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Memorandum M-203

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Project Whirlwind
Servomechanisms Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

SUBJECT: BI-WEEKLY REPORT, PART II, DECEMBER 26, 1947.

To: 6345 Engineers
From: Jay W. Forrester
Date: January 2, 1948

6.0 MATHEMATICS

(Charles W. Adams) Attention is being given to coding procedures in general with emphasis on adjustment of scale factor. Timing studies recently completed by Blumenthal and Hoberg (4.1) should be of considerable use in analyzing time factor in various possible coding procedures.

(M. Daniloff) Memorandum M-176 "Methods of Numerical Integration of Ordinary Differential Equations most suitable for use by Whirlwind I and Whirlwind II" released on December 9, 1947.

Editing of the four papers on the Abraham-Block Multivibrator and the Jordan-Eccles flip-flop circuit continued, principal results are

- a) The conditions necessary for the occurrence of a "jump" in an Abraham-Block multivibrator and Jordan-Eccles flip-flop relay are derived (Eqs. (39), (44), paper #1).
- b) Introduction of a capacity and an inductance into the plate circuit of the latter increases both the sensitivity of flip-flop circuit and the intensity of the output pulse of the trigger.
- c) The condition of instability of a flip-flop circuit is:

$$\frac{r R_a}{R + R_a + r} \phi'(0) > 1$$

where: r - is the resistance between the grid and the point of application of the trigger impulse, R_a - the plate circuit resistance, R - the resistance between the plate of the first tube and the grid of the second, $\phi(i, r)$ plate current as a function of grid voltage (tube characteristic)

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- d) The pulse voltage is a minimum, if the two pulses are applied in opposite phases.

(Edgar Reich) A report on numerical methods for the solution of systems of linear algebraic equations, suitable to Whirlwind computation, is being prepared. The report will be in two parts, the first dealing with elimination methods and also the Southwell technique, the second covering iterative procedures.

After comparing the Doolittle method with the Crout method, it was found that so far as the solution of symmetrical systems is concerned, the two are algebraically identical. The geometrical arrangement used by Crout may however be more suggestive for the formulation of a code.

7.0 INPUT AND OUTPUT

7.2 Analog to Binary Conversion

(C.R. Wiester, Wm. Linvill) Further investigation was made of the two analog-to-binary conversion schemes mentioned in the December 15 bi-weekly report. It is hoped that use of a coarse-and-fine system will eliminate the need for extreme accuracy in the Bell Laboratories decoder tube. A coarse-and-fine system using geared potentiometers has been conceived. A pulse-distributing network will be necessary to convert the serial digit output of the decoder tube to parallel digit form of the computer register.

A VF radar ranging unit is being obtained from the Navy for test of the conversion scheme using time as an intermediate quantity.

7.3 Binary to Analog conversion

(C.R. Wieser, Wm. Linvill) Waiting for further investigation of Analog to Binary Conversion (7.2)

7.4 Magnetic Recording

(Edwin S Rich) Measurements are being made on the magnetic heads for the tape recording system to determine their pulse characteristics.

The tape-driving apparatus has been received from the machine shop and is ready for operation when needed.

Tests on the recording head show that its winding should be 100 turns or less in order to get the desired rapid rise of flux through the head and that the head must be driven from a high current source. The indicated changes in the windings will be made and a suitable buffer amplifier built.

An approximate analysis of the static-reading head has been made to determine an optimum core design and plans are being made to construct another model of this type of head.

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8.0 STORAGE TUBES

8.1 Tube Construction and Testing

8.1.1 Tube Construction and Processing

(S.H.Dodd) Dies are being designed to make 10 pin nonex glass stems for mounting the guns and storage assemblies in the tubes. Several designs will probably be necessary before a set of workable dies are obtained.

(J.H.McCusker) The following tubes were processed with R.L.E. facilities:-

Storage Tubes

S.T. Mod 17

Evaporation Tubes

E.T. Mod 17

Research Tubes

R.T. Mod 2 -(Rough calibration of Eimac 15E vs. Ion Gauge)

R.T. Mod 3

R.T. Mod 4

Vacuum fired anodized aluminum targets G1 and G2 with R.L.E. facilities.

