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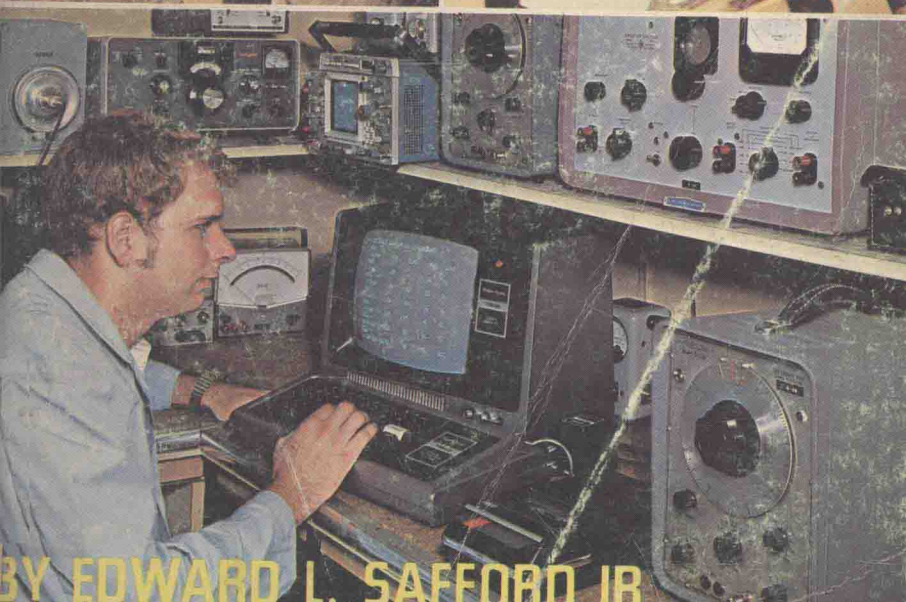

BY EDWARD L. SAFFORD JR

THE COMPLETE MICROCOMPUTER SYSTEMS HANDBOOK

Dedication

Eddie and Susan
&
Mary and Thomas
Who
compute and compute
and compute and COMPUTE . . . !

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Preface

I enjoy a unique position as I fulfill our responsibility as guide in this journey into modern technology: I have some background in computers so that I have some understanding. But I am not so well versed in this subject that I cannot identify with those of you who might not be so well versed either, or who are perhaps even drowned in this subject area. But I also believe I can identify, as you will determine, with those of you who are the hard-working and sometimes frustrated experts in this field.

Thus, we will speak a common language—albeit somewhat technical and mathematical at times—and we will enjoy to the utmost what we can learn and discover and analyze using the new languages of microcomputing. Sometimes the computer language can be difficult and forbidding if it isn't understood.

I will, at times, take it upon myself to interpret these new languages, and I do not restrict myself to such as COBOL, FORTRAN, BASIC, MACHINE LANGUAGE, etc. I find that these become a sort of sublanguage which is vital and necessary *after* you have learned some of these other "language" terms and definitions which enable you to then understand those I have just identified. Indeed, language ability is a primary requisite to the understanding of the theory, operation, maintenance and practices of modern microcomputers or any computers—or even calculators for that matter.

When in a fanciful mood it is often reflected that *we* might be the ones who are being programmed by the computers so that we can

communicate with them and not the reverse—that we are programming them to communicate with us. This programming involves getting a human being to that point of proficiency where he can speak and write and *think* in computer languages so easily and with such versatility that he really does not know he has shifted gears into this new communication medium. The computer just programs us so that we do it without thinking, just as we would speak German to the Germans, Russian to the Russians or French to the French. We speak and think in terms of the computer's language, and that is the key to the whole business of understanding, operation, maintaining and dealing with these kinds of machines.

Is it possible that *we* are machines? If you are experienced with human thought processes and mobility and manipulative capabilities, you begin to see strange and highly parallel similarities between machines, especially the computer-operated types, and members of the human race. When we are young we are taught coordination, either by instruction or experience. We are constantly required to learn by filling our "memory banks" with what is good and what is not—with how to do things and how not to do things. We extract from our memory banks such experiences as are necessary to develop new trial-and-error techniques, so that we can find solutions to new and, as yet, still unknown situations or requirements, no matter what they may be. Perhaps this learning that we must accomplish in order to do all that we want to do with these computers is only a part of the two-way street. The computer must learn as we give it additional capabilities—perhaps at its own request—and we must communicate in order to find out what it needs in order to do what we think we are ordering it to do.

