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N. H. Taylor
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Memorandum 6L-173

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Division 6 - Lincoln Laboratory
Massachusetts Institute of Technology
Lexington 73, Massachusetts

SUBJECT: ORGANIZATION AND TASKS OF DIVISION 6

To: Lincoln Steering Committee

From: Jay W. Forrester

Date: 16 November 1954

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Date:

In the following sections and on the attached figures will be found the organization and duties of Division 6 staff members. The following items may assist in understanding the charts:

1. The name of each staff member is shown in one and only one place. He is listed under his principal activity when there is a division of time.
2. Blanks represent new staff members who need to be hired to carry on the work of the Division. In addition to new hires, some sections will be augmented by non-replaced transfers from other sections within the Division. The effects of such transfers are not shown on the diagrams although sometimes mentioned in the text.
3. Text numbers and figure numbers correspond.
4. Total number of present non-staff is shown on the figures. This memorandum does not include new non-staff which would be required to assist the additional staff members needed.

A. DIVISION 6 GENERAL ORGANIZATION

The Lincoln Laboratory has responsibility for the technical supervision and coordination of the SAGE System. Within the Lincoln Laboratory, Division 6 has responsibility for the equipment at the Direction Center and Combat Center including the AN/FSQ-7, the associated buildings and power sources, and the operational program for the computer including the planning of operational procedures for the system. Other Lincoln divisions have responsibility for radars, data transmission, and communications.

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A. (Continued)

As a part of its duties Division 6 maintains and operates the Whirlwind computer and the experimental Direction Center in the Barta Building. Division 6 is now establishing a prototype Direction Center in Building F; this Center will be built around the AN/FSQ-7 (XD-1) to be delivered by IBM this winter and spring. The writing of programs for these machines is the responsibility of Group 61, as is the training of Air Force personnel to man these Centers. Planning for SAGE System operation; coordination with outside groups using SAGE outputs, such as weapons designers; analysis; simulation; and data reduction are also the responsibilities of Group 61.

The AN/FSQ-7 is being developed and produced by IBM, working closely with Division 6 on all phases of specifications, design, components, circuits, and testing. Prime responsibility within Division 6 for the XD-1 prototype lies with Group 62, while prime responsibility for the production program, including redesign for duplex operation, lies with Group 64. These two groups work very closely together as evidenced by a joint Systems Office which handles formal coordination with IBM. The Production Coordination Office handles technical liaison with outside groups other than IBM. Group 64 built and still maintains the experimental center in Barta. Group 65 provides special vacuum-tube development and construction facilities needed for the FSQ-7 display system.

Group 63 has responsibility for all technical advanced development, including core development and the study of new techniques needed for future machines and for future major additions to SAGE. This group is the only part of the Division not totally committed to SAGE.

Group 60 supplies shops, drafting, and housekeeping for the Division.

The following table summarizes the present personnel and the new staff needed as shown on the attached figures. More than a 50% increase in staff is indicated. This figure seems entirely justified if Lincoln is to carry out the obligations that MIT has accepted in SAGE System engineering management. The number does, however, appear beyond what can be reasonably expected because of budget and floor space limitations. Except for these factors, I believe suitable men could be found.

This overloading of present staff poses a serious problem. We are attempting to work out methods for transferring sections of the job to other organizations, but this is time consuming and increases our liaison commitments. No fully satisfactory solution is yet apparent.

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SUMMARY

<u>Figure</u>	<u>Group</u>	<u>Total Present Personnel</u>		<u>New Staff Needed</u>
		<u>Staff</u>	<u>Non-Staff</u>	
A	Div. HQ	3	3	3
B	61	55	16	56
C	62	27	31	17
D	63	29	29	6
E	64	15	43	4
F	65	8	18	0
G	PCO	8	4	1
H	Sy. Off.	26	3	17
I	60	<u>19</u>	<u>137</u>	<u>3</u>
Totals		190	284	107

PERSONNEL FROM OUTSIDE ORGANIZATIONS

Air Force (6520 AC&W)	48
IBM	8
Bell Telephone Laboratory	3
Western Electric	1
Cleverdon Varney & Pike	4

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1. Division Headquarters

Almost all division work is decentralized into the several groups. The leader of Group 60 also serves as executive officer in assisting with personnel management. The administrative load from visitors, reports, demonstrations and inquiries has exceeded what can be handled by the present single staff member assisting the division head and associate division head. A second staff assistant is needed.

Two top-level planning and time-schedule control men are needed on the Division 6 Headquarters staff to monitor the FSQ-7 and SAGE System schedules of the many organizations involved. These men should be full-time on advanced planning and interpretation of progress reports to foresee potential delays in time to take corrective action.

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B. GROUP 61

Group 61 is engaged in planning, computer programming, operation, test and evaluation, and personnel training for three systems which represent the progression of the SAGE System through the "bread-board," prototype, and production stages. In the past, the primary concern of the Group was the "bread-board," the Cape Cod Direction Center with Whirlwind I. After acceptance of the SAGE System by the Air Force, it became evident that Group 61 must work simultaneously on all three systems: Cape Cod, the Experimental Sage Subsector, using the AN/FSQ-7 (XD-1) prototype, and the production SAGE System. This represents an enlargement of the Group's responsibilities, and the recent reorganization shows clearly that the present staff is very thinly spread throughout the numerous activities required. It should be borne in mind that the Experimental Subsector will continue to operate as a tool for acceptance testing and system development, and this effort will overlap work on the production system for several years.

While planning is a function shared among several Groups, Lincoln's participation in Direction Center operation, operational test and evaluation, and operator training, is carried on almost wholly by Group 61. Until the Air Force has planned and established some agency of its own for computer programming, Group 61 is the sole source of planning and preparing computer programs for all three systems. To meet these numerous obligations, which are increasing with time, Group 61 needs a staff increase to approximately twice the present manning. One extra staff member is needed as an assistant to the Group Leader.

1. 1954 Cape Cod System Operation

This section operates the existing direction center as required to gather experimental data, train operators, and demonstrate the system to visitors. Programming is done when modification of the system is called for. In addition, the Section works as a consulting group to reflect its operating experience in planning the Experimental SAGE Subsector and the production system.

a. Training

This subsection trains Air Force operators in the 1954 Cape Cod System, prepares operators' manuals, and gives indoctrination courses for new Group 61 personnel and outside visitors. Two new staff are needed.

b. Test Coordination

This subsection schedules test aircraft and ground equipment for Group 61 flight tests, issues Operations Plans and Mission Specification, and briefs pilots and radar observers. During missions it maintains radio contact with target aircraft, records their activities, and coordinates with the CAA and the local GCI station. One additional staff member is needed.

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B. 1. (Continued)c. Direction Center Operation

This subsection specifies procedures for the Cape Cod Direction Center, monitors its operation, obtains records for analysis of each operating station, and calibrates and checks out the direction center equipment. One more staff member is needed.

d. Data Analysis

This subsection is responsible for reduction of recorded test data to the form required for evaluation. This includes computer programming for extensive automatic data recording and programming for data reduction. Two new staff are needed.

e. Programming

This subsection modifies the computer program to incorporate any changes which are agreed upon. The subsection also keeps complete records of the computer program, system parameters, and any modifications made. Two more staff members are needed.

2. Experimental SAGE Subsector

The planning and specification of the operating doctrine for the Experimental SAGE Subsector (prototype) is done by this section. It will plan, prepare, and check-out the complete XD-1 computer program.

a. Air Surveillance Subsection

This subsection prepares the computer subprogram and the operators' doctrine for radar data insertion, correlation, smoothing, track monitoring, and height finding. The combination of these tasks requires about 50% of the computer's capacity, and efficient programming is mandatory. Six new staff members are needed.

b. Identification and Manual Inputs

This subsection prepares the computer subprogram and the operators' doctrine for identification of all tracks. Since the major portion of the data inserted manually (punched cards) is used for identification, the insertion subprogram and operators' doctrine is included. One additional staff member is needed.

c. Weapons Direction

This subsection prepares the computer subprogram and operators' doctrine for weapons assignment and for interceptor and antiaircraft control. This function includes raid forming and preparation of displays and doctrine for the Subsector Command Post. Five new staff members are needed.

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B. 2. (Continued)d. Master Control and Display

The master control and display program forms the over-all program framework for the operational subprograms described above. It cycles through these subprograms as they are required and is the communication link between them. It also performs the central service functions of interrogating all operators' push buttons and light guns, and furnishing all displays with the proper format. This subsection requires six staff members.

e. Utility Programs and Card Preparation

This subsection prepares utility programs for executing routine functions (for example, trigonometric functions) used in the operating program and prepares auxiliary programs, such as the read-in program. Its scope will be extended to include diagnostic programs to aid in checking out both operating programs and direction center equipment. The subsection also operates the card preparation facility for XD-1, the Memory Test Computer, and, as machine time permits, computation for the Laboratory. Three new staff members are needed.

f. Training and Battle Simulation

Training and Battle Simulation is an aid to system check-out, operator training and practice, and operational testing. It is a separate facility in the direction center and requires a computer subprogram and operators' doctrine. Because of the shortage of manpower this subsection is not staffed; six new people are needed.

3. SAGE System Planning

This section plans for the numerous features of the production system which are not included in the XD-1 prototype. Three major features not present in XD-1 are: automatic cross telling, duplex computer operation, which requires study of the program for the standby computer, and the Combat Center, which will have its own computing equipment and operational doctrine. In addition, this Section is planning the integration of new system elements which will arrive in the time period of the production system; for example, Bomarc, Talos, a fully integrated anti-aircraft system, etc.

a. Duplex Operation

The first duplex machine will not be available until installation of the first operational SAGE Subsector. Careful advance planning is required to cope with the unique problems of testing and operating the equipment. Operational criteria and displays for switching computers must be developed, the details of communication between the operating and standby computers must be specified, and a method of checking the standby machine must be formulated. Also, there are numerous detailed equipment specifications which require operational advice. Four new staff members are required.

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B. 3. (Continued)b. Combat Center

The combat center (CC) computer will have a task very different from the direction center computer. The concept of a semiautomatic CC is relatively new, and is still in the detailed planning stage. The CC mission is primarily battle supervision and weapon allocation (as distinct from weapon control), and the exploitation of the computer to aid these functions requires a great deal of study and invention. Three new staff members are needed.

c. Special Studies

This subsection is concerned with the integration of system components which are expected to appear in the time period when the production system is being installed. These include Antiaircraft with some form of automatic AAOC, missiles (Bomarc, Talos), operational AEW, Air Traffic Control, and a complete network for ground-to-air communication. At least two more staff members are required.

4. Systems Test Planning

This section plans and specifies operational tests of the Cape Cod, XD-1, and SAGE Systems. These tests fall into roughly three categories, 1) tests to determine the effectiveness of the system, 2) tests on specific parts of the system to study their behavior in detail, and 3) tests (by simulation) to study the effects of extrapolating system parameters (say, intercepting a Mach 2 target). The Section is responsible for generating an over-all program of tests, specifying in detail all individual tests (kind of data, form, duration of test) and interpreting and reporting the results. Close liaison with Bell Telephone Laboratories and the Air Force is required to represent their interests in the test program. The Section needs five new staff members to meet its commitments on schedule.

5. Analysis and Simulation

Mathematical analysis of such fundamental processes as tracking, monitoring, interceptor control, and automatic initiation of aircraft tracks contributes much to the basic understanding of these processes and stimulates ideas for improving them. The companion analysis tool is simulation, which permits experimental study of these statistical processes. Simulation is very valuable in gathering large statistical samples (which would be prohibitively expensive if live tests were used) and in studying the effects on the system of varying parameters which cannot easily be changed in the live system. The Section is working on a simulation program which will include a mathematical model of the radars suitable for investigating the effects of blip-scan ratio, radar noise, scan rate, data accuracy, smoothing parameters, etc. on system kill. This program requires six more staff members.

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B. (Continued)

6. SAGE System Training

The exact responsibilities and procedures for training Air Force direction center operating personnel for the production SAGE System have not yet been established in detail. Although the Air Force has primary responsibility, it will certainly need assistance in establishing its training program; also, we recognize that the Air Force's program has to be successful if the SAGE System is to be effective. Consequently a SAGE System Training Section was established in Group 61 to assist outside agencies by passing on the experience we have gained in training Air Force personnel in the Cape Cod System (and will gain in training for XD-1). This section will have the duties of studying training methods, assisting outside agencies in defining and scheduling an effective training program, and in training Air Force instructors. At present the Section has only one staff member assigned, and six more staff members are needed.

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C. GROUP 62

Group 62 establishes specifications for the FSQ-7 and guides IBM* in the design, construction, improvement, and maintenance of prototype FSQ-7 (XD-1). The major activities of the group have been in the areas of logical design, the basic circuitry design, memory development, major computer component test, and display development and engineering. The liaison activity with IBM has been carried out at all levels. The establishment of formal agreement on specifications has been the function of the Systems Office. See Figure H of organization charts. Over the next two-year period, the activity will be directed toward making the XD-1 operate in the Experimental SAGE System Subsector being constructed at the Lincoln Laboratory. Major errors in equipment design will show up here, and necessary changes will be made and passed on to the production FSQ-7 at IBM. Maintenance procedures will be developed for field use. Data on components will be recorded to guide future component development and improvement.