(P. Youtz) The following tubes were designed, constructed and processed during the past fortnight.

Storage Tubes

S.T. 17 (Embossed Al₂O₃ surface with beryllium in bottom of pockets)

Evaporation Tubes

E.T. 17 (see M - 186)

E.T. 22 (Evaporated calcium chloride and silver oxide on nickel)

E.T. 20 (see M - 186)

Research Tubes - (see M-186)

R.T. 2

R.T. 3

R.T. 4

Gas Data Storage Tubes

Mod VI (see M - 186)

Evaporation tubes mods 18, 23, 24 were scheduled for this period in M - 186. But the surfaces were not needed because each alternate evaporation tube was successful. Mods 18, 23 will be processed later. Mod 24 may never be processed.

Evaporation tubes were processed in the Barta Building.

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Remaining tubes were processed in Building 20.

Components for several evaporation tubes and S.T. mod 23 (see M - 164) were constructed. No more tubes are scheduled to be processed during the academic holidays. This period is needed to inventory facilities and material, construct jigs, and prepare the tube construction facilities for heavier loads. If time permits tube components will be fabricated.

The following tubes are under consideration. Partially designed and constructed. Processing is scheduled to start January 5, 1948. New tubes will be added to this list as analysis of our work indicates the need.

Evaporation Tubes

E.T. 17A (Similar to 17 see M-186)
E.T. 18 (See M-186)
E.T. 23, 25 (Caesium activated silver surfaces)

Storage Tubes

S.T. 21 (See M - 164)
S.T. 22
S.T. 23

8.12 Tube Testing

(W.J.Nolan) An extensive series of tests on storage tubes, mods 11A, 14A, and 15A have been carried out. Although the data taken has not yet been thoroughly analyzed, it indicates that the reading and writing functions of these tubes are operating satisfactorily and that the faulty operation observed previously in storage tests was probably due to the action of the holding beam.

8.13 Storage Tube Demonstration

(S.H.Dodd) The clamp circuit has been modified to reduce switching transients occurring when the signal is clamped and unclamped. These transients have been reduced to an amplitude approximately equal to the S.T. output signal of .1 volts. Further reduction is expected.

Test bench equipment is still being used for demonstration until the demonstrator is in operation.

The clamp circuit for the demonstration unit was modified by changing of circuit components to try to eliminate undesirable transients. Two new tubes were added to reduce signal feed-thru.

The rest of the E.S.T. Demonstration set up is being connected and checked.

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(G.H.R. Campling) The auxiliary power supply for the 2-amp voltage regulator has been completed and installed. This supply has proved quite satisfactory in operation.

At present it remains to free the system of parasitic oscillations. While methods of accomplishing this end have been found, they have involved features which tend to slow down the response of the regulator and to reduce its ability to handle sudden changes in load without the occurrence of large transients in the output voltage.

8.2 Storage Tube Research

8.21 Surface Material Characteristics

(Patrick Youts) Analysis of surfaces from ET 19 and 21 by the chemistry room of the RLE indicated that the silver was activated by the caesium and oxidized by us. Surface contained a very small amount of caesium. Resistance of surface was very low. We attempted in ET 22 to get more caesium on the surface. Resistance of this surface was very high.

Conferences were scheduled for December 22 and 23 to observe some silver activated by caesium work of Carter De Forest and German scientist. Their work does not require exposing the targets after evaporation to air. But their techniques might be adaptable to our work. They distill pure caesium into the tube to contaminate or activate the target. This is a more difficult and dangerous process.

However, during this period we learned how to evaporate the Caesium salts and process research tubes with a caesium activated surface. We await results of the secondary emission studies from the test group to indicate whether we should continue with caesium salts or use pure caesium.

(H. L. Heydt) Storage tubes Mod 20A was subjected to life tests and the secondary emission curve for the storage surface was obtained at frequent intervals. The surface is composed of beryllium evaporated onto Al_2O_3 . The table summarizes important data obtained so far.

