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MULTIPLE INVESTIGATIONS

ON

ADMISSION TO HOSPITAL.

Joseph Ivan Davis

Submitted for M.H.A.

24th December/1970

I, Joseph Ivan Davis, of Unit 11, 62 Ocean Street, Woollahra, N.S.W. 2025, certify that this thesis on "Multiple Investigation on Admission to Hospital", has not been submitted for a higher degree to any other University of institution.

signed. ..

date.....24.:..2.:..70....

ACKNOWLEDGEMENTS.

I wish to express my gratitude to the Chairman of the Repatriation Commission for permission to undertake my Research at the Repatriation General Hospital, Concord, N.S.W. I also wish to thank the Repatriation Commission for permitting me to use information compiled from Departmental files.

The Staff of the Repatriation Department, Sydney, have been most co-operative and helpful and I would like to record my sincere appreciation for their efforts.

SUMMARY.

A review of the current literature reveals little critical analysis of multiple screening tests performed on patients on admission or pre-admission to hospital. The literature illustrates the many advantages to the hospital, staff and patient but fails to demonstrate disadvantages and problems that can arise. The use of automated equipment is discussed and its practical implementation is illustrated.

The installation of automated equipment has presented technical problems under Australian conditions which have not been evident in overseas literature. The automated equipment has not been as reliable as the manufacturers claim and quality-control is still a problem. The capital investment is high and unless the equipment can be fully utilized the investment does not appear to be economically justified. However with greater technological experience the initial problems will probably be overcome in the near future.

A Questionnaire on "Multiple Investigations" on admission to hospital was sent to 1,500 doctors throughout the capital cities of Australia. Three groups of doctors were selected representing Physicians, Surgeons, Residents and Registrars. The purpose was to investigate whether or not these sample groups of doctors were in favour in principle with the concept of "Multiple Investigations" on patients on admission to hospital. The Questionnaire contained various groups of tests from which the doctors were requested to select forty. From the tests recommended by the doctors who answered the Questionnaire a suggested "Battery of Tests" was drawn up. Thirty-one percent of the doctors to whom the Questionnaire was sent re-

plied and of the valid questionnaires returned, seventy-two percent were in favour of multiple investigations on patients on admission to hospital.

A series of one hundred cases treated in the Repatriation Hospital, Concord, N.S.W. was studied. The investigation carried out indicated that if an "Admission Profile" consisting of the tests recommended in the series as drawn up from the Questionnaire and those tests which I considered reasonable and practical under Australian conditions, a possible 1.7 patient days per admission could be saved with an approximate saving of $360,000 per year. Patient care would be improved by the earlier confirmation of diagnosis and there was a possibility of the earlier discovery of additional conditions or abnormalities.

The method used in the implementation of an ADP System into the Pathology Department of the Repatriation General Hospital, Concord,N.S.W. is discussed. Ths ADP System will form the basis on which the future development of an Admission or Pre-Admission centre at this hospital will be developed.

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PREFACE

Society is becoming acutely aware of the many deficiences that exist in the Hospital Systems of most countries. Although problems are individual to the various countries related mainly to social, ethnic, political, economic and geographical differences, there are certain basic difficulties related to fundamental medical problems. The main object of this thesis is to examine how certain multiple investigations on admission (or pre-admission) may assist in the solution of one facet of the hospital care of patients, i.e., in the establishment of a definite diagnosis as soon as possible after admission and the possible discovery of other asymptomatic abnormalities.

In an affluent society, such as in Australia, the individual looks towards better medical and hospital care. Any method by which this can be achieved must be thoroughly investigated and encouraged and it is obligatory upon the hospital not only to keep abreast of modern trends and equipment but to keep foremost the concept of better patient care. Recent literature suggests how automation, mechanisation and where possible computerization of investigations on admission by the use of sophisticated equipment, can produce considerable benefit to the patient, and by reduction of hospital stay, advantages to the community which provides this type of hospital care.

The Australian Society although affluent is still stratified with different treatments and different investigations in the various strata, this is well demonstrated by recent literature on Aboriginal Welfare and Medical and Hospital Benefits records.+ As well as strata variations,

+ M.J.A. P. 821, Oct. 18, 1969, Social & Medical Administration.

mainly based on status and finance, there are other limiting factors such as geographic consideration, political factors and medical resources which must be considered. All these should be understood when contemplating the introduction of Multiple Investigations on admission. However, the basic problems will be those of finance and co-operation.

Bio-Chemical profiles comprising multiple pathological tests on admission to hospitals are carried out routinely by various hospitals throughout the world. The principle of multiple investigations on admission or pre-admission to hospital is to expand this concept, to cover a series of tests and investigations to help establish or confirm the diagnosis as rapidly as possible, to institute the appropriate treatment or evaluate the treatment already undertaken, to diagnose unsuspected disease and in general to provide better patient care.

CHAPTER 1.

A REVIEW OF CURRENT LITERATURE

1. INTRODUCTION

A review of the current literature shows that over the last 20 years there has been a gradual trend in the larger hospitals towards the introduction and carrying out of multiple biochemical investigations related to new and more efficient medical equipment that has been developed. Originally these investigations were few in number but now by automation and mechanizing every possible test the laboratories are producing metabolic and admission profiles performing as many as 60 tests on admission.

The literature reviewed indicates that only a few overseas hospitals have attempted a more extensive profile than a purely pathological one based on a series of blood tests. The reason for this is obvious. These tests can be carried out on a single sample of blood collected by one venepuncture. This concept should be acceptable even to the most conservative doctor, who is at present unable to see any medical advantage to multiple investigations on admission. Measurements may not only reveal the presence of disease or obstruction of organs of the body but can do so possibly before the physician could observe signs and symptoms.

The chapter shows the developing trend of biochemical profiles and the more recent development of electro-cardiograph and chest X-Ray, mass and selective screening methods, and how these can be incorporated into an Admission Profile. Spirometry is also briefly considered. The

whole can then be automated by using data processing and computers.

The concept of "normal values" is discussed and a new approach is shown to be indicated in our standard values.

The chapter in various areas shows the conflict between man and machine, indicating why this conflict exists and how it can be overcome.

The final section dealing with the Kaiser Foundation is included to show how the concept of multiple investigations on admission or pre-admission to hospital has been introduced into one institution in America.

2. SCREENING PROCEDURES IN CLINICAL BIOCHEMISTRY

When a patient is admitted to hospital with symptoms of a disease it is natural to consider whether the disease could have been detected by investigation before the patient developed symptoms. This is of course bound up with the whole question of the early detection of abnormalities before the disease has produced symptoms and if such abnormalities have produced significant changes in blood chemistry. Although the early detection and treatment of disease does not always lead to prevention or cure, it is nevertheless a basic objective of medical practice.(1) To this end screening tests are increasingly being used.

The original concept of metabolic profiles proved too expensive and it was not till after 1958 with the introduction of more sophisticated equipment which could carry out biochemical tests at overall much cheaper rate that the concept of biochemical screening has made steady progress. This has made revolutionary progress since the introduction of multi-channel Auto Analysers. Not only has the cost factor been reduced by as much as 75% in some tests but in others the vital time factor in actually performing the test has been reduced from 24 hours to 4 hours.(2)

The application of laboratory screening in antenatal and infant welfare clinics is well established. Conditions such as anaemia of pregnancy, pre-eclamptic toxaemia and congenital conditions are commonly investigated by the application of simple laboratory tests. More recently, cervical cytological screening techniques have been widely used for the detection of cancerous conditions.

In laboratory medicine the term "screening" is used in a variety

of contexts and has many meanings. The Commission on Chronic Illness Conference on Preventive Aspects of Chronic Disease in 1957,[3] defined screening "as the presumptive identification of unrecognised disease or defect by the application of tests, examinations or other procedures which can be applied rapidly. Screening tests sort out apparently well persons who probably have a disease from those who probably do not. A screening test is not intended to be diagnostic. Persons with positive or suspicious findings must be referred to their physician for diagnosis and necessary treatment."

However, Wilson and Junger (1967)[4] pointed out that screening tests might be diagnostic even though not necessarily intended to be so. These workers emphasised that, by definition, unrecognised syptomatic as well as presymptomatic disease is included in the definition. The former being where a clinician has not correctly associated a patient's symptoms with a disease, whereas in the latter case the patient had a disease state but was not complaining of symptoms.

Screening takes 3 forms:-

1. Mass screening, which involves large-scale screening of the population without selections of groups.
2. Selective screening, where only high risk groups are selected.
3. Multiple or multi-phase screening by combining single tests into groups.

This investigation is concerned with a combination of the second and third forms of screening.

The major part of laboratory investigation of patients is still

based upon discretionary requesting techniques. In most hospitals the Junior medical staff who examine patients on admission request tests appropriate to a provisional diagnosis. Some clinicians add some screening tests which examine the functions of various physiological systems - for instance, qualitative urine analysis and determination of blood urea and haemoglobin.

Following the patient's examination by more senior members of the medical staff and receipt of the results from the first discretionary tests, other tests may be required which necessitate the taking of further blood and its transport to the laboratory.

This process is diagramatically represented in Figure 1 and will be expanded on later. (Page 25)

Due to many developments in biomedical engineering particularly that of the Auto-Analyser system by the Technicon Company, the analysis is probably the cheapest of the various processes shown.[1] The costs of transporting the specimens, and the report and data handling of the request are relatively high.

A natural development of the discretionary tests system is to take one specimen of blood immediately after the patient's admission, have one transport and one data handling cost, and perform as many tests as possible on that specimen. It is anticipated that the number of tests in the near future will be as high as sixty,[2] but between twelve and twenty tests covers a very large proportion of those normally requested in hospitals.[1]

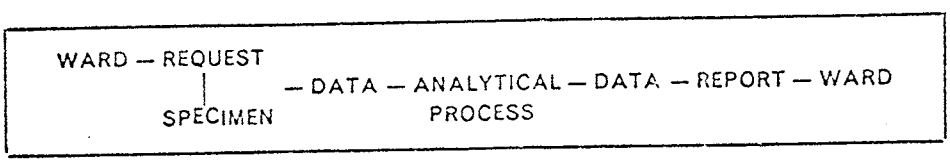


FIG. 1.

Fig. 1. Sequence of events when performing discretionary tests.

3. METABOLIC PROFILES

Results of a survey in two American Hospitals using 28 biochemical tests in most cases showed that at least 3 in 10 patients admitted were harbouring an additional disease or an organ malfunction at such an early stage of development that symptoms were not yet evident. (2)

The performance of a large battery of tests on one 30 c.c. sample of blood can produce a profile from which the function of most body systems may be assessed, such as electrolytes (sodium, potassium chlorides, carbon dioxide), liver, pancreas, heart (bilirubin glucose, amylase, cephalin floculation, thymol turbidity, alkaline phosphatase, G.OT., L.A.T., creatinine phosphokinase) Proteins (Albumen Gamma, Beta, Alpha, Globulins), Kidneys (B.U.N., Creatinine, inorganic phospherous). Thyroid and parathyroid (P.B.I., T-3, Cholesterol, Ca., P. Alk. phos) storage diseases (Uric acid, Cholesterol). To rule out technical errors in these hospitals, clinical chemistries were always repeated and therapy checked before a diagnosis was confirmed.

Fig. 2 is a typical metabolic profile produced at an American Hospital.

Small hospitals will not be able to afford, nor will they have the demand for, the sophisticated laboratory equipment which is continually becoming available. All the larger hospitals will have it by necessity and not by choice. With modern methods of communication it will be a simple matter for the laboratories of major hospitals or centres to carry out the "routine" investigations for the smaller hospitals and to return their profiles or pattern study results.

There is no doubt that smaller hospitals will continue to have a

CONSULTATION SHEET, DEPARTMENT OF PATHOLOGY
METABOLIC PROFILE

PATIENT: JOHN JONES
STREET ADDRESS: --- ----
CITY ADDRESS: --- -----
HISTORY: NO SYMPTOMS; ANNUAL EXAMINATION

RACE-SEX-AGE: W M 62
PHYSICIAN: ---
HOSPITAL ROOM: ---
RECEIVED: JAN 12, 1969

PART I

FAST NO: NON-FASTING: HEMOLYZED: LIPEMIC:

TEST		PATIENT	TEST		PATIENT
SODIUM	139	5	CHLORIDE	97	4
POTASSIUM	3.9	5	CO2		
CALCIUM	11.0	5	BILIRUBIN	1.0	5
CEPHALIN FLOC	0	5	THYMOL TURBIDITY	0.7	5
TRANSAMINASE, GOT	47	6	ALK. PHOSPHATASE	85.0	9
LAP	250	5	BLOOD SUGAR	185	7
AMYLASE	55	3	C-PHOSPHOKINASE, CPK	0.3	5
BUN	15	5	CREATININE	0.9	5
URIC ACID	4.5	5	TOTAL PROTEIN	6.40	5
ALBUMIN	2.88	5	GAMMA	1.47	5
BETA	.64	5	ALPHA-2	.45	5
ALPHA 1	.45	5	PBI	5.2	5
T3	--	-	CHOLESTEROL	225	5
ICR			INORGANIC PHOS		

Normal parameters are: 5 increase, mild 6, moderate 7, marked 8, very marked 9; decrease, mild 4, moderate 3, marked 2, very marked 1; albumin 2.8-3.8; alkaline phosphatase 4-10; alpha-1 globulin 0.05-0.3; alpha-2 0.5-0.9; amylase 60-149; beta globulin 0.6-1.1; bilirubin 0.7-1.0; blood sugar 72-120 (last eight unmarked); BUN 10-20; calcium 9.0-11.0; cephalin floc 0-2; chloride 95-105; cholesterol 175-247; (all eight omitted) CO2 25-30; CPK-creatine phosphokinase 0.0-0.3; creatinine 0.6-1.1; gamma globulin 0.7-1.7; GOT-transaminase 15-45; inorganic phosphorus 3.0-4.5; LAP-leucine aminopeptidase 110-170; LDH, total, lactic dehydrogenase ; PBI-protein bound iodine 4-8; potassium 3.5-5.0; sodium 135-145; T-3 25-35; TT-thymol turbidity 0-4; total protein 6.6-8.4; uric acid 2.6-6.4; HCD hepatocellular damage (CF + TT normal 0-4-4); OD [illegible] (alkaline phosphatase (alk. phosphatase 11+ and LAP 180+).

PART II

DIAGNOSIS (confirm by repeat and check of drugs, food, infusions, psyche)

LIVER	5	OD ≥ HCD	HDC ≥ OD	HCD > OD
		calculus	cirrhosis	viral hepatitis
		ampullitis	toxemia	mononucleosis
		cancer	alcohol	misc. hepatitis
PANCREAS	*	obstruction	diabetes 7	insulinism
(EXCRETORY GL)		inflammation 4	necrosis	islet tumor
KIDNEYS	5	azotemia	gout	
ELECTROLYTES	5	(see above)		cholesterosis
THYROID	5	hypo-	hyper-	drugs
BONES	*	osteopathy 9	supination	parathyroid-hyper (or pancreas)-hypo
MUSCLE	5	cardiopathy	myopathy	
LAP	5	bleeding tendency	cell defect	late pregnancy
PROTEINS	5	hypogammaglobulin	inflammation	albumin
IMMUNE	5	cirrhosis	lupus	myeloma
DISEASE		hepatitis	sarcoid	leukemia
ACUITY	-	1st 10 days	2-4 weeks	2-4 months

COMMENT: SUGGEST BONE MARROW AND X-RAY OF BONES (X-rays negative & 1st bone marrow negative; repeat alkaline phosphatase 82, calcium 11.1, amylase 50; 2nd bone marrow showed early carcinoma suggestive of prostate or pancreas; Editor) Albert E Casey

C. RAY RATLIFF, Ph.D. ALBERT E. CASEY, M.D.

FIG. 2.

pathologist on call for emergencies and some routine tests. However, the vast majority of these tests will be carried out in the laboratories at major centres or a pathology centre not necessarily attached to any hospital.

