Raytheon

A tiny computer guides an Apollo spacecraft from orbit to on-target splashdown . . . A housewife prepares a meal in minutes in her microwave oven . . . A submarine listens for intruders in the deep . . . A seismograph crew explores for oil beneath an African desert.

A radar scans the skies and a supersonic missile stands ready if needed . . . A complex petrochemical plant takes form against a Louisiana sky . . . A high school student discovers for himself the principle of electrostatic energy.

Telephone conversations are carried by microwaves across the Andes to a remote area of Ecuador.

These are but a few of the results of Raytheon technology at work around the world.

Founded in 1922, Raytheon's early years were devoted to vacuum tube technology. A Raytheon rectifier tube freed the radio from battery power and made it a plug-in appliance. As the company grew, it broadened its scope to include transmitting and power tubes.

During World War II, Raytheon met the needs of the Allied powers in Europe for magnetrons, the microwave energy source for radars; and built virtually all of the radars used by the U.S. Navy in the Pacific.

From its strength in microwave technology grew the company's extensive capabilities in missile guidance and in the development and production of advanced missile systems.

Today, Raytheon is an international science-based company with sales in excess of $1 billion and employing more than 50,000 people. Common threads of technology run through and weave together the company's diverse and growing businesses in both government and commercial markets.

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1. *Raytheon produces the Apollo guidance computer and the display/keyboard that gives astronauts access to it.*

2. *Air route surveillance radars are important links in the FAA's nationwide air traffic control network.*

**For Government Markets**

A vital industrial resource in meeting the defense needs of our nation, Raytheon's technological and systems skills are also applied in such important government programs as space exploration, communications, weather surveillance, and air traffic control.

In national defense, Raytheon plays key roles in ballistic missile defense, tactical air and ground defense systems, missile guidance and fire control electronics, antisubmarine warfare systems, military communications, re-entry systems, and electronic countermeasures.

A major contractor in the Sentinel ballistic missile defense system, Raytheon developed and is producing the Missile Site Radars, key elements in the system. The company is also applying its technological and engineering skills to the continuing Nike-X research and development program.

Raytheon created the Hawk surface-to-air missile system, a standard throughout the free world and the first missile in history to intercept and destroy another missile in flight. The original Hawk system has been advanced many times. The latest version, known simply as the Improved Hawk, is expected to serve through the mid-1970s.

The Improved Hawk provides the point of departure for the company's work as prime contractor on the SAM-D Surface-to-Air Missile Development program to meet the air defense needs of the U.S. Army in the late 1970s and beyond.

The Sparrow III air-to-air missile system, developed and produced by Raytheon as prime contractor, is the primary weapon system aboard many U.S. Navy and Air Force aircraft. Raytheon is also the major producer of the infrared-guided Sidewinder air-to-air missile.

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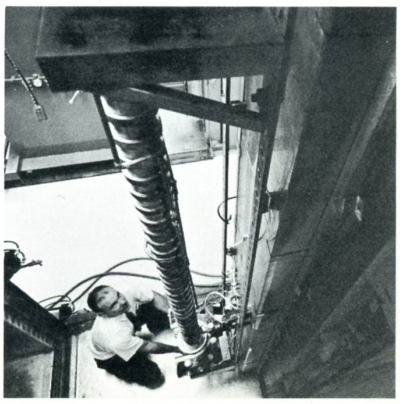
3. *Hawk surface-to-air defense missile is checked at company test site.*

4. *Traveling wave tube for use in advanced phased array radar system.*



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In the nation's space exploration program, Raytheon produces the on-board guidance and navigation computers for the Apollo Command and Lunar Modules and provided many of the data display systems used in tracking orbiting spacecraft.

Through the years, Raytheon's strength in radar technology has steadily increased. Selection to provide the radars for the DEW line across the Canadian Arctic led to a Federal Aviation Agency contract to provide the long range air route surveillance radars that keep track of commercial aircraft.

The company is now working on an advanced display system for the FAA to aid air traffic controllers in identifying, positioning, and guiding aircraft. The company's sensor, data handling, and data display techniques are also being applied to vehicular traffic control.

**For Commercial Markets**

Raytheon's growing commercial and consumer products businesses now account for approximately one-half the company's annual sales volume; compared with only 15 per cent as recently as 1964.

Raytheon management concentrates its attention on synergistic growth in six selected commercial growth markets; electronic components, communications, education, major appliances, data handling, and natural resources exploration and development.

Building upon its origins in electronic componentry, Raytheon today is a major supplier of microwave and power tubes, solid state microwave devices, integrated circuits, and industrial, broadcast and x-ray tubes.

Raytheon microwave communications systems are used in telephone and telegraph networks, link statewide and regional educational television networks, and process data to and from commercial communications satellites.

5. *Display techniques developed for government programs are applied to airline reservations and other commercial uses.*

6. *Microscopic flaws are detected by a laser in optical data processing technique.*

7. *Coordinated instructional materials and science learning apparatus help make science exciting for students.*

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7

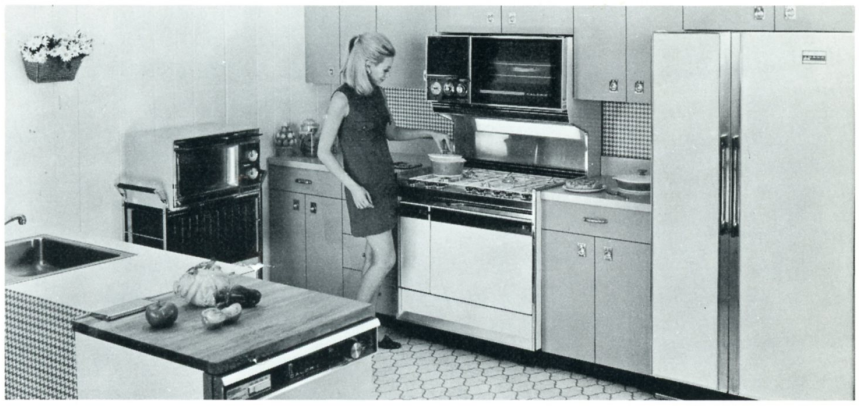
The company serves the education community through D.C. Heath textbooks and other instructional materials for elementary, junior and senior high schools and for colleges and universities; through Macalaster science learning apparatus; and through a variety of electronic learning systems.

Raytheon's primary contact with the consumer is through its Amana Refrigeration and Caloric Corporation subsidiaries. Amana manufactures refrigerators, freezers, the Radarange® microwave oven for the home, room air conditioners, and central heating and air conditioning systems.

Caloric produces a broad line of gas ranges, including the new Ultra-Clean® self-cleaning gas oven and broiler, and a variety of home kitchen and patio products.

Raytheon is also widely known among boatmen for its line of marine electronics equipment. The line includes radars, Fathometer® depth sounders, radiotelephones and radio direction finders.

In natural resources, Raytheon is engaged, through its Seismograph Service subsidiary, in the world-wide search for oil and natural gas; and through its Badger Company subsidiary, in the design, engineering and construction of oil, chemical and petrochemical processing plants throughout the world.



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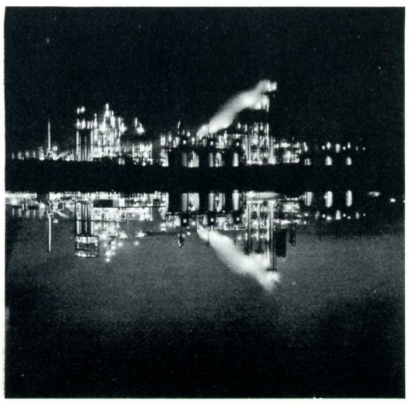
8. *A "Raytheon Kitchen" combines Amana refrigerator and Radarange® microwave oven with Caloric self-cleaning gas range and movable dishwasher.*

9. *Badger-built chemical processing plant at Grangemouth, Scotland.*



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Raytheon Company, Lexington, Massachusetts 02173