S.E. Ratio at Primary Velocity Indicated

	<u>300V</u>	<u>350V</u>	<u>1500V</u>
Initially		2.4	1.3
After 2 days		3.0	1.55
After 6 days	2.2		1.1

Considerable difficulty existed in making the latter measurements.

While Mod 20A is still on life test, Mod 20B, which is very

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similar to 20A, will be subjected to similar tests for comparison.

(M. Florencourt) Life tests on ST Mod 20A were started. There was a trend toward rising secondary emission ratios over the total time interval. This "rising" trend ceased when it was discovered that the secondary electro emission characteristic as a function of beam position had developed two peaks - one on either side of the hole - and that readings had been taken with the beam not positioned for a minimum. Positioning the beam for a minimum now led to a marked decrease from the previous readings, although they were not much lower than the initial readings. It is thought that this rising trend of SE ratios was valid over the first few days and that the peaks developed later to change the trend.

ST Mod 20B (Identical with ST Mod 20A, with no willerite on the collector - consisting of an anodized aluminum storage surface on which beryllium was evaporated) showed an initial SE ratio characteristic much higher than that of 20A. The maximum ratio of 3.6 at 600V for 20B is about 50% higher than that for 20A. In addition the SE ratio is greater than 2.0 at 2000V acceleration potential and the whole characteristic is much flatter.

It was intended to carry on life tests on Mod 20B to compare results with 20A, but these tests have been hampered by holidays and trouble with test equipment, so no long term results can be given for 20B as yet.

Tests on 20A and 20B are to be continued as well as tests on new storage surfaces as they are prepared.

8.22 Anodizing

(Margaret Florencourt) Griddle samples G1 and G2 were anodized to be used in Nolan's thesis work.

8.25 Electrolytic Tank

(S.H.Dodd) The electrolytic tank is being fixed for investigating several of the electrostatic field problems encountered in storage tube designs. This work has been given a lower priority than the life tests and storage tube tests.

8.26 Library Research

(P. Youtz)

No Library research was done during this period.

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8.27 Gas Data Storage

(R.F.Markel) Experimental work on gas data storage tubes has been essentially completed with the tests on Model VI using argon and helium gases. Stability limits of all tubes using these gases have also been determined. Results also indicate the gaps of this type do have the desired average characteristics, but actual performance has been quite erratic. Correlation of results and preparation of the final report are next on the agenda.

8.3 Unclassified

(Patrick Youts) Nonex Presses - We borrowed a vertical sealing machine from A.T.L. Inc. of Chicago. Dies for our nonex presses were destroyed in a fire at A.T.L. Four new dies are being prepared under the supervision of S.H.Dodd. We anticipate some delay in getting these dies. It will require several weeks to develop a technique for working glass with these dies. Meanwhile, we must use inferior presses and decrease the amount of tube construction.

(A.R.Curtiss) 1. Constructing 1-100 μ s Pulse Generator. Wiring completed, except for one Fil. transformer.
 2. Repairs to portable low voltage control and distribution box.
 3. Removed oven from Vacuum System #1 - added Nichrome bus and #4 flexible wire as 230V lead-in to heaters. Re-assembled system and tested.

Peter Darvirris

1. Assembled control box, installed switches, conduit and wired controls for 375V DC Motor Generator Set
2. Assembled low voltage cables and special cable for E.S.T. Demonstrator.
3. Serviced Anodizing Power Supply controls.
4. Modification of Glass Lathe manifold started.

Joseph Crowley

1. Additional work on Clamping Circuit.
2. Modified two E.S.T. life test racks.
3. Assisting with secondary emission characteristic tests - plotting - recording etc.

9.0 SERVOS AND SIMULATION

9.1 Cockpit

9.11 Structure

(E.S. Prohaska) The control column and aileron wheel assembly layout will probably be completed in two weeks.

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A preliminary study of the rudder and brake pedal problem has been made and no difficult problems are foreseen.

Work on the engine noise and vibration system will begin next week.

