containing less solids. As there is a better supply of oxygen in the open tank nitrification takes place then to a greater degree than in the closed tank.

Sewage is composed of liquid waste carrying considerable quantities of solid matter from the kitchen, laundry, and closets. The principal ingredients are vegetable and animal matter, suds, grease, oil from the human skin, and excreta. There are also livery, brewery, abattoir, and manufacturing wastes.

The septic tank proper consists of a water-tight chamber in which the sewage stands from 6 to 8 feet deep. Here it remains as quiet as possible for from 6 to 48 hours, while bacterial action takes place, the period depending on freshness, uniformity in composition and peculiar circumstances, such as the accelerating or retarding effect of certain trade wastes. This bacterial action is a fermentation and the micro-organisms causing it are of the same general character as those which produce vinegar from cider. In consequence the solid matter is reduced to gaseous compounds such as marsh gas and carbon dioxide. The temperature rises in the tank and the gases released by disturbing the surface scum may be ignited.

The tank averages the composition of the sewage, removes the suspended matter and reduces some of that in solution. It decreases the amount of sludge and renders the effluent more susceptible to the nitrifying bacterial action in the filter beds. The amount of organic matter removed, as determined by the albuminoid ammonia, ranges from 17 1/2 per cent, according to Dibden at Exeter, to 46 per cent given by Rideal.

It is not quite clear why some tanks cause little or no odor and others are quite offensive. It is probable that sewage that is subjected to the septic action too long begins to stale, and that odors do not rise if the proper period is not exceeded.

The subsequent process must be of such a character that oxygen is supplied in such manner and quantity that the nitrifying operation goes on rapidly. The air and sewage must be brought into intimate mixture in order that the bacteria involved may act as rapidly as possible. The organic matter in solution is reduced to nitrous and nitric acids from which it readily returns to the harmless mineral salts from which it originally came to make plant life.

Intermittent filtration consists in flowing the sewage over the beds at intervals. The sewage seeps through, dragging air after it and driving air before it. In this manner oxygen is supplied the nitrifying organisms and these oxidizing agents complete the process begun in the septic tank.

After a period of rest, which is really one of activity, the bed is flooded again and the operation repeated again and again.

English methods sometimes employ continuous filtration, the sewage being sprayed into the air and the oxygen entrained by the falling drops and dragged through the pores of the bed. In the latter case the flow is continuous and the beds have no rest period. In the former case automatic apparatus is used to control the intermittent operation. Apparatus of this description is installed at the purification plant at the Eastern Indiana Hospital for the Insane. Five hundred or 1,000 gallons of septic sewage is discharged at intervals upon filtration beds adjacent, the fluid flowing through buried pipes to valves which discharge the effluent into wooden sluiceways pierced at intervals with waste ways which permit practically even distribution over the filtration beds.

The entire success of this purification plant is evidenced by the composition of the flow from the filtration beds. This flow is as clear as spring water and almost chemically pure. The past severe winter, when the thermometer frequently fell to 28 below zero, was an extreme test of the practicability of the plant. The bacteriological action in the septic tank served to increase the temperature of the sewage until the interior of the building containing the tank was uncomfortably warm. The heat generation continued after the tank was emptied and the sewage spread over the filtration beds. At no time during the winter was the filtration bed frozen over, and Clear Creek, into which the purified sewage was discharged, remained open and free from ice for several hundred feet below. This purification plant is operated without the use of any chemicals whatever, without any person in attendance, and has performed all of its intended functions without hitch or stoppage from the first day it was started until the present.

A GASOLINE-ELECTRIC AUTOMOBILE.

By EMILE GUARINI.

The gasoline automobile with electric transmission, which has recently been constructed by the Compagnie Parisienne des Voitures Electriques, of Paris, consists of a gasoline motor, an electric generator, and two electric motors, while storage batteries are not necessarily employed. The energy developed by the gasoline motor is transmitted to the driving wheels, not mechanically, but electrically. The motor drives directly a dynamo which supplies current to the two electric motors that are connected through spur gears to the rear driving wheels.

