Illustrated by Virgil Finlay

THE FEELING

Graphitics was a startlingly new idea!

So revolutionary, in fact, it rocked the top army brass.

Imagine computing—without a computer!

OF POWER

BY ISAAC ASIMOV

JEHAN SHUMAN WAS used to dealing with the men in authority on long-embattled Earth. He was only a civilian but he originated programming patterns that resulted in self-directing war computers of the highest sort. Generals consequently listened to him. Heads of congressional committees, too.

There was one of each in the special lounge of New Pentagon. General Weider was space-burnt and had a small mouth puckered almost into a cypher. Congressman Brant was smooth-cheeked and clear-eyed. He smoked Denebian tobacco with the air of one whose patriotism was so notorious, he could be allowed such liberties.

Shuman, tall, distinguished and programmer-first-class, faced them fearlessly.

He said, "This, gentlemen, is Ladislas Aub."

"The one with the unusual gift that you discovered quite by accident," said Congressman Brant, placidly. "Ah." He inspected the little man with the egg-bald head with amiable curiosity.

The little man, in return, twisted the fingers of his hands anxiously. He had never been near such great men before. He was only an aging low-grade Technician who had long ago failed all tests designed to smoke out the gifted ones among mankind and had settled into the rut of unskilled labor. There was just this hobby of his that the great

programmer had found out about and was now making such a frightening fuss over.

General Weider said, "I find this atmosphere of mystery childish."

"You won't in a moment," said Shuman. "This is not something we can leak to the first-comer. —Aub!" There was something imperative about his manner of biting off that one-syllable name, but then he was a great Programmer speaking to a mere Technician. "Aub! How much is nine times seven?"

Aub hesitated a moment, his pale eyes glimmered with a feeble anxiety. "Sixty-three," he said.

Congressman Brant lifted his eyebrows. "Is that right?"

"Check it for yourself, congressman."

The congressman took out his pocket computer, nudged the milled edges twice, looked at its face as it lay there in the palm of his hand and put it back. He said, "Is this the gift you brought us here to demonstrate. An illusionist?"

"More than that, sir. Aub has memorized a few operations and with them he computes on paper."

"A paper computer?" said the general. He looked pained.

"No, sir," said Shuman, patiently. "Not a paper computer. Simply a sheet of paper. General, would you be so kind as to suggest a number?"

"Seventeen," said the general.

"And you, congressman?"

"Twenty-three."

"Good! Aub, multiply those numbers and please show the gentlemen your manner of doing it."

"Yes, programmer," said Aub, ducking his head. He fished a small pad out of one shirt pocket and an artist's hairline stylus out the other." His forehead corrugated as he made painstaking marks on the paper.

General Weider interrupted him sharply. "Let's see that."

Aub passed him the paper, and Weider said, "Well, it *looks* like the figure seventeen."

Congressman Brant nodded and said, "So it does, but I suppose anyone can copy figures off a computer. I think I could make a passable seventeen myself, even without practice."

"If you will let Aub continue, gentlemen," said Shuman without heat.

Aub continued, his hand trembling a little. Finally, he said in a low voice, "The answer is three hundred and ninety-one."

Congressman Brant took out his computer a second time and flicked it, "By Godfrey, so it is. How did he guess?"

"No guess, congressman," said Shuman. "He computed that result. He did it on this sheet of paper."

"Humbug," said the general, impatiently. "A computer is one thing and marks on paper are another."

"Explain, Aub," said Shuman.

"Yes, programmer. —Well, gentlemen, I write down seventeen and just underneath it, I write twenty-three. Next, I say to myself: seven times three—"

The congressman interrupted smoothly, "Now, Aub, the problem is seventeen times twenty-three."

"Yes, I know," said the little technician earnestly, "but I *start* by

saying seven times three because that's the way it works. Now seven times three is twenty-one."

"And how do you know that?" asked the congressman.

"I just remember it. It's always twenty-one on the computer. I've checked it any number of times."

"That doesn't mean it always will be, though, does it?" said the congressman.

"Maybe not," stammered Aub. "I'm not a mathematician. But I always get the right answers, you see."

"Go on."

"Seven times three is twenty-one, so I write down twenty-one. Then one times three is three, so I write down a three under the two of twenty-one."