9.12 Instruments

(Richard Shaw) Details have been completed of the experimental model of the bank indicator, and some progress has been made on those for the altimeter.

9.13 Control Force Loading

and

(Carleton G. Eaton) Repair/modification of the existing control-force loading equipment is continuing. The machinery of the new differential-pressure regulator has been completed and it is expected that the regulator will be assembled by the first of the year.

Check runs have been made upon the new hydraulic power supplies, and it appears that the dissipation of heat from the oil presents a problem that needs further consideration.

9.14 Elastance, Backlash, Coulomb Friction.

(Mark Flomenhoft) Report M-184 has been completed and it will be distributed shortly.

Meanwhile, a different approach has been attempted in the "linkage problem" treated by the report. Originally the force exerted by the pilot was taken as the measured quantity, leaving the control stick and control surface displacements as the quantities to be calculated. The new procedure, on the other hand, measures the control stick displacement, calculates the surface position as before, and completes the requisite force which must be developed by the force servo as opposition to the action of the pilot.

The tentative conclusions reached are:

- 1) About 133 memory positions are required for one axis.
- 2) A cycle of computation ranges between 500 and 800 microseconds.

9.2 Sampling Servo Stability Study

(Wm. Linvill). An unpublished paper of Prof. Hurewicz of the Math. Dept. explaining in detail a stability criterion of linear sampling servos is being studied. It arrives at substantially the same result given in "Servomechanisms" by MacColl but is much more complete.

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10.0 TRAINING

10.1 Seminar Series

(Robert R. Everett) Work is proceeding on preparation of the basement lecture room. The first meeting of the series will be held on Monday January 5, at 3P.M.

11.0 FACILITIES AND CENTRAL SERVICE

11.1 Publications

(J.N.Ulman, Jr.) The following material has been received in the Library, Room 217, and is available to 6345 personnel.

6345 Reports

M-179	Meeting at Eastman Kodak's Hawk-Eye Plant December 4.	D.Brown
M-167	Electrolytically Produced Oxide Protective Layers on Aluminum. (H.Rohrig)	M.Florencourt
M-171	The Siemens-Schuckert Vacuum Evap. Methods Applied to large first surface mirrors.	M. Florencourt
M-183	Conference Drafting, Air Conditioning and W.W.I Arrangements.	J.W.Forrester
M-192	Flip-flop Life Test Rack - Run No.3	J.J.O'Brien
R-132	Storage Tube Secondary Electron Control with a magnetic field.	J.R.Macdonald
R-131	The Physical Characteristics of Aluminum Oxide Dielectric Layers.	
R-130	Potential Plotting with an electrolytic tank.	
R-128	The Embossing and Anodisation of Aluminum for Storage Tube Dielectric Surfaces.	
R-126	Step Counter for 5-Digit Multipliers	E.Blumenthal
R-129	Conversion of Shaft Position to Binary Code	E.P. Stabler

Library and P.B. Files

Library File

41	Coordination Policy W.W.I Computer	Sylvania Elec.Prod. Servo.Lab. M.I.T.
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| 42. | Theory and Techniques for Design of Electronic Computers Vol. 1 |) Moore School of
) E.E. University
) Pennsylvania |
| 43. | - ditto - |) Vol.II) |
| 44. | Thesis: A storage tube dielectric surface for secondary electron control | J.R.Macdonald |
| 45. | D-C Pulse Studies on Germanium Diodes | H.R.Senf
N.B. of S.Ord.Dev.
Div. |
| 46. | Introductory Survey and Bibliography on Metallic Rectifiers for Computer Circuits | Rotor - Leiner
N.B. of S.Ord.Dev.
Div. |

There will be available in the Library for two weeks only, the following two reports:-

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|--|---|
| Punched-Card Methods in Analyzing Infra-Red Spectra. | Progress Report
Aug.1 - Sept.30
Arthur D Little, Inc.
Cambridge, Mass. |
| Fundamental Research on Cathode Emitters Serial No. 4. | Philips Labs. Inc. |

(John C. Proctor.) The remainder of the 30 sets of Summary Report #2 have been completed. The library now has two sets of the Report available for the use of our personnel.