1. Vacuum Tube Circuits Section

The Vacuum Tube Circuits Section directs the design of the circuits to be used in the AN/FSQ-7. Each circuit that goes into the AN/FSQ-7 must be evaluated by this section before it is accepted. All proposed changes to circuitry in the AN/FSQ-7 must be evaluated by this section before they are approved. The Vacuum Tube Circuits Section trains new circuit engineers for computer circuit design. This section serves both 62 and 64 in the above capacities.

This section needs four more circuit people to keep up with circuit problems arising during the XD-1 test program and to monitor production circuit changes arising in the IBM program.

This section needs to be kept healthy and vigorous; it is our best training ground for future systems people.

2. Display System

This section is designing and will test the display system for the AN/FSQ-7. It is divided into two functionally separable subsections: display engineering, and display development.

a. Display Engineering

This subsection has the responsibility for design and test of the central display frames. These frames include both the digital and situation display generation and testing equipment. This is a piece of work in the IBM contract which was taken over by Group 62 to help IBM

* IBM in Project High has 282 professional people (mostly engineers) plus 203 non-professional people (technicians, draftsmen, clerks, etc.) and about 500 supporting people (subcontractors, service agencies within IBM, etc.) Group 62 and 64 share the guidance of this activity.

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G. 2. (Continued)

to meet their time schedules. The subsection will participate in the installation of XD-1 display equipment and will become a part of the XD-1 System Section when the machine is in Building F. The work of this section has been in the design of pluggable units and frames and in planning the frame testing. In the future, it will do the actual frame testing, modification of the design as required, finishing the drawings (checking and correcting), assisting the re-design of the duplex, getting the complete display system in operation and working with Group 61 in optimizing the operational use of the Duplex System.

b. Display development

The Display Development Subsection has responsibility for following the design and manufacture of the charactron and typotron tubes, investigating all other display tube developments which may be of use to FSQ-7, developing and evaluating new circuits for display, building experimental equipment for demonstrating or measuring new display techniques.

The areas of major interest in the next six months will be in guiding Convair and Hughes through the XD-1 production, getting set up for duplex tube production, and developing a satisfactory large board display. Four new staff members will be required here to provide the types of skills needed in this type of work.

3. XD-1 System Section

This section carries Lincoln's responsibilities to the FSQ-7 production prototype which is to be installed in Building F. The equipment contains about 25,000 vacuum tubes, and this equipment should be installed and tested in less than a year. At present, this section consists of six engineers working on the test floor at IBM, aiding in the individual frame tests as they come out of production. When the XD-1 is moved to Lexington in the first part of 1955, it will be necessary to expand this group to approximately 22 engineers to carry on the over-all test at Lexington, together with a similar group of IBM engineers sent here for this phase of the work. This group will be responsible for the pioneer work needed to demonstrate the capability of an FSQ-7 to cope with the Air Defense problem. Their time schedule is such that a strong group of the most capable people we have should be gathered together in this effort. Some men will transfer from other sections and nine new staff members are needed.

4. MTC Development and Operations Section

The MTC Section is responsible for:

- (1) The operation of MTC as a large-scale digital computer for performing simulated problems posed by the Bell Telephone Laboratories and Group 61.

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C. 4. (Continued)

- 2) Training of system engineers and technicians for the XD-1 system.
- 3) Testing of new computer components such as core memory, drums, display, data links, etc.

It is proposed that the MTC computer eventually become an operating computer for the general use of the Lincoln Laboratory. The number of people required in this activity will decrease with time. Some of the engineers and technicians will go into the XD-1 system section.

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D. GROUP 63, MAGNETIC MATERIALS AND ADVANCE DEVELOPMENT

The two principal activities in Group 63 are:

- 1) Basic research on magnetic materials for digital-computer applications.
- 2) The development of new components, circuits, logical design techniques, and system-design concepts to improve the reliability of digital computers for AN/FSQ-7-type applications.

The magnetic-materials research initially stressed short-range, empirical techniques to provide ferrite memory cores to meet the minimum requirements for FSQ-7. Having accomplished this, most emphasis is now placed on long-range research to improve further the core performance and production yields.

The advance development activity on new components, circuits, etc. seeks a fresh approach to and study of system-design concepts and the large-scale application of new components such as the transistor to eliminate or greatly reduce the number of vacuum tubes in the system.

1. Physics Section

The primary function of the Physics Section is to invent, study, and evaluate new materials which will serve as the basic components in solid-state devices for digital computers. At the present time, the section is working in close coordination with the Chemistry Section.

The section first sought to understand the physical mechanisms which control the shape of the hysteresis loop, the coercive force, and the switching time in metallic and ceramic, polycrystalline, ferromagnetics. The results obtained have proven of considerable value in the development of a superior memory core and are currently giving guidance in the development of satisfactory switch cores.

A study of the electron interactions in ceramic materials has contributed some new ideas which have application not only to the ferrites, but also to ferroelectrics and to ferromagnetic materials with the perovskite-type structure. Present objectives include a further experimental verification of the theoretical studies on the mechanism of flux reversal, requiring careful experiments on single-crystal specimens. (This work is coordinated with the work in Group 37.) The objectives also include exploitation of new electron-interaction concepts which may lead to the development of quite different materials.

The section needs one experienced experimentalist.

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D. (Continued)

2. Chemistry Section

a. Memory Cores Subsection

The objectives of this subsection are:

- (1) Pilot-plant production of memory cores compatible with the General Ceramics core, as an emergency source of supply for the AN/FSQ-7 program.
- (2) Production of superior memory cores for development work in the Memory Section.
- (3) Synthesis of samples for research in the Physics Section.
- (4) Development of magnetic materials for other computer applications.

The work of this subsection is primarily the compounding and processing of ferrites, including some development of both equipment and methods and the more obvious studies of compositions and processing techniques.

As time permits, objective (4) will become a major portion of this subsection's activities, replacing in part the effort now devoted to objectives (2) and (3). Present staff is adequate.

b. Chemistry of Magnetic Materials Subsection

The objectives of this subsection are:

- (1) Study of ferrite chemistry to obtain materials of well-defined chemical constituency.
- (2) Study of the chemistry of related substances.
- (3) Synthesis of new magnetic substances.
- (4) Chemical analysis.
- (5) Study of microstructure.
- (6) Consideration and evaluation of methods for the growth of ferrite single crystals.

Evaluation of the first four months of work in this subsection indicates that the basic chemical studies, which necessitate painstaking laboratory preparations, are understaffed for a reasonable rate of progress.

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D. 2. (Continued)

The addition of two chemists for synthetic inorganic preparations is recommended. The fundamental chemical work is basic to a clear understanding of the magnetic materials which we are now using and to the development of new magnetic materials for computer use.

c. Crystallography and X-Ray Diffraction Subsection

Objectives for this subsection are:

- (1) Determination of exact crystallographic arrangement of constituent ions in magnetic materials.
- (2) Study of crystal orientation.
- (3) Study of lattice parameters.

This subsection is not yet an operating unit. Some equipment has been received but a crystallographer has not as yet been hired. The crystallographic structure work constitutes an integral part in the research program in magnetic materials while objectives (2) and (3) are more of a service for the Physics and Chemistry Sections.

d. Magnetic Core Evaluation Subsection

The objectives of this subsection are:

- (1) Evaluation of magnetic cores received from all sources.
- (2) Development of test equipment for expeditious evaluation.
- (3) Compilation of magnetic and electrical test data.
- (4) Supply of tested cores for development work in the Memory Section.

Current work includes the automation of memory-core testing. Need for a replacement leaves the subsection understaffed.

3. New-Components-and-Circuits Section

The objective of this section is the development of new techniques to improve the reliability and performance of large computing systems. A number of techniques, most of them employing either transistors or magnetic cores are being studied at the present time, but re-evaluation about January 1, 1955, is expected to shift most work to the most promising technique.

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D. 3. (Continued)

Some of the research of this section is carried out by Research Assistants in Electrical Engineering working in Cambridge and will be handled under a purchase order to the Division of Industrial Cooperation. Six new Research Assistants there are working on magnetic-core and transistor circuits, and several doctoral candidates are working on reliability and system problems.

A general evaluation of transistor types is being made in conjunction with Group 35. Individual transistors are subjected to routine measurement of parameters. A study and evaluation of commercial production techniques is being made. Individual circuits are developed and tested, and operated in systems.

An adequate transistor program requires simultaneous efforts on system, circuit, and component levels. An arithmetic element containing several hundred transistors is in the planning stage. With the anticipated development of this system over the following months, the need for one or two new staff members can be expected.

4. Memory Section

The Memory Section is carrying out research, development, and design work which will result in larger, faster, more reliable memories for digital-computer application. The goal for the next year or so is an arbitrary-access, 6-microsecond, core memory in the 65,000-register size, number of bits per register to be somewhere between 16 and 36. If this memory can use core switches and core drivers, the number of cathodes will be very low (order of 1,000); if, in addition, some of the low-level circuits can be transistorized, the cathode count will be even lower. Estimated major problems include the core switches and core drivers, the memory-packaging and core-assembly techniques, and the sensing amplifier. Heavy efforts are being made on the first two right now; the sensing problem is not yet receiving full attention. Work on each side of this major effort is continuing; hopefully a full report on 3:2 selection will soon be available, and a thesis report is now underway on the external-selection, very-high-speed memory. Responsibilities to the MTC, and FSQ-7 memories will continue, but are tapering off.

One additional engineer is needed.

5. System-Design Section

The present objective of this section is the study of system concepts which can lead to a system design similar in performance to AN/FSQ-7, but offering very substantial improvements in logical simplicity and in reliability.

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D. 5. (Continued)

Two staff members are presently studying transistor theory and circuitry as a background for the decisions that must be made in the next few months as to which type of transistor should be concentrated on and which type of elementary simplified communication from central machine to input-output devices.

The staff is adequate for the next few months. Acceleration of activity toward detail design of a specific computer would require several more people having experience in systems and logical design.

6. System-Planning Section

This section will plan and coordinate the progress toward a new computer. Aspects such as packaging, over-all design, system compatibility, and immediate environment will be within its responsibility. Included also may be other portions of a machine which are not covered by other sections.

For the next few months, the decision on components and techniques to be used in the central computer is very critical; this section is cooperating in the survey, analysis, and argument toward making that decision. Once a system is started the section is expected to expand a size which will depend upon the size and time schedule of the system.

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E. GROUP 64, PRODUCTION FSQ-7 AND WWI

The design, installation and maintenance of the Cape Cod experimental direction center and the coordination of design and planning of the AN/FSQ-7 production direction centers are the major Group 64 tasks. The Systems Office, which is jointly staffed by Group 62 and Group 64, is at present the major section of the production FSQ-7 work and is covered in Section H. Some of the subsections of the Systems Office are expected to become full sections in Group 64 in the future. New sections are not being established for handling the production machine basic circuits and display; these activities are being handled by Group 62 sections. Group 64 is now badly undermanned. New personnel requirements as indicated on the Organization Chart will be sufficient to carry the expanding activity of the near future, but will not be able to cope with the expanded requirements which are expected as a result of XD-1 and production machine tests and the impact that these results will have on production design.

1. Production Systems Testing

The System Test Section will help plan and coordinate on-site tests of the production FSQ-7 equipment. Installation and test planning for achieving performance during IBM plant test will be followed by operational test planning. Close liaison with other groups and companies is required. Simulated data or equipment must be supplied where necessary to test parts of the SAGE equipment and programs during the installation phase.

Finally, in cooperation with the Bell Telephone Laboratories' test group and other groups, the plans for acceptance testing of the SAGE System must be developed. After these plans are formulated for the various phases of installation and test, the performance of these tests will be monitored and failure to meet the test objectives studied for possible system changes.

The three new engineers requested for this activity will be assigned to the various phases described above according to their training and abilities.

2. Cape Cod Direction Center Engineering.

The Cape Cod Direction Center Engineering Section furnishes the Control Center facilities for the experimental model of the SAGE System. It maintains the Whirlwind I Computer for a three-shift schedule of operation, installs, tests, and maintains special terminal equipment needed for the Cape Cod System, and trains systems engineers and technicians for the XD-1 and SAGE programs. The work breaks down in to four major tasks as follows:

a. Whirlwind I Computer Engineering and Maintenance.

This subsection carries out preventive maintenance and any necessary trouble shooting and repair of the central WWI Computer for a

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E. 2. (Continued)

three-shift, seven-day-per-week schedule. The system expansion resulting from the Cape Cod Program necessitates continuing improvements in machine reliability and maintenance efficiency. The subsection is giving organized instruction, supplementing these engineering tasks in order to train staff and technicians for system engineering in the XD-1 and SAGE programs. Present staff is adequate.

b. Special Terminal Equipment Engineering.