# apollo 11

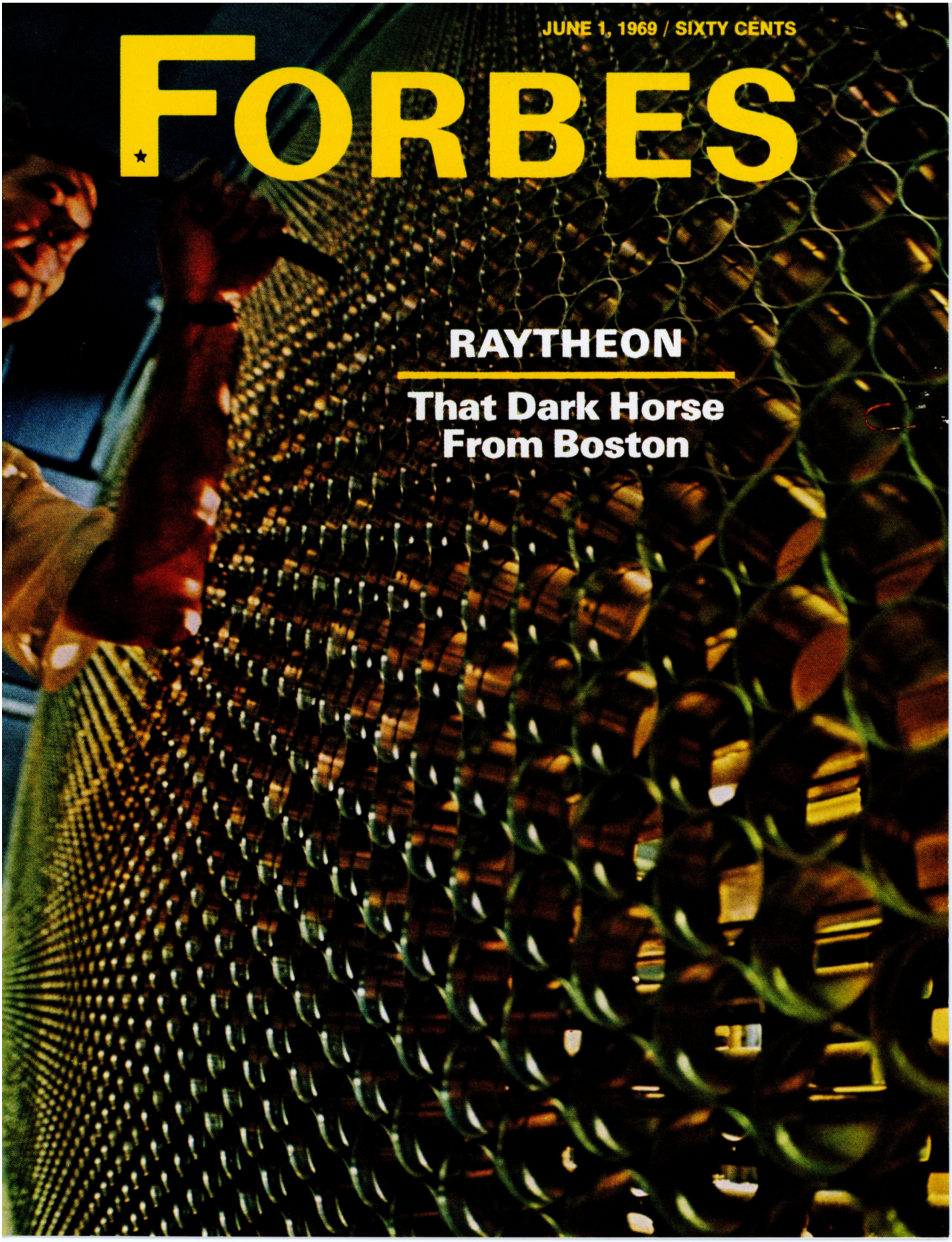
# PRESS KIT

EQUIPMENT DIVISION

RAYTHEON

JUNE 1, 1969 / SIXTY CENTS

# FORBES



## RAYTHEON

## That Dark Horse From Boston

# Raytheon: Radar to Refrigerators

***Can a defense-technology company find happiness in commercial businesses? After several very false starts, Raytheon is demonstrating that it can be done.***

LIKE THE WATCHED POT, Raytheon Co. has started to boil just about the time everyone had given up hope on it. A post-World War II wonder company, Raytheon excited great expectations in the bosoms of growth-seeking investors, only to disappoint them time and again. By 1965, the bosoms stirred no more. Raytheon, at a low of 9½ on the present stock, actually sold below book value and as low as nine times earnings.

"All through the postwar years," explains President Thomas L. Phillips, 45, "Raytheon was one of the better engineering companies. But we weren't capitalizing on it. We were structured wrong and we didn't have the right leadership. Or the right marketing impact."

At one point, Raytheon had a chance to do what ITT has since done: become a great multicompany. From 1956 to 1959 it had as executive vice president, Harold Geneen, who wanted to do with Raytheon what he later did with ITT. Frustrated by the board and by Chairman Charles Francis Adams, Geneen quit, and with his quitting, Raytheon stock took the plunge that carried it from a growth-company category to the dismal status of loaded laggard.

### *Two Aging Birds*

Why did Adams oppose the Geneen approach? Adams is reluctant to discuss it, but apparently he felt that Raytheon, with its commercial business in trouble and its military business dependent primarily on two big programs, was too weak a base on which to build a multicompany. The two military programs, the Hawk and Sparrow tactical missiles, were well along in their production phase and there was very little in the pipeline behind them. Says D. Brainerd Holmes, Raytheon executive vice president: "By 1963, when I joined the firm, Raytheon's government business was very sharply and distinctly on its way down. In my opinion, it was going out of the government business."

Was Adams wrong in blocking Geneen? In a way, yes. For although Raytheon is today a $1-billion company and an 18-times earnings growth stock once again, it is no ITT. But in another way, perhaps Adams was right: Companies, like people, have different life styles and different ambitions. Adams thought that Raytheon should be a technology company, not a multicompany. In the end, he and President Phillips achieved this goal. But not without much sweat and much self-examination.

***"You Can't** just have a big engineering lab with financial controls and get anywhere," says Raytheon President Thomas L. Phillips. "The two missing ingredients when I moved up were marketing and manufacturing know-how."*

The first man chosen to succeed Geneen didn't work out. He was Richard E. Krafve, a former Ford Motor Co. vice president who had headed the disastrous Edsel venture. Krafve spent heavily on research and pushed Raytheon further into television receiving tubes and into semiconductors. After two years of Krafve, Raytheon's sales were up 14% (to $563 million) but earnings were down from $10.5 million to $6.9 million. Raytheon stock was down to 19⅛ from a high of 31¼ at the time Geneen left. Krafve left in early 1962 and is now a consultant.

This time, the departing boss was succeeded by a company man, an insider, Thomas L. Phillips, then 35 and the head of Raytheon's one rock-ribbed profitmaker, the missile and space division.

Says Adams, a shy and self-effacing man: "Without going into the mistakes of the past, these two people weren't the answer. But here was a man—Tom Phillips—who, although quite young, had been brought up in the business and who *really* understood the business, understood the company."

### *Thundering Herd*

The public was not impressed. The coming and going in Raytheon's executive suites had begun to resemble Grand Central Station at rush hour. Adams, apparently unable to cure the company's problems himself, seemed unwilling to step down for someone who could. And who was this Phillips?

Phillips himself had his doubts. "It looked pretty tough!" he says. "I thought I was going to have to punt!" Here's how he diagnosed the situation as it appeared on Dec. 27, 1961:

"There were really three or four outstanding things wrong at that time," he explains.

"First, we had a dependence on too few government programs. It was Hawk and Sparrow, largely, without any real solid base in other things.

"Second, we had a commercial business, of sorts, that was under water. Commercial business should provide a stable base, but if it's less than zero in terms of total contribution, it's a noose around your neck.

"Third, we were overstaffed relative to the size of our business.

"And finally, there were lots and lots of people here without any feeling of belonging—some of them in key positions. They were never really accepted by the people in operating positions. Both Geneen and Krafve said: 'This company doesn't have enough management. We'll recruit it.' And they recruited like mad. We were doing the best business for flesh peddlers of any company in the country!"

The first job was to cut Raytheon's losses. Says Phillips: "For the first year or two, we were shutting off hydrants that were gushing out profits and blood. We liquidated about $40 million worth of business that was losing heavily—some $15 million in germanium semiconductors and another $25 million in receiving tubes."

### *Remember River Rouge*

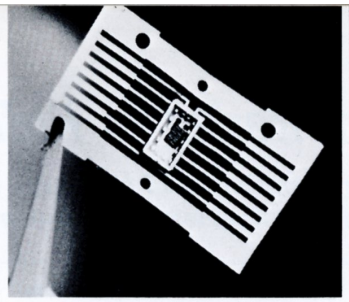
Raytheon had been having difficulties in both areas for some time. One, receiving tubes, was its traditional business, where most of its older employees were, and the other was a crucial building block in its future. Krafve, perhaps remembering the massive assembly lines of Detroit, decided that Raytheon just wasn't big enough in either area. He expanded.

But to Phillips the problem seemed to be technological obsolescence. Receiving tubes, he saw, were about to be outmoded by solid-state technology. Here was Raytheon, a poor fourth in the business behind GE, RCA and Sylvania. And unlike the Big Three, it lacked a captive television-set market, since Raytheon had closed down its money-losing TV-set business six years earlier.

Phillips was convinced that Raytheon germanium semiconductors would soon be replaced by silicon semiconductors. Krafve had just acquired two germanium semiconductor plants from CBS, a decision Phillips describes as "almost catastrophic." Says he: "Had we expanded into those plants, as we were about to do in 1961, our losses would have multiplied, I'm sure, given the condition the company was in."

Accordingly, Phillips backed out of germanium semiconductors altogether and concentrated on silicon semiconductors in a plant Krafve had just acquired from Rheem. Then he closed down the receiving tube business, converting it into a trading operation that bought and sold to the distributor market from Raytheon's Japanese facilities.

