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PET's First Report Card

Last year I wrote an article comparing the eight "personal" computers I had bought, built, designed, re-designed, and debugged (or failed to debug). At that time the PET was only a gleam in its father's (Chuck Pettle's) eye. Now I have one. How does it stack up?

At the end of October my PET arrived, three and a half months after the usual "$800 cash-up-front" type of order that most of the others had required. Although two weeks tardy, it was still less delinquent than any of the others except the SCAMP and TARBELL, which arrived on time. I've come to accept this as a way of life for newly announced equipment, but I find that most people entering this exciting and mobile field of personal computing balk at it. It is particularly true today when you can walk into a "computer store" and get products from maybe a dozen suppliers on an off-the-shelf basis. Furthermore, you pay for them next month on a credit card.

I continually hear the query, "Is it worth it?". It is. The day after I received my PET I took it to a meeting of the Valley Computer Club and was barraged with similar questions from people who already had their own computers.

This "report card" is an attempt to answer some of these questions on an unbiased (I'm not selling anything) basis. Since I have personally built (on the dining room table) or bought and modified (KIM & DATAWORKS) three 8080 based, five 6800 based, three 6502 based, and one SC/MP based microcomputer, the PET has

a lot to live up to. But first, some background.

At the time of this writing Commodore has never advertised the PET, but the magazine articles, television exposure, and convention displays have made it a pre-production marketing phenomenon. In fact, I'm writing this on the assumption that anyone who reads it has already been exposed to its fundamental specifications. In case you haven't, just pick up nearly any back copy of any computer magazine starting last July. Right up to the present time the big question has been: can Commodore produce what they claim for the quoted price and still make enough money to stay in business? To get some "official" answers from them, I wrote a two page letter and received a one sentence reply. It contained an honest admission to "crumby documentation". After this article was half written I had a chance to chat with Chuck Pettle, but the opinions herein expressed are my own, derived primarily from personal "PETting" and augmented by the published references and conversations with sales representatives .

To start with, I'll dive into the deep end of the pool of controversy and say that, in my opinion, they're <u>going</u> to make it -- and make it big. Not with the model I received (serial 171), but with a factor called <u>vertical integration</u> and forward thinking management.

Now let's review some history in order to get a perspective on the pros and cons of grading the PET #171. In a sense this is more of a "mid-term" interim report card, because the documentation required to realize its true potential still hasn't arrived. I've spent most of my time trying to find out (the hard way) just what I bought. There is a gnawing feeling in the pit of my stomach

that they are going to follow in Radio Shack's footsteps and not tell me much more than I already know.

From my point of view the PET is really the third product from MOS Technology, being preceded by my JOLT and KIM (see Photo 1). Although the JOLT is produced by Microcomputer Associates, its debut was a result of their synergistic relationship with the then almost-unheard-of MOS Technology. It was the first microcomputer to really take advantage of read-only-memory (ROM) to reduce hardware. Of course others, such as DATAWORKS with its 5K of operating PROM, had preceded the JOLT (and ALTAIR) by nearly a year -- but the accent was on a firmware operating system, not hardware trade-off. The 6530 mask-programmed chip which combined ROM, RAM, COUNTER and I/O was, in my opinion, almost as big a milestone in LSI progress as the microprocessor itself. Not so much as a technological breakthrough (competing devices had similar complexity), but as a practical adaptation of an emerging technology to take a giant step forward on the path of progress.

Instead of having a single board used only for a teletype port (as on my ALTAIR 8800), the whole JOLT took up less than half the real estate. The forever-drifting adjustments of the ALTAIR were replaced by a ROM/I-O which measured the speed of my TTY and adapted itself! But the real value of the TIM (or DEMON) 6530 was the documentation. Here were 1,000 bytes of I/O and operating system available at power-up, and documented in such a way that its subroutines could be (and were) used in every program I wrote. It also served as a "workbook" for learning practical usage of the 6500 code.

The JOLT had one big disadvantage -- for practical purposes.

had to work on the bit, octal, or hex level. This meant working only in machine language if you had the minimum computer configuration, such as KIM, SCAMP, etc. It took only a few hours of "bit-banging" with op-code conversion to realize that there had to be something better, and BASIC or an alphanumeric assembly language was probably it. Even if you could afford the extras required to get and interface the necessary keyboard and CRT (around $1,000 a few years ago), there were other problems. On the hardware side, you needed memory -- lots of it. You could use RAM, and wait and wait to load BASIC or an assembler. Or, you could pay and pay ($425 for my ALS-8 assembler on PROM) to get a "resident" assembler, BASIC, or both. An even more expensive memory alternative was, and is, the floppy disk, with "magnetic bubble" devices warming up in the bull pen.

On the software side, BASIC has been evolving. Spurred by the San Francisco community in general and Tom Pittman in particular, the old original Harvard BASIC was first freeze-dried to miniscule proportions and then extended. But what is more important is the cost of good software. In the late 60's even moderate software sold in the thousands of dollars per program, with additional hundreds to adapt it to your system. Contrast this to Tom Pittman's TINY BASIC at $5, Chuck Crayne's 6800 ASSEMBLER, or Ed Smith's TRACE/DISASSEMBLER in the $10-$20 bracket and the stage is set for mass usage of computer power. Mask-programmable ROMs could utilize this software at reasonable prices, but only if high volume sales could amortize mask costs. The time has come for an affordable computer that does not require the fervent learning and application of hardware and software

skills heretofore required of a hobbyist.

Enter, the PET. The third entry from MOS Technology (a fourth is on the drawing boards) is another significant step forward for its time. At the time I paid my deposit of $800, the closest competition providing similar specs cost more than twice as much. Since then, both Radio Shack and Bally have left the high-volume gate in the race for the mass market. The Bally machine is aimed at the game sector with implied, but as yet unavailable, extensions into general computing. The Radio Shack TRS-80 is squarely in competition with Commodore's PET, and the factor of vertical integration is likely to keep the field small. Only a few companies such as Texas Instruments (with their wristwatch and calculator mass production-marketing technologies) have the high priced chips it takes to pay the entry fees into such a marketing race. Let's take a look at what vertical integration has done for the PET.

MOS Technology started as an independently financed "splinter group" from Motorola's 6800 development program, with associated legal problems (now resolved). The resultant 6502 microprocessor started as a "cheap" 6800. It uses most of the 6800 instruction set, but is (in my opinion) severely hampered by its lack of a double byte accumulator. This deficiency is somewhat offset by page zero double byte indexing capability, which I've never really been able to master. Others have, however, and the 6502, which seemed to come out of nowhere, burst on the scene in the JOLT as a "show-stopper" at the 1975 WESCON show. I personally feel that the real innovation was the mask programming of the MOS Technology 6530 I/O chip. In any case, MOS Technology was off

and running, nipping at the heels of the well established INTEL 8080 and Motorola 6800. As the price of 8080s and 6800s fell to the under $30 range the 6502 lost its price advantage, but it was staying ahead in other areas -- primarily the KIM. INTEL's INTELLEC and Motorola's EXORCISOR development systems ran into thousands of dollars -- KIM was less than $300. True, it didn't do nearly as much as the "biggies", but for the smaller electronics manufacturer the KIM, with its superb documentation, was an entry into the world of microprocessors. Until very recently, the lack of a good, cheap assembly language and trace for the 6502 has limited my use of it. The availability of Chuck Crayne's assembler for use on the SPHERE 6800 and Processor Tech's ALS-8 for the 8080 have diverted my attention from the 6502. My biggest disappointment with my PET is the virtual nonexistence of the advertised "system monitor". It might have filled this 6502 assembler void. Initial forays into a new field such as microprocessors are usually on a small scale, so the KIM filled the bill admirably (and still does). This resulted in the 6502's being designed into new products and MOS Technology grew. It added memory chips to its line which included character generators as well as the 6502 family.

The JOLT and KIM were both blockbusters when they were announced -- but what do you do for an encore? The APPLE-II and Ohio Scientific Machines had pushed the use of ROM operating systems and hardware/firmware trade-offs right up to the state-of-the-art for 6502. Something radically different was needed.

Enter Commodore. As an early front-runner in the pocket calculator revolution, Commodore was facing the same over-production, price cutting, market saturation problems that had left a trail of corporate corpses all around the world. MITS was almost one of these, and we all know what saved them from disaster. The microprocessor originally evolved from calculator technology -- the field in which MOS Technology also started. Today the calculator field is headed in two directions: the $5 cheapy and the $600 wristwatch-calculator and/or the sophisticated programmable printing calculator with long term memory. How could Commodore compete with T.I. and others who had vertically integrated so that they produced everything "in-house", from LEDs and keyboards to L.S.I. chips? You guessed it -- they bought MOS Technology. Commodore is still in the calculator business, but you have only to look at their stock market history during the last year to see where the action is, or isn't.

When Commodore acquired MOS Technology (and Chuck Pettle), the PET was inevitable. The factors fell into place. The major expense items for an inexpensive computer were no longer the microprocessor chips (less than $10 in quantity) nor the I/O chips, but rather the I/O devices. The TV headed the list, followed closely by the keyboard and cassette recorder. The next generation of microcomputers would require all of these, but was it practical?

There was the spectre of SPHERE. Note the marked resemblance between the brand new PET and my two-year-old SPHERE in Photo 3. The resemblance is more than skin deep. The built-in TVs and dual keyboards are obvious -- not so apparent are the

following: a 10K ROM operating system in the SPHERE (14K for the PET); 36K RAM for SPHERE (8K for PET); PIA, dual cassette, TTY, and modem for SPHERE (dual cassette, IEEE, PIA, and TV for PET). Making allowances for cost of RAM, PROM, etc., a SPHERE which was roughly equivalent to my PET would have cost about three times as much. The problem lies in the fact that SPHERE Corp. went broke about the same time that the PET was being announced. The first announced price for the 4K PET was $500, which promptly slid up to $600, to be replaced by $800 for 8K (the only model delivered, so far). Even at $800, the question on my mind (particularly after shelling out my $800) was, "can Commodore really do it?" Judging from the people I spoke to and the articles I read, the consensus of opinion was that they couldn't. When the promised delivery date came and went (with the same lame excuses I've heard time and again, starting with my first ALTAIR) I, too, began to wonder. As of this writing (early December), Commodore is slipping even further behind in deliveries. Does this mean that they're following in SPHERE's shadow? Will my PET become another SPHERE-like orphan? The Edsel of the personal computers? I think not, and here's why: PET gets "A's" in three categories -- vertical integration, good engineering, and advanced technology. Let's see how PET measures up to competition.