11.2 Standards Committee

(S. Abbott) Conditions covered by last report still prevail.

11.3 Purchasing and Stock

(H. B. Morley) A) In addition to work previously outlined, this unit is now processing Project 647 requisitions, and in most instances locating and ordering the material. Confirming orders are prepared by D.I.C. upon receipt of requisitions.

B) The determination of standards and specifications has become a pressing problem, and in the future will require a more definite program of coordination with the Standards unit and project engineers and technicians.

C) 1. Several samples of standard R.F. Chokes have been Flexseal coated for us by a local concern and will be submitted to engineers and technicians for examination.

2. Samples of BNC Connectors with a new type of

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packing gland have received favorable comment, and if given final approval will be adopted as standard in the future.

3. A new type insulating compound and adhesive (Bostik EXE-152) has been received and will be submitted for examination and comment.

4. A local concern has submitted estimates on duplicating the metal knobs and dials mentioned previously, and since prices compare very favorably with those of the original manufacturer, an order will be placed.

D) Due to the greatly increased work load of this unit, it would help immensely if engineers and technicians would submit requirements for special items as far in advance as possible.

11.4 Electronic Construction

(T.F.Clough) - Storage Tube Construction and Processing -
Evaporation tubes assembled into glass envelopes (sealed in)

E.T.19	E.T.22
E.T.21	E.T.20
E.T.17	

Evaporation tubes processing: The following tubes were evacuated, baked out and the evaporation performed on the vacuum system in our tube laboratory.

E.T.16	E.T.22
E.T.19	E.T.20
E.T.21	

Gas Data Storage tubes assembled into glass envelopes (Sealed in)

G.D.S.T. Mod VI

Gas Data Storage tubes processed on our Tube Laboratory Vacuum system:

G.D.S.T. Mod V
G.D.S.T. Mod VI

Bakeouts of Aquadag envelope coatings:

R.T. 3
R.T. 4
S.T. Mod 17

Bakeouts - Additional:

In addition to the above listed bakeouts - there were experimental oxidizing bakeouts performed on targets removed from E.T. 16 and E.T. 19. Those stems and loading cones requiring it also were annealed.

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Envelopes prepared:

Glass envelopes were prepared for 5 evaporation tubes and one G.D.S.T.

Phosphors:

R.T.3, R.T.4 and S.T. Mod 17 had Phosphor applications

Basings:

The following tubes were based, color coded and prepared for test:

R.T.3	S.T. Mod 20B
R.T.4	S.T. Mod 15B
	S.T. Mod 19

Facilities - A vacuum system support stand has been designed and is in the process of construction in the machine shop.

Stem making jig - P.Y. has secured the use of a vertical stem making jig. S.H.D. is designing the necessary dies for this, after which I will get it into operation. This will allow us to make our own stems.

(F.H.Caswell). The following is a list of tubes fabricated and assembled by me from Dec.13 to Dec.24

Storage Tubes
S.T. Mod 17

Research Tubes
R.T. Mod 3
R.T. Mod 4

Evaporation Tubes
E.T. Mod 18
E.T. Mod 20
E.T. Mod 21
E.T. Mod 22

The storage tube assembling includes electron gun modifications and coating envelopes with Aquadag.

Photographs of each operation of assembling and complete assembled elements were taken wherever possible.

(Herbert A.Ladd) Fabrication of tube elements.

Video amplifier for Storage Tube group (not finished)

Decade resistor box for Storage Tube group completed

Two coaxial switches for Storage Tube group completed.

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Modified Mod. 1 Clamp circuit, completed.