In the process, staff overhead expense was trimmed by some $3.5 million a year from its previous level of $13 million. "I honestly unloaded some of the people who had been brought in and couldn't contribute anything," Phillips explains.



***Back In The Black** after nearly 15 years of losses is Raytheon's integrated-circuit operation (nearly $50 million in volume). Wouldn't it be cheaper to buy the circuits from the Big Three (Texas Instruments, Fairchild, Motorola)? President Phillips doesn't think so. "I don't think a company like Raytheon, which is so dependent on electronics, can afford to be out of this business," he explains. "It may be an expense, but it's a necessary expense. As you see more and more active elements going into a single chip* [above]*, more and more of the value will go to the component supplier—less and less to the equipment and systems supplier like us." Now Raytheon, a strong second-rank producer, is starting to develop proprietary products with advanced technology that use these circuits. "Our computers and displays* [below] *are full of them," says Phillips. This increases volume, stabilizes prices, and boosts profits.*

Having decided what Raytheon wanted to be—a technology company, not a conglomerate and not a big-scale manufacturer of standard products—Phillips reorganized the company to fit its personality. All of the government business—radars, tactical missiles, sonar, guidance and communication systems, displays and special purpose computers—was in two big divisions: Missile Systems and Equipment. The divisional managements were swamped with administrative work and operating details. "The people trying to run the thing had their hands so full of the day-to-day business that they couldn't look ahead towards growth," says Phillips. "I think that's one reason we didn't get more significantly into the space programs." From these two divisions, Phillips separated out two operations: Submarine Signal and Space and Information Systems, putting in "some business management and marketing focus."

Then in late 1963 he made an important decision: He delegated the operating management of the government business—the side of Raytheon he knew well—to an outsider. Phillips moved up to president and chief operating officer and in as executive vice president came D. Brainerd Holmes, then director of Manned Space Flight at NASA and former boss of RCA's Ballistic Missile Early Warning System (BMEWS). "That was really the start of our ability to grow," says Phillips. "By being able to turn over to Brainerd most of the government business and concentrate on the commercial."

### *If, At First . . .*

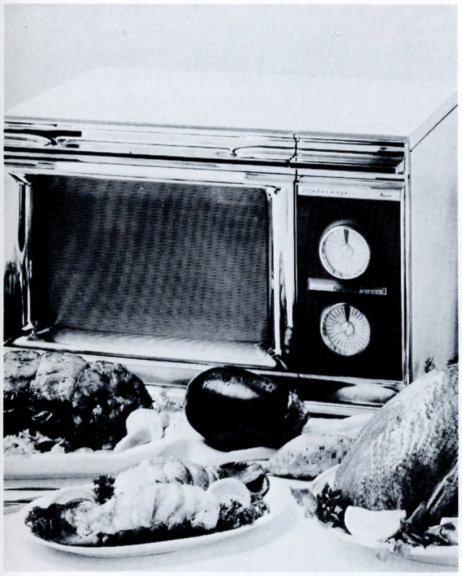
Now, in 1964, Raytheon was resolved to have another try at entering commercial markets profitably. It did so, however, cautiously and with a determination to do things its own way. Phillips' guidelines were: No "one-product-per-market boondoggles" where the cost of building up a marketing force and a distribution channel for a single product priced Raytheon out of the market; and no conglomerate acquisitions totally unrelated to Raytheon technology.

"It was pretty clear that we needed to acquire beachheads in commercial markets which we could then enrich with Raytheon technology," says Phillips. The public still wasn't impressed. It was a commonplace policy statement, and Raytheon's track record in the commercial area was deplorable.

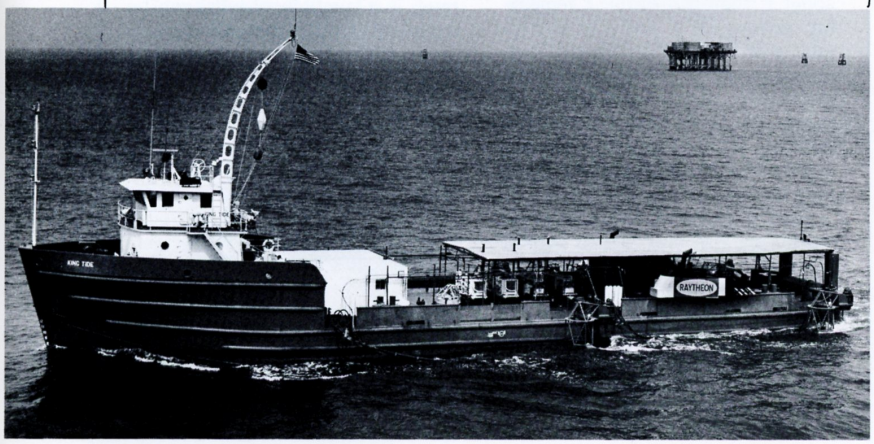
Gradually, however, it became apparent that Phillips meant what he said. His approach was conservative. He added some $40 million in sales in 1965, consisting of three tiny edu-

cational equipment firms and Amana Refrigeration. Another $50 million was added the following year—D.C. Heath, a textbook publisher that had seen better days, and Seismograph Services, a smallish geophysical exploration outfit serving the oil industry. In 1967 came the first major acquisition: The Badger Co., an international engineering firm with sales of $170 million, specializing in the design and construction of petroleum and petrochemical plants. Along with Badger came Caloric, a smallish maker of gas ranges. Together they added more than $200 million to Raytheon sales. Last year, Raytheon made virtually no acquisitions at all, save for a small outfit called Gulf Design.

Synergism (2+2=5) is a tired word, but Phillips did achieve a measure of it. Concrete evidence of technological contributions from Raytheon military knowhow began cropping up in the commercial subsidiaries. Amana is now selling the Radarange microwave oven for domestic use. From efforts to cool microwave tubes for military products came another commercial product, now in final development at Amana, the "miniboiler." Raytheon claims that this unit, the size of a two-pound coffee can, is able to heat an entire home and is expected to be priced competitively with much larger conventional boilers. Seismograph Services, which formerly used explosives in sounding the ocean floor for oil, now uses a sound-emitting device called the hydroacoustic transducer—an off-shoot of Raytheon's sonar work. (This hopefully will appease angry fishermen who claim that explosives kill and frighten fish.) Raytheon is also marketing a low-cost business display system, DIDS-400, a direct transferral from its work in military displays. Among military contractors this is an enviable record of commercial spinoff.



***Commercial Spinoff*** *from Raytheon military technology such as a high-speed domestic microwave oven* (above, left), *a cuddly "miniboiler" for home heating* (above, right), *and sound-wave devices for underwater exploration* (below) *is starting to pay off, thanks primarily to acquired commercial knowhow. "Raytheon had interesting commercial spinoff from its military technology for years," Phillips explains, "but we didn't have either the marketing approach or the commercially oriented management."*




### *Potato Peelers*

It obviously didn't happen by accident. Take the microwave oven. "We had the Radarange before Amana was acquired," Phillips explained. "For many years we lost money trying to sell it to restaurants because there was a rival outfit, Hobart, that supplied everything the restaurateur needed: dishwashers, sinks, potato peelers, the works. And here we were with a marketing staff selling a single item. Now when you superimpose the domestic Radarange on the Amana sales force and distributors, who are out there selling refrigerators, air-conditioners and freezers to the consumer, there's almost no increased marketing cost. Other than promotional. The outlets are well greased. You know darned well what it'll cost you to market it. And therefore you have the bullishness to make the long-term commitments."

Synergism did not grace every Phillips acquisition, to be sure. The self-cleaning gas oven at Caloric, conceived with the help of Raytheon engineers, has had a tough time getting off the ground. And Raytheon certainly hasn't yet performed any magic in its textbook and educational equipment acquisitions (*see box, p. 32*). In both cases Phillips ran into people problems of major dimensions. Says he: "We've done a tremendous amount of work in Caloric, taking a family-owned company and making it into a public company managed in the right way. Just like in this D. C. Heath situation. There's been a complete turnover of people there."

Phillips does not pretend that he has worked miracles with this program. "Some of our acquisitions have been very successful in terms of earning more money for us than the shares we put out [some 6 million to date out of 14 million outstanding], and some we've carried," says Phillips. As a result, earnings per share have only modestly outpaced sales, increasing 166% over late 1961, when Phillips came in as executive vice president, while sales increased 106%.

Put in the perspective of the aerospace and defense industry, one of the

fastest-growing industries in the country, this track record is quite respectable. On a five-year basis, acording to the FORBES Annual Report on American Industry *(Jan. 1)*, Raytheon ranks slightly above average in growth but below average in profitability. But now Raytheon, coming from behind, is starting to pull ahead of the industry in profitability. For the last two years it has ranked well above average in return on equity. And with earnings up 20% on a 3% increase in sales for the first quarter of 1969, that trend is continuing. Not bad for a company that was in serious trouble just six years ago.

Significantly, the earnings growth has come chiefly from Raytheon's traditional business—*not,* as is so often the case, from acquisitions. Says Phillips: "Overall, I would say that the older parts of Raytheon have probably grown faster in earnings per share than its acquisitions." Which means, of course, that the military business, which is the guts of the older parts of the company, has done very well indeed.