Vertical integration is, perhaps, the greatest asset. The PET combines the past experience of product development (JOLT and KIM) with the LSI semi-conductor design and production expertise of MOS Technology and the "offshore" sub-assembly production and aggressive marketing methods which Commodore developed for its calculator line. PET's competitors have equal or greater assets

in one or more of these three categories, but none can match the vertical integration of Commodore-MOS Technology. Radio Shack's TRS-80 comes closest. They have the best mass sales set-up in the world. They also have the only foreign supply expertise which can rival Commodore's. This is perhaps the most important prerequisite for a cost-effective end product.

The highly priced components of a computer system are: TV monitor, memory, CPU (Central Processing Unit), keyboard, and cassette recorder. Competition and mass production have forced the costs of CPU production down to a point where, even if you're making your own microprocessor (MOS Technology's PET, Motorola's EDUCATOR II, etc.), only small reductions in end-product pricing can be realized. All the other items involve the purchase of devices and/or sub-assemblies made abroad. The biggest item is the TV monitor. Most hobbyist computer manufacturers gloss over this item with phrases like, "use your own television set with adapter (not supplied)". The fact is that a reasonable frequency for "your" TV set mathematically limits the readability of characters to 16 lines, 32 characters per line, caps only. Most hobbyists soon find that this limitation, plus competition for time on the family TV leaves little choice but the purchase of a monitor. A commercial TV monitor with adequate bandwidth for lower case, long line displays can cost almost as much as the computer (before it "grew"). In fact, I'm using monitors that cost as much as my PET. Inexpensive but adequate TV electronics comes from Japan, Korea, etc. So does another major "accessory" -- the cassette recorder.

The competition now takes on an international flavor, and International is Commodore's middle name. Most of Radio Shack's line of REALISTIC trade named products are also imported, including the TV monitor and cassette recorder which account for one third of the cost of the TRS-80 system. PET's keyboard is also imported (more on that later). Speaking from personal experience, the business of getting production quantities of proprietary designed high technology hardware from overseas is a major accomplishment. Delivery and quality control require on-site monitoring and this means a truly international organization with established operations in the Orient. Both Commodore and Radio Shack can do this -- but, can anyone else? This is probably the most important factor in vertical integration -- it separates the men from the boys in low-cost, high volume production. I would venture to say that it's entirely possible that these two leaders could produce more cheap personal computers in 1978 than all their competitors combined -- and make money at it. Even with their years of calculator experience, however, it's obvious that Commodore is having overseas production delivery problems (as of December). On the other hand, the TRS-80 is having problems getting its full BASIC underway.

PET's vertical integration includes LSI (large scale integration) production by MOS Technology, and when the dust settles down this may well be the deciding factor. Initially the TRS-80 had an edge because they designed it with LSI already in high production from second sourced suppliers. MOS Technology has had to cope with the "learning curve" problems of getting their new LSI RAM and ROM chips into overseas production. These two items account for most of the costs of the respective CPU boards (see Photo 2). As the

learning curve progresses, the tables should turn and give the PET a clear cut advantage over all comers, including Bally. PET's in-house volume base for the 6550 (4K, 5V, static RAM) could even make this chip a dark horse contender in the 4K memory field. In fact, I'm so impressed with its performance (in spite of four defective chips) that I'm designing it into a 6800 based controller system.

The third factor in vertical integration is marketing. In this area, the small (often "garage" type) computer company is going to have a very, very rough time in the next year or two. Radio Shack with its massive string of franchised outlets has a clear cut advantage, and its parent company (Tandy) is opening a string of computer stores. Another big contender in this area is Bally with the high-powered, hard-sell J.S. and A. doing a spectacular job with what I personally consider to be misleading (but "legal")advertising. In this area the PET is a phenomenon, so far. The Commodore calculators survived in a cutthroat marketplace, so this, along with KIM, gives the PET a solid foundation. It's been further augmented by bringing in experienced personnel from competitors in the field. Any newcomer will think twice before going up against this kind of marketing competition -- the blue chips in this game are expensive.

Another factor sets these three contenders apart from their predecessors -- the "concept of utility". They are not aimed at the hobbyist computer addict market, although the impact will probably hit 7 on the Richter Scale. Bally is a home market adaption of the technology of a company that has dominated the

coin-operated game industry since the one-armed bandit days. Because it has a microprocessor, memory, etc., it qualifies as a microcomputer, but its I/O is currently game-oriented and we'll have to wait and see how economically and technically they can compete in the personal computer arena. So far it only looks good in print. Both the PET and TRS-80 have recognized that the "family" appeal requires electronic game appeal. This makes a TV and keyboard graphics mandatory, which brings up the problem of keyboard and/or joystick input. Although both have graphics capability, neither of them has a joystick (as does the DAZZLER or APPLE-II). I'm sure that this will become available in the future since both have expansion capabilities that can support a joystick. There is a basic difference in the concept of how graphics are meant to be utilized on the PET and TRS-80. The TRS-80 splits each character block into a decoded matrix like the CHROMENCO DAZZLER, APPLE, etc. The PET goes a different route. It provides a unique graphics symbol to virtually every key on both keyboards. This provides a very large selection of fine-line picture elements which cannot be achieved through the older techniques. It also provides unique game playing symbols such as the card characters of hearts, clubs, spades, and diamonds. Descending lower case characters (with "shift") for all alpha characters is also provided, as is reversing of white-on-black to black-on-white. All this flexibility poses several keyboard concept and design problems, since each "letter" key must display six different characters. How can it be done economically? PET's solution was, of necessity, a compromise. By using two calculator-type keyboards (for which Commodore

tooling was probably available) and changing the artwork on the anodized caps, they got an inexpensive (probably the cheapest in the world) alpha-numeric keyboard. The alpha key arrangement is only quasi-standard, but the separate calculator numeric key pad is standard. It is also small enough so that the cassette mechanism can be mounted alongside it and still fit a minimum size case. Both keysets are mounted on the same cost-effectively designed passive mother board. Since the keyboard matrix plugs into the CPU with a single cable (see Photo 2) it would be possible to use a standard spaced keyboard in parallel with, or instead of, the "calculator" board.

The most commonly criticized feature of the PET is the key placement of their keyboard (PHOTO 4). They are more closely spaced than normal, the middle row isn't staggered, and the "feel" of a calculator key isn't the same as that of a typewriter (it's more like a teletype). I'd been told (by a TRS-80 booster) that it was "impossible" to touch-type on the PET. He was wrong. It does take a relearning period, much like going back to a stick shift after driving an automatic for years. When I returned to my full keyboards on the SPHERE and IMSAI I realized that I've always used the hunt-and-peck method for number pad entry, multiple key control character and "special" character entry. Unlike touch-typing a letter, most of my programming is really hunt and peck, and the PET is just about (but not quite) as easy to use as the SPHERE (see Photo 5). A programmer friend and one of our keypunchers claim that PET's keyboard drives them up a wall. But then, how many PET customers are professional data processors?

I understand that the next model PET will have a full keyboard -- it will also cost a lot more. I could easily wire a $40 keyboard to replace the original -- in fact, the original lousy alpha keys on the SPHERE shown in Photo 5 have been replaced, just that way. Then what would I do about the 70 graphic and special characters which aren't available as standard key tops? In short, PET's keyboard isn't great, but neither are the practical alternatives. Another quirk of the PET is the fact that its graphics and lower case display modes are mutually exclusive. It initializes to the graphics mode, and requires a "POKE 59468,14" to convert the display to lower case. A "POKE 59468,12" returns to graphics. This is accomplished by some mysterious hardware/software manipulations involving a PIA and ROM which I haven't deciphered -- yet. You can't mix lower case and graphics. Changing modes changes <u>every</u> shifted character on the screen, but not in memory. It can create some wierd effects which I used to change graphics each second in an experimental "STOPWATCH" program. PET didn't list its lower case capability in specifications at the time I bought it, so it came as a pleasant surprise; one of several "extras".

A REAL-TIME-CLOCK is another of these extras. It doesn't do as much as an S-100 real-time card, but it doesn't cost an extra $130 either. It outputs a six digit, 24 hour clock word, e.g. TI$=235959=23 hours, 59 minutes, and 59 seconds. At 240000 it resets to 000000, and is software pre-setable. It also outputs JIFFIES, which are 1/60 second counts accumulated from 000000. JIFFIES are about as fast as anything you could use with any program written in BASIC. The clock runs off of the 8 MHz

crystal. Although it isn't immediately evident, the real-clock function is an excellent example of the aggressive design policy which makes the PET a technical step forward regardless of price. I haven't figured out exactly how they did it -- yet, but what I've deciphered so far is an impressive utilization of the latest LSI capabilities from MOS Technology. More vertical integration here, and a valuable feature not available from their competitors. Among other things, the TI function is a fundamental building block in "automated home" programming. Since it runs on interrupts, it will keep the time of day as long as power is left on, but unless you "trim" the oscillator you'll have to keep re-adjusting the readout.

By now it should be evident that the PET's low price was not achieved by making a cutdown, stripped version of older technologies. Take the built-in cassette recorder, for instance (Photo 6). All of my other systems require that I not only provide my own, but both the TARBELL and ACR in my ALTAIR/IMSAI are a bit snobbish as to what they like and how it is adjusted. Except for the TRS-80 and PET, cassette recorders are a "hidden" extra expense of personal computing. The garden variety cassette recorder isn't optimized for digital recording. It sacrifices signal-to-noise for low harmonic distortion and ignores phase distortion. Its electronics are an overkill, including automatic gain control which prevents full level recording.