This subsection designs and installs computer input and output data-handling equipment peculiar to the Cape Cod System. Operational specifications for this equipment are determined jointly with Group 61. The subsection develops maintenance procedures for this equipment and refines it to obtain reliability consistent with that of the central computer. Present staff is adequate.

c. Test Programming.

Test-program writing is an integral part of maintenance-procedure development. This subsection produces the computer programs which are required in order to perform marginal checking on newly added equipment. It also trains and assists systems engineers in test-program writing. In the future, programmed trouble shooting of terminal equipment will be investigated.

One additional staff member is needed, since most of this work is being done by a student.

d. Scheduling and Records.

The subsection coordinates the requirements of the different groups who wish to use the computer, so that optimum utilization of computer time is ensured. It also maintains records of service data and of system performance. These are essential in the routine maintenance of the system as well as in analyses of system and component reliability. The present staff is adequate.

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F. GROUP 65, VACUUM TUBES.

The main objective of Group 65 is to assure that AN/FSQ-7 equipment will be provided with vacuum tubes and display tubes of the design and quality required by the system. Work is done in conjunction with IBM and the tube manufacturers carrying on IBM-initiated improvement and development programs. A second function of the group is to supply testing and recording facilities to meet the tube requirements of the Whirlwind Computer and other Division 6 activities.

1. Vacuum Tube Technique and Design Section.

Group 65 maintains in the Barta Building an experimental vacuum tube shop equipped and staffed for construction of all kinds of special tubes, including large CRT's. The Section was originally established to develop and produce storage tubes for the Whirlwind Computer. More recently, in cooperation with Groups 25 and 62, the Group 65 tube shop has been building experimental charactrons and typotrons as a part of the IBM-MIT programs with Convair and Hughes. The tube shop has also built experimental tubes of many kinds for various groups at MIT and Lincoln and represents a substantial Laboratory asset. The Section concentrates not only on experimental construction but on the development of proper production methods for highly reliable, long-life tubes.

2. Tube Evaluation and Test Section.

This Section is responsible for commercially available tube types used in Whirlwind and other Division 6 equipment, including the XD-1. The Section works closely with IBM and the tube manufacturers in establishing specifications, life testing, and evaluation in order to recommend suitable tube types for the development programs in the rest of the Division. The Section also tests tubes for Division use and maintains records on all tested tubes in order to make long-term analyses of tube performance and life.

3. Lexington Tube Shop.

The Lexington Tube Shop, in conjunction with the above Section, maintains test facilities to supply the division needs in Lexington.

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G. SAGE SYSTEM PRODUCTION COORDINATION OFFICE

The SAGE System Production Coordination Office establishes and maintains liaison with industrial and military organizations outside Lincoln and serves as the coordination agency for Division 6 portions of SAGE system planning and implementation, thus providing suitable direction and control of the program with respect to Lincoln's over-all responsibility for the system.

1. Coordination and Preparation of Technical Information Releases

This group coordinates all aspects of planning, development and implementation of the SAGE System with the Lincoln Technical Staff (Division 2, Division 6, etc.) and outside agencies, IBM (Engr. & mfr.); ADES (WE, BTL); AFCRC; ADC, AMC; AFIRO; USAF Headquarters, and other industrial companies and laboratories. It prepares and secures proper approval of Technical Information Releases (T.I.R) to formalize requirements and specifications for the system. Coordination work requires a thorough understanding of the over-all design and operation of the system for participation on working committees, conference attendance, summary of technical material, etc. The areas covered by these releases include not only electronic equipment but communications, power, operational requirements, manpower requirements, system specifications and equipment lists, budget estimates, schedules, logistic support, maintenance, etc. Technical Information Releases are issued not only for Lincoln documents but also for those of other organizations where applicable.

One additional man will be required to supplement the present staff of five in order to handle expeditiously the future load of coordination design changes in most of the above areas. These changes will arise from experience with the prototype (XD-1) system, manufacturing problems, initial duplex installations, etc.

2. Building Requirements and Layout

This group handles planning requirements for the Direction Center and Combat Center Buildings required for the SAGE System. The work includes space allocation, equipment layout, associated mechanical and utility services and all functional requirements of the buildings. Architectural design and construction by Western Electric Company is based on this work. Coordination is required with equipment designers (IBM), air conditioning and lighting consultants (Francis Associates), power system consultants (Jackson and Moreland), various Air Force Commands (ADC - AFIRO), the architect (Burns and Roe), etc.

The anticipated future load will be handled without additional personnel.

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H. FSQ-7 SYSTEMS OFFICE

The FSQ-7 Systems Office coordinates the Lincoln Laboratory and IBM equipment design, maintains liaison with IBM, and executes any tasks which do not fit into existing sections or justify the establishment of separate engineering sections. It is through Systems Office efforts that Lincoln Laboratory guides the 262 engineers working on the FSQ-7 at IBM. This section supplies approximately sixty Lincoln man-days per month spent at IBM in Poughkeepsie.

The Systems Office is jointly staffed by Group 62 and Group 64, representing respectively the XD-1 production prototype of the FSQ-7 and the FSQ-7 production machines. It is through this group that we expect to insure the transmittal of the necessary design changes into the production program based on changing system requirements and on results from XD-1 installation and testing. The section publishes specifications for FSQ-7 equipment after coordination with groups in Division 6, Division 2 and IBM. The organization is fluid to meet new problems as they arise. A description of present tasks follows:

1. Production Planning Information

This section collects data on the phasing of the activities related to the FSQ-7 program so that changes may be evaluated and progress measured. To do this, schedules are prepared and posted for equipment design, production, testing, and installation. They are responsible for coordinating Lincoln's work on components, mechanical design, and floor plan layouts with IBM. This section is understaffed and 4 additional men are required if we are to have adequate information to use in maintaining the time schedules for system completion.

2. Logical Design

Besides contributing directly to the FSQ-7 design, the logical design group provides information on logical design of the SAGE System when necessary for other Division 6 engineers to proceed with the design of equipment or programs. They check the system logic details as submitted by IBM and prepare schematic diagrams.

The production FSQ-7 differs in a number of ways from the prototype (introduction of the duplex concept) and 3 new staff will be required to carry these in parallel.

3. Terminal Equipment Design

The Terminal Equipment group maintains liaison with organizations whose equipment communicates with the FSQ-7 to insure that the equipments are compatible. They perform with IBM the redesign necessary to allow the FSQ-7 to work with new inputs and outputs as systems requirements or

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H. 3. (Continued)

external equipment change. The work of this subsection is increasing; there are constant changes in data link and weapons concepts, new sources and destinations of data to be evaluated, and numerous questions from outside organizations which require engineering work to develop answers. At least 3 more staff are required.

4. Communication (Telephone)

The communication group generates operational requirements for the tactical telephone system of the SAGE System, and prepares traffic diagrams and specifications. They are working on phone-line switching and patching, and data recording insofar as they directly affect the FSQ-7. They are also participating in ground-to-air radio and data link studies, and the specification of the FSQ-7 maintenance intercom net. Two additional staff are needed.

5. Diagnostic Programming

This group is helping to shape the IBM diagnostic program study. They are studying how diagnostic programs should be written and used, and what programs will be needed for the maintenance of the FSQ-7 equipments, both XD-1 and production machines. The present staff should be sufficient.

6. Reliability and Maintenance

This subsection sees that techniques are developed and facilities included in the FSQ-7 compatible with 24 hour/day reliable operation. Towards this end, they will study how the various portions of the FSQ-7 may be checked and repaired with minimum system interruption and how we may benefit from XD-1 experience. This is a big task with many details to follow. It has had inadequate attention thus far and 5 new staff are needed to work with the man who has been transferred from the WWI section.

7. Design Change Evaluation

This committee, under the direction of the Systems Office section leaders, studies and evaluates requests for changes, additions, and re-designs to the FSQ-7. They develop logical diagrams and new equipment designs when necessary to show feasibility and cost of alternatives. This subsection is adequate for the present but may need future expansion.

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I. GROUP 60, ADMINISTRATION AND SERVICES.

In Group 60 are collected some of the administrative and technical services which might otherwise be distributed amongst the technical groups. The Group operates a Model Shop and Drafting Room.

1. Barta Building Operation Section.

The Barta Building Operation section performs all the required services for the operation of the Building. This includes painting, electrical work, moving partitions, minor plumbing and carpentry repairs, operation of the heating system and special carpentry work, as well as the usual functions of cleaning, moving furniture, receptionists and messenger service. These were performed by the Digital Computer Laboratory and have continued with Division 6 rather than being taken over by Division 1.

2. Components Section.

The Components Section consolidates the Division interests in selection, testing, and application of electronic parts in order to assure the highest order of reliability in equipment.

Activities of the Section include:

- (a). liaison with the IBM Project High Components Group in connection with AN/FSQ-7 development, and concurrence in component specifications and application notes;
- (b). testing, analysis and dissection of all failed components from computers and test equipment;
- (c). qualification and approval of vendors for components to be used in this equipment;
- (d). assistance to the Lincoln Laboratory Standards Committee, as Division 6 representative;
- (e). consulting with the Division staff on varied component-application problems, and performing related tests;
- (f). technical direction of inspection of all components to be used in computers and by the Division wiring shop;
- (g). planning and execution of long-range component life-testing and development for the benefit of future computers.

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I. 2. (Continued)

The Components Section strives to become expert in component selection and application, in construction techniques to increase equipment dependability, and in the establishment of equipment records which can yield rapidly and easily many vital performance and reliability statistics.

3. Requisition and Special Stock Section.

The Requisition and Special Stock Section assists the staff of the Division in preparing requisitions and supplies any follow-up necessary by the Division. Adequate records are maintained to permit duplication of previously purchased items, and assistance is provided in obtaining necessary technical specifications. Special stocks of items peculiar to the Division and a Stock Room adequate to the needs of the personnel at Barta are maintained.

4. General Engineering Section.

The General Engineering Section is broken down in to seven subsections;

a. Assembly Shop.

The Assembly Shop assembles experimental electronic equipment for Division 6, except some bread boards which are done in the laboratories and larger orders which must be sent outside. The Shop works from parts lists and drawings prepared by the Drafting Room and processed by Production Control.

A considerable increase in work is expected after delivery of XD-1 to make on-the-job modifications.

An important function of the Assembly Shop is training technicians capable of building or altering equipment to the high standards required in computer applications; these men then are assigned to the technical groups. Major "customers" for trained men at present are: MTC, WWI, and soon the XD-1 installation.

b. Model Shop.

The Model Shop makes many mechanical parts that the Division requires, varying from sheet metal products through tools for molding ferrite cores, including jigs and fixtures used in various Laboratory programs.

c. Inspection Shop.

The Inspection Shop serves to maintain proper quality in equipment of our own or an outside supplier's manufacture. Some incoming

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I. 4. (Continued)

purchased-part inspection is performed here.

d. Production Control Office.

The Production Control Office is responsible for the scheduling of all work to be constructed, including placing orders for outside fabrication when the Division shop facilities are over-loaded. It checks availability of components, initiates procurement when necessary, and sees that drawings and parts are supplied to the shops at the proper time.

e. XD-1 Installation Office.

The XD-1 Installation Office is responsible for following the activities of all contractors related to the erection of Building F and the installation of XD-1 within the Building, including the supervision for IBM of the activities of a group of engineers and draftsmen from Cleverdon, Varney & Pike.

The complex relationships of MIT and IBM with the Air Installations Office and the various contractors are maintained through this office.

f. Mechanical Engineering Group.

The Mechanical Engineering Group serves the needs of Division 6 by providing a consulting service to the various sections in the Laboratory. Typical jobs are the design of carbide tools for the ferrite core program; design of core handling equipment; modification and debugging of the tablet press used in making cores; design of a new type of sub-miniature toroidal coil winding machine; design and supervision of and installation of an isolation base for a motor generator at Barta and design of an azimuth drive for a modified radar indicator.

Work, to date, has been largely devoted to support of the ferrite program. This is gradually being extended to other parts of the Division, thus putting the required mechanical engineering in the hands of trained people.

g. Test Equipment.

The Test Equipment Section is responsible for the electronic test equipment in the Division. A well-established preventive maintenance program has proved very successful. When Division 7 has established a similar program, the amalgamation of certain functions will be considered.

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I. 5.5. Drafting, Reproduction, and Document Section.

The Drafting, Reproduction, and Document Section is broken down in to four subsections:

a. Drafting Room.

The Drafting Room is responsible for the making of all drawings, parts lists, bill of materials and non-photographic illustrations required by Division 6. The present work load breaks down about as follows:

MTC	20%
WWI and Cape Cod	20%
XD-1	30%
Other	30%

With the delivery of XD-1 and the setting up of drawing files here, we anticipate an increased load. This, combined with a present backlog of three months' work, indicates a need for 4 additional draftsmen.

b. Print Room.

The Print Room is responsible for the reproduction and storage of all vellums from the Drafting Room and brownlines from IBM. It handles the distribution of all prints, including proper notification on changes. The anticipated XD-1 load will require one additional clerk.

c. Duplicating Room.