In Germany research has been directed towards:

1. Reducing length of stay in hospital.
2. Effecting savings and overcoming financial difficulties.
3. Overcoming staff shortages.

The above three points should be viewed within the individual hospitals and groups of hospitals so as to avoid duplication and increase efficiency without affecting the quality of treatment given. This can be done by installing modern, centralised, labour-saving equipment in Pathology departments of appropriate size and by adopting efficient methods of co-operation and administration.

(5)

4. THE BIRMINGHAM EXPERIMENT[1]

In 1967 an investigation of admission Biochemical Profile techniques was started in Birmingham by the Ministry of Health. The project was housed in a specially built laboratory with a total floor area of 548 square feet.

The aim of the project using single channel Auto-Analysers was to gain information on the following aspects of hospital admission biochemical profiles.

1. The cost of performing "multi-biochemical" tests.
2. The effect on patient bed-stay, routine laboratory workload and other clinical services.
3. The problems of staffing a laboratory solely devoted to such techniques.
4. The number of new or additional diagnoses which results.
5. The number of unexplained abnormal results produced.
6. The effect of the project on the interpretation of bio-chemical results.

It was decided that biochemical profiles on in-patients would best serve the purpose. There are difficulties in using out-patients. Blood specimens would have to be collected under non-standard conditions with regard to diurnal variation, the time since food was last taken, and posture of the patient. In addition, it would be difficult to assess the effect of such a procedure on in-patient laboratory investigation, other hospital services, bed-stay and subsequent treatment of the patient. Both medical and surgical cases were used in the survey. For practical purposes, it was decided to only collect specimens from new admissions to seven of

the wards in the Queen Elizabeth Hospital, Birmingham.

Sixteen biochemical determinations were initially chosen.

Glucose

Creatinine

Urea

Sodium

Potassium

Total CO_2 content

Albumin

Globulin

Alkaline phosphatase

Bilirubin

Zinc Sulphate Turbidity

Calcium

SGOT

Iron

Uric acid.

Cholesterol.

Two determinations were later removed from the group; the total carbon dioxide content was removed because of difficulties in the correct collection of samples coupled with the inaccuracy of the Auto-Analyser technique in this application, and the zinc sulphate turbidity was discontinued because of the low yield of information from the test.

Specimens for haematological investigation were taken at the same time.

Assessing the Project.

Initial evaluation of the scheme was by completion of a questionnaire on every patient by the clinician who was either the consultant or registrar concerned with him. These were sent to the clinicians at weekly intervals over a period of eight months. The following are the relevant sections of the profile results.

"Would you normally have requested this determination on this patient?" had to be answered on all the tests. The clinician was asked, if the result was abnormal (that is, outside the limits in Table 1,) to place it in one of three categories;

1. An unexpected abnormal result.
2. An unexpected abnormal result leading to a new or additional diagnosis.
3. An abnormal result, unexpected and unexplained at the time of completing the questionnaire.

In defining a test as abnormal the criteria were as set down in Table 1.

ANALYSIS OF REPLIES

Of the first 2,166 questionnaires, 95.6% (2,071) were analysed. The results are shown in Table II, this lists the total number of analyses for each determination on these 2,071 patients. It shows how many of the tests would normally have been requested, and were found to be within the normal range. Also shown are the tests which would not normally have been requested, and these are divided into four categories:

1. Normal.
2. Expected abnormal.

CRITERIA USED FOR MARKING A RESULT AS ABNORMAL							
Determination	*Units*	*Greater than*	*Less than*	*Determination*	*Units*	*Greater than*	*Less than*
GLUCOSE (1-2 hours post-prandial)	mg./100ml	150	50	ZINC SULPHATE TURBIDITY	SHANK-HOAGLAND UNITS	12	
CREATININE	mg./100ml	1.3		ALBUMIN	g./100ml		3.3
UREA	mg./100ml	45		GLOBULIN	g./100ml	3.5	2.0
SODIUM	mEq./L	147	134	CALCIUM	mg./100ml	10.5	9.0
POTASSIUM	mEq./L	5.0	3.6	SGOT	FRANKEL UNITS	35	
TOTAL CO_2	mEq./L	33	24	IRON		200	60
ALK.PHOSPHATASE	K.A.UNITS	14		URIC ACID	mg./100ml	FEMALES 7.0 MALES 7.5	
BILIRUBIN	mg./100ml	1.0		CHOLESTEROL		300	100

TABLE I.

Table 1. Criteria used in the project for marking a patient's results as being abnormal.

The normal limits used on the above criteria were mainly based on the work of Roberts (1967) in Birmingham, using Auto Analyser methods and specimens from blood donors selected in a random fashion.

Test	Grand Total	NORMALLY REQUESTED		NOT NORMALLY REQUESTED				
						ABNORMAL		
		Total	Total Normal	Total	Total Normal	Total Expected	Total Diagnostic	Total Unexplained
GLUCOSE	2069	258	200	1811	1630	25	33	123
CREATININE	2071	307	223	1764	1620	73	12	59
UREA	2068	1342	1139	726	702	5	4	15
SODIUM	2070	1336	1253	734	703	3	0	28
POTASSIUM	2067	1332	1181	735	701	3	3	28
TOTAL CO2	1054	119	89	935	869	16	4	46
ALK.PHOSPHATASE	2063	306	199	1757	1612	37	13	95
BILIRUBIN	2068	237	177	1831	1722	18	9	82
ZNSO4 TURBIDITY	1452	86	75	1366	1338	9	3	16
ALBUMIN	2064	535	409	1529	1485	17	7	20
GLOBULIN	2070	539	409	1531	1363	44	10	144
CALCIUM	2069	242	170	1827	1660	30	15	122
S.G.O.T.	2064	161	109	1903	1869	16	4	14
IRON	2065	136	57	1929	1482	192	72	183
URIC ACID	2066	71	54	1995	1846	59	23	67
CHOLESTEROL	2059	229	182	1830	1705	29	13	83
TOTAL	31439	7236	5926	24203	22307	576	225	1095
Totals as Percent of Grand Total		23.0	18.8	77.0	71.0	1.8	0.7	3.5
Test Normally Requested as Percent of Total			81.9					
Tests Not Normally Requested as Percent of Total					92.2	2.4	0.9	4.5

TABLE 2.

Table 2. Results from analysis of questionnaires.
Compiled on 2166 patients in the Birmingham experiment.

3. Abnormal leading to a new or additional diagnosis.

4. Abnormal, unexpected and unexplained at the time of completing the questionnaire.

"The table shows that on the 2,071 patients, 31,439 tests were performed. Of these 77% (24,203) would not normally have been requested. For individual determinations there was a wide variation in the percentage of patients that would not normally have been tested for serum uric acid, while 35% would not normally have had urea and electrolyte determination.

Of the 7,236 tests that would normally have been requested 81.9% (5,926) were normal; while of the 24,203 tests that would not normally be requested, 92.2% (22,307) were normal, 2.4% (576) were expected abnormalities, 0.9% (225) were unexpectedly abnormal but led to a new or additional diagnosis, while 4.5% (1095) were unexpectedly abnormal and could not be explained at the time of completing the questionnaire.

Examination of the individual determinations shows that of the 225 results that would not normally have been requested but led to a diagnosis, nearly half (105) were either glucose or iron, while of the 1,095 results that would not have been requested but were abnormal, unexpected and unexplained half (542) were in one of four determinations: glucose, globulin, calcium or iron.

An unexpected abnormal result that would not have been requested normally occurred in 42.9% (888) of the patients. In 8.3% (172) of patients there was a diagnostic result that would not have been requested, but in 36.1% (748) of patients there was an unexpected abnormal result

not explained at the time of completing the questionnaire."

RESULTS OF THE PROJECT.

Some interesting conclusions have already been reached.

A complete costing of the analysis shows that all the tests can be performed on a patient at a low cost which could even be considerably reduced with a larger unit having a higher output.

The effect on bed-stay and other clinical services has not yet been assessed. The routine laboratory workload has decreased, and the number of secondary biochemical determinations resulting from preliminary screening has not over-loaded the routine laboratory.

In respect of personnel the project has been most successful, and the staff enjoy working in a laboratory which is almost completely automated.

In this report no distinction was made between a diagnosis of little clinical significance - such as diabetes mellitus in a patient dying of carcinoma - and a diagnosis changing the clinical management of the patient. A number of the patients are being followed up in order that the significance of results which were abnormal and unexplained may be assessed later.

DEFINING NORMAL AND ABNORMAL.

The investigation conducted in the Birmingham Experiment has demonstrated the usefulness of hospital biochemical admission profiles in the detection of unrecognised symptomatic disease. It has also highlighted the problem of defining normal and abnormal values. About one-third of the patients had unexpected and unexplained abnormal results. Our present concepts of normal values are of limited use. Rarely is the

distinctly separated bimodal distribution of normal and abnormal shown in Fig. (3), realised in laboratory investigation. More frequently, the situation shown in Fig. (4) is encountered (Wilson and Junger, 1967).(4). A larger number of our unexpected, unexplained abnormal results fall in the borderline areas of the distributions. Computer analysis showed that these results were significantly more frequent in patients in the older age groups - that is those over 50 years of age. Table (III) shows the age distribution.

It is of interest to note that 60% of patients admitted to hospital wards and surveyed were above 50 years of age, and there were twice as many men as women.

We now appreciate that the "normal" cannot be accurately defined by one distribution curve, because many biochemical values in blood alter with age and sex. This concept is continued on Page 28

5. THE CONCEPT OF CONTINUOUS FLOW ANALYSIS.

"The unprecedented economies of extensive serum profiling, the increase in reliability of the data obtained with automated instrumentation and the facilities for providing not only early detection of incipient disease prior to symptomatic manifestation but also establishing and maintaining individual serum component level as bases for early detection of the onset of asymptomatic chronic maladies, accentuate the importance of multi-phasic investigation."(6)

"The commercial availability of the Auto Analyzer and the advent of multiple analyses has permitted the Clinical Chemistry Laboratory to carry out, on a routine basis, many procedures that would not have been ordered

BIMODAL DISTRIBUTION OF NORMAL AND ABNORMAL.

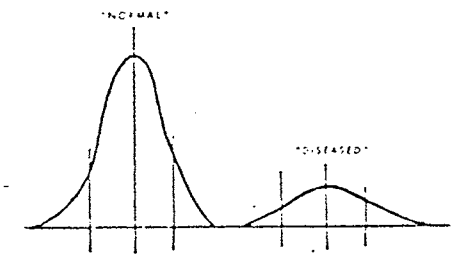


FIG. 3

BIMODAL DISTRIBUTION OF NORMAL AND ABNORMAL AS CONSIDERED BY WILSON AND JUNGER.

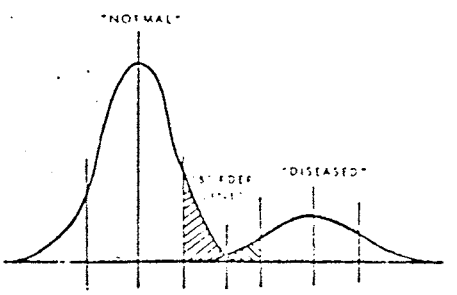


FIG. 4.

AGE DISTRIBUTION OF PATIENTS IN THE PROFILE SURVEY

Age Group (years inclusive)	*Females* No.	%	*Males* No.	%	*Combined* No.	%
10—19	61	2.0	82	2.6	143	4.6
20—29	146	4.9	132	4.4	278	9.3
30—39	163	5.4	146	4.9	309	10.3
40—49	226	7.6	273	9.1	499	16.7
50—59	262	8.8	458	15.3	720	24.1
60—69	228	7.6	459	15.3	687	22.8
OVER 70	138	4.6	215	7.2	353	11.8

TABLE 3.

Table 3. Age distribution of patients in the survey.

a few years ago. The concept of continuous flow analysis has been universally accepted, and its impact on clinical chemistry is now history" (7)(8)

World wide application of this instrumentation to clinical chemical analyses produced a tremendous increase in the output of laboratory data, and it soon became apparent that the analyses themselves were now a minor part of the workload. Serious clerical and logistical problems associated with sample collection, identification, preparation, sorting and loading, and tabulating and reporting results became apparent.

The following sequence of events occur in the non-emergency situations where the ordered tests will be performed on the following day, (using auto-analyzers).

1. The doctor requests analytical tests through the patient's chart which are then transcribed on requisition forms at the nurses' stations.
2. The forms are delivered to the laboratory throughout the day until all analytical test requistions are delivered to the laboratory by sometime in the late evening.
3. The following morning sorting of requistions, equitable set-up, and distribution of work among the technicians is accomplished.
4. The actual bedside and laboratory sample collection and immediate identification of patient and tests are performed, and all samples are transported to the laboratory.
5. This is followed by sample preparation.

6. The samples are then divided into sub-samples depending on the number and kind of tests to be run. Each sub-sample is poured into a separate Auto Analyzer sample cup, with one cup for each test.
7. Identifying lists designating samples to be analyzed by each method are prepared. This obviously requires a separate tray as well as a separate log list for each test.
8. The sample trays are placed in the appropriate Auto Analyzers for analysis.
9. Test results are calculated from the appropriate analog curves and correlated with the correct sample.
10. Transcription of the data to the log lists is then accomplished.
11. Patient summary records, which represent collation of the data for any one patient from several log lists, are then prepared and returned to the requesting physician.

One major company in the health care field reports that there is one chance in six of there being a clerical error involved in the 30 human steps associated with ordering and processing of an X-Ray.(9) It would be interesting to know the error probability associated with the significantly more complex task of serum biochemical analysis. In addition to the significant error probability, results are generally not reported until the end of the day when they are all available. The physician, therefore, would often not see the results until the following

day (that is, three days after requesting them - See Fig. (5))(1)

6. SEQUENTIAL MULTIPLE TESTS.

The concept of sequential multiple analysis developed where multiple tests were performed simultaneously from a single serum sample. All the test results are recorded sequentially on a single sheet of recorder paper in direct concentration terms. Fig. 6 shows an example of an actual recording produced by a 12-channel sequential multiple analyzer.

The paper is precalibrated in concentration terms for each test, and the normal area for each test is shaded in grey allowing immediate recognition of abnormal results. The paper is also perforated so that the complete series of 12 tests (or "biochemical profile") for each patient may be torn off and attached to the actual patient record.

SUMMARY OF ADVANTAGES OF SEQUENTIAL MULTIPLE ANALYSIS.

1. The physician's power of observation is extended. If an admission profile is performed on every patient who enters the hospital, the physician has a better basis on which to judge each patient.

2. A biochemical profile is available even on "stat" or emergency samples within 30 minutes of the time that the blood is drawn. This is an obvious advantage at night or on weekends when the laboratory is not completely functioning. However, this is dependent on a multi 12 being available and set up and ready to run.

3. Immediate recognition of the degree of divergence from normality of results of the 12 tests is possible, since the chemical profile on each patient is provided in graphic form.