PET's cassette takes a radical departure. All the erase-record-play electronics are on the single card shown in Photo 7. Obviously the gutted mechanism supplied in the current models is a stop-gap solution to overseas delivery problems, and

the eventual recorder should be produced at a significant saving over competing systems. The recording method used is a compromise between D.C. saturation digital recording and the frequency shift-audio techniques currently in vogue. D.C. erase is used and square waves are fed directly to the record head. The record current is limited to prevent complete saturation and biased for "centering". On my unit this results in about 8 DB better signal output on playback with improved phase distortion characteristics. My unit also had two "dry-joint" solder intermittents. Finding these necessitated creating a schematic -- the hard way. I also needed the info when I tried to find out why my PET played back its own tapes flawlessly, but couldn't copy from one cassette to another as I've been doing with my SPHERE, etc. The problem lay in the reduced record level and phase distortion. It worked most of the time. It might even be practical for short programs, but it certainly isn't good enough for longer ones or file storage. PET got some demerits when I found that several playback errors were <u>not</u> caught by the double-recording check. I'm sure that a mass cassette duplicating operation will eventually be capable of duplicating digital tapes in this format, but my copy of the first one on the market (<u>not</u> Commodore) was a disaster. I asked Chuck Pettle if PET was designed that way on purpose to give them an edge in the prepackaged software field. He was surprised at my difficulties, and assured me that the intention was to provide a truly interchangeable format for all PET users. There is no problem in interchange of original recordings, only duplicated copies.

I really feel the absence of a counter on the cassette recorder. Unless you restrict your tapes to two or three per side, you wait forever for the playback to find the right program. In desperation I use a separate recorder to find the approximate start position with a counter and then transfer it to the PET. A real pain. Although the BAUD rate is high (1,100 BAUD) a very long preamble, double buffered recording scheme and a motor stop between files slow down the file handling to a snail's pace compared to a TARBELL. The second cassette port is fully implemented on the CPU but, as yet, no recorder is available to make use of it. Hopefully it will have a counter.

Another nice added "extra" is the VERIFY mode. After recording you can rewind and "verify" the tape playback against memory. Since I've eliminated the intermittents in the recorder, it's a bit redundant because there has never been a playback error. Another extra is the unrivalled simplicity of loading a program. You turn on power, insert a cassette, and press "RUN". It tells you to "play" the recorder, displays the label of the first thing it finds, tells you it's loading, that it loaded "OK", and runs the program. Even a very small child can do it -- an "A" rating, if children are to realize the maximum educational potential of personal computing. If you specify a label it will display each label it finds until it gets the right one, then loads it.

The PET's recording format is unique, as are those of most of the new computers -- it looks as though the BYTE standard will bite the dust. The PET maximizes the hardware/software trade-off. It uses almost a bare minimum of analoque devices (room for design

improvement here), a couple of PIA ports, and no UARTs or other serial I/Os. It's the most cost-effective digital recording system I've analyzed, although the EDUCATOR II is a close second. It's an A+ example of saving money with design ingenuity.

Photo 8 shows PET's TV board. All of the other competing computers with CRTs use off-the-shelf monitors or TV modifications. As with the recorder, PET breaks with tradition, gaining improved cost/performance by replacing hardware with firmware. The complex sync signals which use up hardware in both the traditional character generators and monitor are generated by firmware and the very powerful 6522 I/O chip. The video, horizontal, and vertical drives are also available on the rear "user terminal". The video board doesn't need to decode sync or amplify video, so it's simpler (and cheaper) than competing models. Since the screen is built-in close to the operator's eyes, it can be smaller than a separate monitor (such as the TRS-80) and still provide the same legibility -- another saving. There is only one external adjustment: "contrast". My PET needed vertical centering. It was done with the tabs on the neck of the CRT. See Photo 9. A small pot at the rear adjusts the heigth. So far it has been very stable and provides a steady picture with a superior bandwidth, another "A" rated example of cutting costs with creative system design.

Photo 10 shows the CPU board -- PET's brain. It takes less than two minutes to remove it. Wiring harnesses cost money. Both the PET and the TRS-80 keep it to a minimum. ~~Photo — shows how~~ It plug-connects to the power supply, keyboard, video, and recorder. Incidentally, be careful with the keyboard plug. Mine became

intermittent after its first replacement. The leaf spring contacts in the female cord connector are easily overstressed and may have to be reformed with a probe. Note how the four expansion connectors are made directly to the board through slots in the side and rear of the case, a far more efficient arrangement than that of any of my other systems. At this time there is nothing available to connect to them, but when there is, the difference between the utility of the PET and the TRS-80 is likely to give the PET a big competitive edge (see Photo 2). The long connector on the righthand side has what the TRS-80 has on its single expansion port. In addition, the addressing is available decoded into 4K blocks. Current plans call for its use in RAM, ROM, and PROM (2716) expansion. The monitor and assembly language will probably go into ROM.

The current pricing of $200 for 4K of RAM makes PET about the highest priced RAM on the market. When the 6550 moves out on its learning curve, PET should be in a position to provide the cheapest memory around.

The small connector pad in the corner is for cassette #2. You can play the recorder into it. It works, but as yet there isn't any recorder available to use with it. If PET doesn't make one available soon, I'm sure someone else will, and I hope they provide a counter. The center connector brings out the aforementioned video feeds and half of the powerful 6522 PIA programmable I/O. It's called a "User" port and if they document it adequately it could become PET's most valuable asset The upper-left connector is the IEEE-488 buss. If and/or when the S100 buss system yields to another format, it's likely to be the 488. This system is supposed to allow your PET to "talk" with up to 18 peripherals

through a high speed, 8 bit parallel buss. Properly implemented it can be almost as fast as a mother board or backplane.

There are more than 200 devices (a lot from Hewlett-Packard) available for use with the 488. The catch is that most of them cost more than the PET and are "special purpose" test instruments, not really suited to personal computing. Motorola and others are coming out with LSI chips which should make the 488 system cost competitive with the S-100. This won't happen immediately, but when it does, PET will have a well established lead over the rest of the pack, particularly in software. PET gets an "A" here, because Commodore's vertical integration should allow them to make inexpensive peripherals which could be used with competitors' microcomputers, as well as with the PET. The TRS-80 (see Photo 2) with its single unique 40 pin port only rates a "D" when it comes to this kind of expansion, ~~and Bally gets an "F"~~.

PET's power supply, see Photo 11, is 5 volts only (SPHERE uses five different voltages) for the digital equipment. The TV board has its own rectifier-regulators. The CPU board splits the load into three sections with the three 5 volt regulators along the lefthand side. The two power transistors with heat sinks are the motor controllers for the cassette recorders. The regulators are running hot now, so additional loads should be limited.

The 8 MHz crystal clock drives the 6502 microprocessor at 1 MHz. It also provides the TV timing and 60 Hz JIFFIES. The crystal is stable, but the factory feels that plus or minus 1½ minute per day is adequate accuracy. If you want greater accuracy you'll have to trim the driving capacitors next to the crystal. A 6-30 pf variable in parallel with 22 pf did the job

for me (see Photo 12). Now I can trim it like my digital wristwatch. The 24 hour clock is counted with interrupts and should be software independent. I've encountered unresolved problems with a program that continuously reads "TI$" -- it "speeds up" the displayed time.

The 6550 RAMs are 4K, high speed, low power, static, and require only 5 volts. They are pinned as 1K by 4 bits, so they are socket mounted in pairs along the front of the board. Page Ø is at the left and the high nybble is toward the front. If memory problems occur (I've had four failures) you'll need to play "musical chairs", since it's impractical to apply a memory test to the low 1K where BASIC operates its scratch pad. This device gets an "A" for design and a "D" for deportment.

The ROMs in the first units (mine included) were not the MOS Technology devices currently being shipped. They are 2KB devices and are now being soldered in. Although PET is officially rated for 14KB ROM, there is another 2KB of the same ROM used as a character generator. The PET is currently oriented toward the personal computer mass market, but by changing only the ROMs and keyboard caps it could become a super development system, "smart terminal", "dedicated Controller", word processor, type setter, or just about anything micro's are, or will be, used for. It could happen virtually overnight and with the inherent mass production economics, it would be a price cutter in any market. A bit awesome when you think about it, since MOS Technology could supply inexpensive masked ROM for any application.

PET gets a B+ for its metal case. It will probably be replaced by a more durable plastic case, but dies for this size moulding are a long time coming. In either case the PET is utilitarian and its exterior appearance can only be compared to units costing several times as much. It even has a "prop" to hold up the hinged top for servicing ~~(see Photo).~~ The tooling is a little sloppy and some of the holes are mismatched. My degree was in mechanical engineering (a long time ago) and I appreciate good mechanical design. I have to say that PET has it. Not only is the case impressive, but so are the circuit board layout and the overall cost effective design decisions. Three of the four circuit boards are inexpensive "single sided". The case of the TRS-80 is a good design job also, but the overall effect looks like a keyboard with dangling wires to a dominating TV (that won't show "Columbo"), with a cassette and power supply strung around it. The TRS-80 is more attractive than the encased JOLT or KIM, but to the average "housewife", it just doesn't look like a computer when compared to a PET or SPHERE. A housewife's apron-strings are usually knotted with purse-strings, and don't forget it.