"Why under the two?" asked Congressman Brant at once.

"Because—" Aub looked helplessly at his superior for support. "It's difficult to explain."

Shuman said, "If you will accept his work for the moment, we can leave the details for the mathematicians."

Brant subsided.

Aub said, "Three plus two makes five, you see, so the twenty-one becomes a fifty-one. Now you let that go for a while and start fresh. You multiply seven and two, that's fourteen, and one and two, that's two. Put them down like this and it adds up to thirty-four. Now if you put the thirty-four under the fifty-one this way and add them, you get three hundred and ninety-one and that's the answer."

There was an instant's silence and then General Weider said, "I don't believe it. He goes through this rigmarole and makes up numbers and multiplies and adds them this way and that, but I don't believe it. It's too complicated to be anything but hornswoggling."

"Oh, no, sir," said Aub in a sweat. "It only *seems* complicated because you're not used to it. Actually, the rules are quite simple and will work for any numbers."

"Any numbers, eh?" said the general. "Come then." He took out his own computer (a severely-styled GI model) and struck it at random. Make a five, seven, three, eight on the paper. That's five thousand seven hundred and thirty-eight."

"Yes, sir," said Aub, taking a new sheet of paper.

"Now," (more punching of his computer), "seven two three nine. Seven thousand two hundred and thirty-nine."

"Yes, sir."

"And now multiply those two."

"It will take some time," quavered Aub.

"Take the time," said the general.

"Go ahead, Aub," said Shuman, crisply.

Aub set to work, bending low. He took another sheet of paper and another. The general took out his watch finally and stared at it. "Are you through with your magic-making, technician?"

"I'm almost done, sir. Here it is, sir. Forty-one million, five hundred and thirty-seven thousand, three hundred and eight-two." He showed the scrawled figures of the result.

General Weider smiled bitterly.

He pushed the multiplication contact on his computer and let the numbers whirl to a halt. And then he stared and said in a surprised squeak. "Great Galaxy, the fella's right."

The President of the Terrestrial Federation had grown haggard in office and, in private, he allowed a look of settled melancholy to appear on his sensitive features. The Denebian war, after its early start of vast movement and great popularity, had trickled down into a sordid matter of maneuver and counter-maneuver, with discontent rising steadily on Earth. Possibly, it was rising on Deneb, too.

And now Congressman Brant, head of the important Committee on Military Appropriations was cheerfully and smoothly spending his half-hour appointment spouting nonsense.

"Computing without a computer," said the president, impatiently, "is a contradiction in terms."

"Computing," said the congressman, "is only a system for handling data. A machine might do it, or the human brain might. Let me give you an example." And, using the new skills he had learned, he worked out sums and products until the president, despite himself, grew interested.

"Does this always work?"

"Every time, Mr. President. It is foolproof."

"Is it hard to learn?"

"It took me a week to get the real hang of it. I think you could do better."

"Well," said the president, considering, "it's an interesting parlor game, but what is the use of it?"

"What is the use of a new-born baby, Mr. President? At the moment, there is no use, but don't you see that this points the way toward liberation from the machine. Consider, Mr. President," the congressman rose and his deep voice automatically took on some of the cadences he used in public debate, "that the Denebian was is a war of computer against computer. Their computers forge an impenetrable shield of counter-missiles against our missiles, and ours forge one against theirs. If we advance the efficiency of our computers, so do they theirs, and for five years a precarious and profitless balance has existed.

"Now we have in our hands a method for going beyond the computer, leap-frogging it, passing through it. We will combine the mechanics of computation with human thought; we will have the equivalent of intelligent computers; billions of them. I can't predict what the consequences will be in detail but they will be incalculable. And if Deneb beats us to the punch, they may be catastrophic."

The president said, troubled, "What would you have me do?"

"Put the power of the administration behind the establishment of a secret project on human computation. Call it Project Number, if you like. I can vouch for my committee, but I will need the administration behind me."

"But how far can human computation go?"

"There is no limit. According to Programmer Shuman, who first introduced me to this discovery—"

"I've heard of Shuman, of course."

"Yes. Well, Dr. Shuman tells me that in theory there is nothing the computer can do that the human mind can not do. The computer merely takes a finite amount of data and performs a finite number of operations upon them. The human mind can duplicate the process."