The chassis proper is composed of two longitudinal pressed steel members connected by cross members of the same material, thus forming an exceedingly rigid frame of great lightness, which rests upon five springs—two in front and three at the rear—the last of

which is a transverse spring connecting the front ends of the two rear springs. The front axle is provided with ball-bearing steering knuckles, which assure the maximum solidity and great ease of steering. The rear axle, of nickel steel, has near each end, one on each side of the springs, two rounded places, which carry the brackets of the motors. The latter, suspended on their front sides from the ends of the transverse spring, drive directly, by means of a pinion, gear rings attached to the hubs of the rear wheels. All four wheels are mounted on ball bearings. These special bearings are, it appears, unadjustable, without any cones or retainers. An under frame of tubing attached at one end to the generating dynamo and at the other

it is moving. The second lever can be moved to five different positions on a sector having corresponding notches which give the following results: (1) Reverse; (2) starting the motor by the dynamo; (3) off position; (4) coupling of the electric motors in series, the position utilized for steep hills; (5) coupling of the motors in parallel for normal running. On the steering wheel there are also two buttons, as follows: (1) A special button which throttles the gas to the motor and permits of varying the speed of the machine on a level road from 10 to 75 kilometers (6 1/4 to 46 1/2 miles) an hour without operating any other lever; (2) another button controls the shunt-generator regulator which makes possible the easy starting of

CHASSIS OF THE KRIEGER 20-HORSE-POWER GASOLINE ELECTRIC AUTOMOBILE.

end to the front of the chassis by two hangers, supports the gasoline motor.

The explosive motor can be run on either gasoline or alcohol. It is of the vertical, balanced, four-cylinder type, with mechanically-operated valves and unregulatable ignition by magneto. It develops 20 horsepower at 1,200 revolutions per minute. It is direct-connected, by means of an elastic sleeve, to the armature of a dynamo which serves as a flywheel and is placed in line with the motor crank shaft, thus constituting the electric generating group. The generator, attached firmly to the chassis, braces this strongly. The power developed by this generating group is integrally distributed to the two motors, which drive independently the two rear wheels; and by this arrangement the ease of operation is greatly improved, as all the delicate parts of the ordinary gasoline car, such as the transmission gear, the differential, and various universal joints, are done away with. An aluminium casing entirely protects the electric generating group from mud and dust. The radiator, which is placed at the front end of the chassis and which also serves as the water tank, has a very large cooling surface;

the electric generating group and the concordance of the powers of the gasoline motor and the generator by varying the self-regulation of the group.

The driver operates, by means of a pedal at his left, a second electric brake which progressively short-circuits the motors through resistances. Moreover, this pedal, at the start of its movement, cuts off the current by means of a special switch. Another pedal, on the right of the driver, acts on a balanced mechanical brake placed on the prolongation of the armature shafts of the motors. The operation of these two mechanical brakes does not cut off the current from the motors, and thus permits of slowing down the car with a minimum chance of side-slip.

The controller is placed on a cross-piece directly behind the generator and fastened to the side bars of the chassis. This apparatus serves to change the speeds and to couple the motors in series or parallel, corresponding to the different positions of the second lever. From the controller are run the various wires that distribute the energy produced by the generating group to the two motors driving the rear wheels.

A small storage battery weighing about 25 kilo-

LATEST MODEL KRIEGER SIDE-ENTRANCE TONNEAU.

the circulation of the water is maintained on the thermo-siphon principle, thus doing away with the pump, which is a troublesome part of most automobiles. Immediately back of the radiator and in front of the motor is located a powerful fan, which makes a strong forced draft through the tubes of the radiator.

The operating levers are reduced to the minimum and have very simple movements. At the right of the driver are located two levers. The first lever operates a very powerful differential brake acting on the interior of the gear drums attached to the hubs of the rear wheels, and this brake permits of stopping the machine very quickly, no matter in which direction

grammes (55 pounds), serves for starting the generating group without the use of a starting crank. This battery is placed under the seat. It also serves for the independent excitation of the generator, and it is continually recharged by current from the latter, so that it is practically never discharged and always serves as a constant exciter of the generator. There is therefore nothing to worry about with respect to the charging of this battery or its maintenance.

The lubrication of the gasoline motor and the bearings of the generator is accomplished automatically by a force-feed oiler connected to the exhaust, which starts to feed as soon as the motor starts, and ceases as soon as it stops.

On the dashboard of the vehicle is located a voltmeter which indicates the voltage of the generator and the number of amperes supplied by it to the motors. The driver can therefore always verify the power developed by the generating group, and regulate the gas and the shunt in such a manner as to obtain continually the maximum power possible from the gasoline motor. Another volt-meter, placed below the one just mentioned, indicates the voltage of the storage battery which is used for starting.

