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For Your Information

By WILLY LEY

The Supersonic Bot Fly

THERE are some stories that seem impossible to kill off. One of them is the famous statement to be found, colored and framed, on the walls of practically every airplane manufacturer's office, namely that the bumblebee cannot fly. But since the bumblebee cannot read, either, it is unaware of that fact and goes on flying.

THIS story originated in the 1930s with the thesis of a German student. It bore a title something like (I'm quoting from memory) *Aerodynamic Forces on small, plane, vibrating surfaces of the Order of Magnitude on Insect's Wings.* All the thesis intended to prove was that it would not work if the small vibrating surfaces were rigid planes. There are some additional complications in the development of that legend—including some mere typographical errors in several of the equations—but I don't want to go into that now, because the misinterpretation should be clear enough, and I'm more concerned with that other story; the supersonic bot fly.

LET'S nail this at the outset with name, place and sex. The speed champion of this planet is allegedly the male of the deer bot fly *Cephenomyia pratti* which occurs in the valleys of the Sierra Madre. The first man to report the incredible feats of *Cephenomyia* was Dr. Charles H. T. Townsend, who wrote in the *Journal of the N. Y. Entomological Society* (1937):

> Regarding the speeds of *Cephenomyia,* the idea of a fly overtaking a bullet is a painful mental pill to swallow. . . yet these flies can probably do that to an old-fashioned musket ball. They could probably have kept up with the shells that the German Big Bertha shot into Paris during World War I. The males are faster than the females . . . at 7000-foot levels in the Sierra Madre valleys of western Chihauhua I have seen the gravid females pass . . . at a velocity of well over 300 yards a second . . . on 12,000-foot summits in New Mexico I have seen pass me at an incredible velocity what were quite certainly the males of *Cephenomyia.* I could barely distinguish that something had passed—only a brownish blur in the air of about the right size for these flies and without sense of form. As closely as I can estimate, their speed must have approximated 400 yards per second.

Of course, this was interesting, to put it mildly. Apparently Dr. Roy Chapman Andrews, then the director of the American Museum of Natural History, inquired about detail, for he received this letter from Dr. Townsend.

> They are no sooner detected as a passing streak than they are entirely out of sight on a straightaway course. They pass at a speed that is next to invisible—like a flash of light almost—not over half a second—just a blurred streak in the air but never visible and giving no sense of color. The time was checked repeatedly with the shutter of a camera. The data are practically accurate and as close as will ever be possible to measure.

Roy Chapman Andrews quoted this excerpt in *Natural History Magazine* (Oct. 1937), adding that he'd feel more comfortable if it were possible to test this in a wind tunnel.

THAT the story made such a splash and is still reverberating in some popular books can only be due to the fact that people don't read critically what they see in print. For, as a scientific report, Dr. Townsend's article is less than ideal. He "could barely distinguish that something had passed," yet he knows that what had passed were "quite certainly the males of *Cephenomyia*." In the entomological journal, it was "a brownish blur;" in the letter to Dr. Andrews, the blurred streak gave no sense of color. The timing device was a camera shutter, which isn't reliable for small fractions of a second immediately after an overhaul, yet "the data are practically accurate."

All of his comparisons were put into print without any checking whatever. Estimated speed of the brownish (or colorless) blurs was 400 yards per second, or 1200 feet per second, at an elevation above sea level of 12,000 feet. (Speed of sound at that altitude is 1070 feet per second.) At that speed the fly can "probably" overtake a musket ball. Now I don't know whether the muzzle velocity of an old musket has actually been measured, but the muzzle velocity of an old-fashioned six-shooter is 450 feet per second. A .45 cal. slug is hardly smaller than *Cephenomyia;* as a rule, people don't see them. It would be a most interesting experiment to time the bullets from .45 cal. gats with a camera shutter!

On the other hand, the muzzle velocity of the German Paris Gun of 1918 with which the flies "could probably have kept up" was around 5300 feet per second, or about 4½ times the alleged maximum speed of the fabulous bot fly males.

It so happened that I saw galley proofs of Roy Chapman Andrews's article before it was published. My next action was to get myself a picture of such a bot fly and its dimensions, and then invite an aerodynamicist for beer with discussion. We did not ask such irrelevant questions as the acceleration period required to get up to 400 yards per second or 818 miles per hour. We simply assumed that the fly did travel at such speed and calculated its air resistance. In round figures, it was 80 grams, a little short of three ounces. Now it needs power to maintain speed against that much drag. The calculation was simple and ended up with the figure of 0.45 horsepower! These calculations were made as if the thing were an airplane model the size of a bot fly. Then we repeated the calculations for the same size bullet. Same results.