4. Reliability of the results is greatly increased since many of the

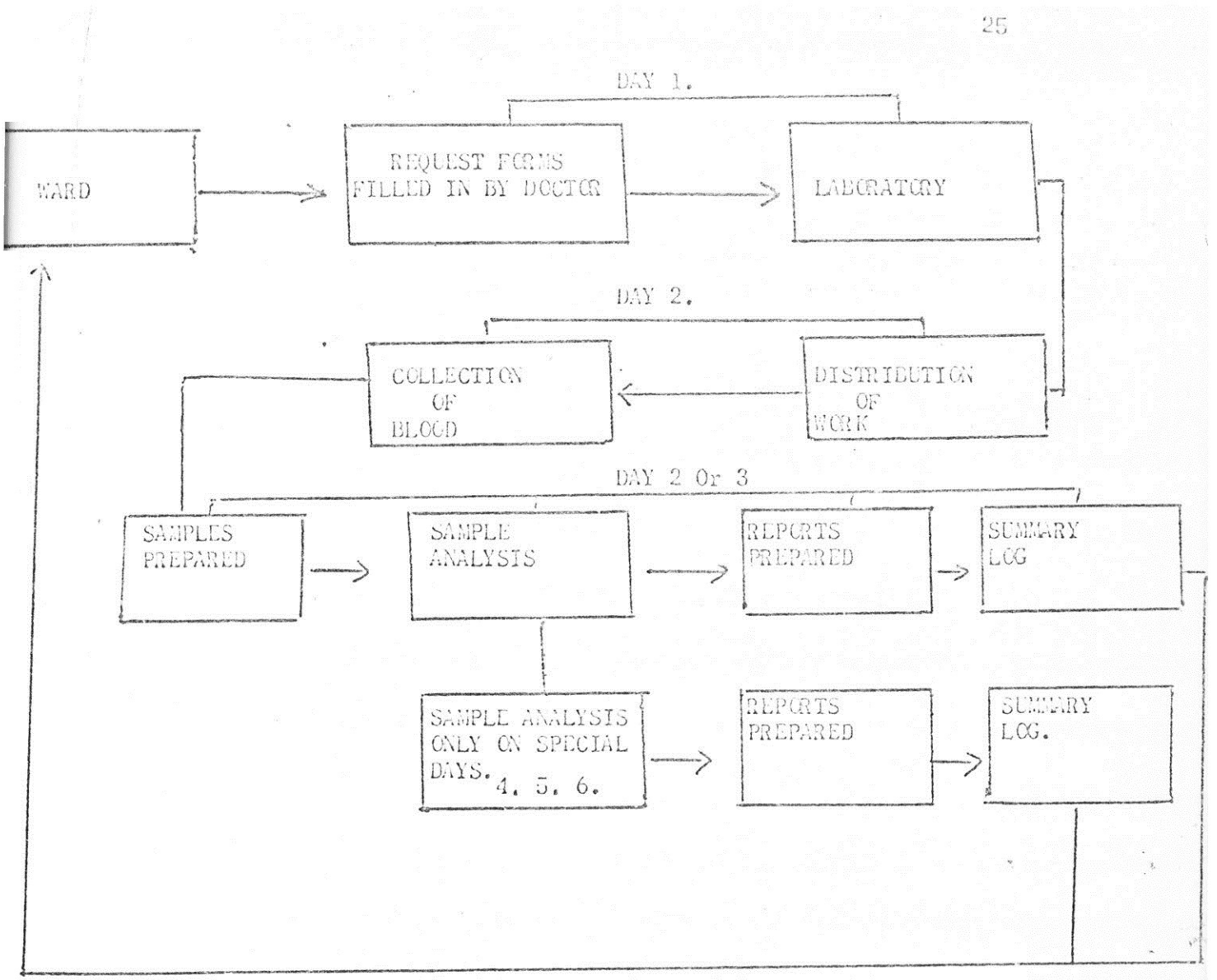


Fig. 5. Work Flow.

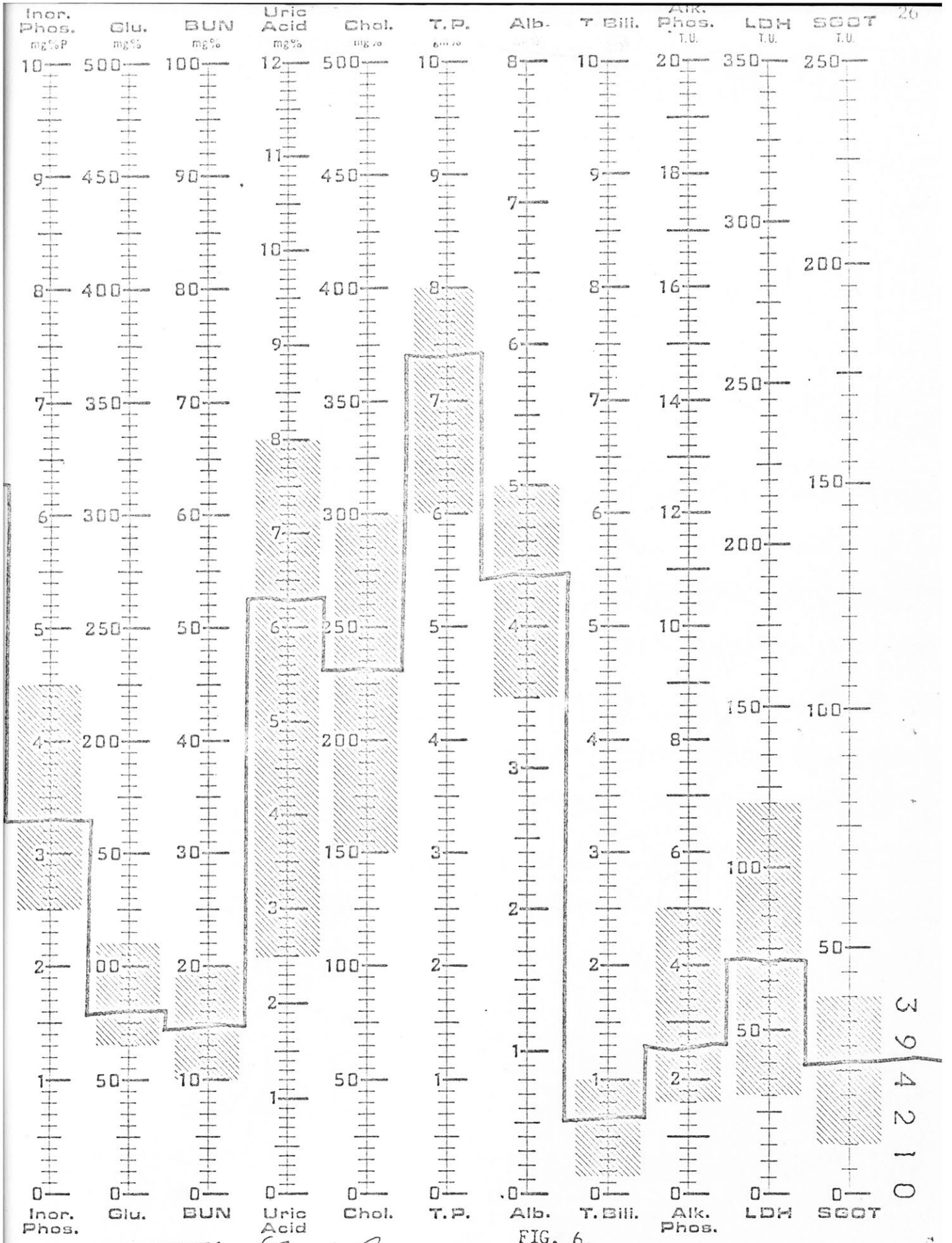


FIG. 6.

Name John McConnell

73451 Rm. 1721 Date 9/20/67

previously described tedious manual steps associated with the analysis, such as requesting, scheduling, collecting, sorting, identifying, analyzing, calculating, transcribing, collating and reporting are obviated along with their inherent susceptibility to human error.

5. The economic advantages are considerable, not only in terms of cost per biochemical profile, but also in terms of more efficient utilization of hospital beds and physicians' time. Consider that:-

(a) Rapid feedback of laboratory information may obviate the need to hospitalize patients pending diagnosis.

(b) Profiling increases the diagnostic capacity of an outpatient clinic by allowing more diagnoses to be made on the basis of one visit alone. This is particularly true in the present situation where laboratory findings are inconclusive and result in the need for further testing.

(c) The length of stay of the average patient may also be reduced for the same reason and this is an important economic advantage.

(d) As previously demonstrated, the Birmingham Baptist Hospital, among many others, provides a metabolic profile of 28 chemistries on every patient prior to admission. This profile, which is based on an SMA 12, is provided at a low cost to the patient.

6. Increased testing as a result of admission profiles has conclusively been shown to result in earlier detection of disease.

7. Disease which is detected in the pre-clinical phase may be treated at a lower therapeutic cost which probably decreased hospital stay and less suffering to the patient.

Until recently, however, there was no guarantee that the added value of unrequested information justified the expense. Approximately a dozen qualified workers undertook the task of objectively assessing the value of this information if gathered as an admitting procedure in a medical centre or hospital. Without exception, their views are reflected in the conclusion reached by Bryan, et al.[10] "The experimental evidence collected demonstrates that sufficient unexpected data are discovered by this procedure to more than justify the new role for clinical chemistry, and that multichannel analysis is economically sound when applied in an appropriately demanding environment."

7. THE "NORMAL RANGE."

The "Normal Range" can be considered as the most useful as a standard of comparison for a given patient's laboratory result when it is derived from a homogeneous subpopulation closely matched to the patient for age, sex, and living habits.[11] Some test values, notable urea nitrogen, cholesterol, and globulin, change with advancing age. The change seems to be due to the inadvertent inclusion of abnormal values in the preparation of the normal range. This is probably because it is more difficult to select older individuals for optimum health. Many apparently healthy older persons are probably suffering from a subclinical form of degenerative disease.

Physicians make diagnostic decisions based on clinical laboratory results. There is often no good set of criteria by which the decisions

are made. In most cases, patient values are interpreted as "normal or abnormal" on the basis of published "normal range." Since "normal ranges" in use today are nearly all derived from small groups of persons inadequately selected for age, sex and other variables and since most of them include values from patients who are not "normal" in the sense of being healthy, the ranges are often unnecessarily broad or all-inclusive. They are further modified by the physician who is influenced by his degree of confidence in the laboratory, his experience and the additional knowledge he may have about the patient.

(11)

Specific difference between groups can be listed as follows:-

1. Young males differ from young females in having higher levels for serum urea nitrogen, creatinine, alkaline phosphatase, cholesterol and uric acid. Young college-student males have the highest mean and widest distribution of levels for uric acid of any group tested, a finding not present in young male hospital employees. Throughout, frequency distributions for uric acid levels for males and females overlapped only slightly the differences being the most obvious in the non-institutionalized younger subjects. The age and sex-related difference in uric acid values was one of the most striking findings of the study.

2. Older males differ from older females in the same way that younger males differ from younger females, except that differences are less marked and disappear in the case of levels for alkaline phosphatase, while serum cholesterol rises to even higher levels in the females.

3. Younger and older females from the same institutional environment differ in that the younger ones have lower levels for serum glucose, urea nitrogen, alkaline phosphatase, and cholesterol. Uric acid levels were

found to be much the same at all age levels among female subjects but were found to vary somewhat with the environment. The older institutionalized males are more similar to older institutionalized females than non-institutionalized males are to females. This suggests a stabilizing effect of uniform diet and living habits.

4. Different subpopulations vary enough in mean values and breadth of frequency distribution so that age and sex differences are sometimes reversed. For instance, an optimally healthy group of young male blood donors has a dramatically higher range of serum uric acid values than any other sub-population and a urea range comparable to older female diabetic risks and older male mental patients.

COMMENT.

The age and sex differences described have already been documented. A number of differences in level for serum urea nitrogen and albumin from one group to another seem to be quite obviously related to the consumption of an institutional diet. Some difference in levels for glucose and inorganic phosphate are due to artifacts of specimen collection. Nevertheless, even when one compares subpopulations from within the same institution, there are potentially useful differences in the frequency distribution of their laboratory results.

The findings illustrate that there is more than one normal range. A normal range derived from a peer group will be narrower than one derived from the population at large. Hence, a given laboratory value can be a more sensitive indicator of disease if it is interpreted from the point of view of the subpopulation. For example consider a patient with a serum urea nitrogen value of 21 mg/100 cc. This value is "abnormal" in 18-year-old girls, but it must be accepted as not unusual in middle-aged

psychiatric patients. The same concept applied to ambulant subpopulations screened for degenerative disease, can discover many potential abnormalities missed when conventional normal ranges are applied. Ideally, each patient should serve as his own "normal range", being measured periodically as he progresses from health into disease. Studies in determing individual profiles are in progress at several centres. (12)

8. CUMULATIVE RECORDS.

The ease with which laboratory records become available to the physician is an important consideration when considering the time he has to devote to patient care. A glance at a cumulative report as in Fig. (7) shows the trend that is developing as a pattern emerges from a series of repeated tests and may indicate or confirm a specific disease. The elimination of the necessity of going through pages of reports is a distinct advantage.

The hospital and the patient also gain from a reduction in the amount of testing required; this is done by eliminating excess and duplication of tests as the physician can see at a glance what tests have been done and seeing what further testing is unnecessary. (13)

Amongst Sydney Hospitals, cumulative results in chronological order on one sheet are being produced. This is done by adding each day's results to the profile. This is initiated on admission then each new result is added to the profile and photostated. Figs. (7) (8) & (9) shows a typical American and Australian report sheet.

9. DISEASE PATTERNS GRAPHES.

In an anlysis of 4,000 chemistry graphs using a Technicon 12/60

MONTEFIORE HOSPITAL AND MEDICAL CENTER
LABORATORY REPORT SHEET

PATIENTS NAME

* FINAL REPORT PAGE 01

BLDG	FLOOR	ROOM	SEX	AGE	A	SV	ACCT. NO.	ADM. DATE	DISCH. DATE	RUN DATE	HOSP NO	DIAG
			M	33	S	S		66 12 08	67 01 11	01/24/67	179701	

TEST DATE MO	TEST DATE DA	TEST DATE YR	AA	TEST NO	RESULT				ACC
					BLOOD CHEMISTRY 1				
					NA (MEQ/L)	K (MEQ/L)	CO2 (MEQ/L)	CL (MEQ/L)	
66	12	10	00		134	3.4	32.0	96.9	0838
66	12	19	00		135	3.3	30.0	96.1	0876
66	12	20	00		136	3.7	29.5	94.5	0200
66	12	21	00		136	3.5	30.0	96.4	0451
66	12	22	00		137	3.3	30.5	91.0	0698
66	12	26	00		134	3.6	27.0	93.0	0971
66	12	26	00		129	4.0	29.0	89.0	0174
66	12	27	00		136	3.1	32.0	89.5	0602
66	12	30	00		134	3.2	33.0	87.9	0434
67	01	03	00		133	4.0	31.5	85.7	0140
67	01	04	00		134	4.2	30.5	89.7	0303
					BLOOD CHEMISTRY 2				
					GLUCOSE	UREA N	CREAT	URIC ACID	
66	12	10	00		160	40	2.0		0838
66	12	19	00			41	2.0	7.2	0876
66	12	20	00			37	2.0		0200
66	12	22	00		169	29			0698
66	12	27	00			31	2.0		0602
66	12	30	00			32	1.7		0386
67	01	03	00			39			0140
					BLOOD CHEMISTRY 3				
					BILIRUB	CEPH FLOC	THYM TURB	ALK PTASE	
66	12	10	00		1.3				0838
66	12	19	00					2.1	0876
66	12	20	00					1.9	0886
					BLOOD CHEMISTRY 4				
					LDH(SGO)	SGOT(RM)	CHOLEST		
66	12	20	00		360	12			0200
					BLOOD CHEMISTRY 5				
					CALCIUM	PHOS	ACID PTSE		
66	12	19	00		8.3	2.5			0876
66	12	20	00				0.05P		0886
					BLOOD CHEMISTRY 6				
					TOT PROT	ALBUMIN	GLOBULIN		
66	12	19	00		6.0	2.9	3.1		0876

FIG. 7

Fig. 7. Example of culmative record of laboratory tests. Patient's name has been deleted.

Information is missing on next page of the digital copy of this thesis.

It has not been possible to be completely digitised all information on page due to tight book fold binding.