Now we come to a consideration where PET gets some low marks: reliability and service maintenance. I give it a D. At the same time there is enough room for improvement so that it could "go to the head of the class". It worked when I received it. Since then I've had four intermittents. Three were bad solder joints and the fourth a defective connector. I've also had four memory failures, a "glitch" in my TV horizontal sweep, drifting vertical centering, undetected "read" errors, off-frequency crystal calibration, and a couple of other wierd goings-on that remain

unidentified. To put it in perspective, I should add that this behavior is better than that of my MITS 8800, MITS 680, IMSAI, SPHERE, JOLT or SWTP (that turkey never did work). Bugs are a way of life when you get the first units off a production line; I expect them. MITS had trouble with bad memory chips on the first 8800 boards -- worse than my PET's. They wouldn't send replacement I.C.s so I reluctantly sent the useless boards back. It was four months and $40 extra before I got working memories from them. The big hangup with bugs in my PET is that there is no service information provided; furthermore, it's unlikely that I'll see a schematic for a long, long time -- if ever. The local distributor doesn't have any more information or spare parts than I do. The 6550s aren't on the market and there are no complete spec sheets available for them. A magazine article had estimated that factory service would require two months with shipping. If you detect a note of frustration, you're right! It's even worse when you see a little LED on the board and know that it's part of a built-in diagnostic system that's using up some of that ROM you bought. Neither you nor your local dealer can use it; it's a factory secret. Now what do you do?

First you call the factory. The girl I got didn't know what I was talking about, and the fellow who might have known was "unavailable". People who went through this with MITS and SWTP in the "old"days (it's changed now) know the script.

After a period of fuming and fretting, punctuated with expletives, I decided that $10,000 worth of test equipment and four years' experience with microprocessors ought to be able to

solve the problem without schematics. It did -- partially. I had to write my own memory test program and use a multi-trace storage scope and several 3 A.M. evenings, but eventually I found the intermittents and some of the bad memory chips (also intermittent). Then, another call to the factory. Things started to look up. This time I was put through to the right man with the right attitude and right answers -- a real gem. Three days later I had replacements and spares, no extra charges, no insistence that I relinquish my cherished PET for an indefinite stay, and a lot of good solid advice as to how to tackle the remaining problems. He also assured me, as did Chuck Pettle, that most warranty repairs were taking less than a week, if worse came to worse.

Okay, so my PET is running pretty well, but what about the housewife in some Podunk town in the midwest, without a well-equipped laboratory, years of experience, and a WATS telephone line? What if she got my #171? Well, as of December her only recourse is to return it to California or Pennsylvania and hope that Murphy's Law, as applied to intermittents, doesn't require too many return trips. However, by the time you read this, PET could be in the best service position any personal computer manufacturer has ever been in.

The information and special wiring harness should be released so that the built-in diagnostics can be utilized by relatively inexperienced people. Faults could be "fixed" by identifying and exchanging the offending circuit. Since there are only four circuit boards and a rudimentary power supply, the built-in

diagnostics, augmented by test cassettes, should easily bracket the problem. From personal experience I'd estimate that most WHILE-U-WAIT-repairs" could be done in less than fifteen minutes. The ability to do this was obviously a design objective. Currently there are two flaws in the "grand plan". All available parts are being used to try to satisfy a huge backlog of deliquent system orders. There are no "spare" boards for dealers or servicemen. Also, documentation and test equipment are not yet available in what Chuck Pettle describes as an "acceptable" form. When I asked him when I would get schematics adequate for servicing the problems with my PET, he told me that only the characteristics of the I/O were going to be released, and the rest would be kept "secret from competitors". In a vain attempt to get him to change his mind, I pointed out that a competent computer engineer could produce a schematic of the whole system in a few days and that any programmer who has written a BASIC interpreter (see "A Tale of Four BASICs", Kilobaud No. 13, January, 1978) could produce a source listing of the ROMs. In point of fact, the only firms which possess these in-house skills are his competitors! As they say about gun control, "If you make gun possession a crime, then only criminals will possess guns." If PET (or Radio Shack) refuses to supply schematics to servicemen and product designers, then the only people who can get the information are their competitors with skilled manpower. I admit I'm biased by the many unnecessarily wasted hours I've spent "debugging" my PET (maybe I should use flea soap), but I can't help feeling that Chuck is adhering to a short-sighted policy. However, I feel that he's a very reasonable

man, so hopefully someone else can succeed where I failed, and we'll all benefit.

After re-reading what I've just written, it's evident that, with the exception of the service and documentation problems (which may not exist by the time this is printed), the PET has been depicted rather positively. As a matter of fact, Commodore could easily drop a perhaps fatal wad on the PET venture. Several local dealers who were pushing PET a month ago are now telling customers to buy something else because "Commodore is going broke". I suspect that delinquent deliveries and "cash-up-front" dealer policies are the real motivation, but how much of this can PET take? One look at the gutted cassette recorder implies a big problem with overseas supplies. Less obvious, but unmistakeable, evidences abound to attest to the probability that my cold-solder-joint intermittents are the result of questionable production practices and relaxed or inadequate quality control. No matter how cost-effective a product design may be or how dynamic the pre-production sales effort, if you can't produce a reliable product on schedule with efficient and minimal after-sales service, you'll lose the ball game -- remember Viatron? MOS Technology had problems with the early KIMs (mine went back twice), and successfully solved them. I'm betting that PET will have a similar success.

When it comes to software PET gets a C, with an "incomplete" noted in the margin. The bare bones listing of Micro-soft's latest BASIC makes it difficult to work with, much less evaluate. Someone

else will have to do that after the manual is published. So far it's about the same as the Crayne BASIC I've been using on the SPHERE and the MITS on the ALTAIR. It's faster, the error messages are better and the files are double buffered, but watch out for commas within quotation marks, such as addresses in FILE programs -- they tend to act as delimiters. If you're used to using abbraviated instructions, you'll be disappointed. Also, the literature lists a SQR (square root) function. Mine won't do this, but it will execute $x^{0.5}$ (x ↑ 1/y). The original specs called for 4K basic operating system. Compared to the SPHERE operating system I'm using with only 2K of PROM, the PET is a disappointment. There are "USR" and "SYS" commands in BASIC but no facility to load, or generate machine code except by writing your own program to "POKE" it in BASIC. I had hoped that they would at least start where the two-year-old SPHERE system left off. If I were to put the Crayne's SPHERE BASIC in ROM along with the current ROM operating system that consists of V3D, PDS, Mason's X-DBUG and Programma Assoc. text editor, it would require 20% less ROM and provide many features not found in this version of the PET. This includes utility subroutines such as number-base conversion, multi-byte division and multiplication, block moves, hex-decimal-ASCII conversions, etc.

After all the pros and cons have been considered, it looks to me as though Commodore's PET has the brightest future of any microcomputer I've ever evaluated. It could graduate summa cum laude. Right now it's on shaky ground and could conceivably

flunk out, as did the SPHERE. It could have the short term success of the average microcomputer, such as the JOLT. No matter how history marks its final report card, a new era of mass usage of artificial intelligence has been ushered in by Pettle's PET.

Photo Captions:

Photo 1. A Family Portrait: PET, center, with granddaddy JOLT, left, and proud father KIM, right.

Photo 2. Front Runners: TRS-80 CPU and keyboard, left. PET's CPU and keyboard, right. Note the 5 outputs on the PET and single port for TRS-80.

Photo 3. Now defunct SPHERE, right, is very similar to PET, left. Note the combined keyboard, TV, CPU, integral dual cassette controls, and number pad. PET's cassette is built-in.

Photo 4. PET's controversial "calculator" keyboard, with quasi-standard key placement and conventional calculator number pad. Note variety of graphic symbols available with shift. Lower case is also implemented - see text.

Photo 5. My SPHERE's original alpha keyboard was replaced as shown. Note pasted editing and control labels on fronts of keys. Specialized timing controls at far left are not standard.

Photo 6. Gutted cassette is probably a stop-gap measure. Note absence of usual electronics, speaker, jacks, etc.

Photo 7. All of the cassette record, playback, and erase electronics are on this single small PC card.

Photo 8. PET's TV chassis is unique in that most of the controls have been replaced by firmware. The single-sided card has only 2 electrical controls.

Photo 9. Centering of script is done by rotating the two black tabs on the neck of the tube.

Photo 10. PET's brain: Bottom 16 chips are RAM. 7 ROM chips above contain operating firmware. Power supply and cassette #1 are along left side. Output ports are along rear. BUS and memory expansion are at left rear.

Photo 11. The power transformer, filter capacitor, and 110 AC control are the only electrical devices directly wired to the chassis.

Photo 12. Author's modification of 8 MHz crystal oscillator with trimmer capacitor trims 24 hour clock to high precision, but software problems remain.