A year later, Dr. Irving Langmuir of General Electric published an article in *Science* (vol. 87, No. 2254, March 11, 1938), with results even more devastating. Wind pressure against the head of the fly at 818 mph turned out to be eight lbs. per square inch, which should be enough to crush it. Power to maintain speed against such wind pressure: 370 watts or about ½ horsepower, requiring a food intake of 0.31 grams *per second*, which is roughly 1½ times the weight of the insect.

SUCH statistics disposed of Dr. Townsend's supersonic speeds neatly and simply.

Then Dr. Langmuir tried to establish how fast they *do* fly. He took a piece of solder of the right size and spun it on a thin silk thread, timing it with a telechron clock, and using the brightly illuminated white ceiling of the laboratory as a background.

When the solder fly moved at 13 mph, its shape could no longer be seen, but its size could be estimated correctly. At 26 mph, it was just visible as a moving object. At 43 mph, it appeared as a faint line (direction of movement could no longer be seen) and at 64 mph it was simply invisible.

The conclusion was that the speed of 26 mph best agreed with Dr. Townsend's description. Power requirement for 25 mph would be 0.0034 watts, corresponding to a food intake of five per cent of the body weight per hour.

However, Dr. Langmuir went back to the 818 mph speed originally alleged. The flies had always missed Dr. Townsend, but obviously their maneuverability at supersonic speed cannot be too accurate. Now if one had hit—well, there would have been an impact force of 140 kilograms or 310 pounds. Penetration would depend largely on where it happened to hit, but a blow in the eye or even on the chest would be likely to be fatal.

It is just barely possible that

the inhabitants of the Sierra Madre are in a dark conspiracy to bury their victims of such accidents without informing the sheriff or Dr. Townsend, thereby eliminating all traces of *Cephenomyia's* deadliness. I rather doubt it.

Legs and Wings

WHY do insects have six legs, but less than six wings? At first glance this may look like an exceedingly idle question, yet it can be answered and the answer involves both evolutionary history and engineering principles. I admit that a bookkeeper and a general can do their jobs without this information, but when it comes to science fiction authors and readers, such a discussion may prove helpful.

Let's begin at the beginning, with the ancestors of the insects. They were creatures which anybody but a professional zoologist would take to be centipedes. There were quite a number of legs to begin with, thirty pairs or more. In the course of insect evolution, this number was uniformly reduced to three pairs. Apparently everything beyond that number constituted dead weight. But why did the insects stop the reduction at that point? Why didn't they go below that? (Only some parasitic insects have less than three pairs of legs—none at all.)

The answer has been pointed out by Prof. U. N. Lanham of the University of Michigan. When an insect walks, it lifts the front and hind legs on one side and the middle leg on the other. This forms a tripod, something an engineer recognizes at once as a stable support. Then the other set becomes a tripod. Anything less than a tripod would be unstable and require a balancing act.

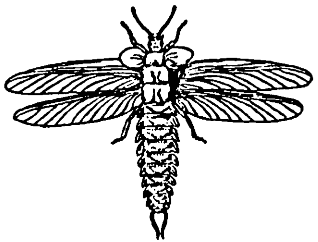
Reptiles and mammals do this beautifully all the time, but insects can't follow their example for two reasons. One is that they are encased in armor and too stiff. Reptiles and mammals can shift their flexible bodies subtly for balance and many of them also have a tail to help. The other reason is that insects are too small; if they should fall, they do so too fast for a correction to be made. Try balancing first a pencil and then a broomstick on your finger and you'll find out what size has to do with balance.

It is interesting in this connection to note that the praying mantis, which habitually walks on four legs (although it has six), is rather large and unusually flexible. And in climbing, the front pair, which has evolved into a set of insect traps, usually has to help out.

But how about the wings?

The multiple pairs of legs of the insect ancestors were *not* accompanied by a corresponding number of appendages which could become wings. Insects did not try to sprout wings until after the number of their legs had been reduced to three pairs. But the first winged insects apparently had three pairs of wings, too. In the oldest example we know (see illustration) the first pair is already considerably reduced, but it is still there. Our contemporary insects either have the original second and third pair left—for example, dragonflies and butterflies—or the original middle pair. There is just one small and unimportant group, also tiny in size, which retained the original third pair, the *Strepsiptera*.

If the picture of *Stenodictya* reminds you of early designs of "flying machines" with lots of wings, you are right and you also know the reason. You can have a pair of wings which serve more or less in the fashion of the rotor of a helicopter. Or you can have one pair which serves as wings, airplane-style, with another pair serving as propellers (beetles do just about that). But anything beyond that causes interference, ruins the aerodynamics of the design and grounds the experimenter.