AGE	HOSPITAL NUMBER	WARD
SEX	H.M.O.	SHEET NUMBER B

"NORMAL RANGES" FOR ADULTS IN BRACKETS

Specimen Lab. Number Received	Specimen Lab. Number Received
Specimen Lab. Number Received	Specimen Lab. Number Received
Specimen Lab. Number Received	Specimen Lab. Number Received

NOTE: IS=insufficient specimen, US=unsuitable, NI=not indicated, AC=accident to specimen

REPORT DATED

☐ Discard all earlier copies of Sheet B, Number ..... .

☐ File TEMPORARILY as the top sheet of the case papers.

☐ File this sheet PERMANENTLY with the patient's case papers.

FIG. 8.

DIVISION OF CLINICAL CHEMISTRY

	AGE	HOSPITAL NUMBER	WARD
			34
	SEX	H.M.O.	SHEET A NUMBER

SPECIMEN	BLOOD : PLASMA : SERUM									
LAB. NUMBER										
RECEIVED										
SODIUM (135–150 meq litre)										
BICARBONATE (24–32 meq litre)										
CHLORIDE (95–105 meq litre)										
POTASSIUM (3.5–5 meq litre)										
UREA (15–45 mg 100ml)										
URATE (2–7 mg 100ml)										
CREATININE (0.1–1.2 mg 100ml)										
BILIRUBIN, TOTAL (< 0.5 mg 100ml)										
BILIRUBIN, PROMPT (ml)										
ALK. PHOSPHATASE (3–13KA units 100ml)										
G.P.TRANSAMINASE (< 18 i.u. litre)										
G.O.TRANSAMINASE (< 20 i.u. litre)										
LACT.DEHYD'RASE (50–300 i.u. litre)										
TOTAL PROTEIN (6.3–8g 100ml)										
ALBUMIN (3.5–5.5g 100ml)										
GLOBULIN g 100ml)										
ELECTROPHORESIS										
CALCIUM (9–11mg 100ml)										
INORG.PHOSPHATE (2.5–3.5mgP 100ml)										
GLUCOSE (60–100mg 100ml)										
BIOCHEMIST										

"NORMAL RANGES" FOR ADULTS IN BRACKETS

NOTE: IS = Insufficient specimen, US = Unsuitable, HM = haemolysed, NI = not indicated, AC = accident to specimen

REPORT DATED

☑ Discard all earlier copies of Sheet A, Number.....

☐ File TEMPORARILY as the top sheet of the case papers.

Fig. 9

certain patterns were apparent.(14) These patterns may be an indication of specific diseases or provide clues that will indicate what further tests should be performed.

For example, patients who suffer myocardial infarctions have higher levels of serum glutamic oxaloacetic transaminase and lactic dehydrogenase. Physicians, of course, know this, but sometimes do not appreciate how quickly these enzymes rise and how long they remain elevated. Transaminase goes up six to twelve hours after chest pain starts, peaks at twenty-four hours, and usually drops to normal in four to five days. Lactic dehyrogenase may not rise for twelve hours, reaches its peak at two to three days, and may not descent to normal for ten days to two weeks. By using two enzyme tests, physicians can better gauge when infarction occurred, how extensive it is, and whether it is progressing (Fig. (10)). Also graphs may show if the patient is hyper-cholesterolemic, diabetic, uremic, or if he has a congested liver with abnormal function tests. (Figs. (11), (12), (13)). This information may help the doctor to assess the patient's prognosis and manage him later.

10. THE INTRODUCTION OF DATA PROCESSING AND THE COMPUTER.

It has been said that clinical chemistry is the fastest growing of the health sciences, and in most large hospitals, the annual number of clinical chemical tests has doubled every five years since 1946. The technological explosion of the last sixty years has kept pace with, or surpassed, the population expansion; and the clinical chemistry has not lagged behind.(6)

Technology in general and the computer in particular are helping lift a tremendous burden off the shoulders of clinical pathologists. By

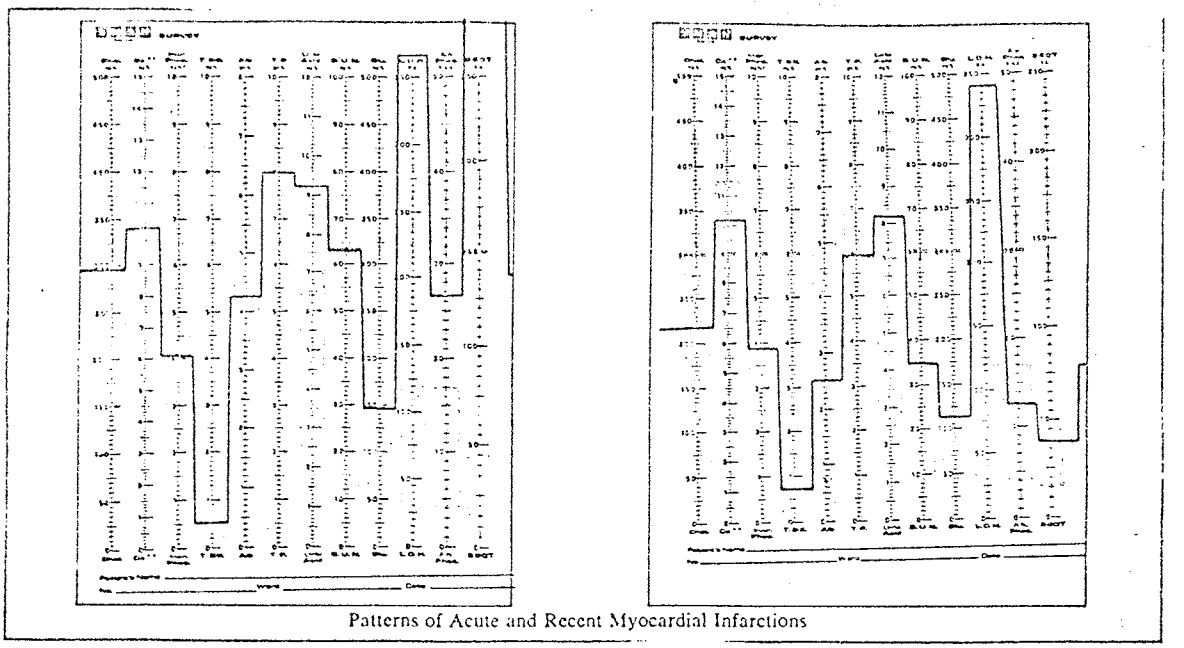


FIG. 10.

Fig. 10. - Graph on left is from a 70-year-old diabetic male with azotemia (note uric acid elevation) whose heart had infarcted 20 hours before. Graph on right is from a 51-year-old man with known gout who had suffered infarction eight days before. His transaminase had returned to normal on the fifth day.

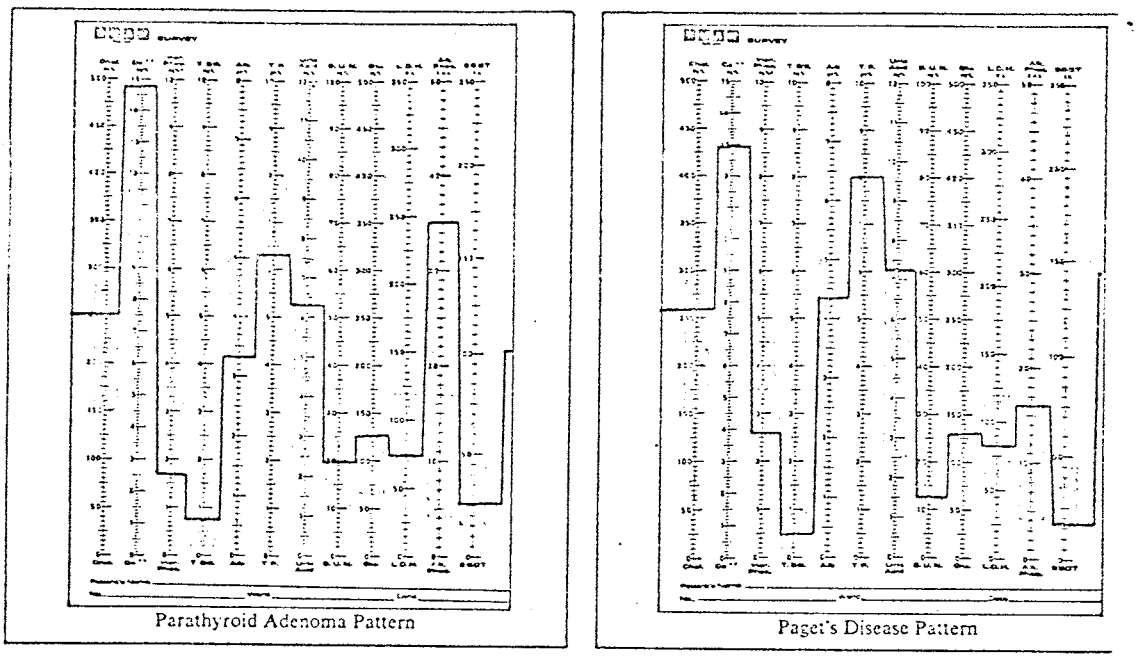


FIG. 11 & 12.

Fig. 11 & 12. Left graph is from a 60-year-old man with a history of repeated kidney stones and mental depression. Graph on right is that of an 83-year-old woman with Paget's Disease.

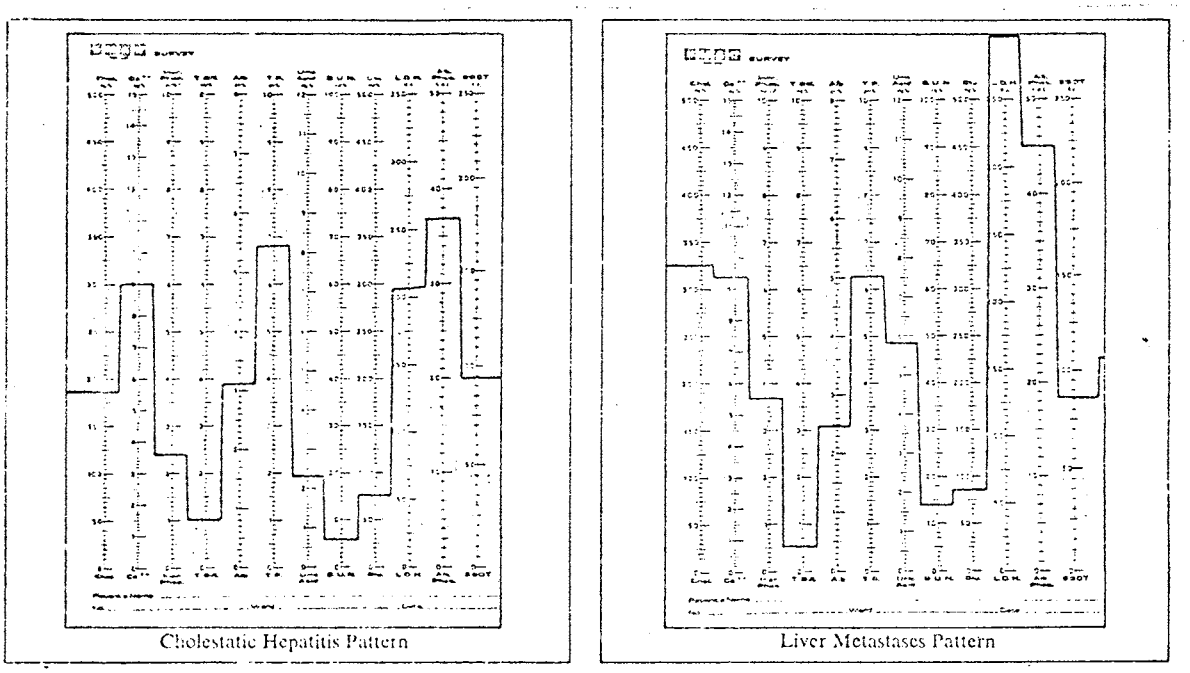


FIG. 13

Fig. 13 - Graph on left shows serum changes in a 29-year-old woman who had serum hepatitis after transfusion. Serum graph on the right was from a 57-year-old woman with colon cancer which had produced large nodules in the liver. When metastatic masses occupy a large part of the liver, both lactic dehydrogenase and alkaline phosphatase usually go up.

creating unique instruments and systems they are giving promise of bringing both a staggering work load and the paper work associated with it under control. The amount of work growing over the past decade has been expanded into enormous dimensions by five major considerations.(15)

1. The recognition that the important scientific advances made in laboratory medicine represent valuable adjuncts to the diagnosis and treatment of disease. As a result, there is an increasing reliance upon and an enhanced demand for large numbers of laboratory tests which are becoming increasingly complex and difficult to perform.

2. An insufficient number of adequately trained or experienced personnel able to perform these procedures accurately, precisely, swiftly and economically.

3. The use of relatively archaic methods of clinical laboratory management, the retention of obsolete technical procedures, and the existence of small cramped hospital laboratories.

4. The scanty budgets and unattractive salaries for professional and technological staffs which restrict entry into this field of people with talent and strong motivation.

5. Increasing public and professional concern with unsatisfactory levels of laboratory accuracy.

Modern improved instruments can produce more test results, in less time more cheaply, using less manpower of lesser technical training and operating in smaller spaces; the number of measurements has risen so precipitously that it threatens to inundate clinical pathologists and physicians. Procurement of large numbers of specimens and the clerical procedures necessary to prepare them for testing by automation pose sig-

nificant problems in maintaining proper identification of the specimen, of the patient, and of the test desired. The accuracy of calculations and the correctness of the final test results are put in question because of the enormous amount of necessary clerical effort which still is carried out slowly and inefficiently. As a consequence, an imbalance in laboratory operations has developed, the automation of instrumentation not being matched by a similar increase in automation of information handling. This imbalance threatens to cancel or diminish the advantages accruing from the technological advances in instrumentation.

The resolution of these problems, therefore, requires additional technical support, precedent for which already has been established in industry and research, namely, the introduction into the clinical laboratory of data processing and of the computer.

11. COMPUTERS AND HOSPITALS.

Computers of one kind and another are almost commonplace nowadays in industry, commerce and the sciences. However, computer exploitation has lagged to some extent in medicine, there is no doubt that we are on the threshold of wide ranging developments in practically every field of hospital work.(16)

In Australia, we are behind the Unites States of America and the United Kingdom in using computers in our hospitals but recent events point to an acceptance of the use to which computers can be put.

In considering computers it is important to consider two types - the digital computer and the analogue. The basic difference between these machines is that the digital computer counts and the analogue computer measures.

MEDICAL APPLICATIONS.

The range of applications of a purely medical nature is small when applied to medical diagnosis and treatment. It has been said that less than 1% of medicine is calculable but a great deal of medicine is involved with raw and processed data.(10)

Some medical applications include:-

Computer assisted daignosis (and this includes EEG and ECG wave form analysis).

Pathology Laboratory Tests reporting.

Radiotherapy calculations.

It is the medical application of computer which has, perhaps, aroused the greatest controversy especially in diagnosis. The Physician is inevitably limited to his own experience of disease and what he can remember from the literature. He is under some pressure to make a diagnosis as rapidly as possible and could be greatly helped in this process if he could be provided with access to a matrix of all known signs and syndromes of disease and up-to-date experience of the occurrence of symptoms. Given access by telephone, for example, to such a computer matrix he would state the observations he has made, and the computer would then print out six diseases, say, in order of probability.

There are assumptions made to achieve such a result, and complications arise due to specificity and weighing. Nevertheless, this could be a powerful diagnostic aid - particularly where a rare disease may be involved. Clinicians tend to assume that the introduction of such procedures are a gross interference in the doctor-patient relationship in that "auto-

matic" diagnosis will eliminate the diagnostician. This reaction springs from lack of understanding of the statistical techniques involved, but it may be some years before this is a developed application.[17]

COMPUTER MULTI-TESTING.