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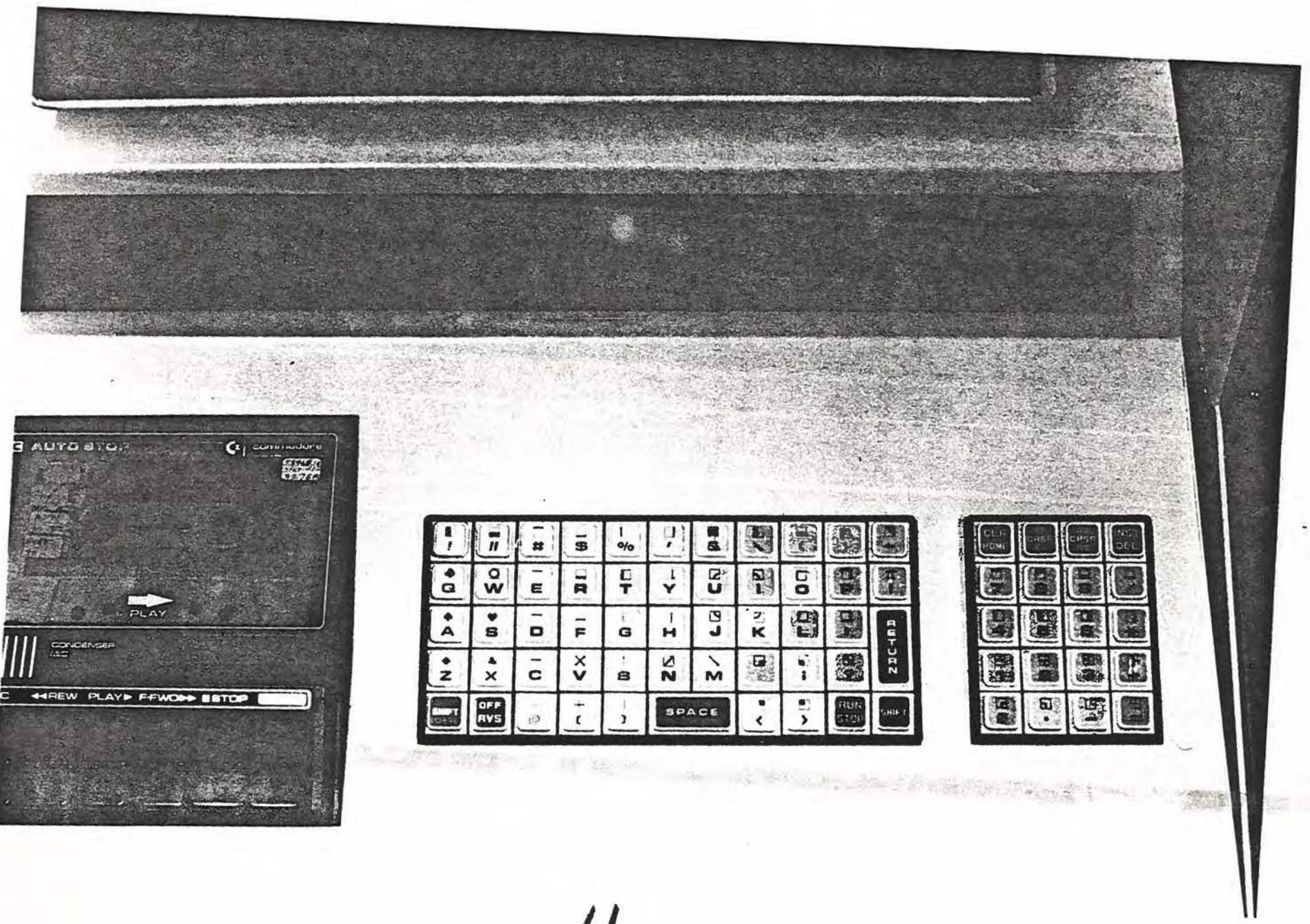
#3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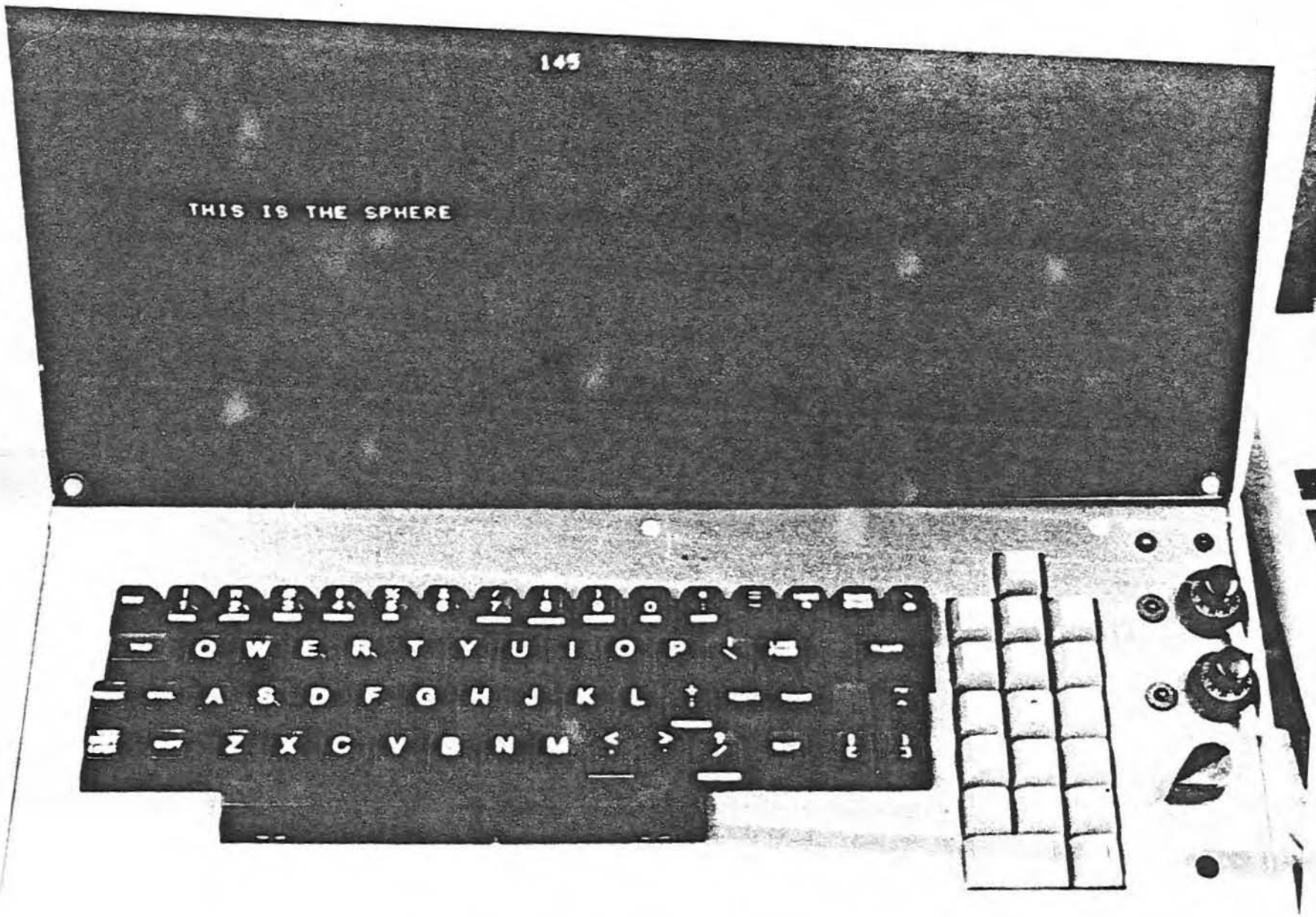
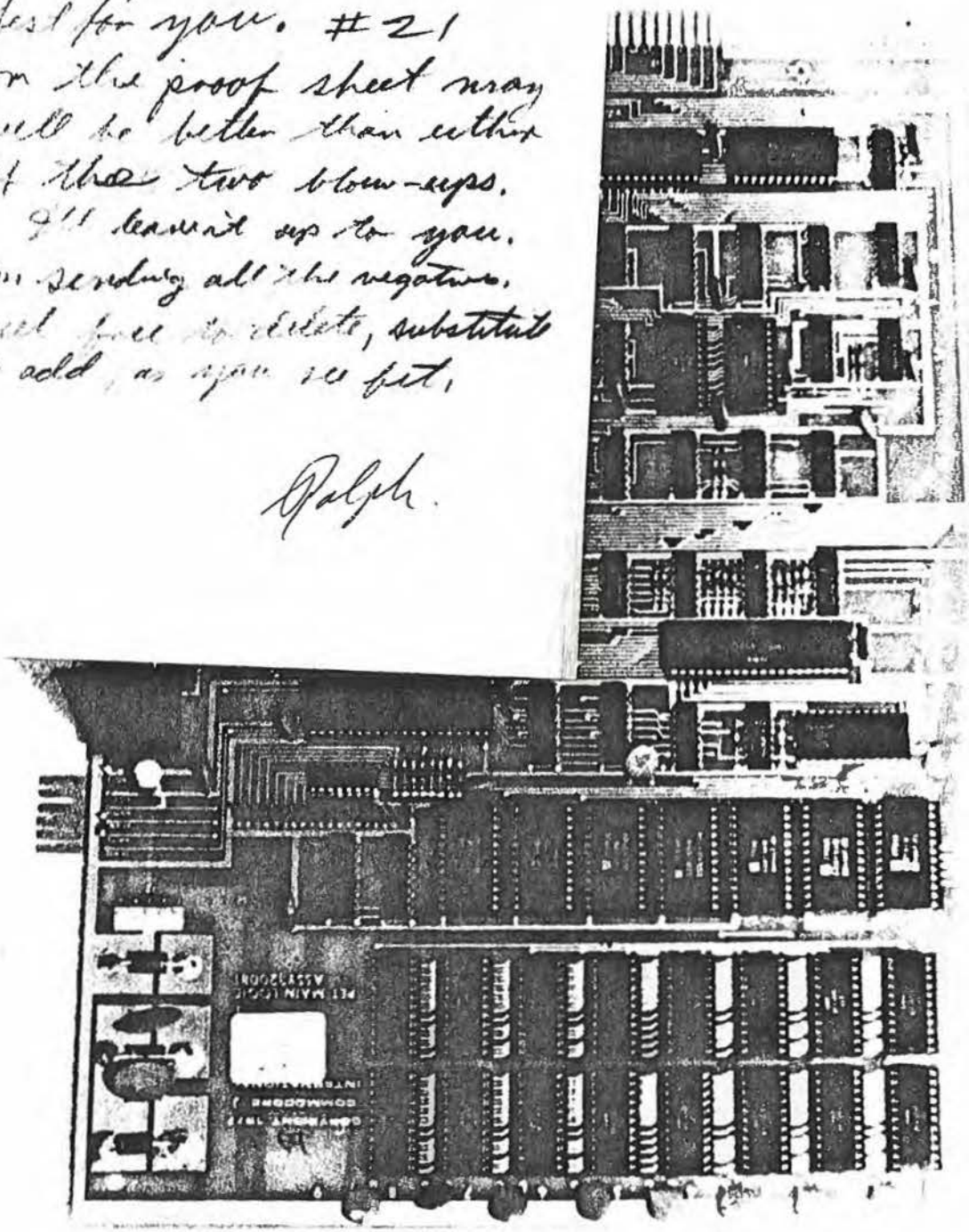