"We're not very vulnerable to any one program any longer," says Phillips. "We have ten or twelve very substantial—each is at least $10 million in volume—very fundamental programs of quite long duration. I don't think there will be any drastic curtailments in our military business."

Executive Vice President Holmes points out another strength: The company has a great deal of work "in the pipeline." Says Holmes: "I would say slightly over half of our defense work, something like $350 million worth of business, is not yet in production. It's government-sponsored research and development on long-range programs."

### *And Vietnam?*

What about Vietnam? Surprisingly, Raytheon's Vietnam business is quite small; it is limited chiefly to the production of fuses. Thus, an American withdrawal will not mean a sudden, sharp decline in business as it may for manufacturers of helicopters, fighter aircraft and airborne equipment.

One of these programs *is* tied to the controversial Sentinel-Safeguard ABM system. Suppose the Nixon Administration is defeated and the system is *not* deployed? All that will happen, says Phillips, is that Raytheon may not grow quite as fast. Raytheon's involvement in the program is limited to an important subcontract from Bell Telephone Laboratories for research and development on missile-site radar. "Regardless of what happens to deployment," says Phillips, "this program has continued research and development significance for us."

Raytheon's present military business is concentrated in its basic area of expertise: tactical defensive missiles. Technologically, these are the most sophisticated missiles built, and Raytheon completely dominates the field. Competitors like Hughes Aircraft, RCA, General Electric and General Dynamics are far behind in volume. It's estimated that at least 80% of the air-to-air missiles presently arming U.S. fighter planes (primarily Sparrow and Sidewinder) are made by Raytheon. In surface-to-air missiles for defense against incoming aircraft and missiles, two systems are presently deployed: Western Electric's Nike Hercules and Raytheon's Hawk. Over the next few years Hawk will be replaced by an interim program: Raytheon's Improved Hawk. Eventually, they will be completely replaced by SAM-D, also of Raytheon (For the story of how Raytheon almost lost the SAM-D contract, see box below). In addition, Raytheon has important contracts in military communications, electronic countermeasures, night vision devices, sonar and air traffic control for the

## *JUST A LITTLE EXTRA EFFORT*

RAYTHEON'S prime contract on the SAM-D surface-to-air tactical missile is the big one that almost got away. This anti-missile missile is to be the U.S.' first-line air defense of the Seventies and Eighties. Presently it is in advanced development with an engineering budget of $15 million. When it is deployed, starting in the mid-Seventies, Raytheon could reap $100 million or more a year in revenues from it for as long as a decade. That's real mouth-watering stuff by defense industry standards. But in 1964, Raytheon *lost* this contract in open competition. It came as a brutal shock.

Executive Vice President D. Brainerd Holmes remembers it vividly. Says he: "In 1964, when the program was called AADS-70, we bid along with RCA and Hughes Aircraft. GE had been dropped before the final runoff. We lost. We lost to RCA and Hughes, neither of whom we felt were anywhere near as qualified as we were. And that was unthinkable. Our future was tied to this thing."

Why did Raytheon lose? Holmes blames it on cockiness: "We lost because our people knew more about it than the Army. I remember getting off a plane in Huntsville, where MICOM (Missile Command) is, and if you were sensitive you could almost smell it. You know, 'We know how to do missile systems. What does this customer know about it?' Well, that's a *great* way to win a job."

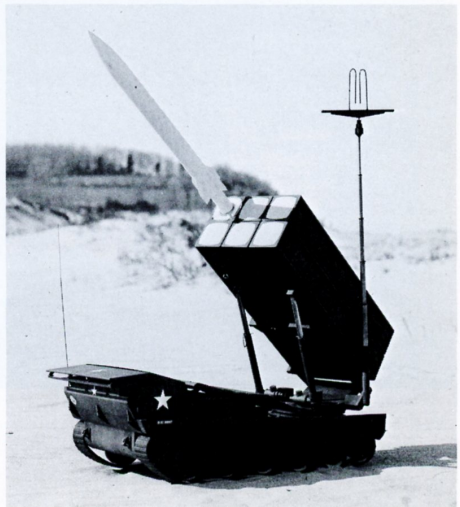
Missile Systems boss Joe Alibrandi puts it this way: "Losing came as a real shock to a lot of us who felt, you know, 'How could we *possibly* lose?' "

Thus humbled, Raytheon battled for a second chance. Says Holmes: "We were able to get an agreement that Raytheon could get back in if the requirements for AADS-70 should change considerably." Then Raytheon pulled out all the stops and really went after it. "Anything the guys needed they *got* and they got it *fast,*" says Holmes. "We were spending our own money—millions."

"We made some significant commitments in people, dollars and hardware, so that we actually configured some of these advanced concepts in hardware," says Alibrandi. So we could say 'Here is a typical guidance system utilizing the concepts we've described. Look at it. See how it works. Here's a way of measuring sensitivity.' We made up our minds we were going to win that contract and we just brought everything to bear."

It worked. "The requirements did change, as we thought they would," says Holmes, "and we were invited to make a bid again. And we won. The guys in that laboratory who took quite a traumatic beating because of this became better people."

Today, many Raytheon employees have a key chain with the date May 18, 1967 inscribed on it in gold letters. That date means more than just victory on the SAM-D contract; it is symbolic of what can be done with a little extra effort.



Air Force and the Federal Aviation Agency.

Joseph Alibrandi, 40, boss of the Missile Systems division, Raytheon's largest, describes the company's competitive posture in the military area this way: "We're in a very enviable situation. In the surface-to-air picture, we see production business out into the early 1980s. That's a long way to look in this business.

"We feel our next big area of military growth will be avionics," he says. "It's a newly focused effort for us. It's attractive—first, because it's not a new technology to us. Second, we've already addressed the question of integrating complex systems in aircraft on the Sparrow program. And we feel we need to have competence in avionics or else it would interfere with our future in missiles. The Government is going to procure more on the basis of an overall system in the future."

Already there has been significant restructuring in the government group indicating a change of focus. On Apr. 10, the Space and Information Systems division was broken up. One segment, the small but fast-growing electronic countermeasures and re-entry-penetration-aids business, was made a separate division. The remainder, primarily computer guidance systems for the Apollo program and fleet ballistic missiles, was given to the Equipment division.

### *Another Beachhead*

Phillips knows full well, however, that overall his defense industry is unlikely to grow much from here on. That is where the—to date—less profitable commercial business comes in.

In the consumer area, Phillips says he is anxious to make another acquisition to raise Raytheon's consumer business to over 50% of sales. "I strongly would like to have another major beachhead, this year if we could, a real good partner that's a bellwether in its field," he says. "We're in four major commercial markets now: components and electronics, education, natural resources and appliances. I'd like still one more market—but not a sixth, seventh and eighth. We won't get a little $10-million thing here and a $20-million thing there." Given Raytheon's happy experiences with its Amana acquisition, the odds are it might have something to do with white goods. In the past this has been a very tough market to enter, but unlike many firms that have had difficulty in this area, Raytheon is contributing a new technology. Phillips concedes that "it might, for example, be broadening an existing product line." He also hints that there may be further small acquisitions within the four existing markets.

And so it is that while Raytheon missed out on a chance to become another ITT, it succeeded more than almost any other defense company in redirecting its defense technology into civilian goods. After nearly 20 years of false starts, this typically intellectual, typically New England company seems on the proper track. This time, the Dark Horse from Boston may indeed make it. ■

## "PEOPLE HAD VAGUE NOTIONS . . ."

LIKE IBM, RCA, General Electric, Xerox, CBS and many others, Raytheon has an education unit. Also like IBM, RCA, General Electric, Xerox, CBS and many others, that education unit is not setting the world afire.

"People had vague notions like, 'Well, gee, if you can build a rocket, that kind of expertise ought to be good for schools.' Now we all know that the whole education system has enormous problems. But no one ever looked at the *cost*. Sure, technologically, you can do almost anything you want in this field. But the cost is *enormous*."

These remarks were not made by a skeptical outside observer. They were made by Francis S. Fox, boss of Raytheon's education unit.