It seems entirely possible that one might wish to vary the tests which were included in a multi-test battery depending upon the geographic ethnic and environmental factors which establish specific disease risk factors at any particular test centre.[18] This would not in any way affect the value of the computer in correlation and recording the results, it would only affect the programming and interpretation of results.

As shown, there is the likelihood that disease or dysfunction may be detected by taking into account patterns or combinations of test results. There is evidence that computer can recognize patterns or combinations of results as significant, even though the constituent results might not be significant if considered individually. This could be an important aspect of computer inspection of multiple laboratory measurement. Others have noted in dealing with computer interpretation of electrocardiographic measurements[19] and other diagnostic processes that there is considerable redundancy in traditional measurements. This suggests that it may be possible to eliminate some of the measurements or laboratory determination which now seem necessary. This has not yet been confirmed.

A hopeful aspect of multi-test screening is the likelihood that the establishment of baseline values for an individual will make subsequent deviations from the baseline during disease more easily detectable.

One investigator has stressed that the concentration of blood constituents varies less within time for a single person than within a population at any moment in time.[21] This has already been shown with respect to serum glutamic-oxalacetic transaminase.[18] This fact as previously shown can be useful in early recognition of myocardial infarcation and other diseases. Previous baseline data which can be retrieved by a manual or computer system can be invaluable in this regard. Developments in this area will owe much to the concepts of "Biochemical individuality"[21] and of the "Chemical fingerprint."[22]

Systems must be selected which allow the test batteries to be altered based on the needs of the individual hospital and type of patient It seems unlikely that maximum value can be derived from pre-admission testing unless the data is processed and disseminated and made retrievable by electronic computer systems.

12. PROBLEMS IN ALTERING ESTABLISHED PROCEDURES AND THE INTRODUCTION OF DATA PROCESSING INTO LABORATORIES.

At U.L.C.A. Hospital in Los Angeles responsibilities for designing, testing, and implementing the automated collecting and reporting procedures resides in the hands of the laboratory director. Successful attempts to alter the established pathways of medical communication require the cooperation and full support of the medical personnel in charge. So, working with their own personnel, and with the assistance of research funds that permitted them to perform initially the automated data handling procedures in parallel with established methods, they passed successfully from skepticism on the part of the production personnel through tolerance to full acceptance.[23]

Experience in the clinical laboratory demonstrated clearly that it was possible to persuade associates and employees to try, for a limited period, new methods as a personal favour to management, but no long-sustained effort towards acceptance of new techniques can be expected unless the individuals involved in the day-to-day manipulation of data soon receive some tangible benefit as compensation for the effort that is initially required to effect change of any kind.

Even though the anticipated long-term objectives are desired and shared by many persons and the methods to be employed can be demonstrated to be potentially superior, the momentum of established procedure is an ever-present deterrent. Resistance to change, often only passive in its expression but almost universal in its distribution, easily can be lethal to the best plans. Change must be coupled with demonstrable benefit for those involved if voluntary association in an effort of this type is to be sustained. For this reason, the hospital embarked initially only upon those changes that would aid the clinical laboratory. In so doing an effective communication system was developed that served the entire hospital, but did not create extra work for the laboratory people in order to achieve these objectives.

Once benefit becomes evident and compensation is at hand in return for effort required to effect change, a second powerful human trait becomes apparent, i.e. the comparison between new and old, between the progressive and backward method, and between computer-controlled printing and handwritten document. The individual realised the personal advantages and improved patient care that results from the use of automation and the integral part he has personally played in it. The automated data-handl-

ling techniques in the clinical-chemistry laboratory were of necessity developed test by test, rather than applied simultaneously to all 90 tests. Some technicians soon were in the forefront of the new era and others were held back on the sidelines awaiting their turn. Although it had been originally intended to develop only a small segment of the clinical chemistry data processing as an experimental demonstration, it soon became impossible to proceed along these lines. As the new system began to work, those left with the old insisted upon inclusion. Within a few months, it was necessary to go from a cautious pilot demonstration to a full-scale conversion of the entire clinical chemistry section.

THE USEOF PUNCH CARDS IN LABORATORIES.

Because the availability of qualified personnel has not kept pace with the inc reased demand for laboratory service, the Laboratory Director, Department of Pathology, Conemaugh Valley Memorial Hospital, U.S.A. has had to search for new methods of increasing the effective productivity of his staff. Some efficiences have been achieved with automated chemical procedures, but in most laboratories, these automated techniques have not permitted concomitant economies in the clerical aspect of the analyses.(24)

It is evident that process control computers, will be found in many laboratories as a partial solution to the data handling problem, but the many difficulties attendant upon the establishment of such a system have precluded widespread installation.

The Director's decision to pursue a punched-card system as the first step in the automation of laboratory data handling was based upon

the realization that substantial amount of systems analysis would be required before any automated system could be instituted. The manual data handling system in use at that time permitted many opportunities for human intervention that would not be acceptable in an automated system, and it seemed that a punched-card system would be an economical first step toward overall automation.

Laboratory data processing systems employing punch card unit record equipment can be used.[25] [26] [27] While the systems offered definite advantages over manual systems, they had several disadvantages, which, while perhaps not apparent in the environment in which the systems were developed, would seriously compromise acceptability in a community hospital.

The laboratory reporting system was developed with several constraints; the omission of any of which would affect its acceptability.

1. The system would have to be patient oriented, i.e. it should be capable of presenting laboratory data in a format that would be significantly more useful to the clinician in his evaluation of the patient's status, than the method in present use. This pre-requisite for clinical usefulness meant that the system must not delay the reporting of laboratory data and that the data should be presented in a summarizing format.
2. The system should not be significantly more expensive to operate than the former system, although it was recognized that additional costs would be acceptable if significant benefits could be obtained.
3. It should be a simple task for the nurse to request a laboratory service. Because the nursing staff includes many part-time employees,

the director elected not to generate a machine-processable requisition at the nursing station. Acceptable input to the system would be ensured by doing their own key punching. (by personnel familiar with the procedures).

4. The operation of the system should not require highly trained data processing specialists but should be operable by personnel familiar with laboratory activities.

5. The system should not require additional participation of bench technologists in data processing activities. Hopefully, a new system might reduce the clerical burden of the technical staff, thereby increasing their productivity and efficiency.

6. The system should reduce the need for transcription and the attendant opportunities for error.

7. The system should be capable of producing appropriate records for billing and statistical reports.

The System

A detailed study of the System introduced at this Hospital is in Appendix I C1./1/1 to C1/1/6

Evaluation of the System

"The system has many advantages over a manual reporting system. First the installation required a complete systems analysis of departmental operations, the result of which indicated that closer control should be exercised in some areas and less in others. Second, we feel that the system has permitted closer control over clerical errors. Since all reports

are now checked before being sent to the floor and because inexplicable day-to-day variations are immediately apparent, the technical staff knows that a confirmation will be expected before a report will be released. Because of this, they have become much more alert to abnormal values and insist upon checking their results with another technologist before releasing them for key-punching. Errors due to equipment malfunction have been rare."

"Perhaps the greatest advantage of the system is the presentation of data in a summary format. Not only does it assist the clinician in following serial studies and seeing subtle trends in his patient's data but also affords the pathologist greateropportunity to review each report, cull out unexplained variations, suggest additional studies, or offer an opinion regarding interpretation. The laboratory report thus becomes a more powerful tool in the care of the patient."

"The disadvantages of the system centre about the cost of operation. Since the decision was made to keep this function under the control of the laboratory, it is difficult to spread the costs over other hospital departments."

"With approximately the same level of personnel effort and about twice the expenditure for equipment, the data processing needs of the entire hospital could probably be met. The system has not significantly reduced the clerical effort expended by technologist although significant diminution of effort has been achieved by the nursing personnel responsible for placing the reports on the medical record and thos responsible for the compilation of statistical reports."

" This sytem offers advantages that outweigh the disdavantages. Its

establishment has been an invaluable first step on the way to computerized laboratory reporting and will make subsequent steps much easier and more intelligent than would have otherwise been possible."

The use of punch cards and summary formats are an integral part of multiple investigations upon admission to hospitals and whilst they may not be originally incorporated in the initial stages, will, nevertheless, follow on. The system shows how efficient is the use of three report method (laboratory results can be received in the ward in the minimum of time) and the value of the summary format is demonstrated.

13. THE ELECTROCARDIOGRAPH.

With the introduction of the Analog-Digital computer and the ultra-sophisticated type of electrocardiograph machines, electrocardiograph investigations can be introduced into a system of multi-screening on admission to hospital. The ever-increasing volume of knowledge that has been acquired on the incidence of previously undetected cardiac disease, with the ultimate poor prognosis, if not treated, makes cardiac assessment vital expecially in those over the age of 30 years. This section deals with mass screening, both in hospital groups and unselected groups, showing the value of computer diagnosis where there is no available cardiologist. The accuracy of the computer is demonstrated and shows how it compares favourably with human interpretation. The vital time factor is also considered. Both off-line and direct-line computarization of results is shown.

The use of the 12 lead and the standard 6 lead cardiograph is considered. It could well be that a preliminary screening by the use of 6 leads instead of the more universally accepted 12 leads will be used as a routine procedure on admission. Although not discussed, in the U.S.A., one lead electrocardiographs have been extensively investigated but the error in diagnosis is far too high for them to be of any medical value.

In multi-screening on admissions to hospitals the use of the electrocardiograph without its combination with a computer would be too time-consuming and impractical. Investigation in the U.S.A. has shown the use of the digital computer in the interpretation of electrocardiographs to be a valuable tool, especially to the non-cardiologist physician.

The computer programme, once stored in the computer, is retrieved

unerringly and as often as is requested, and all quantitative aspects of the electrocardiograms are analysed. The results are consistent and the computer is uninfluenced by anything other than the stored criteria. The physician is influenced by what is seen and on occasion may not see a second or third abnormality present, and this is especially likely if the first one seen is of some magnitude.

14. THE INTRODUCTION OF COMPUTERIZED E.C.G. INTERPRETATIONS.

In 1962, at the Iowa Methodist Hospital, reasonable criteria for the various electrocardiographic abnormalities commonly encountered in adults were selected. Programmes were written to include all major abnormalities except certain of the arrhythmias. Electrocardiograms exemplifying these were selected and technicians were instructed how to measure exactly the various components of the tracings. Guidelines outlining the details of measurement were formulated and put into pamphlet form so that technicians could repeatedly refer to them in the interest of standardization in the handling of data.

Measurement cards were then completed by the technicians for each tracing. IBM cards were punched, with four being required for each electrocardiogram. One 80-column card was punched for the patient's name, the date on which the tracing was taken, the patient's age, the hospital number, and the research number. A second card was punched with data for heart rate, rhythm, and P-R and Q-T intervals, and with amplitude measurements for complexes in the standard and augmented leads. A third card included data for the precordial leads through to V4 and a fourth card includes the remaining precordial leads. These cards were then ready to be used as data input. (28)

The minimum "machine" requirements for running the electrocardiographic programme included one of each of the following:

IBM 1441

Central Processing Unit with 8,000 character storage area.

1443 Printer

1447 Console and a 1442 Reader or Reader Punch.

A schematic outlining computer logic sequence is seen in Fig. (18). Each electrocardiogram was checked by the computer for patient's data (name, hospital number, research number etc.) and then for electrocardiographic data.

RESULTS OF THIS SERIES.

Four thousand four hundred and sixty nine electrocardiograms were analzyed by the computer. Each computer diagnosis was checked by a cardiologist and each of the cardiograms were read by him in order to check computer accuracy. His diagnosis and that of the computer were in agreement except for nineteen electrocardiograms.

COMMENTS.

One of the drawbacks of the programme was that a considerable amount of time must be spent in teaching technicians to do the measurements properly. Also, a skilled technician required on the average, 10 minutes to make the appropriate measurements. These must then be transferred to cards, as indicated earlier. The total time required to completely process each electrocardiogram, including a printed diagnosis from the computer was about 11 minutes. In order to circumvent measurement by a technician and to shorten the time required for processing, and in order to make possible direct transmission of analogue data to the computer, an Analog-Digital

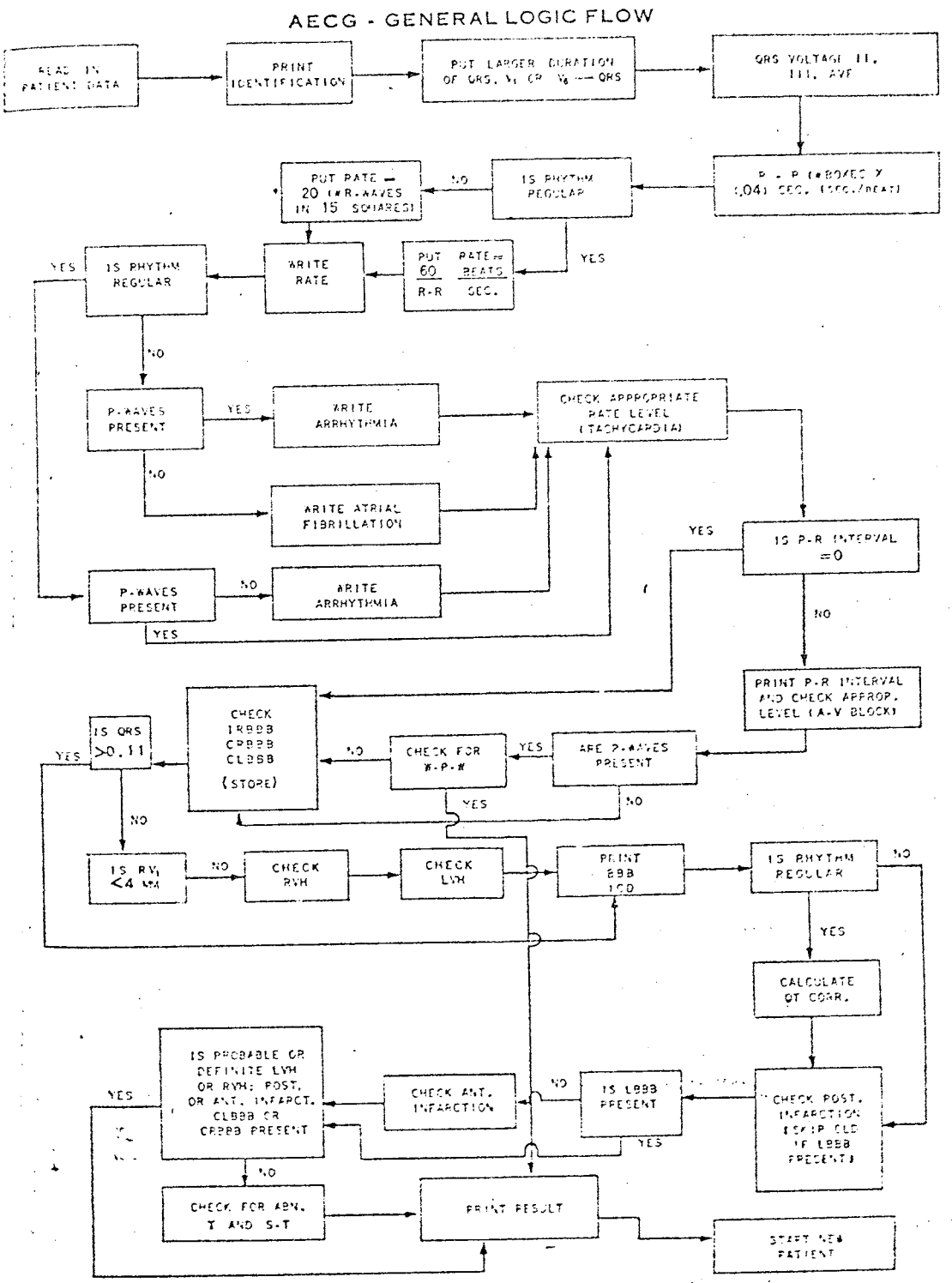

AECG - GENERAL LOGIC FLOW
READ IN PATIENT DATA
PRINT IDENTIFICATION
PUT LARGER DURATION OF QRS, V5 OR V6 — QRS
QRS VOLTAGE II, III, AVF
P - P (#BOXES X .04) SEC. (SEC./BEAT)
IS RHYTHM REGULAR
NO
PUT RATE = 20 (#R-WAVES IN 15 SQUARES)
YES
PUT RATE = 60 / R-R BEATS / SEC.
WRITE RATE
IS RHYTHM REGULAR
YES
NO
P-WAVES PRESENT
YES
WRITE ARRHYTHMIA
CHECK APPROPRIATE RATE LEVEL (TACHYCARDIA)
NO
WRITE ATRIAL FIBRILLATION
P-WAVES PRESENT
NO
WRITE ARRHYTHMIA
YES
IS P-R INTERVAL =0
YES
NO
PRINT P-R INTERVAL AND CHECK APPROP. LEVEL (A-V BLOCK)
ARE P-WAVES PRESENT
YES
NO
CHECK FOR #-P-#
YES
NO
CHECK IRBBB CRBBB CLBBB (STORE)
IS QRS >0.11
YES
NO
IS RV1 <4 MM
NO
CHECK RVH
CHECK LVH
PRINT BBB ICD
IS RHYTHM REGULAR
NO
YES
CALCULATE QT CORR.
CHECK POST. INFARCTION (SKIP OLD IF LBBB PRESENT)
IS LBBB PRESENT
NO
YES
CHECK ANT. INFARCTION
IS PROBABLE OR DEFINITE LVH OR RVH; POST. OR ANT. INFARCT. CLBBB OR CRBBB PRESENT
YES
NO
CHECK FOR ABN. T AND S-T
PRINT RESULT
START NEW PATIENT

FIG. 18.

computer was needed. This was later developed.