145
THIS IS THE SPHERE

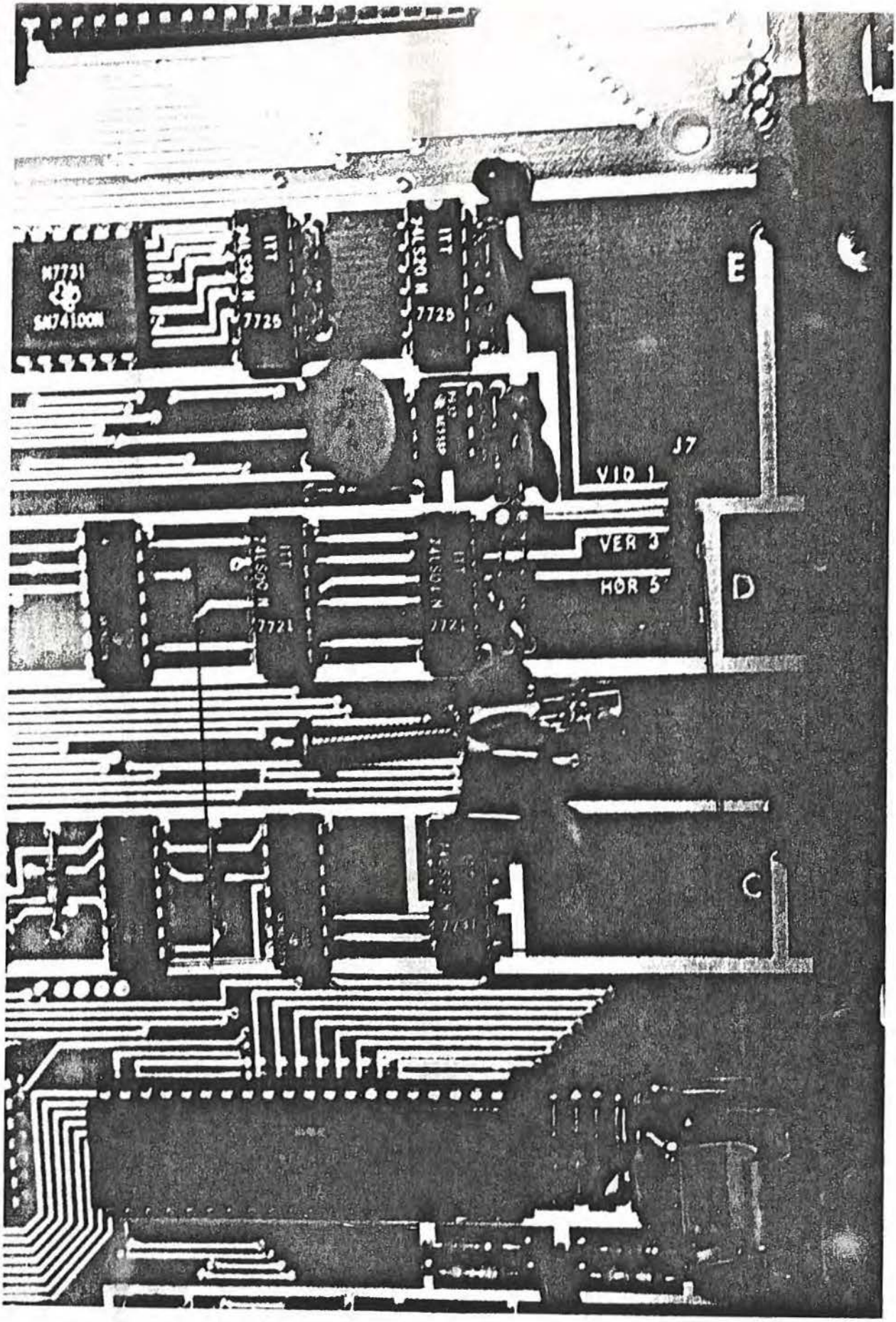
JOHN

I don't know which "#10" photo will work best for you. #21 on the proof sheet may well be better than either of these two blow-ups.

I'll leave it up to you. I'm sending all the negatives. Feel free to delete, substitute or add, as you see fit.

Ralph.

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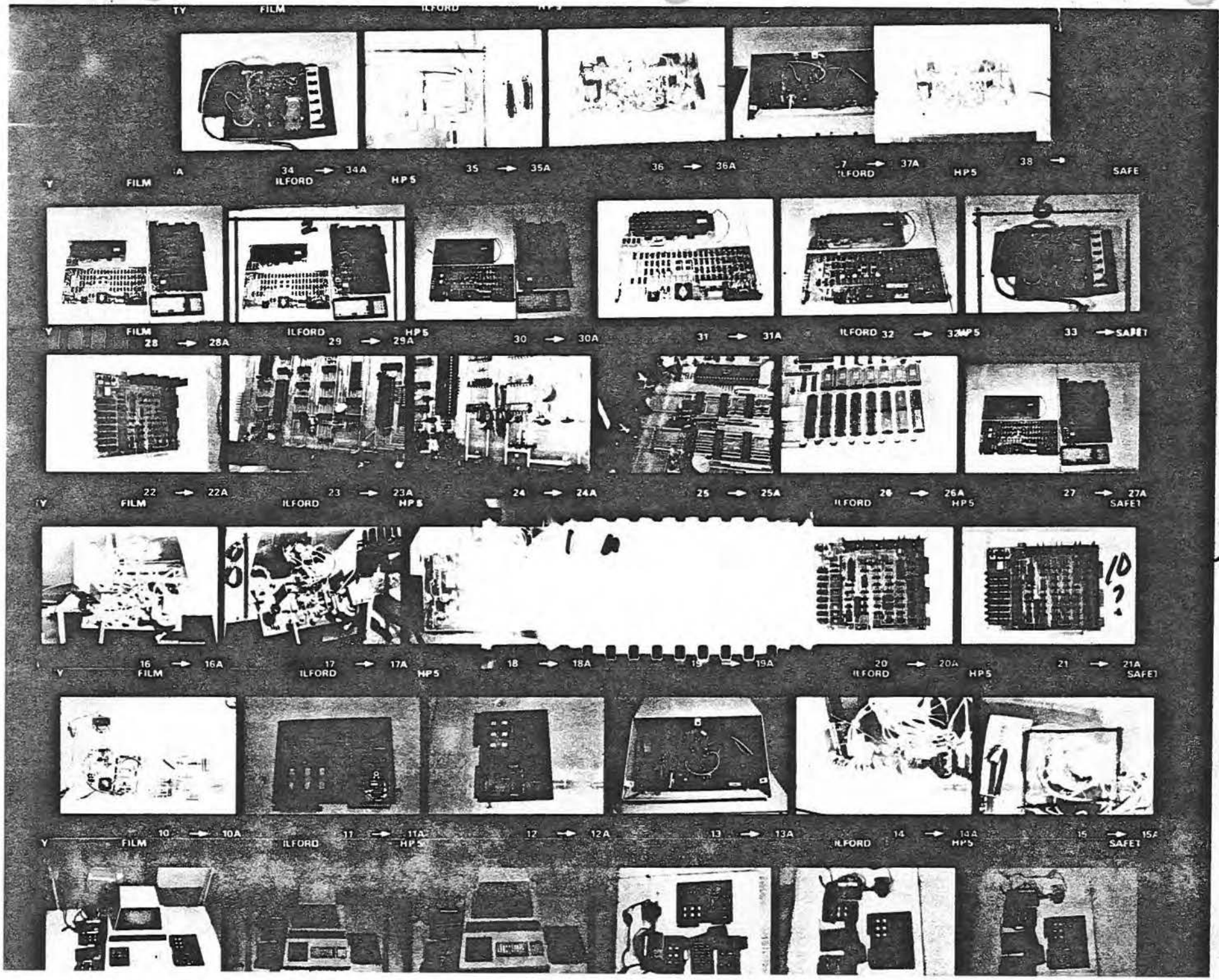
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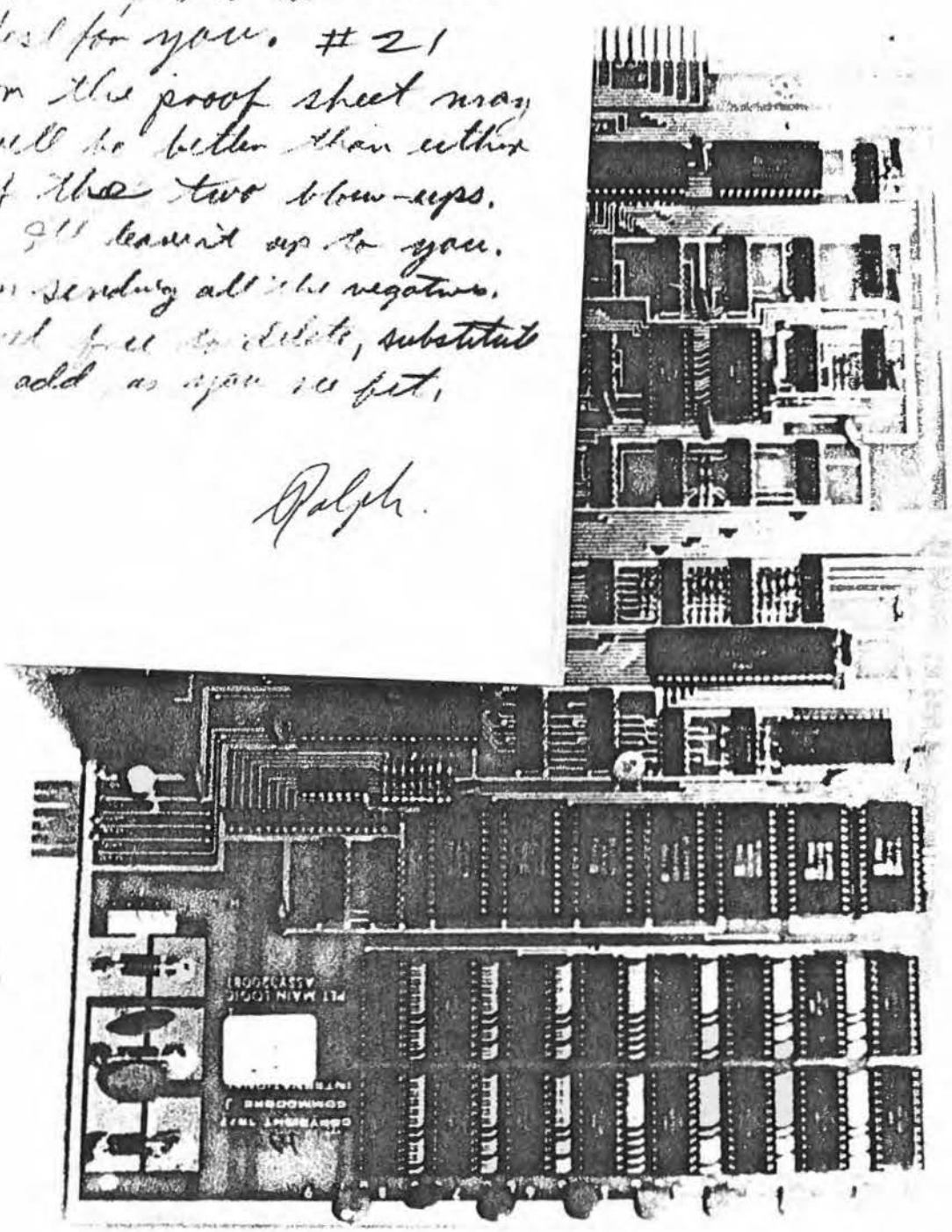