So we need language information. That is going to be a fun experience we hope, gaining it from the pages of this work. Next we want to examine some types of computers and look at them in terms of what they have and don't have in common. If we are now or later going to become involved with them, we'd at least like to know how to pick the type we want to become associated with. We reserve the right to pick our "mental companions" as we have the right to choose our friends. So perhaps we need to do some thinking and examining in this area of who they are, what they are and how they are and so on. You know, you get very friendly with a computer—for example, think of the names of some: "PET," for one, and you'll think of others. They become personal and more than machines, especially when they "talk back" to you. I've always liked this aspect of a computer's capability because I can manipulate it to tell me what *I*

want to hear, not what I should hear. All right, if you are a perfectionist, it will write to me on a display screen or tape or paper or whatever. Soon, however, and *very* soon now, it will *speak* to me and I can even choose the kind of voice I want it to have to tell me what I want to hear—sometimes, at least. Other times I suppose I will have to do just like others do: listen to it tell me what it thinks or has calculated or determined, whether I like the message or not. What good is a computer if it just keeps telling you that you are right, anyway?

It is inevitable that our progression should take us behind the scenes to find out what makes such devices tick, and tick they do! They are clock-controlled—ask anyone. We will have some fun here and perhaps some mind challenging concepts to mull over as we pursue this over a second cup of coffee. Why go into this? It is true you don't need to know how an automobile runs to know how to use it. You are so right. But it's fun, and we have never avoided a little fun on the side. Besides, if we can put it together so that it is simple and easy to understand, then perhaps we can gain a better appreciation of what the darn thing does as it programs us.

Once we have some understanding of how a computer operates, we then want to operate it. We will also want to know what kind of information we will get as an output and why we are getting the information we are getting. We may well want to examine the outputs in terms of something other than a printed graph or word or line pictorial. We may want to examine the possibility of using the computer output to control other devices which could be electrical, electronic, mechanical, optical, or atomic in nature. There is a large field in the area of automation which uses computers to guide, steer, and activate and deactivate mechanical devices. So it will be interesting to look at the computer's output to see if signals are there in proper arrangement and form to make all this possible and probable. Of course, we know they are there.

I once talked to a programmer who was in the midst of the most magnificent frustration I have ever witnessed. The reason was insufficient input data and input data of the wrong kind. This leads to an examination of what kinds of input data we need for microcomputers according to the job we expect them to do for us. Why data is needed, how it is used, what kinds of data are there and so on will give us a good understanding of this important part of computer use and operation.

Everyone knows that a computer needs a *program*. Well, just what is it? How is it developed? Why is it necessary? How many

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kinds of programs are there? Where do we get programs? Will all programs run on the same kind of machines? Why do we have to have different programs for different machines if, indeed, we do? As you can see there are a thousand and one questions in this area alone. We have found that a person can make a very fine and lucrative career for himself in this field if one has the intelligence and understanding necessary to develop programs for various kinds of operations or actions. Once a program has been put together in its first form, then comes the debugging in which operation one turns to thousands of cups of coffee and other stimulants and forgets that there is a day and night, or that hours are supposed to be divided up for meals and sleep and recreation and family and such. And one finds his eyes crossed, his mind blown (in some cases) and his hate, admiration, loyalty toward, or respect for his computer—be it a personal type or a company monster—increased with every second. Of all the words a person hates to see on the screen "You have an error" are the worst!

Well, 'tis true that some kind computers will then tell you where and why there is an error. Some persons say that this is remarkable and keeps one from going totally insane. That doesn't mean the computer will necessarily tell you how to fix the problem. After all, it does ascribe some intelligence to the human object. But the better ones can be helpful, and they do try to assist during those long and lonely hours when pressures and panics and deadlines and bosses and other such trivia impose such vast images upon your almost short-circuited mind. Yes, we do want to examine some of the program concepts now in general acceptance.

As if it weren't enough to have program troubles, we have to have a machine, that like its human counterpart, sometimes blows a fuse. How do you diagnose a computer, which after all is a machine. Sometimes I hate to write a word or sentence like that because I've found that some of these kinds of machines can actually read. Who knows when sometime, at some hour, the telephone will ring and I might get a call from—well, you know who! But I said it and I say it again—a machine. We will want to take a look at how the experts diagnose machine illnesses and what they do to try to cure them. It may be interesting to look at some of the kinds of problems they encounter when they are actively at work. There seems to be more there in this area than meets the eye.

Related to this, of course, is the computer test equipment. There can be no more frustrating situation than to assume that a computer is working as it should because it hums and buzzes and

advances the printer or makes the graphs or prints out on the screen, and then find out that it is *not telling the truth.* If we have unknown data arrangements and manipulative programs, we might be tempted to believe what the machine tells us, unless we have a way to check its veracity.

In another of our TAB books, we looked at the computer-controlled robot and examined in a basic manner what this computer has to do to control such a secondary machine. We will look at some computer aspects of this kind of control in this work, but if you are interested, we recommed this guide as a good starting point in a fascinating field.