The Duplicating Room handles all Multilith and Ditto reproduction for Division 6, and correlates and assembles all reports. Paper consumption is about 60,000 sheets per week. About sixty percent of the work is for Group 61. The remainder of the work is fairly evenly distributed over the rest of the Division. It appears that we will have to put the single Multilith Machine on a two-shift basis to meet a steadily increasing demand.

d. Document Room.

The Document Room stores and distributes all Division 6 memoranda, and maintains the necessary indexes and records. At present, nearly 6,000 different documents are on file. The break down of time spent handling different classes of documents is about as follows:

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I. 5. (Continued)

Cape Cod, Group 61, and XD-1	50%
WWI	10%
IBM	10%
PCO	10%
MTC	5%
Component Test Reports	5%
Slides	5%
Outside Distribution	5%

6. Publications Section.

The Publications Section serves principally as an editorial service for reports originating in the Division. Supervision of the Barta Building photographic facility is provided.

7. Power Section.

The Power Section has worked on the various power problems as they have developed in the Division. Starting with WWI, the experience gained there has been carried over in to laboratory installation, MTC, XD-1 and the Duplex Central. The present break down of staff time is about as follows:

3 men	XD-1. planning and installation
2 men	Duplex Central planning
1 man	MTC and miscellaneous

One additional staff man is needed to work on the Duplex Central planning, and 2 technicians should be available to this group after the XD-1 installation.

Signed:

Jay W. Forrester
 Jay W. Forrester
 Head, Division 6

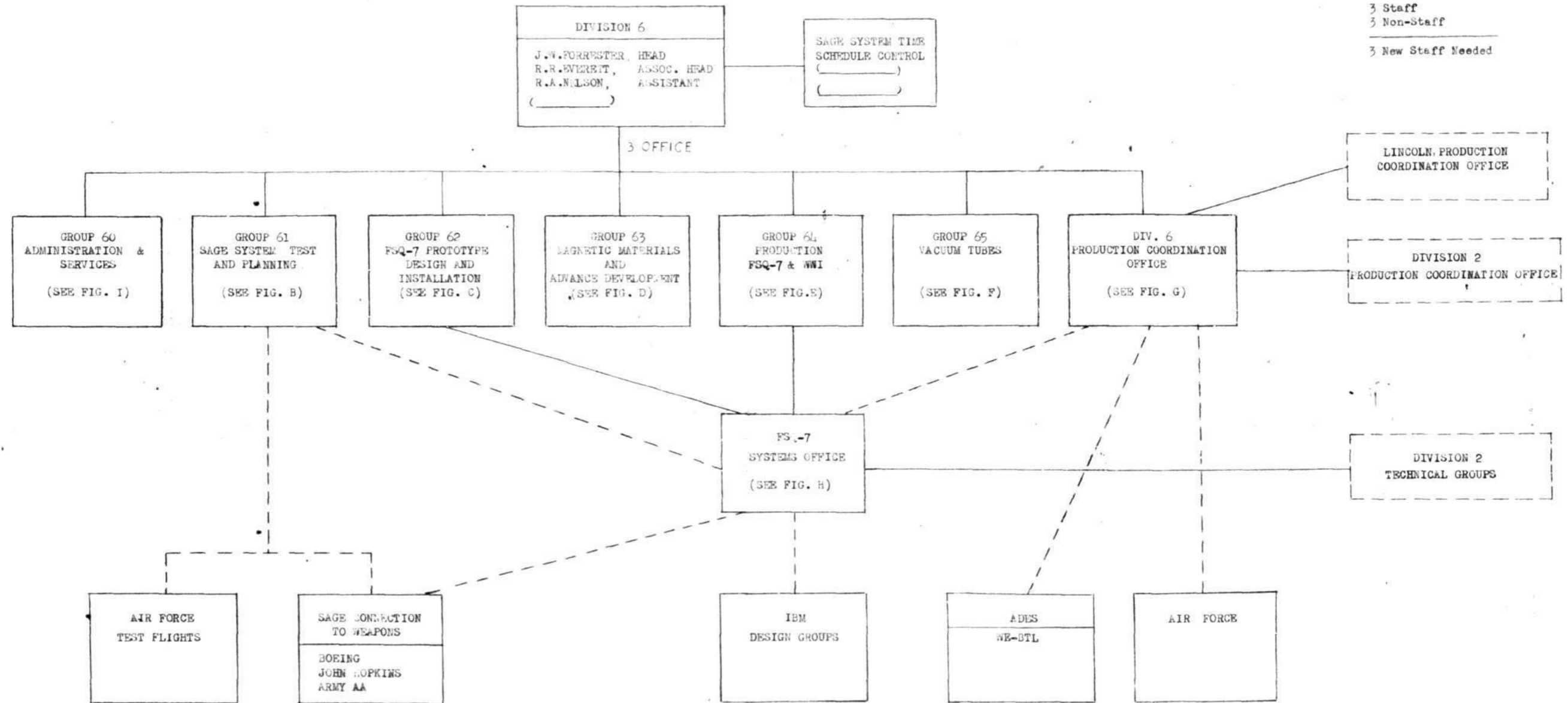
Attached: 9 Figures

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3 Staff
3 Non-Staff
3 New Staff Needed

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DIVISION 6 ORGANIZATION
FIG. A

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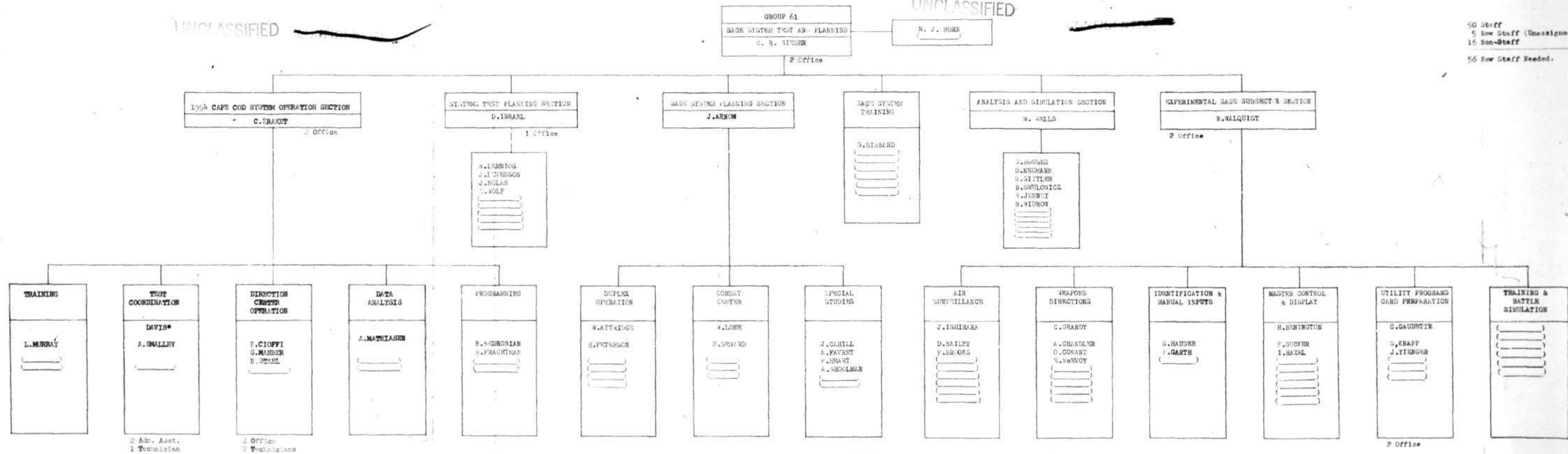
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MEMO - 6L-173

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50 Staff
5 New Staff (Unassigned)
16 Non-Staff
56 New Staff Needed.



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GROUP 61
SAGE SYSTEM TEST & PLANNING
FIG. 8

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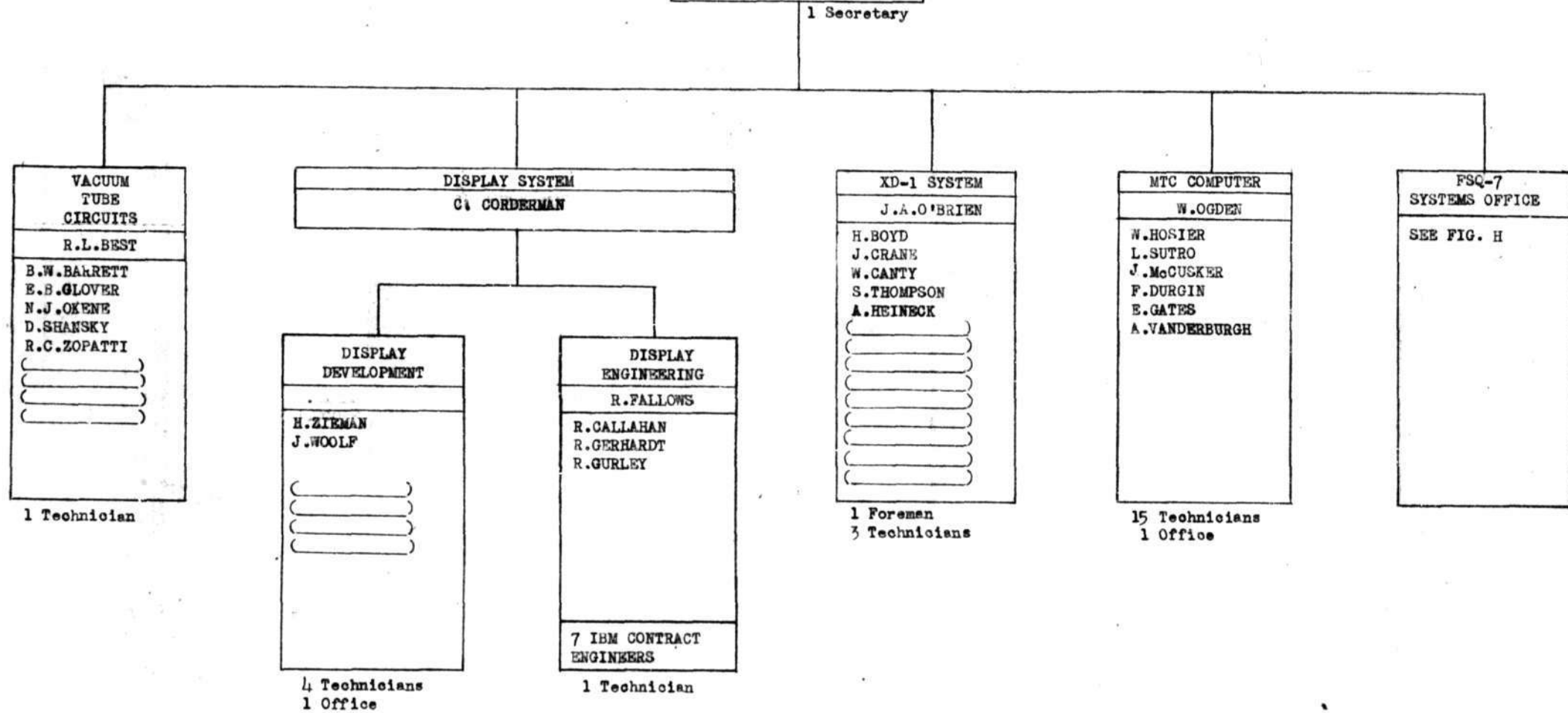
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GROUP 62
FSQ-7 PROTOTYPE DESIGN AND INSTALLATION
N.H.TAYLOR

