. 35; paras. 0046, 0096, 0101 and 0118. Pazik also teaches a clear receptacle that is received by a receptacle adapter wherein the clear receptacle provides a secondary attractant to bees. Fig. 1; paras. 0046, 0048 and 0132. |
| | |
| 14. The carpenter bee trap of claim 13, further comprising a receptacle removably attached to the receptacle adapter. | Pazik teaches a receptable that is removable and thus temporarily attached to the trap. Para. 0118. |
| | |
| 15. The carpenter bee trap of claim 14, wherein the receptacle is clear or translucent. | Pazik also teaches a clear receptacle that is received by a receptacle adapter wherein the clear receptacle provides a secondary attractant to bees. Fig. 1; paras. 0046, 0048 and 0132. |
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| 16. The carpenter bee trap of claim 13, wherein the trap entrance unit comprises at least one top panel that overhangs a side wall of the trap entrance unit. | Warner discloses a top panel that overhangs a side wall of the trap entrance unit. Fig. 1. |
| | |
| 17. The carpenter bee trap of claim 13, wherein the at least one entrance hole extends at an upward angle. | Both Pazik and Windsor teach a hole that is substantially horizontal or at an upwards angle. *See* Pazik at Fig. 2; para. 0015 and Windsor para. 0018. |

*Prince, Pazik, Windsor, Warner & Page*

| Claim Element | Prior Art Citation |
|---|---|
| 1. A carpenter bee trap comprising: | Pazik discloses a flying insect trap. Para. 0001.<br><br>Prince discloses a carpenter bee trap. Col. 1, ll. 30-35. |
| a trap entrance unit forming a plenum being made of wood or a wood substitute; | Prince discloses a bee trap having a trap entrance unit with a plenum made of wood or a wood substitute. Col. 2, ll. 18-23.<br><br>Alternatively, the trap of Pazik forms a plenum and is manufactured from a wood substitute. Para. 0007. |
| said trap entrance unit having at least one hole drilled there-through and sized to mimic a natural carpenter bee nest tunnel so as to provide a primary attractant; | Prince teaches a trap entrance unit with multiple holes therein which are sized to attract carpenter bees. Col. 2, ll. 32-38. |
| said hole extending from the outside of the trap unit to a plenum interior; | The holes in the trap entrance unit taught by Prince extend from outside to the inside of the trap entrance unit. Figs. 1, 4, 5, 6 and 9. Col. 2, ll. 32-38. |
| said hole being configured to extend substantially horizontally or at an upward angle; | Pazik teaches a hole that is substantially horizontal or at an upwards angle. See Pazik at Fig. 2; para. 0015. |
| a means to shelter an entrance to said hole is provided to reduce the admittance of ambient light; | This is a means plus function pursuant to 35 USC § 112(f).<br><br>Warner teaches a flange that provides shelter to the entrance hole. Fig. 1; col. 1, ll. 47-50. |