So if you invent some interesting insect forms for the planet Bombastus, see to it that they have more than four legs. And avoid flying centipedes with 60 legs and 48 wings.

The Diameter of Pluto

PLUTO, as you know, is the outermost of the known planets of our solar system, discovered in 1930. But ever since its discovery, Pluto has managed to pose riddles. At the time when it was still listed as "suspected to exist," astronomers who had given the matter some thought would have expected it to be a rather large planet—about the size of Neptune, which has a diameter of 31,000 miles—and they would have expected it to be rather far out. The average distance of Neptune is 2,800 million miles, so the next planet outside of Neptune should have been around 4,000 million miles.

But Pluto proved to be much

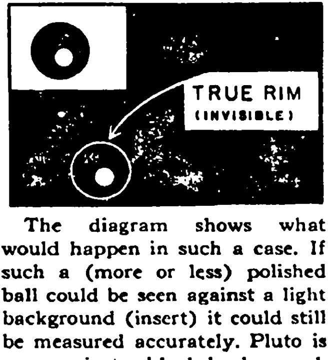
closer than expected, with part of its orbit *inside* the orbit of Neptune, thus having a much more eccentric path than any other planet, even worse than Mercury. And it was found to be much smaller than expected. It seemed to have about the same size as Earth and the diameter guessed at was put down at 7,700 miles, with a question mark attached. Since its gravitational influence appears to be about that of Earth, this would have led to about the same density, which in the case of Earth is 5.5 times that of water.

Then, in 1950, twenty years after its original discovery, Dr. Gerard P. Kuiper succeeded in actually measuring its diameter with the aid of the 200-inch telescope on Palomar Mountain. The apparent diameter turned out to be 0.22 seconds of arc, which, for the known distance, gave a "real" diameter of 3,550 miles, the same as that of Saturn's largest moon, Titan.

The joy over this accomplishment, however, practically vanished when one started to calculate a little. The gravitational influence was still about that of Earth, but with such a small diameter, the average density of Pluto would have to be about 55!

There is no element with such a density. Iron has a density of 7.8, uranium 18.7, gold 19.3, platinum 21.4 and osmium 22.5. Astrophysicists know that the crushed matter of stellar cores must be denser by far than 55, but Pluto is not heavy enough to crush matter.

Something had to be wrong and the latest guess at what it might be is that our measurement of Pluto suffers from "specular reflection." The term is derived from the Latin *speculum for* "mirror" and simply means that a sufficiently smooth planet might reflect light in the manner of a polished ball.



The diagram shows what would happen in such a case. If such a (more or less) polished ball could be seen against a light background (insert) it could still be measured accurately. Pluto is seen against a black background, though, and in that case we would measure not the planet, but the reflection.

This suggestion, first offered by Sir James Jeans, would resolve that impossible density of 55 for a rather small planet. But it does nothing to answer what we really want to know—the true diameter of Pluto.

Science fiction authors would probably be more interested in the seeming smoothness of the planet's surface. Ice or frozen gases might explain it, for Pluto is an extremely frigid world. But we won't know, of course, until we get there and see for ourselves.

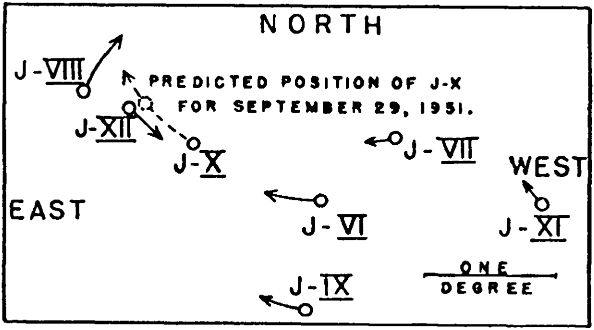
More on Moons

THE date of September 29, 1951, marks the discovery of the twelfth satellite of Jupiter, or J-XII. The discovery was made photographically with the 100-inch telescope on Mt. Wilson and the discoverer was Dr. Seth B. Nicholson, who is the only living man to have discovered four satellites of Jupiter—J-IX, J-X, J-XI and now J-XII.

But there was quite some confusion connected with that discovery. Dr. Nicholson, naturally, did not take his plates for the purpose of looking for another satellite of Jupiter. He wanted to check the movement of the faint Jovian satellites, specifically his own earlier discoveries.

To understand what follows, look at the diagram (adapted from a *Mount Wilson and Palomar Observatories* diagram) which shows how the sky near Jupitor would have looked that night to a sensitive instrument of a sufficiently wide angle.