Total Personnel (not including systems office)
 27 staff
 31 non-staff

 17 new staff needed



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 GROUP 62
 FSQ-7 PROTOTYPE
 DESIGN AND INSTALLATION
 FIG. C

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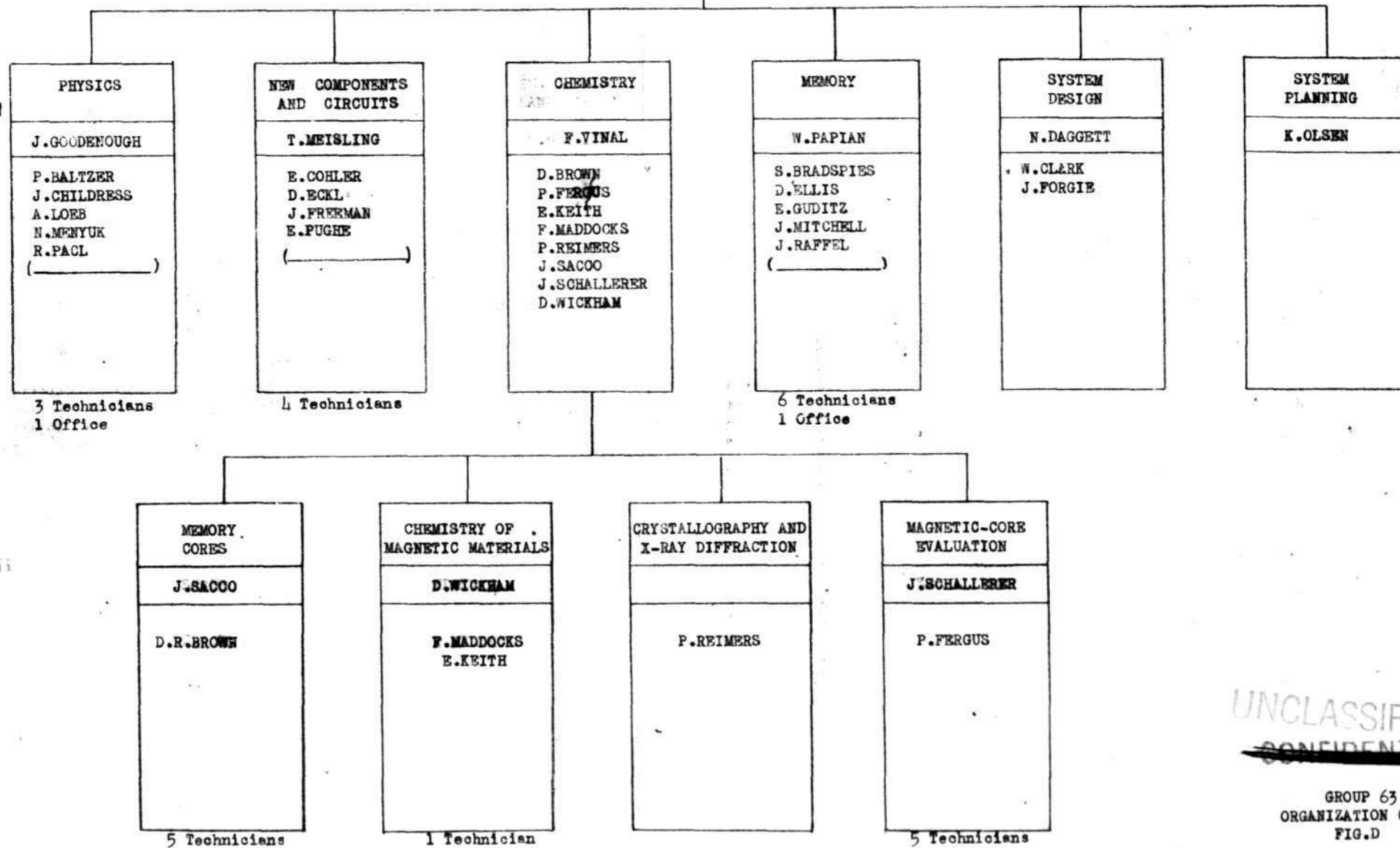
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GROUP 63
MAGNETIC MATERIALS AND ADVANCE DEVELOPMENT
D. R. BROWN

29 Staff
29 Non-Staff

6 New Staff Needed.

1 Secretary

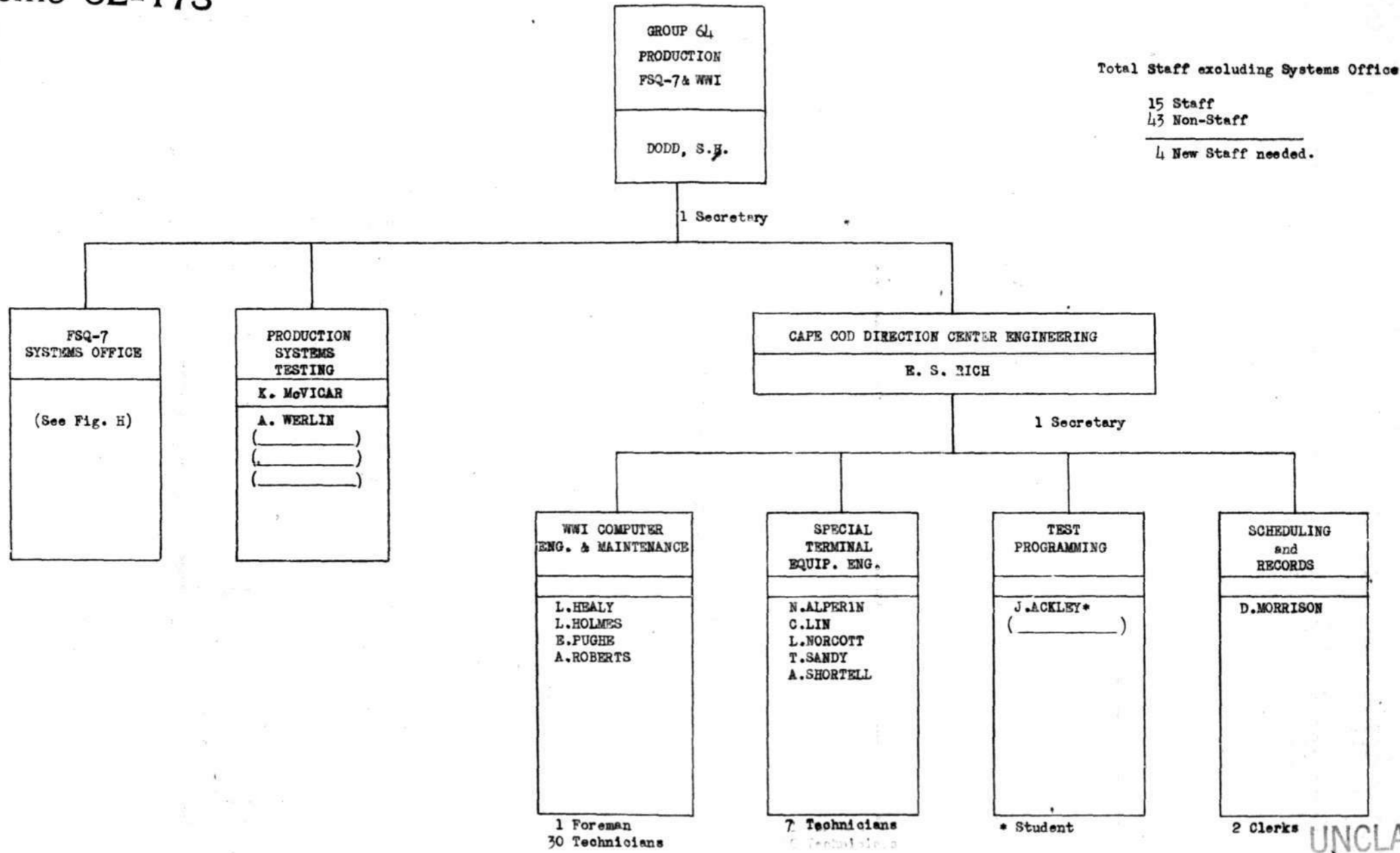


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GROUP 63
ORGANIZATION CHART
FIG. D

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Total Staff excluding Systems Office

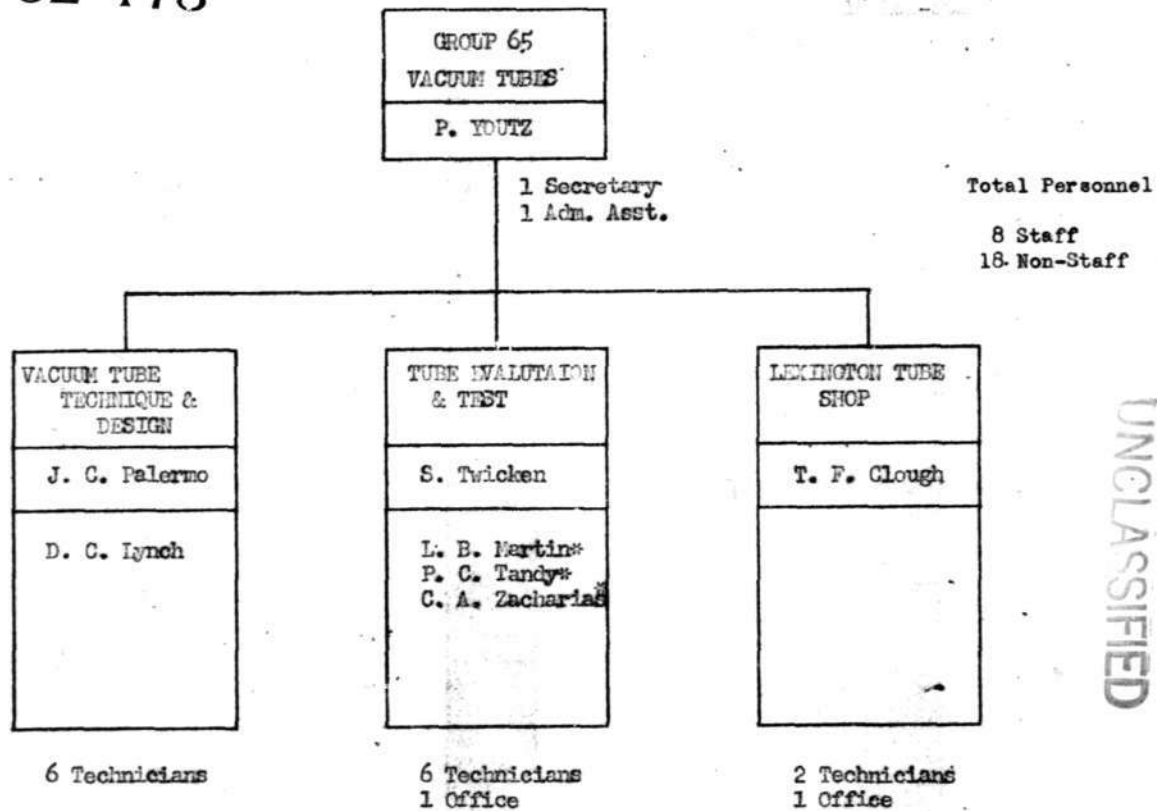
15 Staff
43 Non-Staff

4 New Staff needed.

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GROUP - 64
PRODUCTION
FSQ-7 & WWI
FIG. B