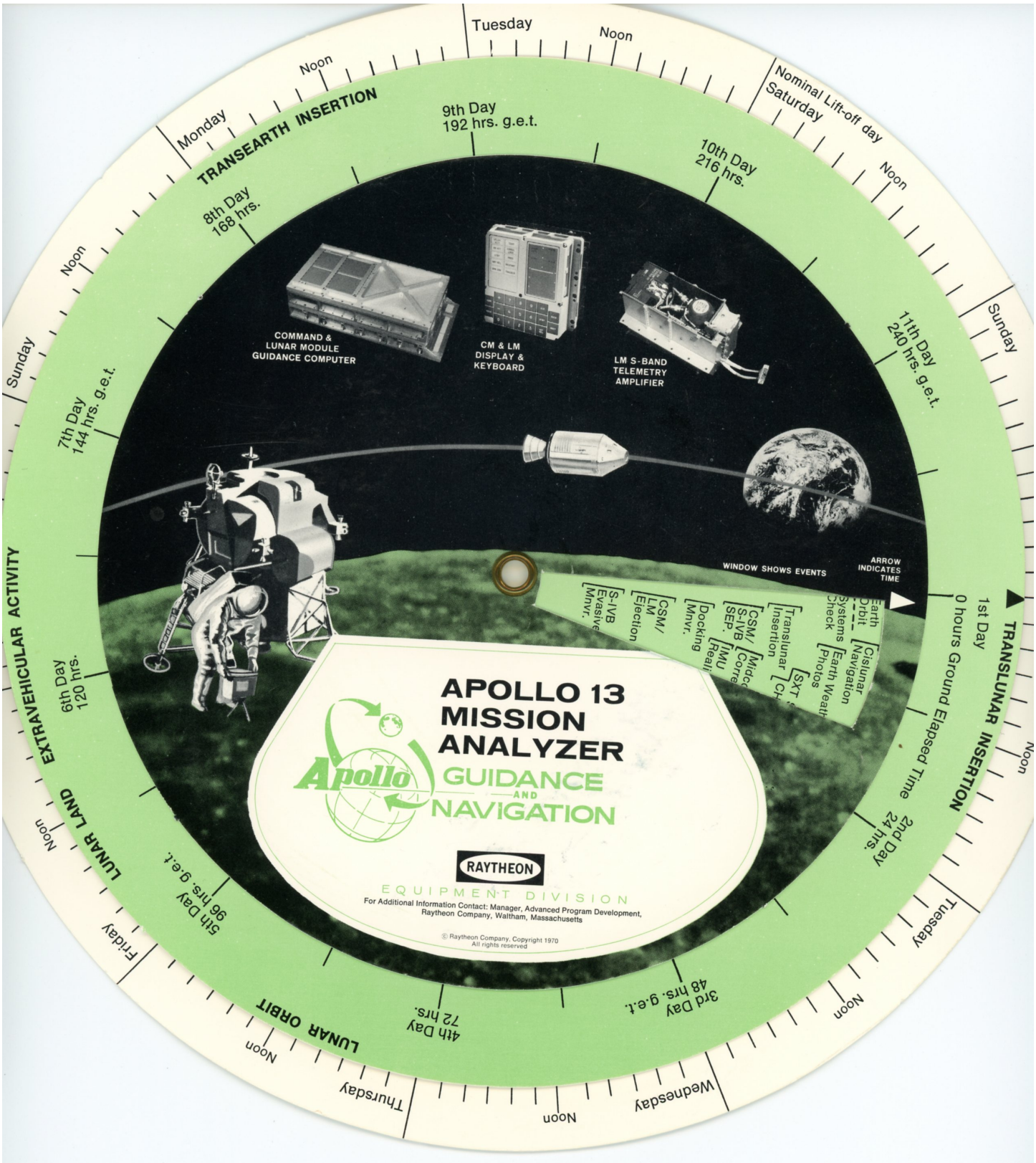
Raytheon's troubles have been typical. Starting in 1965, it began buying education outfits: first, three small firms, each with a volume of $6 million or less: Dage-Bell, Edex, Macalaster, and then, in 1966, Boston's venerable D.C. Heath, with revenues of some $18 million. Fox has few kind words for Heath. Says he: "D.C. Heath had stagnated for a whole decade. There were no young people in the business. As an information base there was *nothing*. It was incredibly bad . . . out of one vest and into another. I don't think D.C. Health would have survived if we hadn't acquired it." Both Macalaster and D. C. Heath have been completely restaffed by Raytheon. "We've brought in some 35 guys in the top levels of management at D.C. Heath alone," says Fox.

***Fox of Raytheon***

Frank Fox was brought in about a year ago after frustrating experiences at McGraw-Hill and General Learning, an affiliate of Time Inc. and General Electric. "Tom Phillips approached me and said 'I've got some problems and I need someone to straighten them out. You run it,'" says he. Has Fox turned it around? Not at all, he admits. "The year 1966 was the *end*, in my opinion, of a period—a double decade of unbelievable growth in population and in dollars spent," says Fox. "In 1966 the Government stepped in and a lot of people thought it was the beginning of a new growth period. Now, looking at it three years later, I think it was the last gasp of spending. It was stopped by a taxpayer revolt. The question now is: 'Who is going to pay for education?' Now we are in a tough market . . . it's in a retrenched position."

In other words, Raytheon made that very common mistake of unwary investors: It bought a fashionable business at the high. But Tom Phillips isn't giving up. "For the long pull, I'm glad we're in it," says he. Fox claims he intends to make more acquisitions in the book-publishing field, primarily to get more talented people. He *still* believes there will one day be a technological revolution in education. "Where I differ from some of my colleagues is that I think it's going to take much longer," he explains. In the meantime, the emphasis falls on internal improvements. "We're in a spot where we have to take business away from someone else because our product is better and because we market more effectively," he observes. Prentice-Hall, McGraw-Hill, Harcourt Brace & World *et al*, take note.


RAYTHEON COMPANY, LEXINGTON, MASSACHUSETTS 02173


Tuesday
Noon
Nominal Lift-off day
Saturday
Noon
Monday
TRANSEARTH INSERTION
9th Day
192 hrs. g.e.t.
10th Day
216 hrs.
8th Day
168 hrs.
Noon
Sunday
11th Day
240 hrs. g.e.t.
Sunday
7th Day
144 hrs. g.e.t.
COMMAND &
LUNAR MODULE
GUIDANCE COMPUTER
CM & LM
DISPLAY &
KEYBOARD
LM S-BAND
TELEMETRY
AMPLIFIER
WINDOW SHOWS EVENTS
ARROW
INDICATES
TIME
Earth
Orbit
Systems
Check
Cislunar
Navigation
Earth
Photos
Translunar
Insertion
CSM/
S-IVB
SEP.
CSM/
LM
Ejection
S-IVB
Evasive
Docking
Mnvr.
EXTRAVEHICULAR ACTIVITY
6th Day
120 hrs.
TRANSLUNAR INSERTION
1st Day
0 hours Ground Elapsed Time
Noon
APOLLO 13
MISSION
ANALYZER
Apollo
GUIDANCE
AND
NAVIGATION
RAYTHEON
EQUIPMENT DIVISION
For Additional Information Contact: Manager, Advanced Program Development,
Raytheon Company, Waltham, Massachusetts
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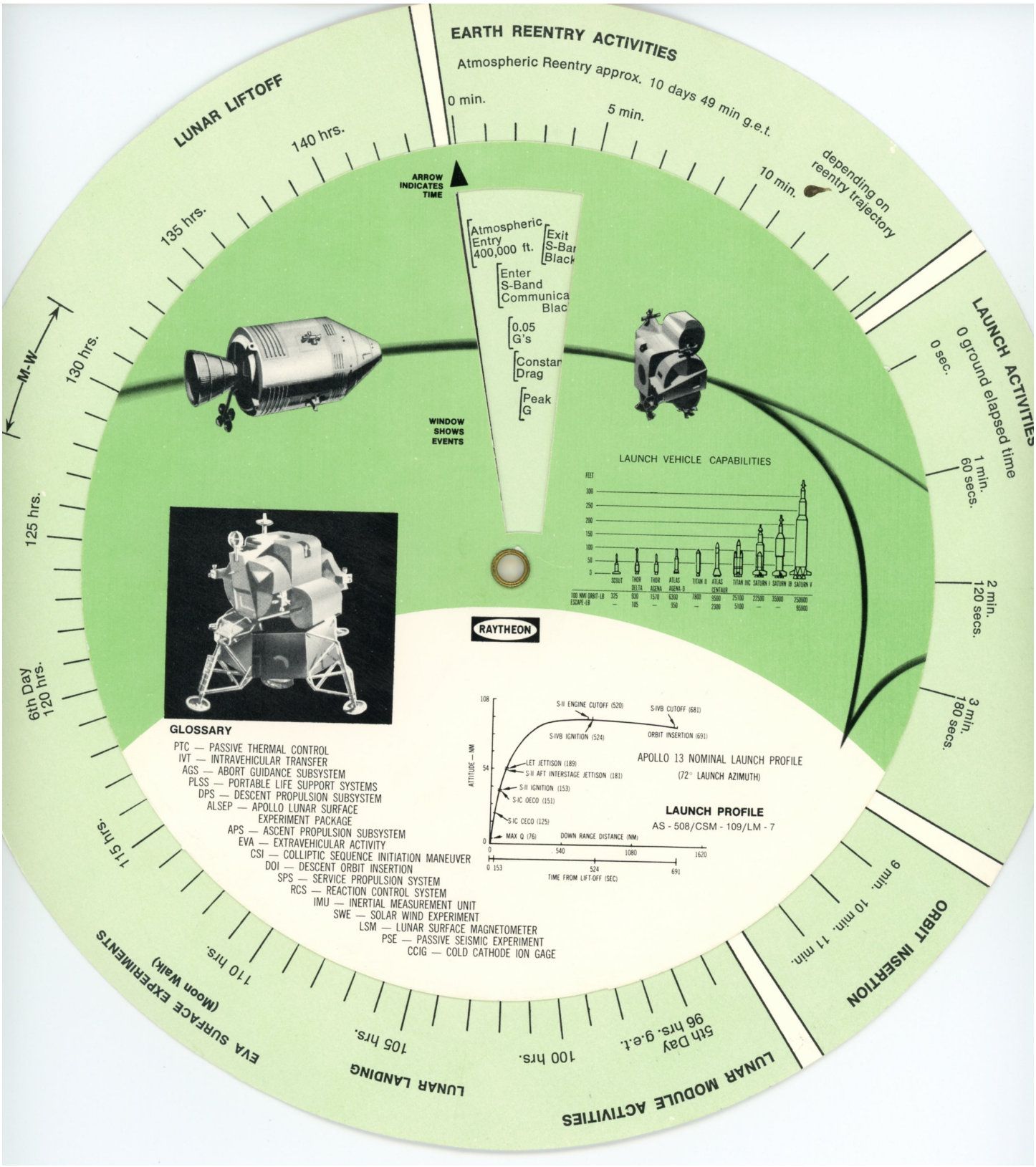
LUNAR LAND
Noon
2nd Day
24 hrs.
Tuesday
Noon
Friday
5th Day
96 hrs. g.e.t.
LUNAR ORBIT
3rd Day
48 hrs. g.e.t.
Noon
Thursday
4th Day
72 hrs.
Wednesday
Noon