The president considered that. He said, "If Shuman says this, I am inclined to believe him,—in theory. But, in practice, how can anyone know how a computer works?"

Brant laughed genially. "Well, Mr. President, I asked the same question. It seems that at one time, computers were designed directly by human beings. Those were simple computers of course; this being before the time of the rational use of computers to design more advanced computers had been established."

"Yes, yes. Go on."

"Technician Aub apparently had, as his hobby, the reconstruction of some of these ancient devices and in so doing he studied the details of their workings and found he could imitate them. The multiplication I just performed for you is an imitation of the workings of a computer."

"Amazing!"

The congressman coughed gently, "If I may make another point, Mr. President— The further we can develop this thing, the more we can divert our Federal effort from computer production and computer maintenance. As the human brain takes over, more of our energy can be directed into peace-time pursuits and the impingement of war on the ordinary man will be less. This will be most advantageous for the party in power, of course."

"Ah," said the president, "I see your point. Well, sit down, congressman, sit down. I want some time to think about this. —But meanwhile, show me that multiplication trick again. Let's see if I can't catch the point of it."

PROGRAMMER SHUMAN did not try to hurry matters. Loesser was conservative, very conservative, and liked to deal with computers as his father and grandfather had. Still, he controlled the West European computer combine and if he could be persuaded to join Project Number in full enthusiasm, a great deal would have been accomplished.

But Loesser was holding back. He said, "I'm not sure I like the idea of relaxing our hold on computers. The human mind is a capricious thing. The computer will give the same answer to the same problem each time. What guarantee have we that the human mind will do the same?"

"The human mind, Computer Loesser, only manipulates facts. It doesn't matter whether the human mind or a machine does it. They are just tools."

"Yes, yes. I've gone over your ingenious demonstration that the mind can duplicate the computer

but it seems to me a little in the air. I'll grant the theory but what reason have we for thinking that theory can be converted to practice?"

"I think we have reason, sir. After all, computers have not always existed. The cavemen with their triremes, stone axes and railroads had no computers."

"And possibly they did not compute."

"You know better than that. Even the building of a railroad or a ziggurat called for some computing, and that must have been without computers as we know them."

"Do you suggest they computed in the fashion you demonstrate?"

"Probably not. After all, this method—we call it 'graphitics', by the way, from the old European word 'grapho' meaning 'to write'—is developed from the computers themselves so it cannot have antedated them. Still, the cavemen must have had *some* method, eh?"

"Lost arts! If you're going to talk about lost arts—"

"No, no. I'm not a lost art enthusiast, though I don't say there may not be some. After all, man was eating grain before hydroponics and if the primitives ate grain, they must have grown them in soil. What else could they have done?"

"I don't know, but I'll believe in soil-growing when I see someone grow grain in soil. And I'll believe in making fire by rubbing two pieces of flint together when I see that, too."

Shuman grew placating. "Well, let's stick to graphitics. It's just part of the process of etherealization. Transportation by means of bulky contrivances is giving way to direct mass-transference. Communications devices become less massive and more efficient constantly. For that matter, compare your pocket computer with the massive jobs of a thousand years ago. Why not, then, the last step of doing away with computers altogether? Come, sir, Project Number is a going concern; progress is already headlong. But we want your help. If patriotism doesn't move you, consider the intellectual adventure involved."

Loesser said, skeptically, "What progress? What can you do beyond multiplication? Can you integrate a transcendental function?"

"In time, sir. In time. In the last month I have learned to handle division. I can determine, and correctly, integral quotients and decimal quotients."

"Decimal quotients? To how many places?"

Programmer Shuman tried to keep his tone casual. "Any number!"

Loesser's lower jaw dropped. "Without a computer?"

"Set me a problem?"

"Divide twenty-seven by thirteen? Take it to six places."

Five minutes later, Shuman said, "Two point oh seven six nine two three."

Loesser checked it. "Well, now, that's amazing. Multiplication didn't impress me too much because it involved integers after all, and I thought trick manipulation might do it. But decimals—"

"And that is not all. There is a

new development that is, so far, top secret and which, strictly speaking, I ought not to mention. Still—We may have made a breakthrough on the square root front."

"Square roots?"