Memo 6L-173



*Research Assistant

GROUP 65
VACUUM TUBES
FIG. F

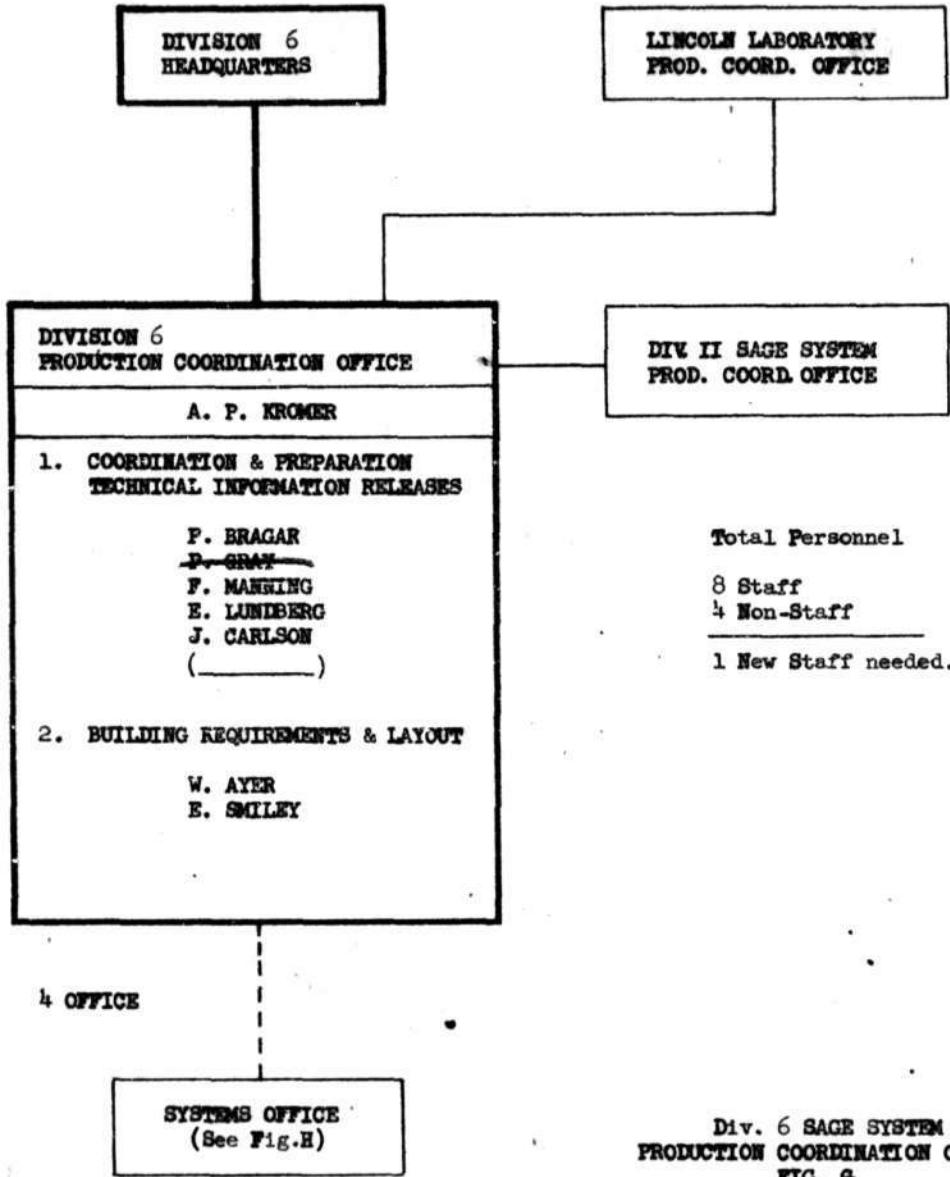
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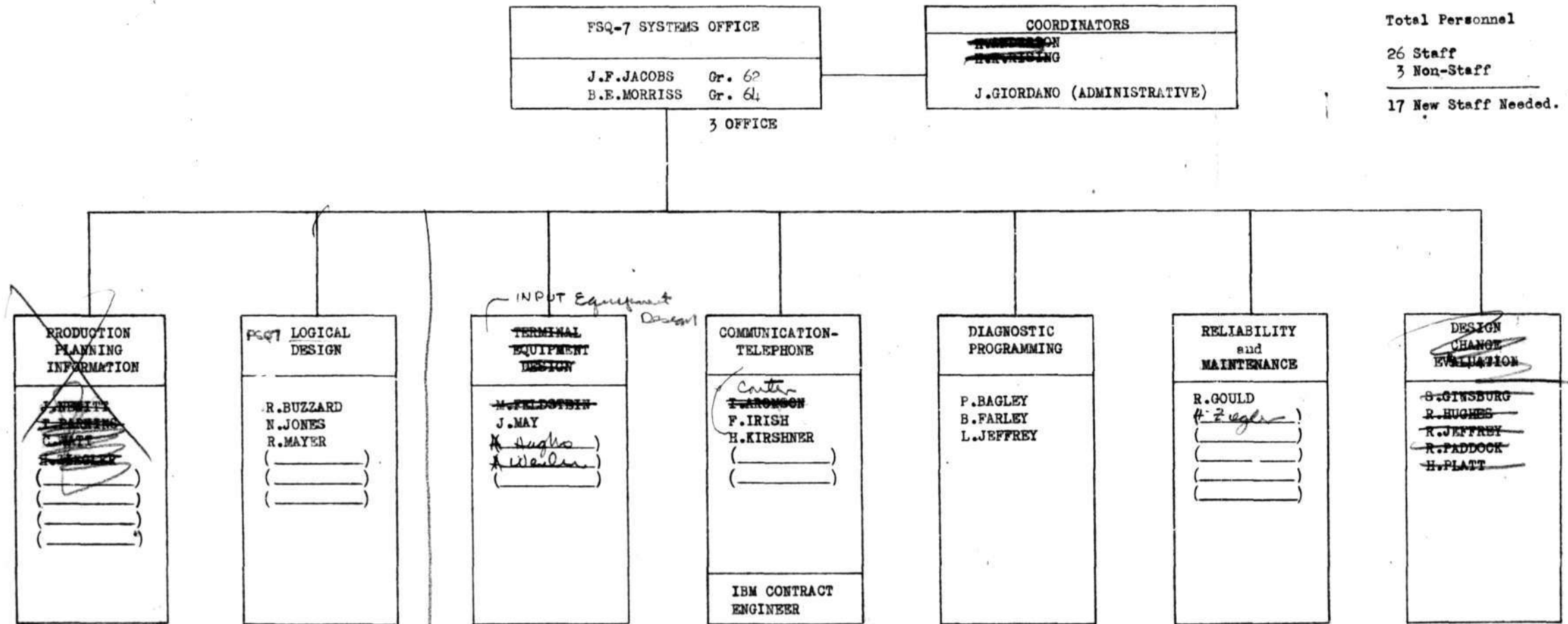
Div. 6 SAGE SYSTEM
PRODUCTION COORDINATION OFFICE
FIG. 6

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Total Personnel
26 Staff
3 Non-Staff
17 New Staff Needed.

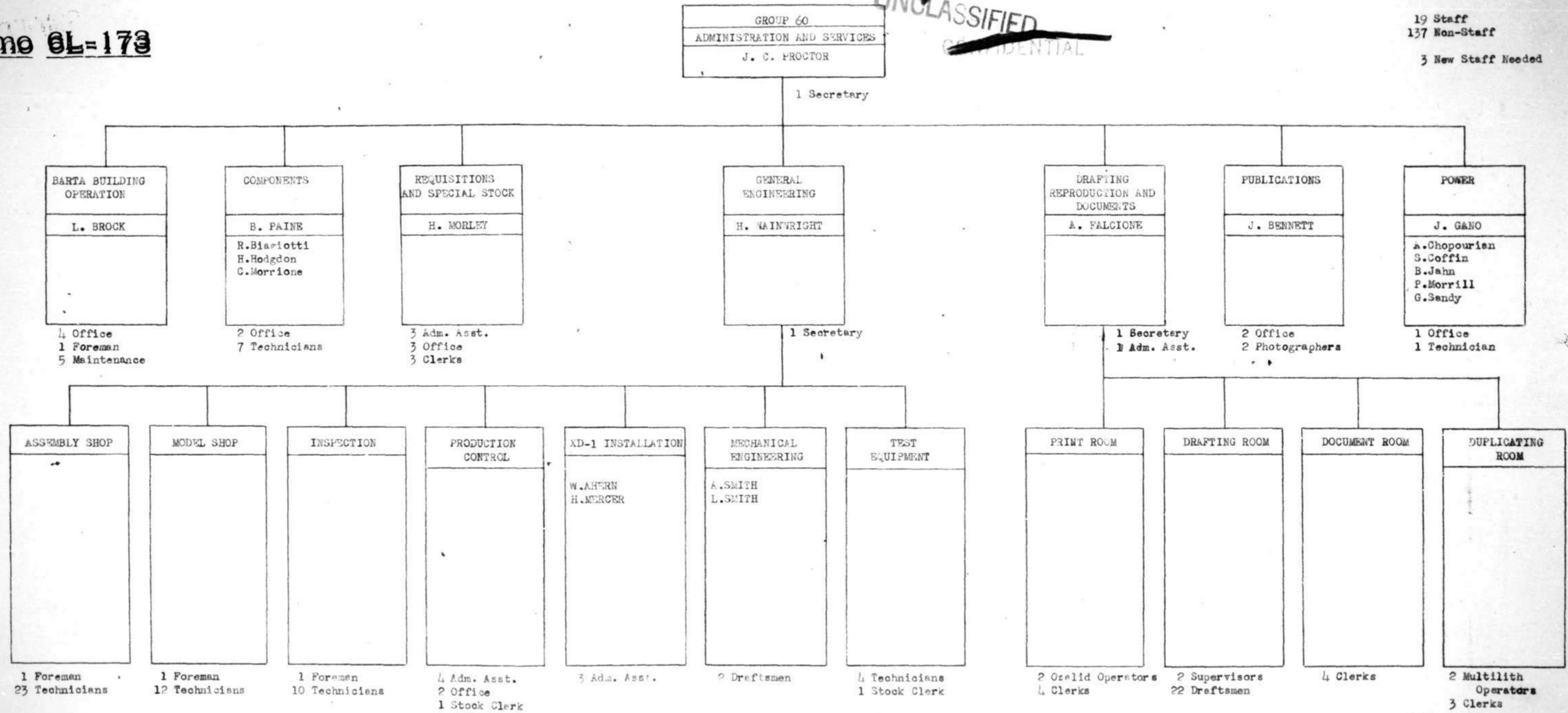
antipal equipment Design
H. Resney
M. Feldman
S. Gensberg

FSQ-7 SYSTEMS OFFICE
FIG. H
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19 Staff
137 Non-Staff
3 New Staff Needed

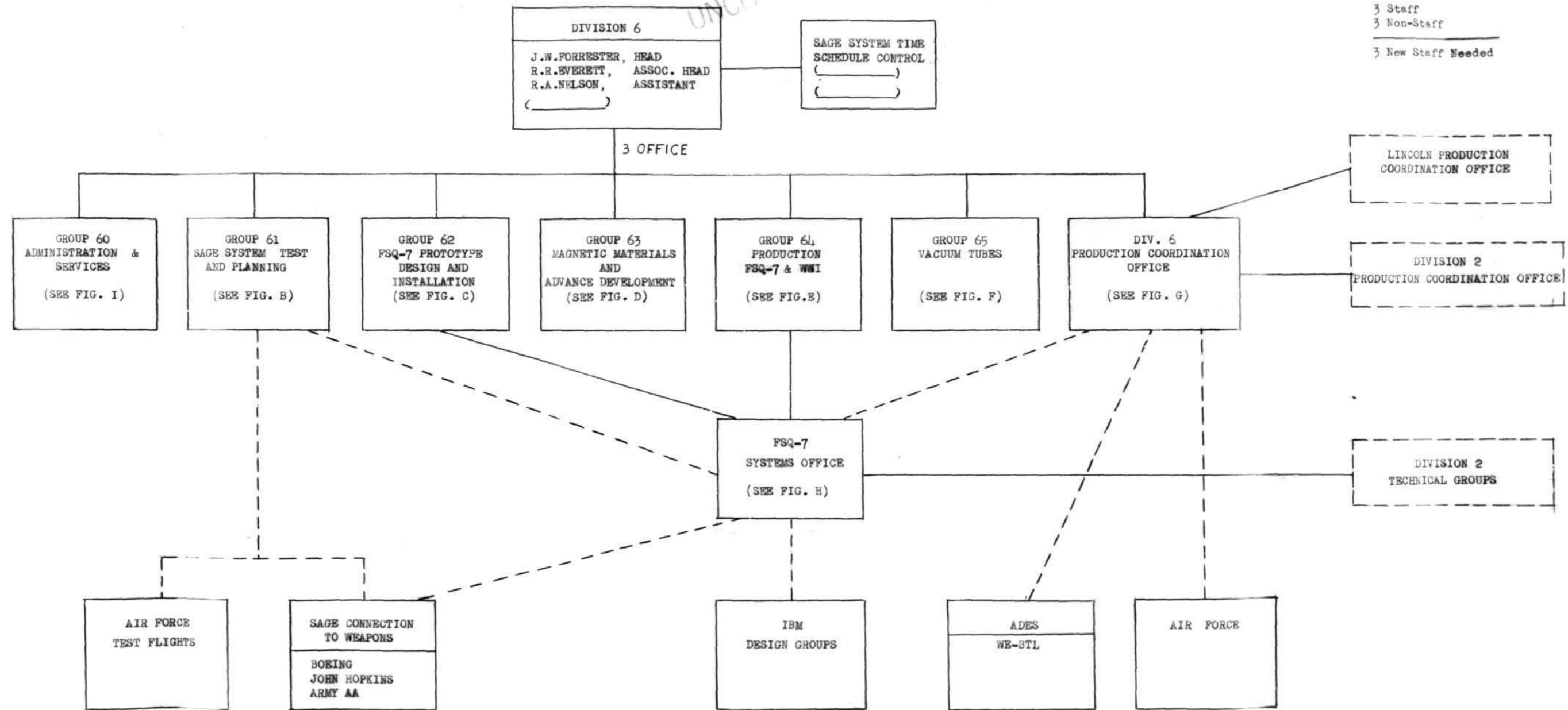


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GROUP 60
ORGANIZATION CHART
FIG. 1

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3 Staff
3 Non-Staff
3 New Staff Needed

DIVISION 6 ORGANIZATION
FIG. A

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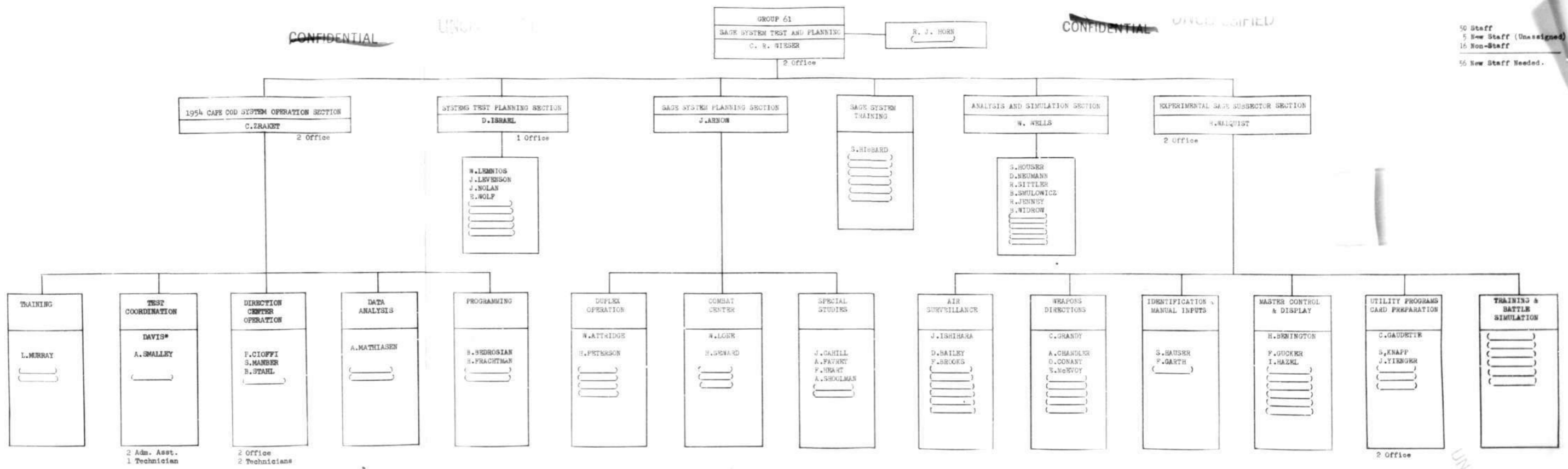
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MEMO-6L-173

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50 Staff
5 New Staff (Unassigned)
16 Non-Staff
56 New Staff Needed.