EARTH REENTRY ACTIVITIES
Atmospheric Reentry approx. 10 days 49 min g.e.t.
0 min.
5 min.
10 min.
depending on reentry trajectory
LUNAR LIFTOFF
140 hrs.
135 hrs.
130 hrs.
125 hrs.
6th Day 120 hrs.
115 hrs.
110 hrs.
105 hrs.
100 hrs.
5th Day 96 hrs. g.e.t.
9 min.
10 min.
11 min.
ORBIT INSERTION
LUNAR MODULE ACTIVITIES
LUNAR LANDING
EVA SURFACE EXPERIMENTS (Moon Walk)
M-W
LAUNCH ACTIVITIES
0 ground elapsed time
0 sec.
1 min. 60 secs.
2 min. 120 secs.
3 min. 180 secs.
ARROW INDICATES TIME
WINDOW SHOWS EVENTS
Atmospheric Entry 400,000 ft.
Exit S-Ban Black
Enter S-Band Communica Blac
0.05 G's
Constan Drag
Peak G
LAUNCH VEHICLE CAPABILITIES
FEET
300
250
200
150
100
50
0
SCOUT
THOR DELTA
THOR AGENA
ATLAS AGENA-D
TITAN II
ATLAS CENTAUR
TITAN IIIC
SATURN I
SATURN IB
SATURN V
100 NMI ORBIT-LB 325 930 1570 6300 7800 9500 25100 27500 35000 250000
ESCAPE-LB — 105 — 950 — 2300 5100 — — 95000
RAYTHEON
GLOSSARY
PTC — PASSIVE THERMAL CONTROL
IVT — INTRAVEHICULAR TRANSFER
AGS — ABORT GUIDANCE SUBSYSTEM
PLSS — PORTABLE LIFE SUPPORT SYSTEMS
DPS — DESCENT PROPULSION SUBSYSTEM
ALSEP — APOLLO LUNAR SURFACE EXPERIMENT PACKAGE
APS — ASCENT PROPULSION SUBSYSTEM
EVA — EXTRAVEHICULAR ACTIVITY
CSI — COLLIPTIC SEQUENCE INITIATION MANEUVER
DOI — DESCENT ORBIT INSERTION
SPS — SERVICE PROPULSION SYSTEM
RCS — REACTION CONTROL SYSTEM
IMU — INERTIAL MEASUREMENT UNIT
SWE — SOLAR WIND EXPERIMENT
LSM — LUNAR SURFACE MAGNETOMETER
PSE — PASSIVE SEISMIC EXPERIMENT
CCIG — COLD CATHODE ION GAGE
S-II ENGINE CUTOFF (520)
S-IVB CUTOFF (681)
S-IVB IGNITION (524)
ORBIT INSERTION (691)
LET JETTISON (189)
S-II AFT INTERSTAGE JETTISON (181)
S-II IGNITION (153)
S-IC OECO (151)
S-IC CECO (125)
MAX Q (76)
ATTITUDE — NM
108
54
0
DOWN RANGE DISTANCE (NM)
0
540
1080
1620
0 153
524
691
TIME FROM LIFT-OFF (SEC)
APOLLO 13 NOMINAL LAUNCH PROFILE
(72° LAUNCH AZIMUTH)
LAUNCH PROFILE
AS - 508/CSM - 109/LM - 7

SPACE AGE needleworker "weaves" core rope memory for guidance computers used in Apollo missions. Memory module will permanently store mission profile data on which critical maneuvers in space are based. Core rope memories are fabricated by passing needle-like, hollow rod containing a length of fine wire through cores in the module frame. Module frame is moved automatically by computer controlled machinery to position proper cores for weaving operation. Apollo guidance computer and associated display keyboard are produced at Raytheon Company plant in Waltham, Massachusetts.

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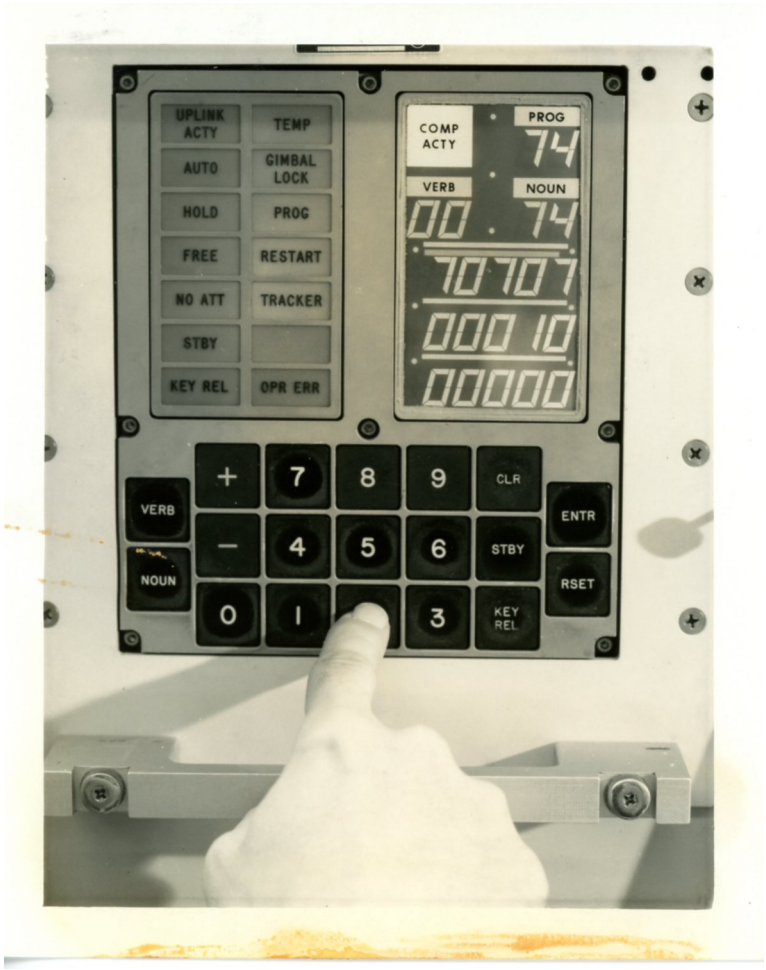
SPACE AGE 49925A

Public Relations
Raytheon Company
Lexington, Massachusetts
(617) 862-6600 ext.415


UPLINK ACTY
TEMP
AUTO
GIMBAL LOCK
HOLD
PROG
FREE
RESTART
NO ATT
TRACKER
STBY
KEY REL
OPR ERR
COMP ACTY
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VERB
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ENTR
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4
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KEY REL

APOLLO DSKY is run through test program at Raytheon Company plant in Waltham, Massachusetts. DSKY, for display and keyboard, is the visual and electronic link between astronauts and the guidance computer and is the control point for guidance and navigation of the space vehicles. Apollo guidance computer and DSKY's are produced by Raytheon Company's Equipment Division.

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APOLLO DSKY 69 49922A

Public Relations
Raytheon Company
Lexington, Massachusetts
(617) 862-6600 ext.416

PRECISE MEASUREMENTS are made by Raytheon Company photo-interpretation specialist in lunar landing site selection program at NASA Houston. Using a Mann Comparator, coordinates of points marked in stereoscopic views of the moon's surface can be measured to less than four one-hundred-thousandths of an inch. The Comparator is used in the spatial triangulation step in the painstaking process of selecting potential lunar landing sites.