15. TRANSMITTING ELECTROCARDIOGRAPHS TO A CENTRAL COMPUTER STUDY NO. I

At Hartford Hospital, Conn. U.S.A., recording of electrocardiograms are made on portable data acquisition carts, which simultaneously record a traditional 12-lead tracing and inscribe the signal on F.M. magnetic tape.(29) In this fashion recordings are made for 20 patients daily in the Outpatient Department and the Emergency Room. The tape is rebound and played into a Bell System Dataphone, which is connected by private line with the computer centre in Washington, D.C. The signal is modulated on a carrier frequency in the voice range and can thus be monitored as an audible signal. Computer processing provides measurement and interpretation of the electrocardiograms. Results are mailed or teletyped to the hospital. During the conduct of this project, 5,300 electrocardiograms were transmitted for analysis by the system during the period of August, 1965 to February, 1967.

COMPUTER REPORTS.

A control Data Corporation 160-A digital computer was programmed to measure each lead of the 12-lead electrocardiogram and provide a diagnostic interpretation based on these measurements.

In Fig. (19) which shows a computer report on a single normal electrocardiographic tracing, the computer diagnosis appears below the table of wave measurements of each lead. The electrocardiogram on which this report was made is shown in Fig. (20). Fig. (21) is an accurate computer report on the abnormal electrocardiogram shown in Fig. (22). The computer noted the presence of right bundle branch block, identified the pattern of acute

INSTRUMENTATION FIELD STATION HEART DISEASE CONTROL PROGRAM
COMPUTER PROCESSED ELECTROCARDIOGRAM

12

NAME NUMBER 124551 DATE 01-19-67 TIME 09--

DIAGNOSIS MEDS NONE

HEIGHT 70 WEIGHT 196 AGE 41 FEMALE TAPE 0291

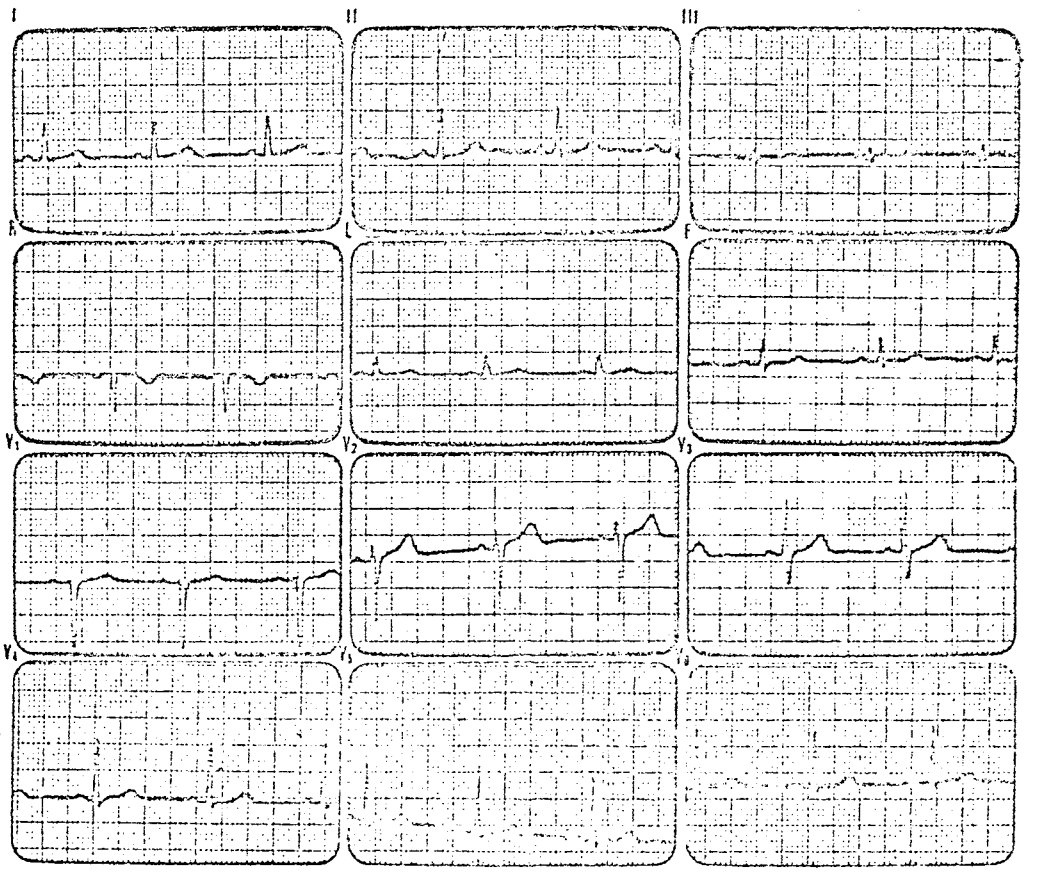
BP NORMAL-SYSTOLIC 139 OR LESS AND DIASTOLIC 89 OR LESS OPTION 000

LEAD	I	II	III	AVR	AVL	AVF	V1	V2	V3	V4	V5	V6	
PA	.08	.10	.03	-.09	.06	.04	.06	.11	.07	.07	.07	.08	PA
PD	.08	.09	.05	.10	.08	.03	.07	.10	.07	.07	.07	.08	PD
P'A	.00	.00	-.03	.00	.00	.00	.00	.00	.00	.00	.00	.00	P'A
P'D	.00	.00	.09	.00	.00	.00	.00	.00	.00	.00	.00	.00	P'D
QA	.00	.00	-.06	.00	.00	.00	.00	.00	.00	.00	.00	.00	QA
QD	.00	.00	.02	.00	.00	.00	.00	.00	.00	.00	.00	.00	QD
RA	.68	.80	.10	.00	.35	.44	.03	.28	.91	1.06	1.08	1.06	RA
RD	.07	.06	.02	.00	.07	.05	.01	.04	.05	.06	.06	.06	RD
SA	.00	-.07	-.12	-.72	.00	-.11	-1.22	-1.05	-.55	-.11	-.11	-.06	SA
SD	.00	.01	.02	.06	.00	.02	.07	.05	.04	.02	.02	.01	SD
ST	.12	.12	.12	.12	.12	.12	.12	.10	.09	.12	.12	.12	ST
STO	-.01	-.02	-.02	.02	.00	-.05	-.02	.01	.01	-.05	-.04	-.02	STO
STM	.01	.01	-.03	-.02	-.01	-.03	.07	.11	.07	-.04	-.03	.01	STM
STE	.03	.04	-.02	-.03	.02	-.03	.07	.16	.09	.00	.00	.04	STE
TA	.16	.20	-.04	-.18	.08	.08	.15	.41	.34	.14	.15	.17	TA
TD								.20	.20				TD
PR	.14	.14	.15	.15	.12	.12	.14	.12	.13	.12	.12	.13	PR
QRS	.07	.07	.06	.06	.07	.07	.08	.09	.09	.08	.08	.07	QRS
QT	.34	.37	.26	.36	.34	.35	.35	.40	.39	.37	.37	.38	QT
RATE	70	66	67	69	69	66	71	64	65	67	67	65	RATE
CODE	2	3	2L	3	3	2	2	3	2	3	3	2	
CAL	97	97	97	97	97	97	97	97	97	97	97	97	CAL

AXIS IN	P	QRS	T	Q	R	S	STO	ST-T	QRS-T
DEGREES	42	34	42		39	-65	-90	132	08

1111 WITHIN NORMAL LIMITS

FIG. 19



HARTFORD HOSPITAL
DEPARTMENT OF MEDICINE EKG SCREENING PROJECT

NAME		AGE 41	LOCATION Hfd. Hosp.	HOSPITAL NUMBER	DATE 1-20-67
PR .14	QRS .07	QT .37	RATE & RHYTHM 66	MEAN QRS AXIS 21°	

DESCRIPTION

INTERPRETATION

Detailed interpretation is on following sheet

Within normal limits

Reviewed by _____ M.D.

ELECTROCARDIOGRAPH REPORT NO. 4552

KH 1304

FIG. 20

INSTRUMENTATION FIELD STATION -- HEART DISEASE CONTROL PROGRAM
COMPUTER PROCESSED ELECTROCARDIOGRAM

12

NAME NUMBER 127350 DATE 11-12-66

DIAGNOSIS MEDS UNKNOWN

HEIGHT WEIGHT AGE MALE TAPE 6

B.P. UNKNOWN OPTION 000

	I	II	III	AVR	AVL	AVF	V1	V2	V3	V4	V5	V6	
PA	.03	.22	.15	.00	.00	.16	.00	.00	.03	-.15	.00	.03	PA
PD	.06	.09	.11	.00	.00	.10	.00	.00	.03	.07	.00	.04	PD
P'A	.00	.00	.00	.00	.00	.00	.00	.00	-.05	.00	.00	.00	P'A
P'D	.00	.00	.00	.00	.00	.00	.00	.00	.07	.00	.00	.00	P'D
RA	.00	,25	.20	.40	.37	.23	.91	.45	.00	.00	.04	.12	RA
RD	.00	.05	.04	.09	.11	.04	.12	.11	.00	.00	.01	.03	RD
SA	-.17	-.78	-.65	.00	.00	-.71	.00	.00	-.29	-.12	-.32	-.30	SA
SD	.08	.09	.09	.00	.00	.10	.00	.00	.07	.05	.09	.08	SD
R'A	.00	.00	.00	.00	.00	.00	.00	.00	.25	.00	.00	.00	R'A
R'D	.00	.00	.00	.00	.00	.00	.00	.00	.08	.00	.00	.00	R'D
ST	.12	.12	.12	.02	.12	.04	.12	.02	.04	.07	.04	.12	ST
STO	.03	-.14	-.18	.01	-.01	-.14	.00	.23	.36	.50	.24	.04	STO
STM	.01	-.08	-.04	.03	-.09	-.11	-.17	.21	.29	.42	.33	.10	STM
STE	.10	.46	.46	.02	-.19	-.09	-.30	.19	.26	.42	.34	.14	STE
TA	.06	.29	.26	-.21	-.19	.25	-.34	-.28	-.21	-.07	.18	-.07	TA
TD				.17		.16		.16	.14	.14	.14		TD
PR	.17	.14	.14	.00	.00	.14	.00	.00	.13	.07	.00	.14	PR
QRS	.08	.14	.16	.09	.11	.14	.12	.11	.15	.05	.10	.11	QRS
QT	.23	.35	.38	.28	.29	.34	.29	.30	.34	.27	.28	.42	QT
RATE	87	90	89	90	89	88	88	105	87	106	89	88	RATE
CODE	C3LA	3C	2	4C	3C	3C	4C	4C	4	A4L	5C	3C	
CAL	201	201	201	201	201	201	201	201	201	201	201	201	CAL

AXIS IN DEGREES	P	QRS	T	Q	R	S	STO	ST-T	QRS-T	ANGLE IN DEGREES
	71	261	69		22	260	-83	152	168	

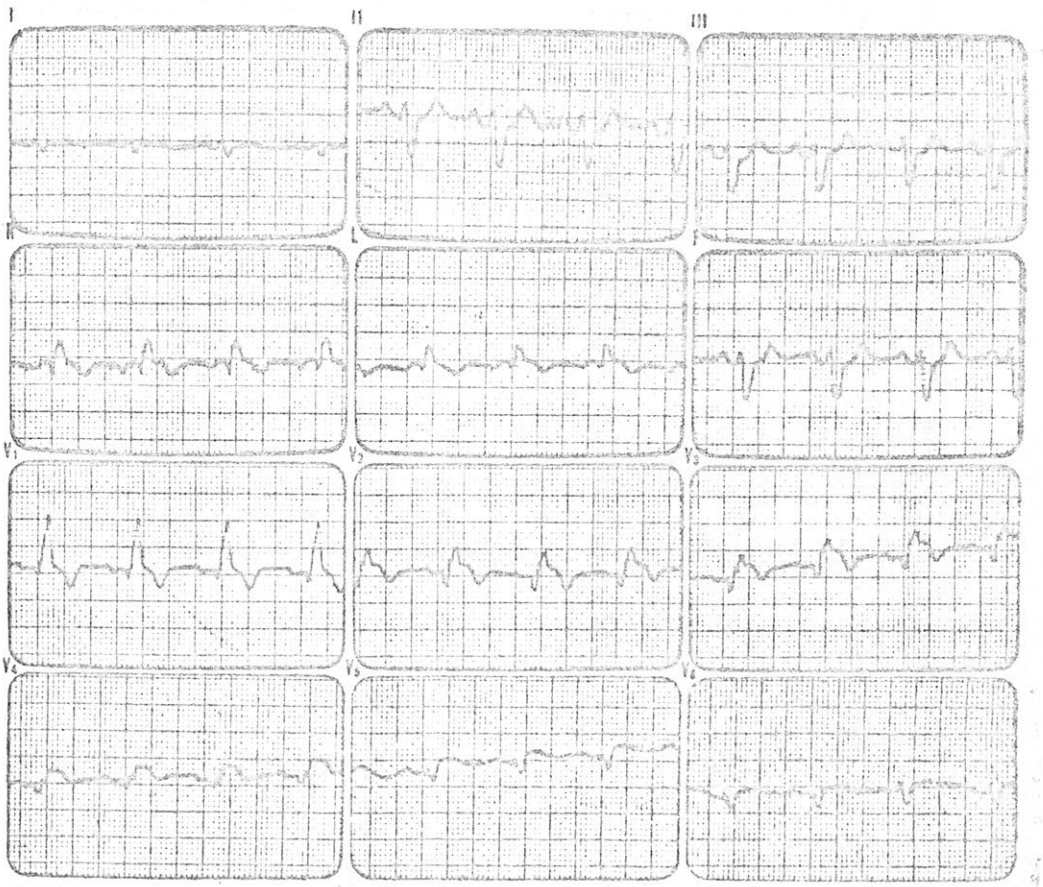
5112 SMALL OR ABSENT R WAVES IN 2 LEADS OF V2-5, AND ST ELEVATION. CONSISTENT WITH ACUTE MYOCARDIAL INFARCTION----ANTERIOR

4421 QRS PROLONGATION OF .12 SEC. TERMINAL FORCES TO THE RIGHT AND ANTERIOR RIGHT BUNDLE BRANCH BLOCK

1121 VENTRICULAR RATE OVER 100 IN 2 OR MORE LEADS: TACHYCARDIA

8321 QRS AXIS WITHIN THE RANGE OF 140 TO 269: MARKED RIGHT AXIS DEVIATION

FIG. 21.