J-IX and J-XI were easily accounted for. So were J-VI and



J-VII, which are much brighter and could not be mistaken for any of the high-numbered satellites. And on a plate far to the east there was J-X, right in the position for which it had been predicted for September 29. But to the west of J-X, there was a new faint body. Most likely it was another Jovian satellite and, since they are numbered in the order of discovery, it was clearly J-XII.

Then followed a frantic series of HACs (Harvard Announcement Cards), the first giving the position of the "western object." Some two weeks later, there came another, stating that Dr. P. Musen of Cincinnati Observatory had identified the object as J-X. Doctor Musen realized that the prediction for J-X had been mistaken; J-X was in its orbit, all right, but had not yet reached the position predicted for September 29. (In fact, it did not get there until 20 days later.) Hence Dr. Nicholson's "western object" was merely J-X, three weeks behind schedule.

The next HAC told that story and pointed out that the object in the place where J-X should have been must be a new satellite.

A week later, there came another HAC, giving more precise positions and warning that Minor Planet No. 1003—Lilofee—was also nearby.

Meanwhile, Dr. Nicholson had found that his new object, suspected to be J-XII and originally taken to be J-X, was traveling relative to Jupiter in the opposite direction of J-X's well-established movement.

By the end of November, it was all straightened out. J-XII is a member of the outer group of Jovian satellites; it is retrograde and some 14 to 15 million miles from Jupiter. Its orbital period must be more than 600 and might be closer to 700 days. And since it could be mistaken for J-X, it has about the same brightness, which indicates that its diameter must be about the same, less than 20 miles.

If J-X had not been predicted wrong, J-XII might have been overlooked.

I wonder how J-XIII will be discovered.

—WILLY LEY

ANY QUESTIONS?

How can a rocketship turn in space?

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There are three methods for turning a rocketship in space. The simplest is a short blast from the rocket motor with full deflection on the steering vanes which are in the exhaust blast. These steering vanes are typical for the V-2's steering system. The second method is to have the whole rocket motor swivel mounted and to blast with tilted motor. This is typical for the Navy's Viking rocket.

A third method, not yet actually used, would be to have a wheel spin inside the rocket, while no propulsion is applied. If you have a wheel spinning in one direction, the rocket will have to turn in the opposite direction. If you have three wheels mounted at right angles to each other inside, the rocketship can be turned into any direction by spinning the appropriate wheels.

Of course, turning by spinning wheels does not change direction of flight, but merely the direction in which the nose is pointing. To move in that new direction, you need rocket motors.

Which subjects should I study for later work in rockets and in astronautics?

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This question, which comes to me in my mail at least once a week, is hard to answer generally, for much depends on what the student intends to do later. Theoretical astronautics is the child of astronomy and theoretical physics. A man who wants to contribute to space travel theory and solve some of its problems (which are distinct from strict engineering problems) would be essentially a theoretical physicist with a thorough grounding in astronomy, especially "astronomy of position," that branch dealing with the movements of bodies in space.

As for rocket engineering, there are now three major branches. One group of "rocket engineers" specializes in telemetering and guidance systems; these are originally electronics engineers. Another group specializes in the building of the rocket proper; these are essentially aeronautical engineers. The third group, the "rocket engineers" proper, are the men who design, build and test rocket motors; they are specialized mechanical engineers.

In short, if you want to work in rocket engineering, you have to be an engineer first, because rocket work is a specialization of various branches of engineering. Of course chemists, metallurgists and medical men have also contributed to astronautics. Again, however, they were chemists, metallurgists and doctors before they specialized.

A number of colleges and engineering colleges give special courses. I know that there are such courses at the University of California (Los Angeles), at California Institute of Technology, at Ohio State University, at Massachusetts Institute of Technology and at Princeton University. There are probably still others of which I haven't heard yet.

An analogy is often drawn between the atom and the Solar System, wherein the Sun represents the nucleus. But now the nucleus is known to be a multiplicity of parts, and electrons are unknown to possess satellites. Therefore: to what phenomenon of the astronomer can the atoms of the physicist be made analogous?

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None. That analogy dates back to the days when nothing was known about the atom except that it had to have a nucleus and something around the nucleus. To draw such an analogy nowadays makes even less sense than the assertion that Mr. X resembles an elephant because both have one head, four limbs, two eyes in the head, one mouth with teeth and a stomach that demands food. Such an analogy completely disregards all dissimilarities for the sake of a few similarities.

In a solar system, you have one planet per orbit, all orbits in about the same plane and all planets of different sizes. In an atom, you have several electrons per orbit, all of the same size and (except in the case of the hydrogen and the helium atoms) more than one orbital plane.

Send your science questions to Willy Ley c/o GALAXY. He'll answer them all by mail or in this department. Keep them short, a few at a time and print or type them, please!