Photo Credit: NASA

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PRECISE MEASUREMENTS

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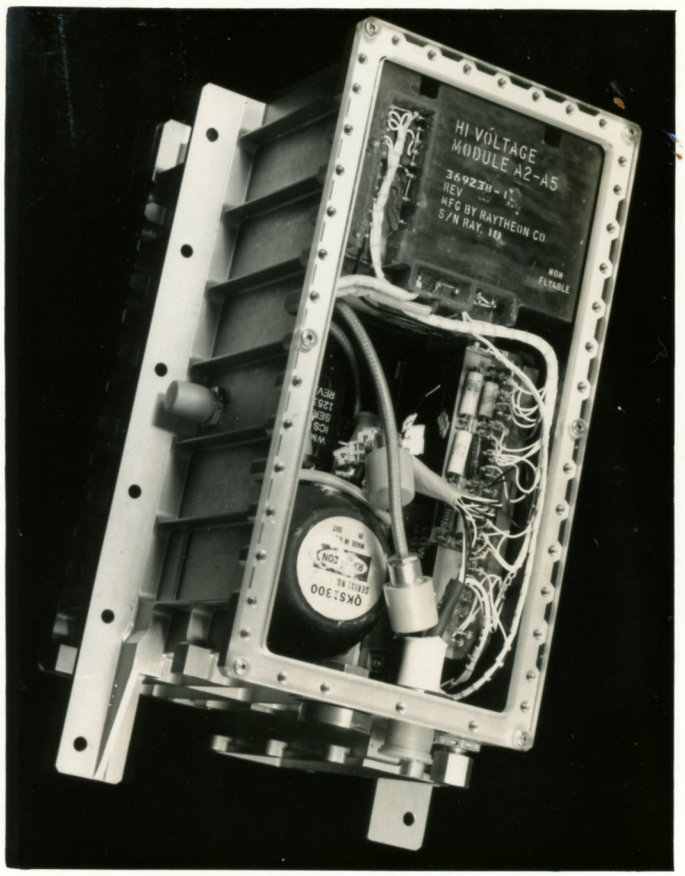
Lexington, Massachusetts
(617) 862-6600 ext.416


HI VOLTAGE
MODULE A2-A5
MFG BY RAYTHEON CO.
S/N RAY-10
NON
FLTABLE

SIGNAL BOOSTER -- Microwave amplifier produced by Raytheon boosts voice and television signals at the Apollo lunar module for transmission to command module and to earth.

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SIGNAL BOOSTER 69 52112A

Public Relations
Raytheon Company
Lexington, Massachusetts
(617) 862-6600 ext.416


DISPLAY & KEYBOARD
POWER CONTROL
CONSOLE
DISPLAY & KEYBOARD
AGC CURRENT
DSKY KEYBOARD VOLTAGE
UNIVERSAL DSKY DIMMERS
DCVM
DCVM MONITOR
APOLLO GUIDANCE

ED-186
7/16/69

GUIDANCE PROGRAM is entered in Apollo display keyboard (DSKY) in test program of computer at Raytheon Company plant in Waltham, Massachusetts. Apollo guidance computer and DSKY's are used in both command and lunar modules to solve guidance and navigation problems during space missions. The DSKY is the visual and electronic link between astronauts and the guidance computer and is the control point for guidance and navigation of the space vehicles. Both units are produced by Raytheon Company's Equipment Division under contract to AC Electronics Division of General Motors Corporation.

# # #

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GUIDANCE PROGRAM 49920A

Public Relations
Raytheon Company
Lexington, Massachusetts
(617) 862-6600 ext.416

RAYTHEON COMPANY
Office of Public Relations
Lexington, Massachusetts 02173
617-862-6600 Ext. 413

James Sterling
HOME: 617 369-3315
ED-189 7/16/69

FOR IMMEDIATE RELEASE

Electronic relays receive their own shake-down cruise at Raytheon Company before acceptance into the elite group destined for space flight.

The testing technique has proved so successful in screening out potentially bad relays that it is now being used by other contractors in the space program.

Relays purchased by Raytheon for use in the Apollo guidance computer and its control center, the display and keyboard (DSKY), are made to exacting specifications. Despite extremely strict controls during manufacture of the relays, occasionally small particles of foreign matter creep in and are sealed in the case.

Under zero gravity conditions of space flight, these particles are weightless and float around within the relay enclosure. If they lodge between relay contacts, they can cause erratic operation if not complete failure of relay functions. The problem is of concern, since large number of relays are used, some 120 in the DSKY alone.

To protect against this, a vibration screening technique was developed at the Sudbury Engineering Facility of Raytheon's Equipment Division. The method uses shaking at random vibrations covering frequency and amplitude ranges that impart the most energy to free particles inside the relay can.

While undergoing the shaking, the relay contacts are monitored for "opens" and "shorts". In addition to spotlighting relays with particle contamination, the method provides a bonus -- that of showing up constructional defects that might have escaped previous inspections and tests.

- more -

The method is being extended to the test of other components to sort out potential troublemakers. Integrated circuits used in quantity in modern electronic systems are being screened successfully by this technique.

Raytheon Company produces the Apollo guidance computer and its display-keyboard under a contract from AC Electronics Division of General Motors Corporation, prime contractor for the Apollo guidance and navigation system.

# # #

RAYTHEON COMPANY
Office of Public Relations
Lexington, Massachusetts 02173
617-862-6600 Ext. 413

John E. Severance
HOME: 617 MU8-7148
ED-194 7/16/69

FOR IMMEDIATE RELEASE

Microscopic examination of thousands of lunar photographs by Raytheon Company photo-interpretation specialists helped determine the final selection of a landing spot for the first moon landing by American astronauts.

Working under a subcontract from Lockheed Electronics Company at NASA's Manned Spacecraft Center, Houston, Texas, specialists from Raytheon's Autometric Operation examined photographs of potential landing areas using advanced-design magnification, stereoscopic, and plotting instruments.

The program provided a selection of candidate sites that were checked further in computer-simulated landings of the Apollo Lunar Module. A number of candidate sites meeting both vehicle and orbital constraints were selected and forwarded by the Manned Spacecraft Center to the Apollo site selection board for final selection.

In selecting candidate landing areas, it was also necessary to analyze the approach path. The approach terrain must be free of sharp slopes and large rocks, craters, and hills that may be misinterpreted by the Lunar Module's landing radar.

Called "footprints", the elliptically-shaped, candidate landing areas having topographic features suitable for a Lunar Module landing were then used in a series of computer simulated landings to determine statistically the probability of the lunar module landing on various degrees of slope.

Working on high and medium resolution photographs returned by the five lunar orbiter missions, the Raytheon specialists performed a variety of operations varying from the simple counting of craters to the precise measurement of the distance between points on the moon in the spatial triangulation process.

Raytheon's Autometric Operation, which is located in Alexandria, Virginia, is also engaged in data collection and reduction systems for reconnaissance, mapping, and geodesy on both government and industrial programs.

Other Apollo program work at the company includes production of the guidance and navigation computers and associated display-keyboards, which are used by the astronauts to guide the command and lunar modules during the missions; the Apollo tracking displays, which are used in the Manned Space Flight Tracking Network to monitor flights; and the microwave amplifier for the Lunar Module S-band communications system.

# # #

RAYTHEON COMPANY
Office of Public Relations
Lexington, Massachusetts 02173
617-862-6600 Ext. 413

John E. Severance
HOME: 617 MU8-7148
ED-192 7/16/69

FOR IMMEDIATE RELEASE

While a Raytheon produced computer is solving guidance and navigation problems for the astronauts of Apollo 11, the flight will be monitored on Raytheon produced displays at sea and on the ground.

Nine display systems developed by Raytheon Company's Equipment Division, Wayland, Massachusetts and manufactured at the company's North Dighton, Massachusetts plant have been installed in six ground tracking stations and aboard three Apollo tracking ships in NASA Goddard's world-wide Manned Space Flight Tracking Network.

During the historic flight, radio signals from the spacecraft will be presented on the large television-like screens in alpha-numeric form -- letters and numbers -- as contrasted with the varying voltage dial readings of the earlier flights of Gemini and Mercury.

With the displayed information from the spacecraft, NASA personnel at Houston Manned Space Flight Center will be able to monitor and judge spacecraft performance during all vital maneuvers and under all conditions throughout the whole flight.

The display systems have been installed at Carnavon, Australia; Guayamas, Mexico; Ascension Island; NASA Goddard, Greenbelt, Maryland; two at the Manned Spacecraft Center, Houston, Texas; and one each aboard three Apollo tracking ships.

A display system consists of one aeromedical monitor console; four spacecraft systems consoles; one command communicator console; one maintenance and operations console; one memory character generator; and for shipboard installations, a flight dynamics console.

- more -

The Apollo Guidance Computer, which is produced at Raytheon's manufacturing facility in Waltham, Mass., is a high-speed, general-purpose digital computer designed specifically for space applications.

All vital maneuvering and navigation commands during the flight are processed by the computer, the "brain" of the spacecraft's guidance and navigation system.

The display systems were produced for NASA under a $6 million contract. Production of the Apollo guidance and navigation computer is under multi-million dollar subcontracts from AC Electronics Division of General Motors Corporation. The guidance and navigation system was designed by Massachusetts Institute of Technology's Instrumentation Laboratory.