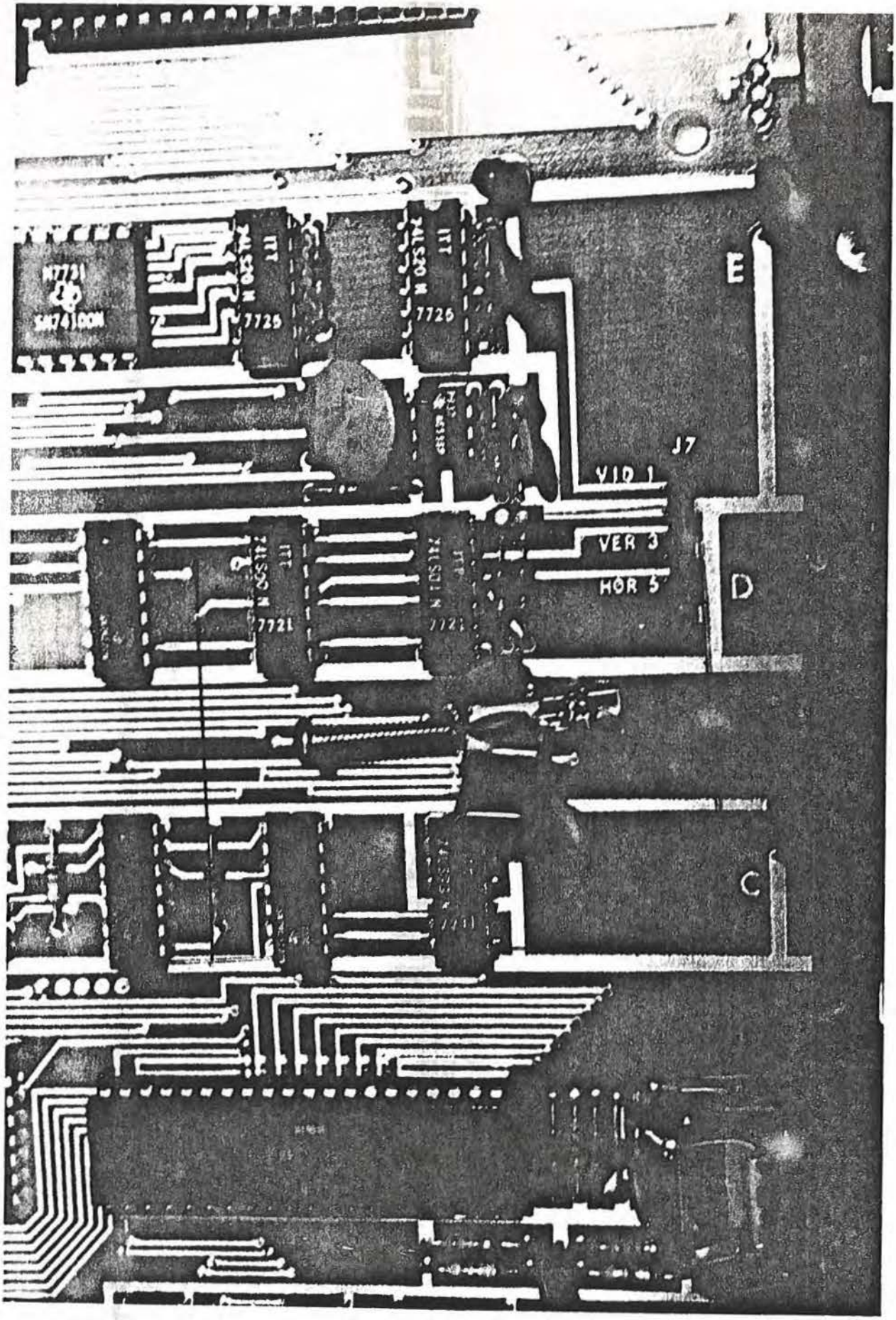
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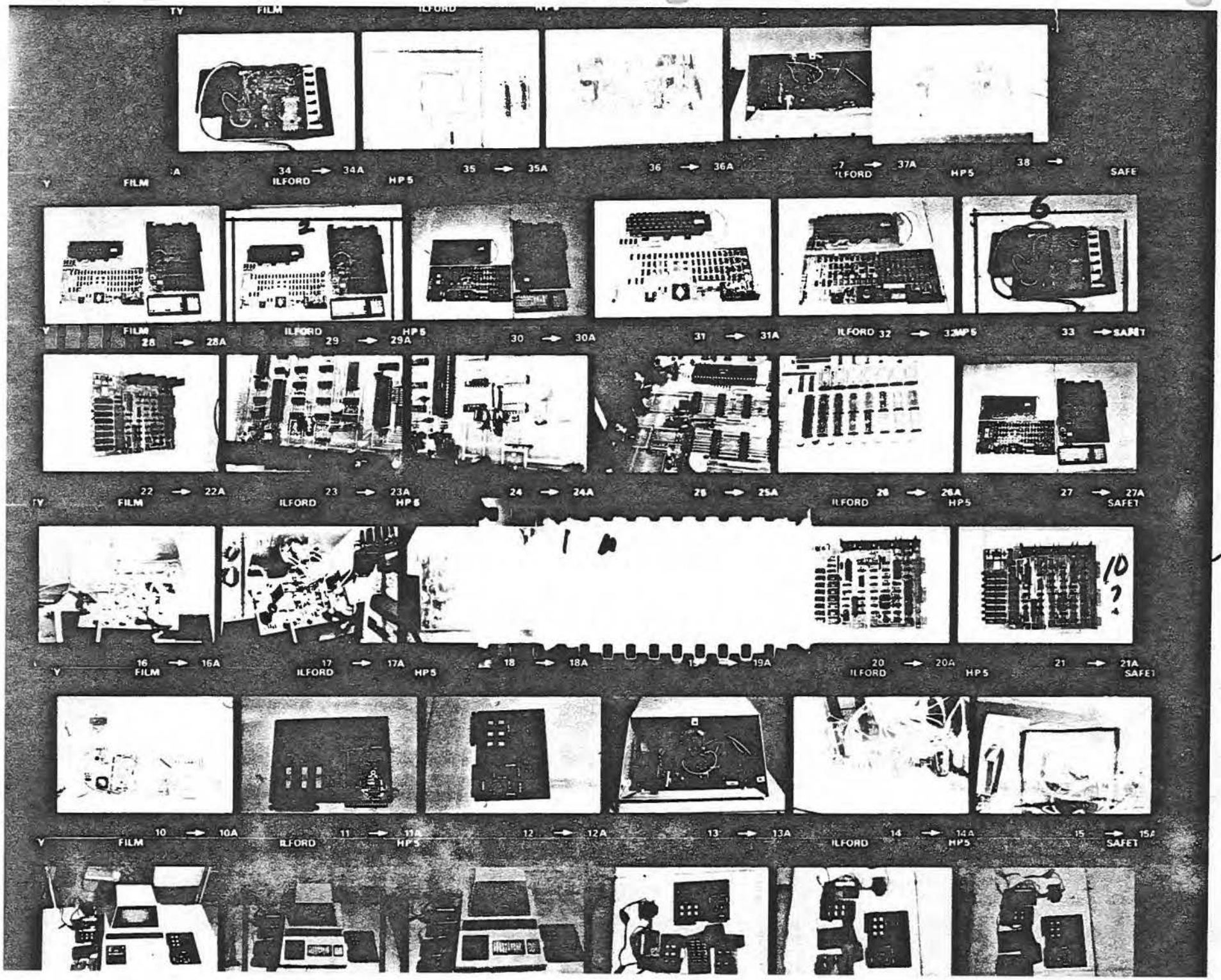
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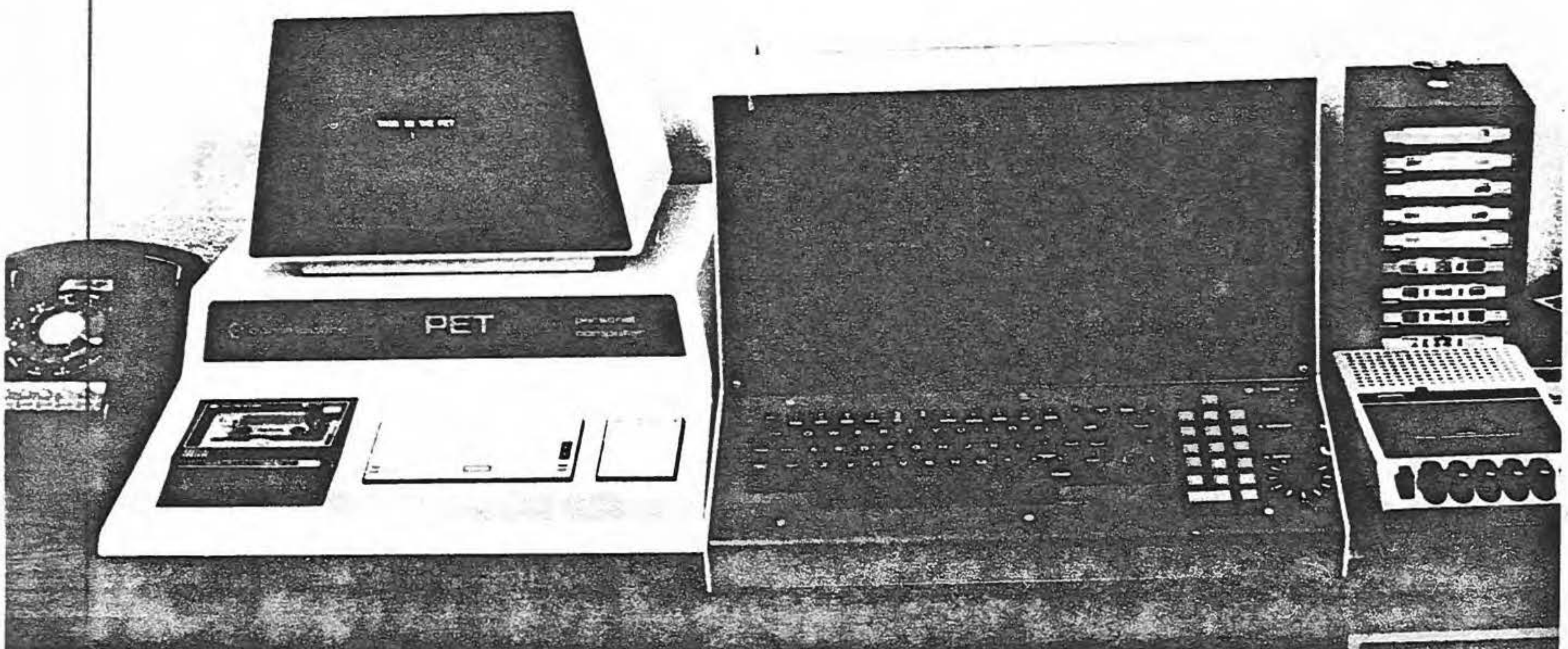