Finally, we want to examine the concept of tying computers together, no matter how dangerous this might sound to some. Tying computers together so that your personal computer, for example, becomes a terminal for a larger, more efficient computer is now a possibility. Since computers may grow in size as libraries, mathematical solving units and idea generating plants, we will want access to them from our own small microcomputers. No problem will be too complex to solve and no information will be so hard to access that we cannot obtain it and have it presented to us in a fine personal form which will make it easy for us to understand. The level of the presented output can be according to your own personal background.

If there is such a thing—and there is—as a *special computer,* we will try to find out what it is, what it can do, why it exists and how it is used. That will bring us to the end of this current work and probably open up the doorway to more books.

Once again, let me thank you for taking up this work. May all your computers love you and do what you ask them to do, and may they never have or pose any problems which you cannot solve easily and confidently.

Edward L. Safford, Jr.

Chapter 1
Calculators, Computers and Common Sense

Let's take a hard look at calculators and computers and see what the differences are between these two generic electromechanical devices. We will try to understand how to select a type and size which will meet our needs—if we have a need—and then try to understand what we must do in order to get any use, pleasure, instruction, assistance, or whatever from the instrument. We already know that when we stop in a computer supermarket—whatever the name of the place may be—we will be inundated with all kinds of statistics regarding the capabilities and glorious pictures of how it can fit into our life style and perhaps even change that for the better. And who is to say that this kind of sales pitch is wrong?

Once we have been convinced, by ourselves, or by others that we do need a machine such as one of the types suggested, then the questions become which one, what type, how complex, and what's the price? Also, what will it do, how does it operate, and so on. Looking for answers to such questions may lead you into a dozen stores or computer marts and in each you will be convinced, almost totally, that the kind sold there is exactly what you are looking for. The answers to all your questions will be given and will be positive for the kinds of computers that particular place is pushing. Such is the capability of the good computer salesman. He will count on the fact that your knowledge is limited, and that his use of some computer language makes him sound professional.

So it is up to you, the individual, to determine first of all if he really needs a machine; second, whether it should be a calculator or a

computer; third, whether it should be a low-cost, simple type, or a moderate cost (for computers) expandable type, or a rather elaborate type with everything already on it now, and expandable to even more than that in the future. Let us try to find some answers suitable for our own questions.

DIFFERENCES BETWEEN CALCULATORS AND COMPUTERS

We're taking the liberty of defining the two types of devices as *calculators* (even though they may be programmable) and *computers*. A calculator is a unit which can perform just mathematical operations. That is its intended purpose and its *only* purpose. A computer, on the other hand, can be made to resolve concepts and give particular displays for games, graphics and such. It can solve equations as well as simple mathematical relationships, so it can do everything that a calculator can do and more. A computer's big claim to fame is that is has a *memory* (usually a pretty large one) in which it can store data and commands and then put them together in some kind of acceptable fashion for you. This occurs when you push the keys to form a word such as RUN. The calculator can solve all sort of mathematical problems and also give you instantaneous sums, differences, multiplications and division. It can temporarily store some intermediate steps in a computing process that you are fashioning. It can display or print out the answer.

A computer can also be made to control various other things around the home, office, car, boat, or airplane, which derive their operation from electrical energy. This would apply to heating and cooling, security, cooking, lights and so on. We know that you will be able to think of a thousand other uses which a computer could control around your own home, or office or other location. A calculator as such, cannot do this.

A computer can "talk" to other computers when properly connected to them over a telephone line or other such communications link. Thus, it can get data and information, or give data or information and request resolution of bigger problems than it alone can handle. It can then show you on its displays the results of whatever kind of problem, situation, or information request that you might have made to it. Again, the calculator cannot do this.

So it seems that the calculator is a tool which can be used to solve primarily mathematical problems. It requires *your* brain and fingers to perform the various operations necessary to produce a solution. It can give you some assistance, for example, in determining the square root, inverse functions, or some trigonometric values