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GROUP 61
SAGE SYSTEM TEST & PLANNING
FIG. 8
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GROUP 62
 FSQ-7 PROTOTYPE
 DESIGN AND INSTALLATION
 N.H.TAYLOR

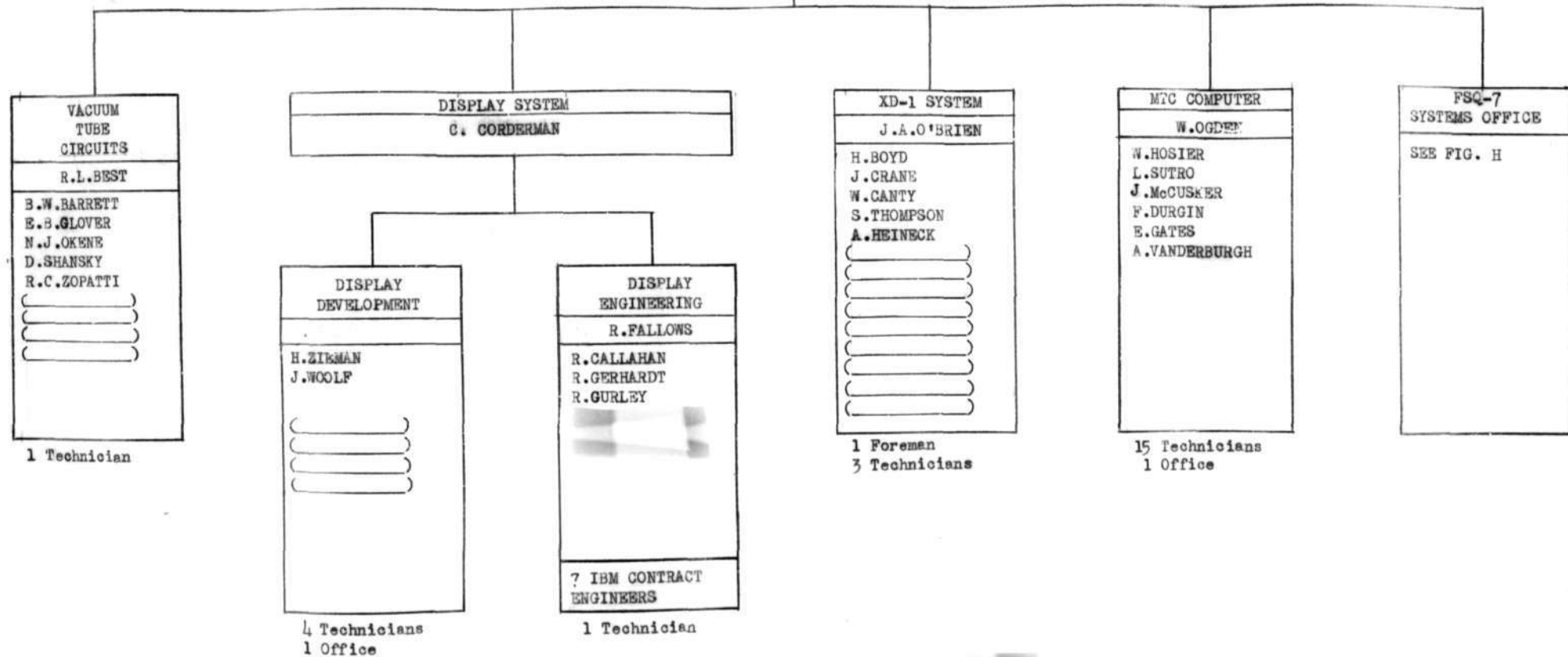
1 Secretary

Total Personnel (not including
 systems office)

27 staff

31 non-staff

17 new staff needed



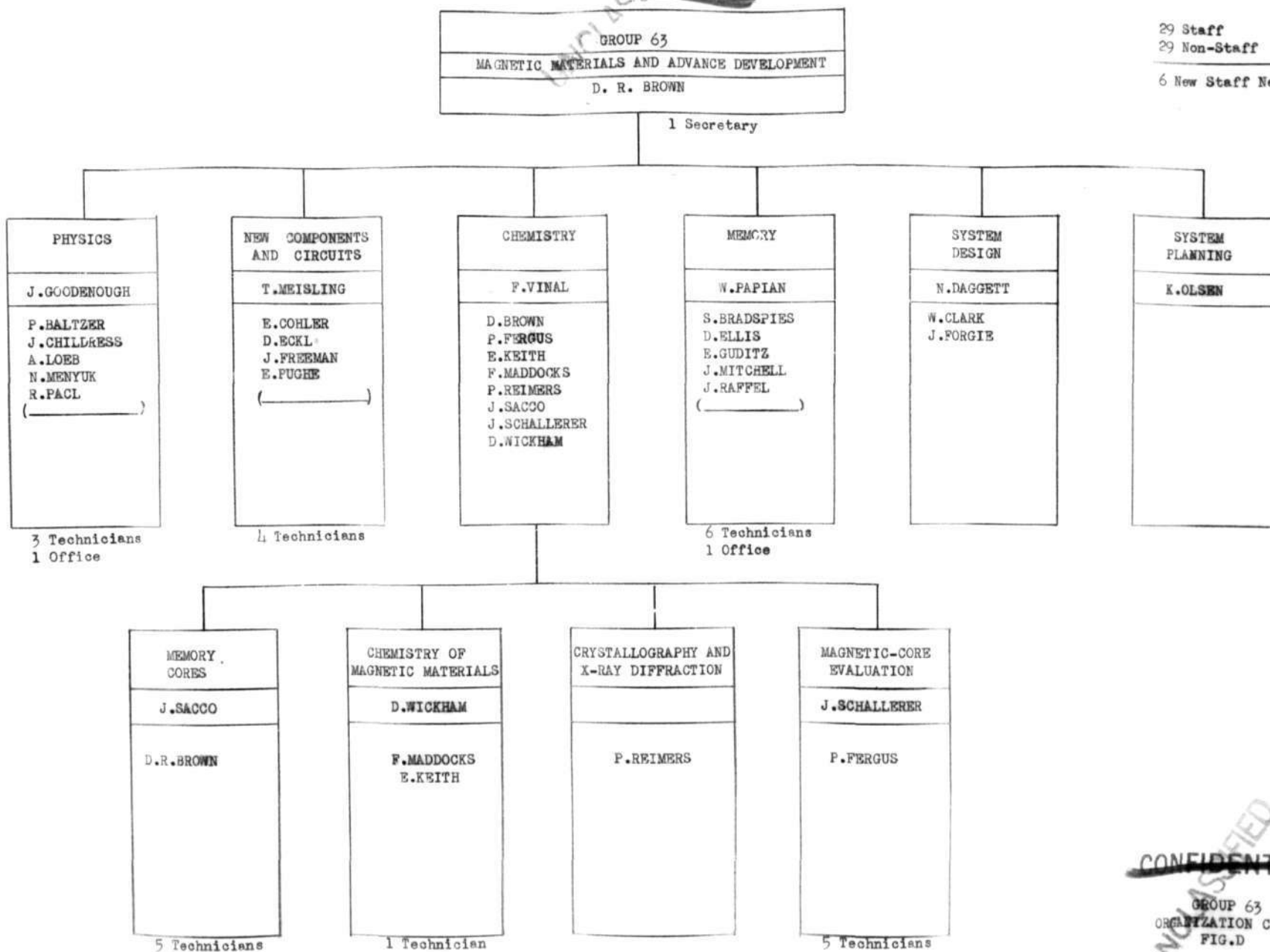
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GROUP 62
 FSQ-7 PROTOTYPE
 DESIGN AND INSTALLATION
 FIG. C

MEMO 6L-173

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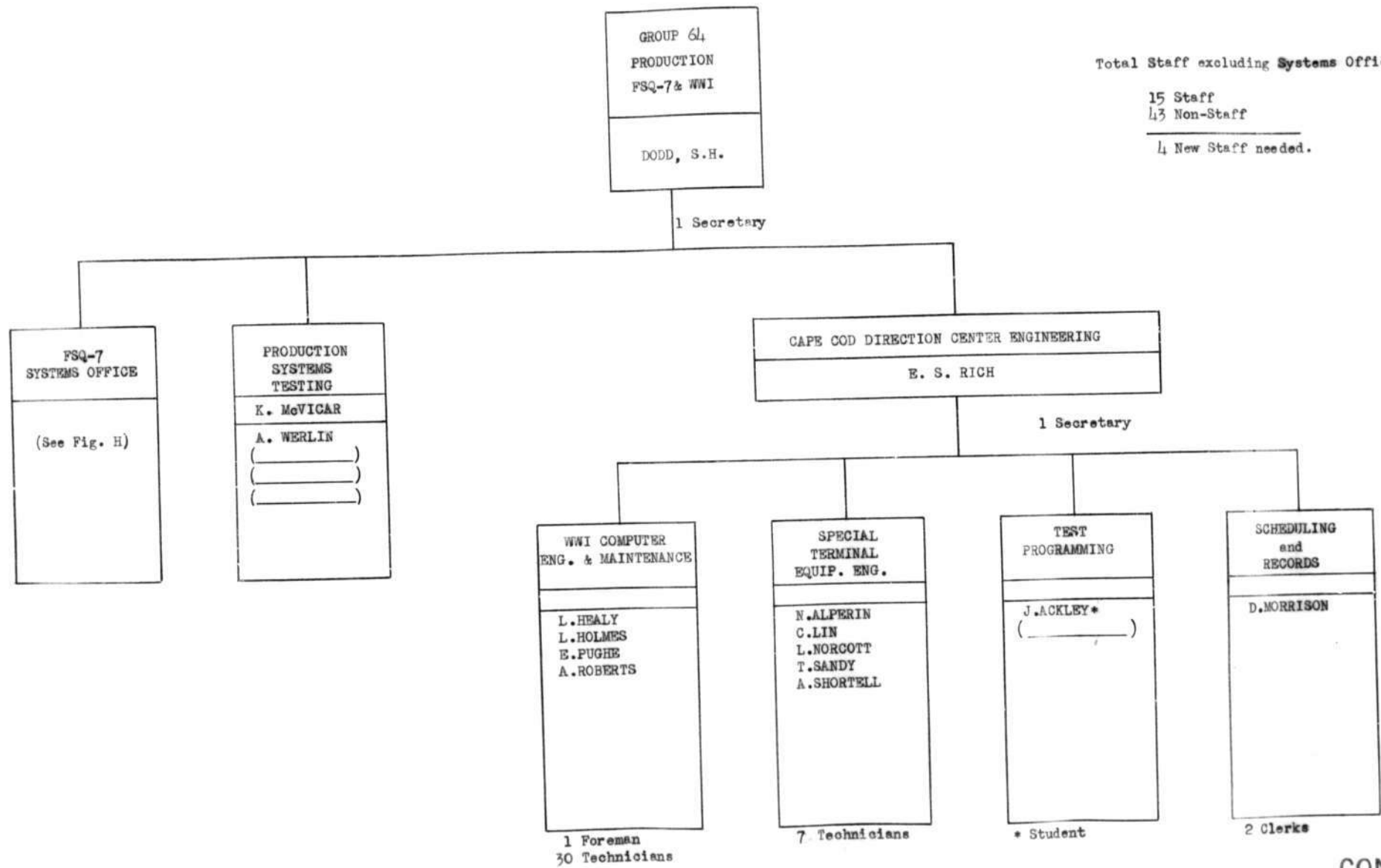
29 Staff
29 Non-Staff

6 New Staff Needed.

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GROUP 63
ORGANIZATION CHART
FIG. D

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Total Staff excluding Systems Office