HARTFORD HOSPITAL
DEPARTMENT OF MEDICINE EKG SCREENING PROJECT

NAME		AGE 77	LOCATION Hfd. Hosp.	HOSPITAL NUMBER	DATE 11-10-66
PR .24	QRS .18	QT .38	RATE & RHYTHM 89	MEAN QRS AXIS 261°	

DESCRIPTION: Small or absent R waves in 2 leads of V2-V5, and ST elevation. Consistent with acute myocardial infarction——anterior

INTERPRETATION: QRS prolongation of .12 sec. terminal forces to the right and anterior
Right bundle branch block

Ventricular rate over 100 in 2 or more leads: Tachycardia

QRS axis within the range of 110 to 269; Marked right axis deviation

Detailed interpretation is on following sheet

Reviewed by _____ M.D.

HH 1066

ELECTROCARDIOGRAPH REPORT NO. 7350

FIG. 22.

anterior myocardial infarction and also noted tachycardia and an abnormal mean QRS axis of 261°.

To assess the total error within the computer diagnostic system, for the purpose of correction of the system, computer electrocardiographic reports at the Hartford Hospital have been compared with physician interpretation of the same tracings. The physicians and the computer each interpreted the tracings utilizing the specific criteria of the Medical Systems Development Laboratory.(79) Results of this analysis are currently being used to improve and modify the computer diagnostic programme. In the present study 400 electrocardiograms were read independently by the computer and by one of two Hartford Hospital physicians. Then the two physicians, together reviewed both their initial reading and the computer report and reached a final "standard" diagnosis. The computer diagnosis was then compared with this "standard". It would have been of interest to study the variation in observations between the two physician readers; however, this was not examined in the present study.

Observer Variability and error has previously been shown to be a significant factor, indicating to us that physician observations may be an imperfect yardstick by which to measure computer accuracy.(80,81) The method employed in this study was designed to reduce the factor of human observer variability to a minimum by requiring consultation between two physicians and review of the computer report in establishing the final "standard" diagnosis.

This study does not permit a truly valid comparison of diagnostic accuracy between computer interpretation and individual observer interpretation, that is, without consultation. What is involved is really a

test of agreement on quantitative criteria for the various electrocardiographic abnormalities. If the "standard" diagnosis agreed with the computer it was judged that the computer had been accurate in its performance. Of course, in a given case both the computer and the physicians utilizing "consultation" could be wrong. No attempt was made to validate the electrocardiographic diagnoses utilizing other independent information such as hospital records, chest roentgenograms, autopsy protocols. An expanded investigation of this sort would be a logical extension of the present study. The investigators initially wished to determine the ability of the computer to accept electrocardiographic signals and report out diagnoses utilizing previously agreed upon criteria.

Four hundred consective computer electrocardiogram reports were analyzed. Thirty-four electrocardiograms were designated technically unsatisfactory because four (4) or more of twelve (12) leads were not measured by computer. This was most often caused by arrhythemia, excessive base-line drift, or patient artifact. Three hundred and sixty-six (366) remaining electrocardiograms were subjected to further analysis.

RESULTS

Computer vs. Standard Diagnoses.

Most computer reports contain from one to six diagnostic statements on each electrocardiogram. If all the computer diagnosis agreed with the standard diagnosis "final complete agreement" was noted (Table 4). This occurred in 71% of the tracings. If a single major diagnostic discrepancy was found, the computer report was deemed "unacceptable." This occurred in 11% of the tracings. A minor diagnostic discrepancy that altered the over-all sense of the report was deemed to make it "Unacceptable." This

	No.	%
Final complete agreement	261	71
Minor disagreement, report acceptable	51	14
Total acceptable reports	312	85
Minor disagreement, report unacceptable	14	4
Major disagreement, report unacceptable	40	11

TABLE 4.

Computer vs. "Standard" Electrocardiographic findings in 366 Cases+

+Consecutive computer-read electrocardiograms = 400; incomplete data or technically unsatisfactory electrocardiograms = 34; remainder for evaluation = 366.

occurred in 4% of the tracings. Reports with minor disagreemnt which were considered acceptable were found in 14% of the tracings. Thus, in total, 85% of the reports were acceptable.

Accuracy of Individual Diagnoses

The 366 technically satisfactory electrocardiograms included 611 "standard" diagnostic statements. The computer performance in each diagnostic category was determined. Table 5a shows computer accuracy in diagnosing "major" electrocardiographic abnormalities (defined as Ischemia, Infarction, Hypertrophy, Conduction Defects, or moderate to marked S-T, Segment Deviation). The computer correctly identified 12 of 15 instances of diaphragmatic Myocardial Infarction, 61 to 68 instances of Left Ventricular Hypertrophy, 4 of 4 Right Bundle Branch Blocks, 3 of 4 Left Bundle Branch Blocks, and 19 of 23 moderate to marked S-T Segment Elevations.

The sensitivity, that is, the computer's ability to label major abnormalities correctly when present was 91% (177/194). This was achieved at the expense of some "over-reading". For example, the computer falsely designated 14 instances of Diaphragmatic Myocardial Infarction and 11 instances of Right Bundle Branch Block. These errors were found to be due to oversensitive criteria or to specific and correctable "bugs" within the computer diagnostic programme. Review of tracings by physician readers failed to reveal Q waves of sufficient magnitude to justify a computer diagnosis of Diaphragmatic Myocardial Infarction in 14 instances. Since computer measurement frequently identifies waves as wider than observed by human observation, an adjustment in criteria for wave duration was found

	Standard Diagnoses (no.)	Computer and Standard Agree	False Positive by Computer	False Negative by Computer	Semantic Preference by Standard
Anterior myocardial infarction	35	31	3	4	15
Diaphragmatic myocardial infarction	15	12	14	3	
Ischemic T waves	21	20	2	1	
Wide QRS-T angle, ischemia or "strain"	18	16	1	2	7
Left ventricular hypertrophy	68	67	0	1	
Right ventricular hypertrophy	3	2	0	1	
Right bundle branch block	4	4	11	0	
Left bundle branch block	4	3	0	1	
S-T segment deviation, moderate to marked	23	19	9	4	7
Intraventricular conduction defect	3	3	0	0	
Total	194	177	40	17	29

TABLE 5A

Major Electrocardiographic Diagnoses - Computer Findings.

necessary to correct this over-reading.

Table 5b summarizes the distribution of minor electrocardiographic diagnoses according to the standard and the computer performance. Tachycardia, Premature Systoles and first degree A-V Block were accurately identified by the computer. The false-negative column shows a tendency for the computer to faile to note Bradycardia. This failure was due to a simple programming error and has been corrected. The P wave problem is currenty under study. QRS Axis, Junctional S-T Depressions and nondiagnostic T Wave changes were accurately identified. There was a tendency to over-read minor S-T Depressions.

Computer Separation of Abnormal from Normal Tracings.

The computer's ability to identify tracings as normal or abnormal is examined in Table 6. The computer identified all 253 standard abnormal tracings as abnormal and 92 of 113 standard normal tracings as normal. There was not a single false normal reading by computer. There were 21 false abnormal readings according to the "standard."

At the Mayo Clinic a system for transmission of electrocardiograms from the heart station to an electrocardiogram processing console elsewhere in the same building has been in operation. Console tape records the signal which is later analyzed by a computer as an aid to physician interpretations.

Computer Diagnostic Accuracy in this study is summarized in Table 7. The computer accurately designated 87% of minor diagnoses. 81% of normal tracings were correctly identified. Of all 611 standard diagnoses, 87% were correctly identified by the computer.

	Standard Diagnoses —(no.)—		Computer —Agrees—		False Positive by Computer		False Negative by Computer	
Rate	*64*		*51*		*0*		*13*	
Bradycardia		29		16		0		13
Tachycardia		35		35		0		0
Arrhythmia present	*26*		*21*		*1*		*5*	
Premature beats or atrial fibrillation		17		16		1		1
Premature ventricular contractions		9		5		0		4
P-R interval	*33*		*31*		*4*		*2*	
Short P-R		14		13		2		1
First degree A-V block		19		18		2		1
P wave abnormality	*11*		*9*		*22*		*2*	
P mitrale or pulmonale		3		3		12		0
Abnormal atrial focus or nodal rhythm		6		4		7		2
Left atrial abnormality		2		2		3		0
Q-T prolongation	*10*		*7*		*1*		*3*	
QRS axis	*65*		*60*		*7*		*5*	
Right axis deviation		7		6		3		1
Left axis deviation		49		46		2		3
$S_1S_2S_3$		7		7		1		0
Parietal or peri-infarction block		2		1		1		1
Low voltage	*3*		*3*		*0*		*0*	
Junctional S-T depression	*24*		*24*		*4*		*0*	
Minor S-T depression	*14*		*11*		*9*		*3*	
Minor S-T elevation	*3*		*3*		*1*		*0*	
QRS-T angle wide (nondiagnostic)	*12*		*10*		*3*		*2*	
Nondiagnostic T abnormality	*35*		*31*		*5*		*4*	
Tall precordial T waves	*4*		*3*		*0*		*1*	
Totals	*304*		*264*		*57*		*40*	

Figures in italics indicate subtotals.

TABLE 5B.

Minor Electrocardiographic Diagnoses - Computer Reading.

	No. of Electro-cardio-grams	Computer Normal	Com-puter Ab-normal
Standard normal	113	92	21
Standard abnormal	253	0	253

TABLE 6.

Table 6. Computer separation of Electrocardiograms into normal and abnormal.

	Standard Diagnoses (no.)	Computer Agrees —with Standard— (no.)	(%)	False Negative —by Computer— (no.)	(%)	False Positive by Computer (no.)
Major diagnoses	194	177	91	17	9	40
Minor diagnosis	304	264	87	40	13	57
Normal	113	92	81	21	19	0
Total	611	533	87	78	13	97

TABLE 7.

Table 7 - Summary of Electrocardiogram Diagnoses - Computer Reading.

Accuracy of Physician Reading Compared to Standard Diagnosis

Since the standard diagnoses referred to in the foregoing studies were determined by physicians reviewing both their initial electrocardiographic interpretation and the computer report, it was possible to compare the initial unassisted physician reading of the electrocardiograms to the standard diagnoses. This was of interest as it provided one measure of the usefulness of computer reports in aiding and correcting physician interpretation.

The Physician Reading of major Electrocardiographic diagnoses is compared with standard diagnoses in Table 8. Physicians agreed with 79% (154/195) of standard diagnoses. In one instance, the physicians had initially determined criteria for Anterior Myocardial Infarction, but measurements were within normal limits on the computer report. The standard (review of physician and computer report) determined that the physicain was initially wrong because of inaccurate measurement of Q Waves and R Waves. This, this is listed as a false positive by the physician.

There were 40 major diagnoses missed by physician readers. These are designated as false negatives by the physician. In each instance, the physician had to agree that the computer report was correct. However, in 10 cases which the computer interpreted as Anterior Myocardial Infarction and 7 cases which it interpreted as Left Ventricular Hypertrophy, the physician believed that the wave abnormality was so borderline that he would have preferred not to make these interpretations. In other words, the computer criteria for these abnormalities were considered to be too sensitive. Since criteria were previously agreed upon and used uniformly throughout the study, this semantic preference for a criteria change was

	Standard Diagnoses (no.)	Physician and Standard Agree	False Positive by Physician	False Negative by Physician
Anterior myocardial infarction	35	25	1	10 (S)
Diaphragmatic myocardial infarction	15	14	0	1
Ischemic T waves	21	21	0	0
Wide QRS-T angle, ischemia or strain	18	11	0	7 (S)
Left ventricular hypertrophy	68	50	0	18
Right ventricular hypertrophy	3	2	0	1
Right bundle branch block	4	4	0	0
Left bundle branch block	4	4	0	0
S-T segment deviation, moderate to marked	23	21	0	2
Intraventricular conduction defect	3	2	0	1
Total	194	154	1	40

TABLE 8.

Table 8 - Major Electrocardiographic Diagnosis - Physician Reading.

indicated by a letter (S) in the appropriate column in the tables, but the physician diagnoses were still listed as false negative.

The distribution of minor electrocardiographic diagnoses by physician readers is given in Table 9. There were 91 false negative diagnoses. In each instance, the physician initially failed to note a diagnosis, and the correct diagnosis was provided by review of the computer report. This was largely dependent upon accurate computer measurement of heart rate, P-R intervals and QRS axis. Physicians over-read four instances of non-diagnostic T Wave Abnormalities.

EVALUATION OF OBSERVED RESULTS.

The present study suggests that computer agreement with standard electrocardiographic interpretation is greater than physician agreement. However, physician and computer did not make the same kind of "errors." The computer tends to over-read by clinical standards, whereas the physician is more prone to errors of omission.

It is evident that the two together are better than either alone. Physicians utilizing computer electrocardiographic reports in preparing final interpretations can provide precise consistent diagnosis. This evaluation also suggests that computer electrocardiographic reports are excellent for screening abnormal electrocardiograms.

A high degree of accuracy was noted in individual diagnostic categories. 87% of all diagnosis were in agreement with "standard" interpretation. The system can provide a useful aid to physician reading of the electrocardiogram. Improvement in criteria and certain programme corrections based on this and other evaluations should result in even more accurate and useful reports. However, it is important to note that whatever

	Standard Diagnoses (no.)		Physician Agrees		False Positive by Physician		False Negative by Physician	
Rate	*64*		*52*		*0*		*12*	
Bradycardia		29		25		0		4
Tachycardia		35		27		0		8
Arrhythmia Present	*26*		*26*		*0*		*0*	
Premature beats or atrial fibrillation		17		17		0		0
Premature ventricular contractions		9		9		0		0
P-R interval	*33*		*17*		*0*		*16*	
Short P-R		14		5		0		9
First degree A-V block		19		12		0		7
P wave abnormality	*11*		*8*		*0*		*3*	
P mitrale or pulmonale		3		2		0		1
Abnormal atrial focus or nodal rhythm		6		4		0		2
Left atrial abnormality		2		2		0		0
Q-T prolongation	*10*		*1*		*0*		*9*	
QRS axis	*65*		*54*		*0*		*11*	
Right axis deviation		7		5		0		2
Left axis deviation		49		43		0		6
$S_1S_2S_3$		7		5		0		2
Parietal or peri-infarction block		2		1		0		1
Low voltage	*3*		*1*		*0*		*2*	
Junctional S-T depression	*24*		*6*		*0*		*18*	
Minor S-T depression	*14*		*8*		*0*		*6*	
Minor S-T elevation	*3*		*2*		*0*		*1*	
QRS-T angle wide (nondiagnostic)	*12*		*9*		*0*		*3*	
Nondiagnostic T abnormality	*35*		*27*		*4*		*8*	
Tall precordial T waves	*4*		*2*		*0*		*2*	
Totals	*304*		*213*		*4*		*91*	

Figures in italics indicate subtotals.

TABLE 9.

Table 9. Minor Electrocardiographic Diagnoses - Physician Reading.

diagnosis the computer makes, final physician review of all abnormal reports is mandatory prior to clinical use.