The maintenance is reduced to that of the commutators and the brushes.

The principal dimensions of the vehicle are as follows: Wheel base, 2.6 meters (8.53 feet); track, 1.4 meters (4.59 feet); total length of the chassis with pump handles for the springs, 3.85 meters (12.63 feet); width of chassis 0.8 meters (2.62 feet); extreme width from end to end of the chassis, 1.6 meters (5.24 feet); length of the body, 2.45 meters (8.03 feet); front tires, 910 by 90 millimeters (35.82 x 3.54 inches); rear tires, 920 x 120 millimeters (36.22 x 3.72 inches). The total weight is about 1,000 kilogrammes (2,204 pounds), or about 150 kilogrammes (330 pounds) more than an ordinary chassis of the same power.

M. Krieger places at 80 per cent the efficiency of his vehicle, from the crank shaft of the gasoline motor to the rim of the wheels, while in ordinary gasoline vehicles having the usual gear transmission, the efficiency scarcely ever reaches 60 per cent. At the same speed, the Krieger car should therefore consume 20 per cent less fuel than a car of the same weight, having a gear transmission. With the same consumption, it should run at a 20 per cent greater speed.

USEFULNESS OF THE AMERICAN TOAD.*

By A. H. KIRKLAND, M.S.

THE heavy tax levied by insects on nearly all agricultural crops is well known to farmers. Nearly as well known, thanks to Agricultural Experiment Station experts and others, are the principal remedies for combating these pests. But in the long run nature provides the most efficient checks on insect increase, and these often are but little understood or appreciated. While the value of birds as destroyers of noxious insects is now becoming generally recognized, the silent, inconspicuous work of insect parasites and certain predaceous animals receives but slight recognition even from those who are most directly benefited. Thus the common toad, nocturnal, of quiet habit and appearance, renders notable service to farmers and gardeners throughout the entire growing season; yet to many its worth is unknown, while to others it is even an object of disgust, if not of fear. It must be admitted that to some the toad can never be an attractive animal. Nature has denied it the gay colors of bird life or even the sinuous beauty of some of its reptilian relatives. Yet, judged by the standard of good works, the toad does not suffer by comparison with any of the lower animals.

The toad has always borne the burden of false and even ludicrous misrepresentations. We have adopted in their entirety the principal European traditions concerning the toad as set forth by the early writers on natural history. These ancient savants, who did so much to establish the study of nature, had the failing, not confined to that age, of confounding fancy with fact. Thus the popular superstitions of that time are curiously interwoven with their statements concerning the life history and habits of the toad. The early writings on this subject teem with vague and ludicrous fancies of the toad's venomous qualities, its medicinal virtues, and more commonly of the valuable toadstone or jewel to be found in its head. All these traditions are to be met with even in this era of progress, and coupled with them we hear of the equally surprising ability of the toad to produce warts on the hands; to poison infants by its breath; to bring good fortune to the house in whose new-made cellar it takes up its abode; and, finally, to cause bloody milk in cows if killed by accident or design. The writer well recalls the shock his credulity received when in the inquisitive stage of boyhood he faithfully tested several of these superstitions with only negative results. When so much that is false has been written about the toad it may not be amiss to increase the scanty literature of facts concerning this humble servant of man as determined by a somewhat intimate acquaintance extending over a decade or more.

The toad is of direct service to man by reason of the noxious insects which it destroys. Should it feed on beneficial insects, it would be to that extent an injurious animal. There is only one way to determine accurately to what extent an insectivorous animal is beneficial or injurious, and that is by a careful examination of the contents of a sufficiently large number of stomachs collected at different dates and over a suitable range of territory. While field observations furnish important circumstantial evidence and aid to an understanding of the kind and condition of food found, the stomach examinations, as Prof. F. E. L. Beal has so aptly put it, "constitute the court of final appeal." Patience, strategy, and good eyesight will enable one to study the feeding habits of such animals, but the absolute identification of the kind and quantity of their food cannot be made at long range. For accurate results the material devoured must be available for careful analysis, often under a microscope.

The writer a few years ago collected and examined 149 toads' stomachs, particular effort being made to

secure representatives from different sections and from a wide range of places, i. e., gardens, fields, hills, woodlands, city streets, etc., during every month of the feeding season. This number is doubtless too small to show the exact status of the toad in the region covered, yet it is sufficient to afford interesting data for some general conclusions. With the exception of a few stomachs preserved in formalin, all were examined while fresh, the stomachs being split along the outer curvature and the contents carefully washed into a glass dish. The material thus obtained was separated into its proper groups, identified, and its percentage of the entire bulk estimated and noted. The number of stomachs examined, by months, was as follows: April, 7; May, 30; June, 66; July, 29; August, 10; September, 7; total, 149.