15 Staff
43 Non-Staff

4 New Staff needed.

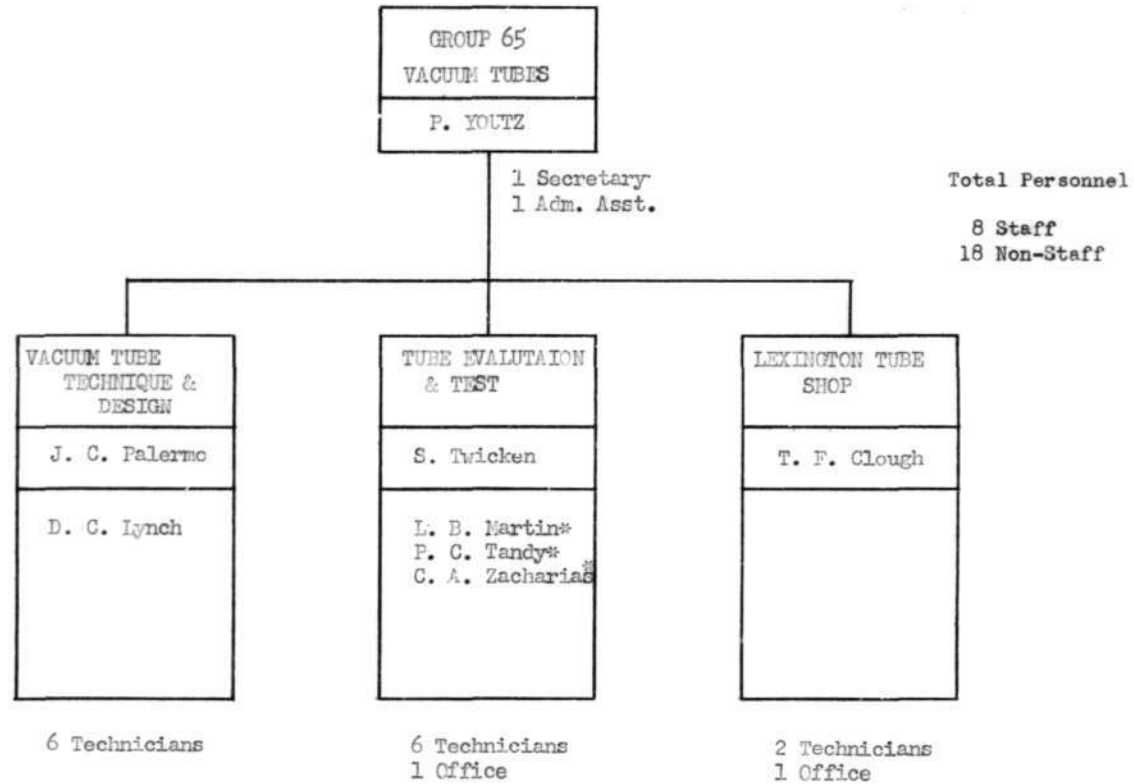
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GROUP 64
PRODUCTION
FSQ-7 & WWI
FIG. E

APPROVED FOR PUBLIC RELEASE. CASE 06-1104.

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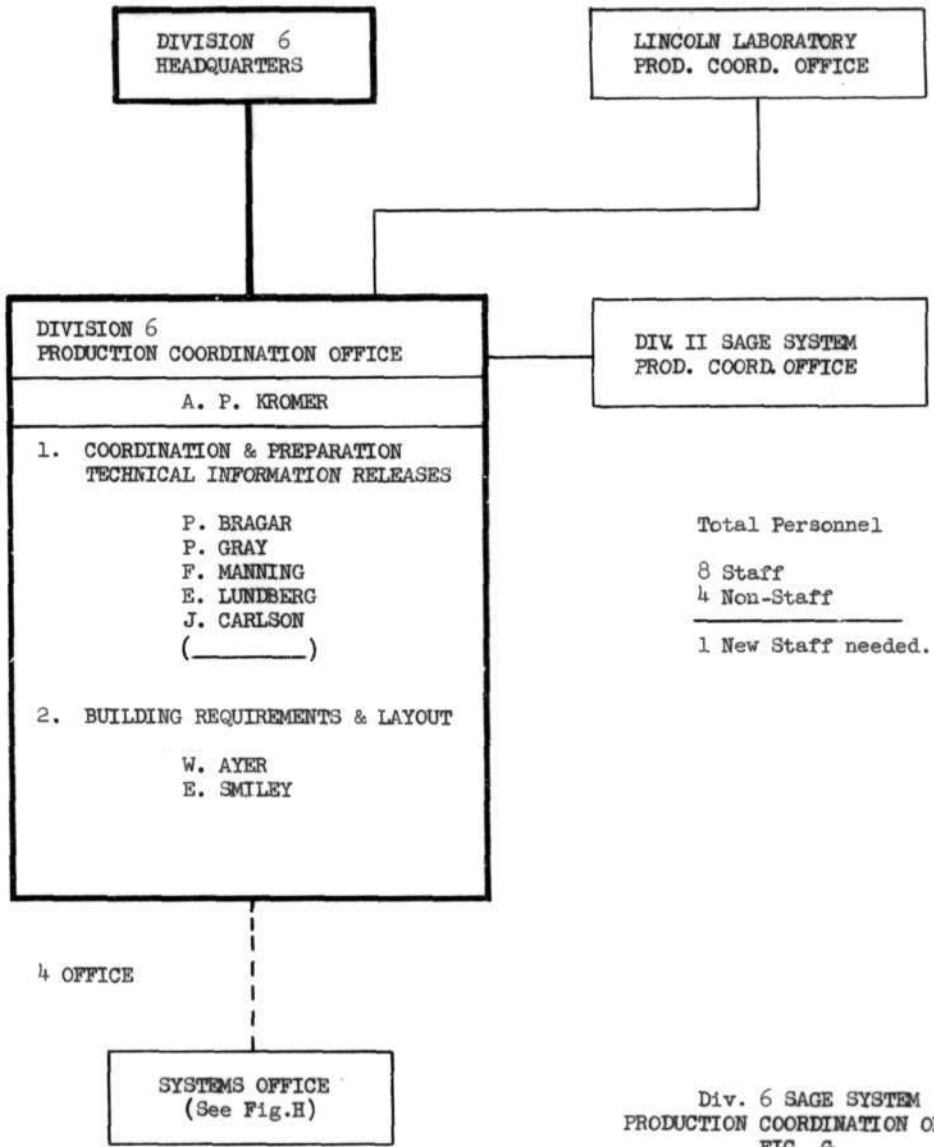
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*Research Assistant

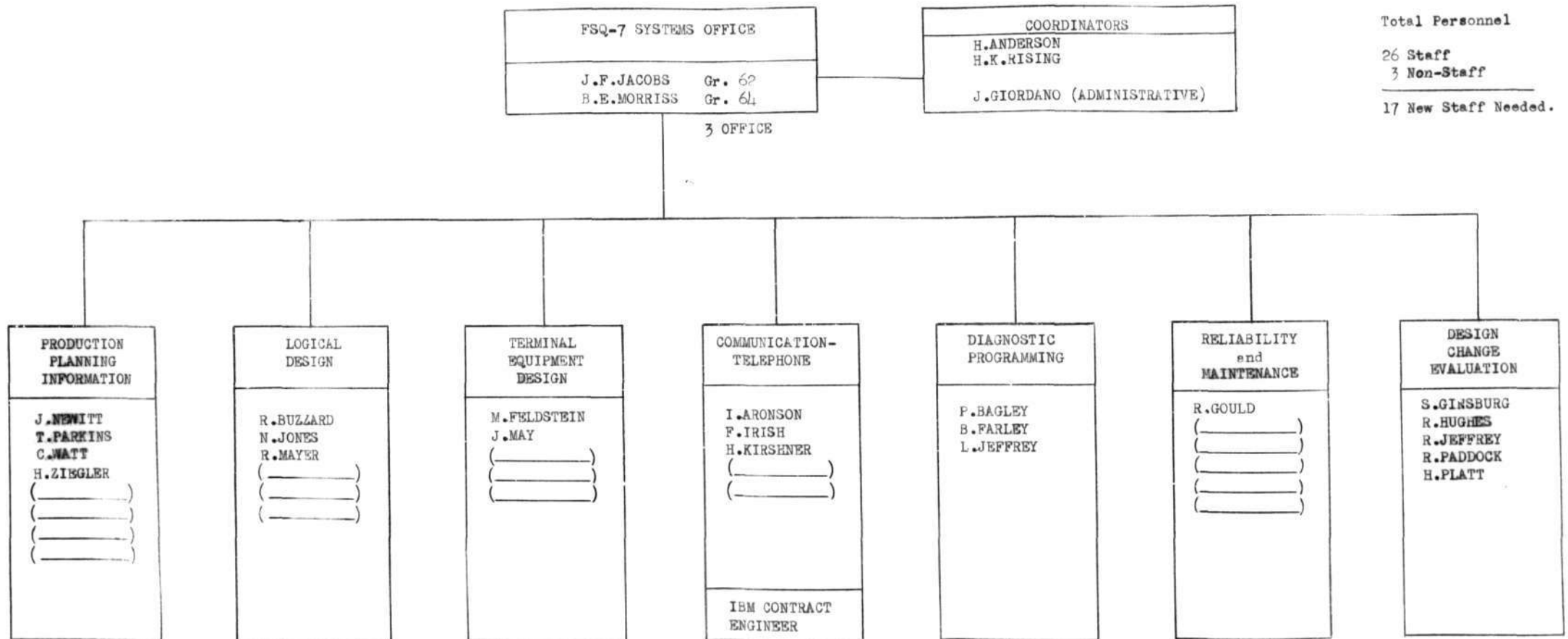
GROUP 65
VACUUM TUBES
FIG. F

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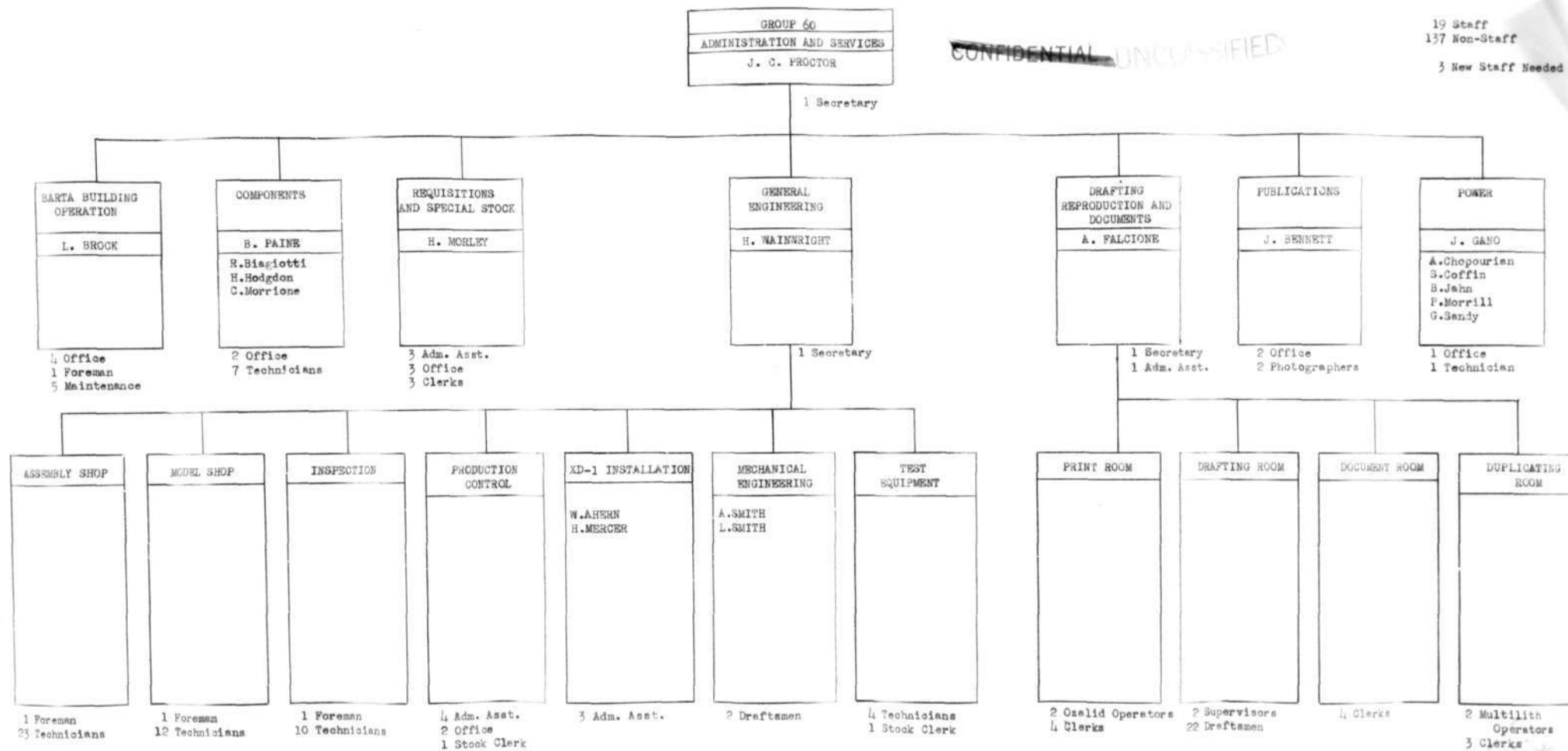
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Total Personnel
 26 Staff
 3 Non-Staff
 17 New Staff Needed.

FSQ-7
 SYSTEMS OFFICE
 FIG.H

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GROUP 60
ORGANIZATION CHART
FIG. 1