(Robert H Murch) The following units are in the Electronic Laboratory for construction:

- 1) 20 D.C. Bench outlet boxes in MachineShop for machine work.
- 2) 5 Rack Power Control Units.
Work on Proto-type stopped until steel panels come in.
- 3) 4 Single Pulse Synchronizers.
Will be completed Monday Dec. 29.
- 4) 4 Binary Freq. Dividers 4:1 and 2:1.
Drawings sent to machine shop, Dec. 17, for machine work.
Expect to be able to start construction as soon as machine work is completed.
- 5) Gate tube test rack. - will be completed about Jan 1.
- 6) 2 Periodic Program Controls for Multiplier, one completed except for chassis mounting brackets which are out of stock. One more is to be built to convert multiplier to an adder.
- 7) Test panel for multiplier. - The multiple output Freq. Divider 16:1 and 32:1 is being layed out. Dan Mach is working on this full time.
- 8) 25 RG62/U Coax cables using solid brass pressure sleeve. Cables are being made now.
- 9) 25 D.C. Power Cables - no technicians available at present to make these.
- 10) 40 Nameplates for A.C. Circuit Breaker Boxes.
Engraving completed. Edges have to be smoothed when sanding machine is repaired.
- 11) 10 sets of nameplates for D.C. Portable Disconnect Boxes.

It will take about 6 weeks to complete the work that is in the Lab. at present. This is based on 5 men to do the work. The other two technicians are employed full time on other jobs. Ernest Näckerson is assigned full time to repairing and testing test equipment. Arthur Heinen is assigned full time to George Hoberg for pulse transformer work.

The above estimate does not include time required for machine work on Jobs Number 1, 2, 4, 6 and part of 7, which have been or will be given to the machine shop

11.5 Drafting

(C.W.Watt) A) & B) Drafting procedure memo A-34 is finished and is

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awaiting distribution. Another memo on drafting standardization of schematics was prepared.

C) Putting A-34 into effect will involve some education. Anyone having questions on the operation of the new system, or suggestions for improving it should see a member of the Project Whirlwind Drafting Committee, Watt, Boyd, Falcione, or Leary.

(A.M. Falcione) 1) Until such time as additional draftsmen are obtained, all work is being cleared for processing in order of priority. This priority is determined through consultation with the various group heads involved.

2) It is necessary for efficient drafting room operation that the Engineer submitting rough sketches for processing to final drawings make the sketches legible and complete. There have been instances where rough sketches submitted are not legible or complete to the extent that a draftsman can proceed without delay. Much time would be saved for the Engineer and the Drafting Dept. if rough sketches submitted are clear, legible and complete.

3) The necessary forms and rubber stamps required for compliance with the proposed Administrative Memorandum A-34 have been ordered and should be ready for use by Jan 1, 1948.

11.6 Unclassified (Parts Lists.)

(Harold Mercer) It is expected the new form for 6345 Electronic Parts Lists will be ready shortly. In the meantime I am making rough drafts of Parts Lists for each new unit as the drawings become available from Drafting.

(John A Proctor) The lecture room is being prepared for the seminar series. Sinks have been removed and classroom chairs borrowed from the Institute. Exit signs and emergency lights are to be installed. Painting is now in progress. The lapel "mike" is being attached to one of the Gray Audograph machines and a P.A. system to be installed.

Arrangements have been made with Buildings and Power for snow removal this winter.

(A. Taylor) The overall work load is still too light for efficient operation of the mechanical group. The back-log contains about three days work.

The machine shop is making simple parts for use in electronic equipment and turning out discs of aluminum for the S.T. Lab.

Machine work on aluminum chassis could be speeded-up about 30% if chassis made of an alloy were used.

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Two electronic technicians have been assigned to the Mechanical Lab. One is constructing equipment for the Storage Tube Lab. and the other will be drilling terminal boards. The machine shop requires a replacement for a Lab. Ass't "A".

If materials are received on the dates promised the Annealing oven will be delivered to the Storage Tube Lab. January 12..

12.0 GENERAL

(Jay W. Forrester) Many inconsistencies are arising in our use of E-series vs. M-series for memoranda. In general, E-series are for distribution of technical information to all members of the staff. M-series are primarily for limited, specified distribution, but should be used for proposals, discussions, and comments even when sent to all staff members.

In reporting on work, more information will be helpful on expected completion dates and dates on which information is required from others.

AH.