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| | Alternatively, Windsor teaches walls that would shelter an entrance hole. Figs. 2 and 4. |
| said trap unit further comprising a receptacle adapter being substantially located at the bottom of said trap unit and being configured to receive a clear or translucent receptacle; | Pazik teaches a clear receptacle received by a receptacle adapter at the bottom of the trap. Fig. 35; paras. 0046, 0096-0099, 0101 and 0188. |
| a receptacle received by said adapter situated to allow ambient light to enter through said bottom into said plenum interior, thereby providing a secondary attractant; said receptacle further being provided to receive trapped bees. | Pazik teaches a clear receptacle received by a receptacle adapter which receives and helps retain the receptacle that catches bees and provides a secondary attractant for bees as ambient light may enter through the bottom of the receptacle. Fig. 1; paras. 0046-0048.<br><br>Carpenter bee's phototactic behavior was well known in the prior art as early as 2006. Page, pg., 261; Pazik 0023. |
| | |
| 2. The carpenter bee trap of claim 1, wherein the receptacle is temporarily attached to the trap. | Pazik teaches a receptable that is removable and thus temporarily attached to the trap. Fig. 0033-0036; Para. 0118. |
| | |
| 4. The carpenter bee trap of claim 1, wherein the receptacle is configured to be screwed into said bottom of said plenum. | Pazik discloses a receptacle capable of being screwed into the plenum. Fig. 35; para. 0118. |
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| 7. The carpenter bee trap of claim 1, wherein the diameter of the at least one hole is between ½ inch to ¾ inch. | Windsor discloses that the entrance hole is between ½ and ¾ inch. Para. 0023. |
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| 8. The carpenter bee trap of claim 1, wherein a back panel of the plenum is vertical and has a flat exterior to allow flush mounting. | Windsor discloses that the back panel of the plenum is vertical and has a flat exterior for mounting flush. Figs. 4, 5A, 5B, 5C and 5D; paras. 0019-0020. |
| | |
| 13. A carpenter bee trap, comprising: | Pazik discloses a flying insect trap. Para. 0001. Prince, col. 1, ll. 30-35. |
| a trap entrance unit formed of wood or a wood substitute, wherein at least one side of the trap entrance unit has at least one entrance hole that extends from outside the trap entrance unit to an interior of the trap entrance unit, wherein the at least one entrance hole extends substantially horizontally or at an upward angle with a size and shape configured to provide a primary attractant for carpenter bees, and | Prince discloses a bee trap having a trap entrance unit with a plenum made of wood or a wood substitute. Col. 2, ll. 18-23. Prince teaches a trap entrance unit with multiple holes therein which are sized to attract carpenter bees. Col. 2, ll. 32-38. The holes in the trap entrance unit taught by Prince extend from outside to the inside of the trap entrance unit and are substantially horizontal. Figs. 1, 4, 5, 6 and 9. Col. 2, ll. 32-38. |
| wherein the trap entrance unit further comprises an exit opening for providing an exit path from the interior of the trap entrance unit; and | Pazik teaches a hole that is substantially horizontal or at an upwards angle. Fig. 2; para. 0015. |

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| a receptacle adapter located at the exit opening of the trap entrance unit, wherein the receptacle adapter is adapted to receive at least one receptacle and is adapted so as to allow at least some ambient light to enter the interior of the trap entrance unit via the exit opening, thereby providing a secondary attractant for carpenter bees. | Pazik discloses a receptacle adapter configured to receive and help retain a clear or translucent receptacle. Fig. 35; paras. 0046, 0096, 0101 and 0118.<br><br>Pazik also teaches a clear receptacle that is received by a receptacle adapter wherein the clear receptacle provides a secondary attractant to bees. Fig. 1; paras. 0046, 0048 and 0132. Carpenter bee's phototactic behavior was well known in the prior art as early as 2006. Page, pg., 261; Pazik 0023. |
| | |
| 14. The carpenter bee trap of claim 13, further comprising a receptacle removably attached to the receptacle adapter. | Pazik teaches a receptable that is removable and thus temporarily attached to the trap. Para. 0118. |
| | |
| 15. The carpenter bee trap of claim 14, wherein the receptacle is clear or translucent. | Pazik also teaches a clear receptacle that is received by a receptacle adapter wherein the clear receptacle provides a secondary attractant to bees. Fig. 1; paras. 0046, 0048 and 0132. |
| | |
| 16. The carpenter bee trap of claim 13, wherein the trap entrance unit comprises at least one top panel that overhangs a side wall of the trap entrance unit. | Warner discloses a top panel that overhangs a side wall of the trap entrance unit. Fig. 1. |
| | |
| 17. The carpenter bee trap of claim 13, wherein the at least one entrance hole extends at an upward angle. | Both Pazik and Windsor teach a hole that is substantially horizontal or at an upwards angle. See Pazik at Fig. 2; para. 0015 |