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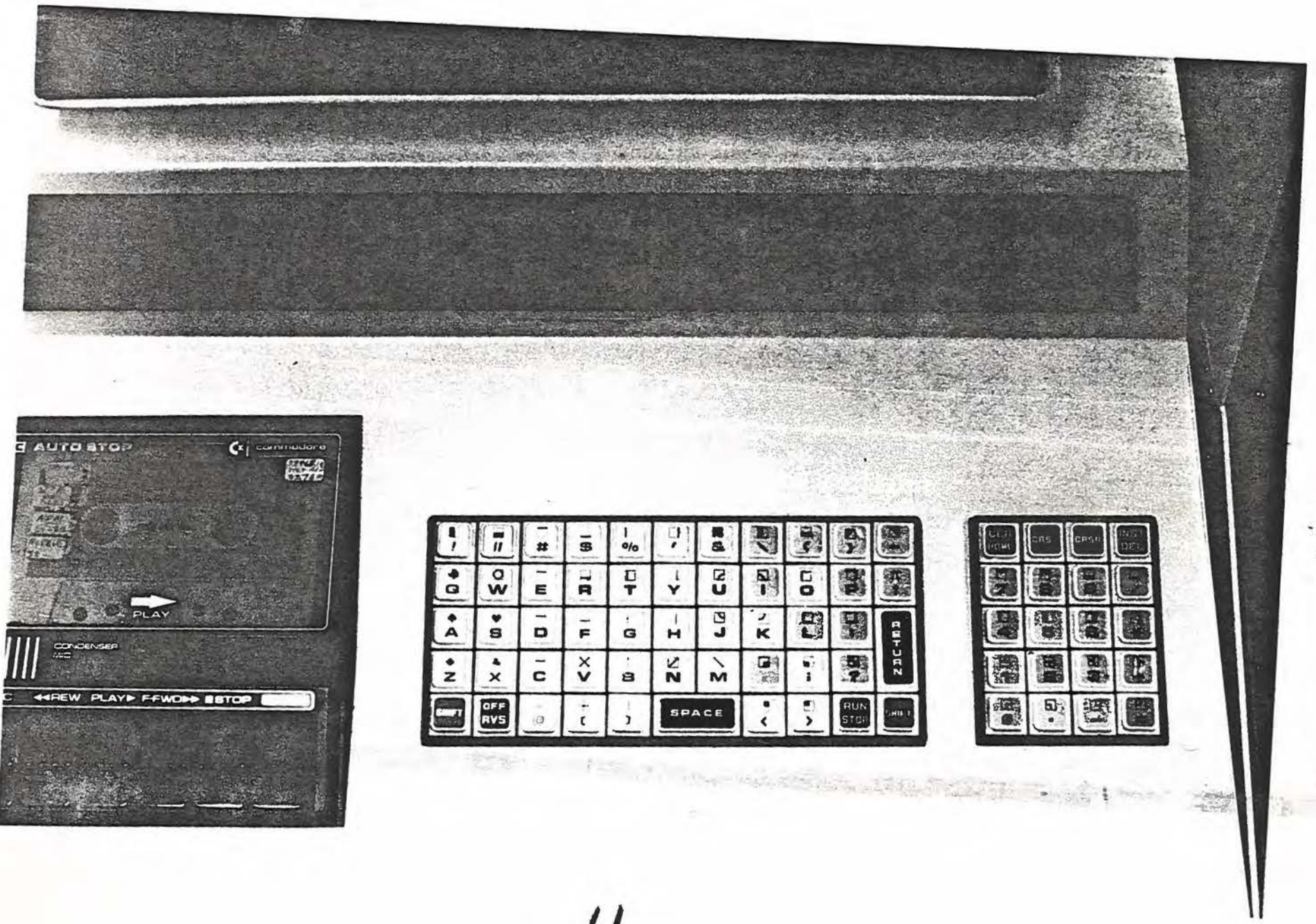
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commodore
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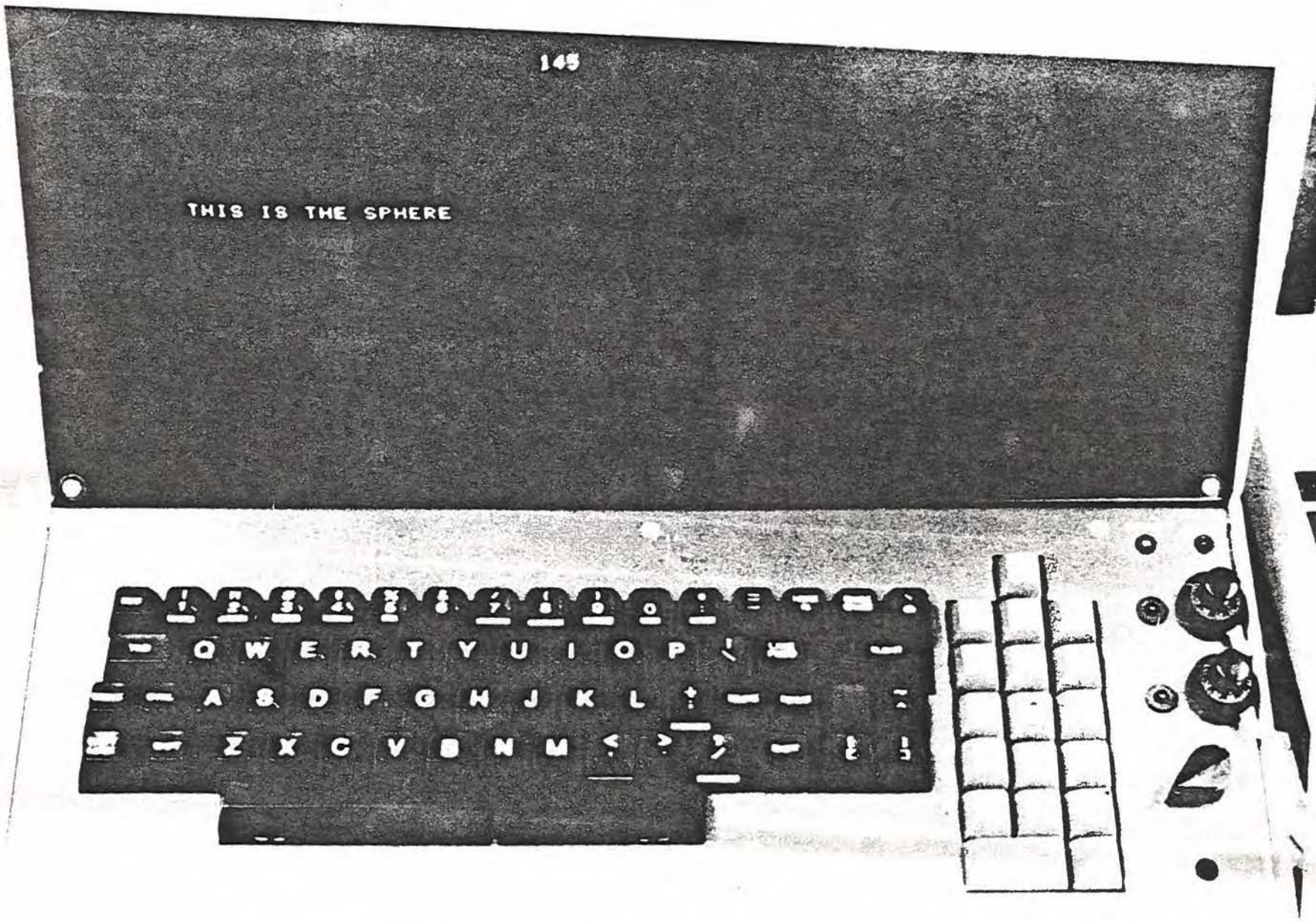
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