The nature of the vegetable and mineral matter found in the stomachs needs no further mention. The animal matter recognized constitutes 93 per cent of the total food, of which 77 per cent was insects and 16 per cent other forms. As might be expected, nearly all the animal matter is composed of terrestrial species or of forms which at some time frequent the ground for shelter or migration.

The common angleworm was present in 14 stomachs, principally in toads taken soon after showers, and formed 1 per cent of the total food. Rains drive the worms to the surface, where they fall easy victims to a particularly hungry toad. From studying toads in confinement, it appears that worms are not preferred by that animal as an article of diet, but may be eaten. Worms are of great service in tilling and aerating the soil, as Darwin has so well shown. On the other hand, they often cause great annoyance in greenhouses and in flower beds out of doors. Since the toad frequents the abodes of man, it seems probable that the good done by worms in such localities may well be offset by their damage as above mentioned.

Snails are a serious pest in greenhouses and gardens, where their depredations on lettuce and other succulent plants are well known. Several of the large naked snails common in gardens were found in the stomachs, while, in the case of the shell-bearing snails, it was found that the acid stomach juices of the toad were sufficient to dissolve the shell in a short time. It seems a little strange that such slow-moving animals should attract the attention of the toad, yet it is apparent that the animal finds them suitable articles of food, as shown by their constituting 1 per cent of the total stomach contents.

Sow Bugs.—These small creatures were most numerous in stomachs taken in the late summer, and made up 2 per cent of the food for the season. Their damage to roots of orchids, violets, pansies, roses, etc., has been frequently noted by florists. By destroying them the toad renders a distinct service.

Thousand-legged worms form a constant article of diet, as many as 77 having been found in a stomach. Ten per cent of the food of the toad was of this class. They are frequently called "wire-worms," although this name belongs properly to the young of the "click beetles." Farmers often find the attacks of these myriapods on potatoes a serious matter. The late Dr. J. A. Lintner has recorded an instance where for two years in succession a potato crop was severely injured by these "worms." Many cases of injury to newly-planted potatoes have come to the writer's attention, while others have recorded the partial destruction of cucumbers, tomatoes, etc., from this cause.

It is not strange that such active creatures as spiders form 2 per cent of the toad's food. Naturally most of the spiders were of terrestrial species. How much good spiders accomplish is an open question, but since they destroy large numbers of flies we have included them in the column of beneficial insects. It should be noted, however, that the spider's web often catches those active parasitic flies which would otherwise serve man through the destruction of injurious caterpillars. Perhaps a fair statement would be that the harm the toad may do by including 2 per cent of spiders in its menu is offset by the 13 per cent of snails, sow bugs, and "thousand legs" which it destroys. This brings us, then, with a clean balance sheet to a consideration of its insect food in the strict sense of the term.

Grasshoppers, crickets, etc., were found to make up 3 per cent of the food of the toad, and included several of the common species of the hay field, as well as house crickets, tree crickets, and cockroaches. The damage to grass and grain crops by grasshoppers is too well known to require more than mere mention. The black house cricket is often a nuisance, while the cockroaches and water bugs are even worse. The small roach or water bug was often found in stomachs of toads taken on city streets. The toad is entitled to unstinted praise for its work in destroying these insects.

We come on debatable ground when we take up the economic importance of ants. The writer for the purposes of this paper has regarded them as of neutral value. Most entomological writers regard lightly the shortcomings of these industrious and highly intelligent creatures. Certainly one cannot observe their systematic domestic arrangements and evident reasoning powers without a feeling of sincere admiration. During the season of their activities they destroy a certain number of soft-bodied insects and carry off more dead ones as a provision against future need. On the other hand, they care for and distribute plant lice and certain other related insects, infest lawns, walks, and dwellings, attack cooked food, and often make of themselves an unmitigated nuisance, as many a perplexed housekeeper can attest.