# # #

RAYTHEON COMPANY
Office of Public Relations
Lexington, Massachusetts 02173
617-862-6600 Ext. 413

John E. Severance
HOME: 617 MU8-7148
ED-188 7/16/69

FOR IMMEDIATE RELEASE

Miniature digital computers produced by Raytheon Company are used to guide the Apollo command and lunar modules during missions scheduled in the program.

The Apollo Guidance Computer (AGC) is produced at Raytheon's Equipment Division, Waltham, Massachusetts under contract to AC Electronics Division of General Motors Corporation.

During a flight, astronauts enter various maneuvering instructions into the AGC by means of the Display and Keyboard (DSKY). The DSKY is the visual and electronic link between astronauts and the computer and is the control point for guidance and navigation for the space vehicle.

Through the 19-button keyboard, instructions or interrogations of the computer are entered in digital codes prefaced by pressing either the "VERB" or "NOUN" buttons or both. A typical entry has the form of VERB 18, NOUN 29, ENTER. In general the verb sequence indicates an action to be taken and the noun sequence indicates which portion of the memory register the action is entered.

If instructions to the computer are incorrect -- for example, an unprogrammed sequence or an incorrect number sequence -- the DSKY's operator error light begins flashing indicating that something is amiss.

- more -

If the command is "correct" or acceptable to the computer, the astronaut pushes an enter button and the computer takes over using inputs supplied to it by other portions of the guidance and navigation system.

In response to a "correct" command or interrogation, the computer will perform some action ending with the display of digital information on the electroluminescent panels of the DSKY. Further steps or input on the part of the astronaut may be necessary to finish the particular sequence.

The computer can also "communicate" its needs to the astronaut when a data request or signal is needed. VERB or NOUN numbers will flash at a 1 1/2 cycle per second rate until the astronaut takes action.

The computer is the "brain" of the guidance and navigation system that evolved from studies and design work at Massachusetts Institute of Technology's Instrumentation Laboratory. It weighs approximately 70 pounds, and its memory cycle time is less than 12 millionths of a second. Single addition requires less than 24 millionth of a second to perform.

Other major portions of the guidance and navigation system are an inertial measurement unit (IMU) produced by AC Electronics, which establishes and holds a stable onboard frame of reference and measures spacecraft acceleration by using MIT-designed gyros and accelerometers; and an optical unit, produced by Kollsman Instrument Corporation, used for sighting by the astronauts allowing them to re-align periodically IMU spatial orientation with reference to stars and to earth and moon landmarks.

The total system is designed to couple what men can do best -- pattern recognition in sighting such references as stars -- with what machines can do best -- tedious and repetitive computation and high speed switching.

The system is self-sufficient in that it can perform all guidance and navigation functions of a complete mission with no aid from the ground. Nevertheless, there is also a redundant operational capability from the ground through tracking networks and radio links.

# # #

RAYTHEON COMPANY
Office of Public Relations
Lexington, Massachusetts 02173
617-862-6600 Ext. 413

James Sterling
HOME: 617 369-3315
ED-187 7/16/69

FOR IMMEDIATE RELEASE

Voice, television, and telemetry signals originating from the Apollo 11 Lunar Module (LM) will get the big boost for their translunar journey to earth from a Raytheon microwave amplifier.

The microwave amplifier is part of the LM S-band communications system produced by RCA and proved in operation during the orbital flights of Apollo 5 and Apollo 9. It will be used for communications between the LM and the Command and Service Module during the period they are separated for the flight of the LM towards the lunar surface.

In the landing of the LM on the moon, it will be used by the astronauts for television and telemetry transmission directly to the earth.

The amplifier uses Raytheon QKS 1300 Amplitron* crossed field amplifier tubes developed for this application. An efficient tube, the QKS 1300 provides a high level of reliable performance in the space environment and a power-off, feed-through mode of operation for low-data-rate communications.

For reliability, the amplifier uses two redundantly operating Amplitrons each with its own power supply. Power supplies are solid-state, dc-dc converters providing control of warm-up, mode acquisition, and recycling on removal of the drive signal.

Total weight of the unit in its pressurized case is 19.4 pounds.

Raytheon Company also supplies the digital computers and their associated display keyboards used in the guidance and navigation systems of both the command and lunar modules.

Grumman Aircraft Engineering Corporation is the prime contractor for the Lunar Module.

# # #

*A Trademark of Raytheon Company

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Office of Public Relations
Lexington, Massachusetts 02173
617-862-6600 Ext. 413

John E. Severance
HOME: 617 MU8-7148
ED-190 7/16/69

FOR IMMEDIATE RELEASE

The miniature digital computers that will solve the astronauts' guidance and navigation problems in the lunar landing mission are of advanced design using microminiature components and sophisticated packaging techniques.

Produced at Raytheon Company's Equipment Division, Waltham, Massachusetts, under a contract from AC Electronics Division of General Motors Corp., the computers and their associated display keyboards are used in both the command and lunar modules.

Main function of the Apollo guidance computer is to store data defining flight profiles for spacecraft missions. This data is composed of position, velocity, and trajectory information and is used by the computer to solve flight and steering equations during orbital injection and mid-course guidance maneuvers.

The solutions determine the required magnitude and direction of thrust and are fed to the engine-control portion of the spacecraft as a series of signals.

The control point for the astronauts in the flight is the computer's associated display and keyboard. Through the so called DSKY, the astronaut loads information into the computer to initiate various program functions and to perform tests on the computer and other subsystems in the guidance and navigation system.

The DSKY displays the program functions being executed by the computer, specific data selected by the astronauts, and any malfunctions that may occur in the system. It also routes data from the guidance computer to the spacecraft telemetry system.

# # #

RAYTHEON COMPANY
Office of Public Relations
Lexington, Massachusetts 02173
617-862-6600 Ext. 413

John E. Severance
HOME: 617 MU8-7148
ED-193 7/16/69

FOR IMMEDIATE RELEASE

The "brain" of the guidance and navigation system making possible the historical Apollo moon flight and landing is a small digital computer produced by Raytheon Company in Waltham, Massachusetts.

It was designed specifically for space flight and weighs less than 70 pounds. It is approximately one cubic foot in volume.

A versatile unit, the computer has two memories -- a non-destructible wire rope memory for storage of data to solve flight equations and an erasable, or scratchpad, memory for entry of new variables during the mission.

The problems solved by the computer are controlled by automatic sequencing or manually at the discretion of the astronauts.

The computer interfaces with the astronaut through the DSKY (display-keyboard) and with the optical subsystem and the inertial measurement unit to make up the on board guidance and navigation system.

By means of the optical subsystem, the computer is supplied with data obtained by the astronauts in line-of-sight measurements to celestial objects. The computer can also track stars automatically.

The inertial measurement unit supplies the computer with gyro reference data so that the computer flight program can establish where the spacecraft is in space.

The computer is responsible for many tasks during the mission beginning with a pre-launch alignment of the inertial measurement unit by means of a gyro computer program.

- more -

During liftoff and the initial stages of the flight, the computer monitors the trajectory of the Saturn fourth stage for proper orbital insertion. In earth orbit, the astronaut checks the orbital path of the spacecraft by taking optical sightings on known landmarks, the computer recording data and time and calculating orbital trajectory.

After translunar injection, optical sightings are taken on known stars, the locations of 31 of which are stored in the computer's memory. When the astronaut identifies the star, the computer automatically locates it for optical sighting and, after the astronaut verifies that the sighting is correct, aligns the inertial measurement unit automatically.

During the coast to the moon, trajectory information is calculated by the computer and if an error exists, the computer can automatically correct the course by firing the spacecraft engines. So far in moon flight missions, these mid-course trajectory changes have been kept to a minimum because of the initial accuracy of the guidance and navigation system.

When the spacecraft nears the moon, the computer calculates how long the thrust engine must burn and at what angle the spacecraft should enter into a lunar orbit. Once in orbit, the computer plots the lunar orbital path of the spacecraft prior to separation and descent of the Lunar Module.

In the Lunar Module, an identical guidance computer having different flight program information stored in its memory works in conjunction with the landing radar to guide the bug to the selected landing spot by controlling the burn of the descent engine.

Liftoff from the moon requires the computer to control the ascent engine by calculating time and angle of burn to place the Lunar Module into a rendezvous orbit.

Docking is accomplished with aid from the computer working in conjunction with the rendezvous radar. After the LM is jettisoned, the computer calculates time and duration of service propulsion system engine burn to free the spacecraft from lunar orbit and send it on its computer programmed transearth coast. If necessary, mid-course corrections are made during the long coast to earth.

Before earth entry, and after the command module is separated from the service module, the last and most critical task of the computer is to control the re-entry trajectory and steering. This is done by controlling lift and drag of the spacecraft to bring about the proper re-entry angle.

The Apollo guidance computer is produced under a subcontract from AC Electronics Division of General Motors Corporation, prime contractor for the guidance and navigation system. The system was designed by Massachusetts Institute of Technology Instrumentation Laboratory.

# # #