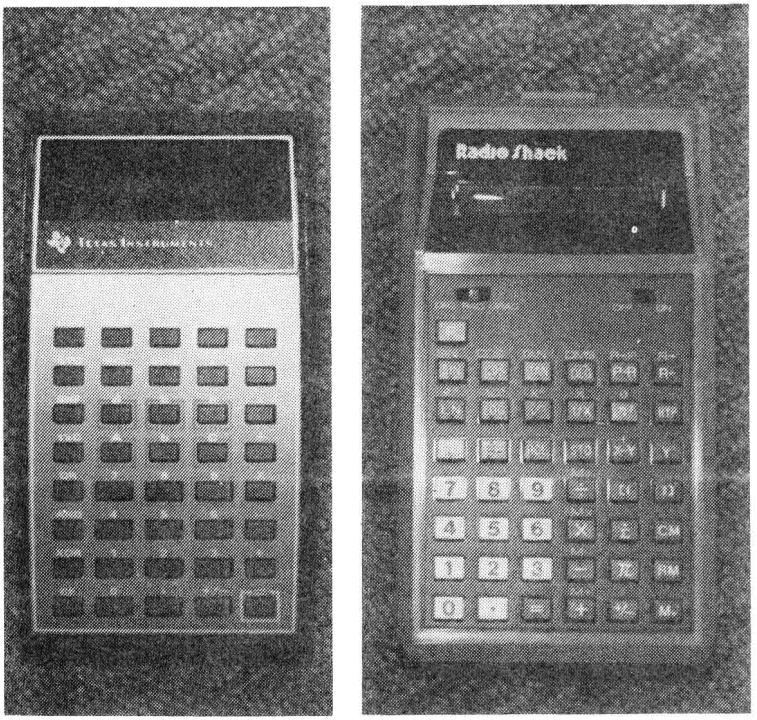

Fig. 1-1. Two scientific calculators, one by Texas Instruments and one by Radio Shack.

and other such typical functions as shown on the face of the calculators of Figs. 1-1 through 1-5.

Of course, you can get simpler calculators which merely do the basics of adding, subtracting, multiplying and dividing. If we keep the batteries to the proper charge level and push the right button and don't forget to insert the proper sign during each data input figure, we can expect to come out with a display that gives us the information we want at that moment.

But even with a calculator, which some say cannot make any mistakes, we have to keep our wits about us in order to determine whether we have made a mistake or not. Usually, we will estimate what an answer should be and then check to see if the calculator hits the "ball park" value before going on. That way we catch some errors which we introduce into these perfect little systems.

A computer will require just as much of an alert status on our part as the calculator. But the computer may also help us. It is not uncommon for a computer to print out the word ERROR or its

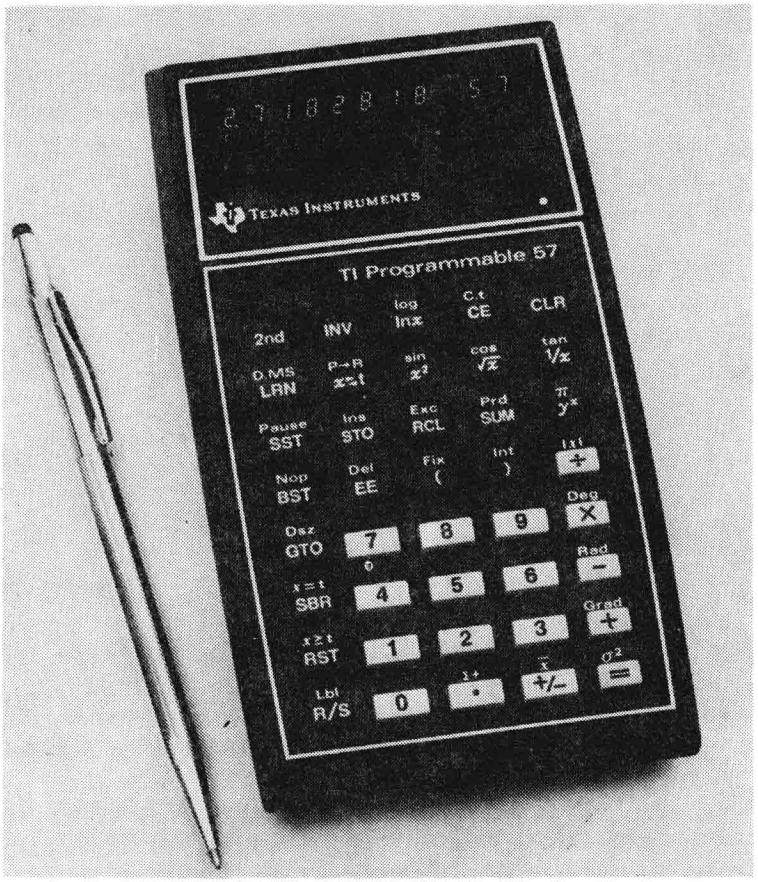

Fig. 1-2. Texas Instruments' Programmable 57 scientific calculator.

equivalent and then quickly indicate in plain English just what *we* did wrong. Isn't that nice? We can go back a line or word or character and put in the correct symbol, letter, number or whatever and proceed on from that point. Some computers can also give you at any point in your systematic programming operation an over-view of what you have done so far by printing out a listing of all data and operation it has so far stored in its memory.

Yes, the computer is a more powerful tool and more versatile device. It requires more effort, and we will be required to learn much more to make it work for us properly. But we can do this, and usually quite easily and in a most interesting manner from the guide books for that particular type of computer, just as we have to learn from the Users Manual which comes with a calculator.

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