Ants constituted 19 per cent of the total contents of the stomachs examined. The greatest number was found in the May examinations, when they were present in 70 per cent of the stomachs and formed 23 per cent of the food for that month. Aside from ants a few allied insects—such as bumble bees, honey bees, wasps, and hornets—and two ichneumon flies were noted in the examinations. The latter insects are beneficial as parasites on certain caterpillars. Bee-keepers have informed the writer of cases where toads had taken position at the entrance of hives, and thus destroyed a large number of bees. This loss might have been avoided by raising the hives above surface of the ground. Since the toads feed principally at night, such cases are probably of rare occurrence.

There is a certain family of active black or metallic ground beetles, which are usually present in gardens, fields, or woodlands, feeding for the most part on soft-bodied insects, and occasionally varying their diet by attacking low-growing fruits. These ground beetles undoubtedly are beneficial, as a whole, although the damage to strawberries by certain species has caused considerable loss at times. The most serious charge to be laid against the toad is the destruction of these ground beetles, which make up 8 per cent of the total food.

On the other hand, the members of the May-beetle and click-beetle families are commonly present, and furnish 6 and 5 per cent, respectively. The May-beetle, or June bug, is unfavorably known as the parent of the white grub, which, in certain years, destroys large areas of grass land and lawns, and also works havoc on the potato crop. Promiscuous shooting of crows has removed one of the principal checks on this insect; hence the service of the toad in this connection is of especial value. The "rose bug," or rose-chaffer, was found in several stomachs.

The common wireworms, which attack newly planted corn, are the progeny of the click-beetles, and these insects were present in large numbers in the stomachs examined. Wireworms also attack potatoes, lettuce, cabbage, and other garden crops.

Snout-beetles, or weevils, make up 5 per cent of the toad's food. These insects, of which the plum curculio is a good type, are among the most difficult pests to combat. Nearly all have the habit of dropping to the ground and feigning death when disturbed, thus giving the toad a chance to capture them. Among the species found in the stomachs were two specimens of the plum curculio, and many which bore in standing timber and shade trees.

Potato bugs, cucumber beetles, and their allies amounted to 1 per cent of the total food. The injurious habits of these species need no comment. Of equal rank were the carrion beetles (1 per cent) of possibly beneficial habits, and miscellaneous beetles (1 per cent). The latter, aside from an occasional ladybug (beneficial), are of no special importance. The sole value of the carrion beetles lies in their habit of burying or devouring dead animal matter which might otherwise become offensive.

The young or larvae of moths formed 28 per cent of the total food; cutworms forming 16 per cent, tent caterpillars 9 per cent, and miscellaneous caterpillars 3 per cent. The destruction of cutworms is of special importance. These insects feed by night, and the grower only learns of their presence through the loss of his lettuce, cabbage, and other plants. Hand labor offers the most practical remedy, and this is ably assisted by the efforts of the toad. To appreciate fully the number of cutworms a full-grown toad may consume, one should watch these animals in a field infested by army worms, which are members of the cutworm family. Three toads taken under such conditions contained, respectively, 9, 11, and 55 army worms. These soft-bodied insects are quickly digested, and the toad's capacity for cutworms seems only limited by the supply.

The insects consumed by the toad are chiefly those of terrestrial habit. Yet the good work of the toad is not confined to insects of this class. There are a large number of caterpillars which feed ordinarily on trees, yet seek the ground when ready to transform, and these fall easy victims to the toad. The common tent caterpillar of the wild cherry and apple well illustrates this point. These caterpillars when full grown often travel considerable distances in search of suitable places for cocoon making.

In May these insects formed 18 per cent of the food, and for the season 9 per cent. This insect is a pest of the first rank on apple trees and occasionally works on cherry, plum, and peach. It is much preyed upon by the cuckoo and oriole, while the toad secures a fair proportion of those that escape the birds. From 15 to 20 were often found in the stomachs, 37 being the largest number noted. The writer once saw a black-billed cuckoo eat 35 of these insects at one meal. That bird is well protected by wise laws. The toad has equally as good a record, but receives no legal protection from wanton cruelty.

Among miscellaneous caterpillars, which formed 3 per cent of the food, were noted such injurious species as the gypsy moth, canker-worm, Vanessa, grape and celery caterpillars, tomato worms, cabbage worms, etc. An abundance of active gypsy-moth caterpillars in certain Massachusetts localities often proves sufficient to tempt the toad from retirement even at midday. Three of the toads' stomachs examined contained, respectively, 7, 15, and 65 gypsy caterpillars. As a means of checking the increase of such a serious pest the value of the toad is small, but the case is of interest as showing that tree-infesting caterpillars are often captured by this animal.

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