"It involves some tricky points and we haven't licked the bugs yet, but Technician Aub, the man who invented the science and who has an amazing intuition in connection with it, maintains he has the problem almost solved. And he is only a technician. A man like yourself, a trained and talented mathematician ought to have no difficulty."

"Square roots," muttered Loesser, attracted.

"Cube roots, too. Are you with us?"

Loesser's hand thrust out suddenly, "Count me in."

General Weider stumped his way back and forth at the head of the room and addressed his listeners after the fashion of a savage teacher facing a group of recalcitrant students. It made no difference to the general that they were the civilian scientists heading Project Number. The general was the over-all head, and he so considered himself at every waking moment.

He said, "Now square roots are all fine. I can't do them myself and I don't understand the methods, but they're fine. Still, the project will not be side-tracked into what some of you call the fundamentals. You can play with graphitics any way you want to after the war is over, but right now we have specific and very practical problems to solve."

In a far corner, Technician Aub listened with painful attention. He was no longer a technician, of course, having been relieved of his duties and assigned to the project, with a fine-sounding title and good pay. But, of course, the social distinction remained and the highly-placed scientific leaders could never bring themselves to admit him to their ranks on a footing of equality. Nor did he, himself, wish it. He was as uncomfortable with them as they with him.

The general was saying, "Our goal is a simple one, gentlemen; the replacement of the computer. A ship that can navigate space without a computer on board can be constructed in one-fifth the time and at one-tenth the expense of a computer-laden ship. We could build fleets five times, ten times as great as Deneb could if we could but eliminate the computer.

"And I see something even beyond this. It may be fantastic now; a mere dream; but in the future I see the manned missile!"

There was an instant murmur from the audience.

The general drove on. "At the present time, our chief bottleneck is the fact that missiles are limited in intelligence. The computer controlling them can only be so large so they can meet the changing nature of anti-missile defenses in an unsatisfactory way. Few missiles, if any, accomplish their goal and missile warfare is coming to a dead end; for the enemy, fortunately, as well as for ourselves.

"On the other hand, a missile

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with a man or two within, controlling flight by graphitics, would be lighter, more mobile, more intelligent. It would give us a lead that might well mean the margin of victory. Besides which, gentlemen, the exigencies of war compel us to remember one thing. A man is much more dispensable than a computer. Manned missiles could be launched in numbers and under circumstances that no good general would care to undertake as far as computer-directed missiles are concerned—"

He said much more but Technician Aub did not wait.

Technician Aub, in the privacy of his quarters, labored long over the note he was leaving behind. It read finally as follows:

"When I began the study of what is now called graphitics, it was no more than a hobby. I saw no more in it than an interesting amusement, an exercise of mind.

"When Project Number began, I thought that others were wiser than I; that graphitics might be put to practical use as a benefit to mankind; to aid in the production of really practical mass-transference devices perhaps. But now I see it is to be used only for death.

"I cannot face the responsibility involved in having invented graphitics."

He then deliberately turned the focus of a protein-depolarizer on himself and fell instantly and painlessly dead.

They stood over the grave of the little Technician while tribute was paid to the greatness of his discovery.

Programmer Shuman bowed his head along with the rest of them, but remained unmoved. The technician had done his share and was no longer needed, after all. He might have started graphitics, but now that it had started, it would carry on by itself overwhelmingly, triumphantly, until manned missiles were possible, along with who knew what else.

Nine times seven, thought Shuman with deep satisfaction, is sixty-three and I don't need a computer to tell me so. The computer is in my own head.

And it was amazing the feeling of power that gave him. **END**

WHAT IS YOUR SCIENCE I.Q.?

ANSWERS: 1—Solid with 12 plane faces. 2—Sagittarius. 3—It never varies. 4—Tin. 5—Temperature at which vapor pressure equals one atmosphere. 6—Scientific study of Mars. 7—Gypsum, fluorite, topaz. 8—Lever, wheel, pulley, inclined plane, wedge, screw. 9—Joining similar molecules to make a larger one. 10—Nobellium. 11—Both lack true roots, stems, leaves. 12—Nitric and hydrochloric acids. 13—Wind velocity of 70 m.p.h. 14—Temperature when substances change magnetic behavior. 15—Fission, budding, spores.