Clinical Application

The computer does not eliminate the physician's responsibility to be knowledgeable of all data pertinent to the patient. Accurate machine determination of P-R, QRS, Q-T and rate relieve the physician of the burden of measurement. Although the physician does not ordinarily make these determinations in every lead as the computer does, he usually measures and notes any abnormal QRS pattern, S-T or T Wave Abnormality when he encounters an abnormal tracing. He also takes the time to write out his final interpretation. This need not be done when the computer report is available, as all of the measurements and all of the diagnoses are already printed. If the physician is in agreement with the diagnosis he can merely place a check next to the computer statement. If he wishes to amend the report he can easily delete or add to the printed diagnostic statement. Computer diagnoses can thus be reviewed and approved or amended with great speed.

In an effort to determine the time-saving factor in computer use, 300 serial electrocardiograms were read by a physician with the computer reports in front of him. The average time spent per electrocardiogram was 32 seconds. Three weeks later these same 300 serial electrocardiograms were read by the same physician without the computer report. The average time spent per electrocardiogram was 2 minutes, 27 seconds. There was approximately a five-fold reduction in physician review time per electrocardiogram utilizing computer reports.

Advantages of this automated system are numerous. Resident and

hospital staff electrocardiographic teaching can be aided by providing consistent guidelines for interpretation.

The data permit a precise quantitative approach to learning electrocardiography, supplementing the qualitative pattern recognition methods.

16. AN OFF-LINE SYSTEM FOR E.C.G. DIAGNOSIS BY DIGITAL COMPUTERS STUDY NO. 2.

Recent development in technology of computer, analog-digital conversion units, and the tape recorder has made broader studies of automatic diagnosis of electrocardiograms possible (30)

This section considers an off-line system, using the magnetic tape recorded electrocardiograms from patients in hospital, to be applied in medical centres which cannot afford a computer for exclusive use. The E.C.G. is illustrated as part of multi-phase screening on admission in units which otherwise could not afford facilities to carry out this routine procedure. The efficiency of the computer is again illustrated.

METHOD

As the samples, 402 ECG recordings of normal, 230 recordings with Left Ventricular Hypertrophy (LVH), 369 recordings with Right Ventricular Hypertrophy (RVH), 143 recordings with combined Ventricular Hypertrophy (CVH), 113 recordings with Myocardial Infarction, 91 recordings with Right Bundle Branch Block (RBB) and 44 recordings with Left Bundle Branch Block (LBBB) 1392 in total were used. These diagnosis were made on the basis of clinical findings or laboratory examination such as Chest X-ray Film, conventional 12 lead electrocardiograms, phono-cardiograms, blood chemistry, right heart catheterization, and operation and autospy notes in a part of them.

The Analog-data was then converted into a digital form, using an analog-to-digital converter (DATAC) and then on a HITAC 5020 digital computer.

To classify electrocardiograms into several categories, namely, to make computer diagnosis of electrocardiograms, a logical decision tree method on the basis of the joint probability was adopted, details of which are illustrated in Fig. 23.

AUTOMATIC INTERPRETATION OF ECGs.

The diagnostic accuracy of the automatic interpretation used was 92.2% in normal, 82.5 in LVH, 75.6 in RVH, 61.3 in CVH, 95.0 in infarction, 100.0 in bundle branch block and 86.9% of 1392 ECGs in total.

Low accuracy was recognized in diagnosis of RVH and CVH, compared with those of the other groups.

The time consumed in diagnosis was 15 second per one patient, ECG, using a HITAC 5020 digital computer.

Two examples of computer diagnosis are shown in Fig (24 and Fig. (25).

Diagnosis of ECGs by computer was compared with that by physician. More than 80% of computer diagnosis were identical with physician's diagnosis. Especially, consistency between computer diagnosis and physician's was observed in more than 90% of ECGs with infarction and normal ECGs.

However, consistency of CVH was poor, compared with the others. This fact suggests the difficulty in diagnosis of CVH as previously reported.

"Advantage of the computer diagnosis is to make instantaneous and exact diagnosis possible. The inter-or intra-observer variation in diagnosis may be solved by computer diagnosis with the good reproducibility and quantitativeness. ."(30)

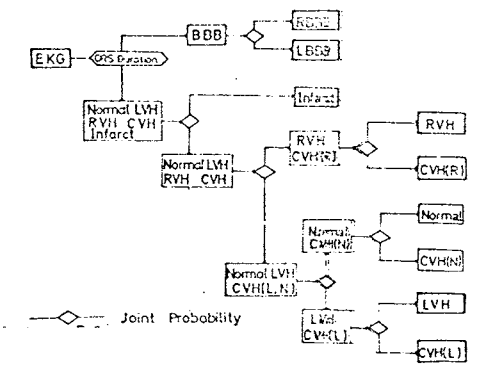


FIG. 23.

Fig. 23. Decision Tree system for the ECG pattern classification. Each step of the discrimination was made according to the difference between the joint probabilities for its diagnostic categories.

Measurements.

PD	11	PQD	170	QRSD	85	QTD	410							
ST (X,Y,Z)			−0.03	0.01	0.01			T (X,Y,Z)		0.42	−0.37	0.53		
Q (A,D,PT)			X	−0.13	21	19	Y	0.00	00	00	Z	0.00	00	00
R ( )				1.60	43	43		0.26	19	11		0.09	29	13
S ( )				−0.05	19	67		1.95	56	43		0.22	35	48
R′ ( )				0.00	00	00		0.00	00	00		0.00	00	00
Interpretation														
A ( )			0.00047		0.00042		0.00349		0.07691					
			INF 4		Grade 2									
Suspicion of Infarction														
R ( )			0.00043		0.00271		0.0018		0.06137					
L ( )			0.00030		0.06976									
C ( )			0.00004		0.02913		0.00064							
Normal														

Fig. 24 An example of the print-out of the automatic interpretation of the ECG by computer.
No: Identification number of the case.
QRSD: Duration of the QRS complex.
QTD: Duration of the QT interval.
AL ( ): The 30 measurements.
A ( ), R ( ), L ( ), C ( ): The joint probabilities for infarction, RVH, LVH, and CVH.
Final diagnosis by computer was normal in this case, and identical with that of physicians.
A·····Amplitude (mV)
D·····Duration (msec)
PT·····Time from the beginning of QRS complex to the peak of the wave

No. 33

Measurement

PD	81	PQD	162	QRSD	101	QTD	399							
ST (X,Y,Z)		−0.04	−0.03	0.18		T (X,Y,Z)		−0.11	0.11	0.33				
Q (A,D,T)		X	−0.03	13	3	Y	0.00	00	00		Z	0.00	00	00
R ( )			0.98	59	53		0.43	32	19			0.13	16	11
S ( )			−0.42	21	77		−2.01	59	66			−2.00	69	45

Interpretation

A ( )	0.00965	0.03768	0.00300	0.04850
	INF 2	Grade 1		
	4	1		

Infarction

FIG. 25.

Fig. 25. - An example of the print-out of the computer diagnosis. In this case, the computer diagnosis was made to be an infarction, and consistent with autopsy finding.

17. ECG SCANNING USING 12 LEADS OR 6 LEADS.

Two thousand ECGs were randomly selected from the files of the Cardio-Pulmonary Station, Naval Hospital, Philadelphia. The population sample included active duty and retired military personnel, their depeds, service academy and civil service applicants, and veteran patients. All records were interpreted by one cardiologist without knowledge of prior 12-lead interpretations. The patient's age, sex, height, weights, and blood presssure were available. The six standard leads (I, II, & III aVr, aVL & aVF) were classified as normal or abnormal using criteria given in standard reference texts.(31, 32) Following analysis of these leads, the 12-lead ECG was re-analyzed without benefit of six-lead interpretation. Any discrepancies between six and 12-lead ECG interpretations were recorded.

RESULTS.

Sixteen hundred and forty-eight subjects were men; 353 were women. 71% (1,433) were between 40 and 70 years of age. Twelve hundred and sixteen (60.8%) were normal when both 6 and 12-leads were analyzed and 730 (36.5%) were abnormal. Twenty-eight (2.25%) false-positives and 26 (3.44%) false-negatives were found. The specificity of the method was 97.75%, the sensitivity 96.56%. Seven hundred and fifty-six abnormal tracings occurred in the study. Detailed data are presented in Table. 10.

Significant undetected abnormalities included seven tracings compatible with Left Ventricular Hypertrophy and six with probable old Myocardial Infarction. Eighty-three tracings compatible with Anterior Myocardial Infarctions were found in the entire study when 12-lead ECGs were available. No Inferior or Active Myocardial Infarctions were overlooked when standard leads were analyzed. Forty-one of 83 tracings compatible with anterior

6 Leads	12 Leads	Category	No.	(% of Total
Normal	Normal	Normal	1,216	(60.8)
Abnormal	Abnormal	Abnormal	730	(36.5)
Abnormal	Normal	False-positive		
		ST segment abnormality	8	
		Suspicious qR complex in III	5	
		P-wave abnormality	8	
		Early repolarization	3	
		S1, S2, S3 as RBBB	2	
		S2, S3, as LAD	2	
		Subtotal	28	(1.4)
Normal	Abnormal	False-negative		
		Anterior myocardial infarction	6	
		Left ventricular hypertrophy	7	
		Right bundle branch block	5	
		Anteriorly directed T-vector	7	
		Left atrial hypertrophy	1	
		Subtotal	26	(1.3)
		Total	2,000	(100)

TABLE 10.

Table 10 - Screening results from 2,000 Electrocardiograms comparing standard (6) and standard and precordial (12) leads.

Infarction shows abnormal left Axis deviation. T-Wave Inversion in lead I was seen in 25, and 14 had a combination of both abnormalities.

COMMENT.

The clinical usefulness of the ECG in detection of unsuspected heart disease has been emphsized in recent years. While the correlation between clinical data and ECG findings is often poor, the presence of abnormality in the ECG of an asymptomatic individual may be the only clue to potentially significant heart disease; (34, 35 & 36) (37, 38) 3% to 6% of asymptomatic males under 40 years of age have demonstrable 12-lead ECG abnormalities. (39, 40 & 41) An estimated threefold increase in 12-lead ECG abnormalities exists from available surveys of older populations. (42, 43 & 44). A 28% incidence of abnormality has recently been reported. (45) Comparable data with only standard-lead analysis are negligible. (45) Cooper et al have cited a computer survey of 9,660 ECGs and noted 35% incidence of detectable abnormality when standard leads were analyzed: 45% had abnormalities when 12-leads were used. The populations studied in this series more closely parallels a random sampling than the usual hospital population. The difference in observed false-negative were expected; the false-positives probably represented errors in ECG interpretations.

Analysis of standard-lead ECGs as a screening procedure permits more rapid data acquisition, minimal patient inconvenience and less physician interpretation time. The comparison of the value of 6 and 12-lead ECG interpretation is still being assessed. If a high degree of correlation is obtained this method of screening would be more economical, rapid and accurate. However, further investigation is necessary, before 6-lead Electrogardiographs will be accepted.

18. CHEST X-RAY.

Selective mass screening can be considered as being introduced with the advent of World War II, 1939. On enlistment in the armed forces chest X-Ray was carried out in some countries as a routine procedure. The statistics of these X-Rays have not been published in any of the standard journals.

Now 30 years later, in Australia, it is compulsory for adults to have a yearly chest X-Ray. Non-compliance can be punished by law. There has been a resultant dramatic influence on the incidence of Tuberculosis, and the early detection of asymptomatic lung and Cardiac Disease has shown the value of preventive medicine in mass surveys.

Routine chest X-Rays are usually carried out in Australia on admission to all State and Commonwealth Hospitals, even in individuals who have had a chest X-Ray in the last 12 months. Chest X-Rays in Private Hospitals are mainly selective being generally restricted to those on whom a chest X-Ray is part of a diagnostic investigation.

19. MASS RADIOLOGY IN ENGLAND.

Mass Miniature Radiography was introduced in England in 1943, a special 35 m.m. film was used in an apparatus especially designed for the purpose, as a result of the recommendation of the Joint Tuberculosis Council. The object was the detection of persons in the general community with suspected Pulmonary Tuberculosis, particularly in workers and entrants into employment, especially in factories where numbers were greatly increased by the needs of the war. The committee advised that the examination should be repeated at intervals.

"It was found by Thompson in investigating the volunteers undergoing mass-radiography examinations that in the first general public survey in England in 1944, that of those patients discovered with active Pulmonary T.B. needing treatment 50% admitted, on questionning, to symptoms of cough, lassitude or chest pain. An interesting observation is that only 14% had consulted their family doctor with symptoms."(46)

In the subsequent five years, approximately 3 million persons were examined, with an incidence of 3.8 per 1,000 with active Tuberculosis and a further 5.0 per 1,000 requiring supervision for quiescent or doubtfully active lesions. These may be compared with recent (Ministry of Health, Report of Chief Medical Officer on the state of the Public Health, 1960; 1961; 1962;) - Table 11, figures.

In addition to finding Tuberculosis, Mass Miniature Radiography has had no small measure of success in discovering other unsuspected diseases, such as congenital and acquired disorders of the heart, Sarcoidosis, malignant disease and Pneumoconiosis. The Chief Medical Officer to the Ministry of Health draws attention to this in the report quoted above. In 1961 malignant Neoplasms were diagnosed in 2,677 persons, congenital cardiac abnormality in 452, acquired cardiac abnormality in 8,411 and Pneumoconiosis in 2,494 persons. Its contribution to the health services of the nation as a whole and to the control of Tuberculosis in particular, has thus been substantial.

In East Anglia a relatively high incidence of congenital heart lesions in children was found. Chest X-Rays in North Staffordshire showed a high incidence of Pneumoconiosis in some industries. Repeated X-Rays at

	Persons Examined	*Tuberculosis requiring active treatment or close supervision*	*Tuberculosis requiring occasional supervision*	*Combined rate*
1959	3,581,070	1·8	2·3	4·0
1960	3,131,810	1·6	1·9	3·5
1961	3,179,280	1·4	1·9	3·3

TABLE II

Table II - Rate of Detection of Tuberculosis per 1000 examined during 1959-61 in England and Wales. (Ministry of Health - Report of Chief Medical Officer. 1960; 1961; 1962.)

six-monthly intervals for men aged 45 or over, in the hope of finding Bronchial Carcinoma at an early stage, is a matter of great interest and still the subject of research.

The T.B. Council in England considered there were two main objects of a chest radiology service.

1) The diagnostic X-Ray service primarily concerned with problems of chest illness in sick patients, provided by general hospital or chest clinic X-Ray departments.

2) The mass radiography service which operates in a special field distinct from the examination of hospital patients and has different aims and methods. Yet the division is not complete, for certain groups of the population can appropriately be examined by either organisation.

However there is a third group - all patients (adult?) admitted to hospital as part of the concept of multiple investigation on admission.

20. DUAL READING IN MASS RADIOGRAPHY

There is now a considerable amount of literature on the subject of observer error in the interpretation of chest X-Rays and on the value of dual reading in reducing this error.(48) This is of particular importance in mass miniature radiography, where large number of X-Rays are viewed in rapid succession. Early investigators suggested that a single observer might miss on an average 25-35% of abnormal lung shadows and this error may be reduced to between 6 and 7% by a second and independent reading of the film. Later investigators found that there was an error of 10% for a

single observer which was reduced to 2% by dual reading and concluded that "dual reading is essential in radiographic surveys." The conclusion reached was that the yield of active Tuberculosis might be raised by 5-7%

RESULTS OF 10,000 EXAMINATIONS.

Recall Rate - 576 were recalled for examination on full-sized film. Of these, Reader A recalled 421 and Reader B 429, the average figure being 424.5; the recall rate for dual reading was approximately 35% higher than for single reading. Cardiac abnormalities were excluded from the experimeht.

Radiological Analysis of the Recalls. - In order that the results of the trial could be compared with those of other workers, the recall films were first analysed radiologically and placed in 3 categories.

Significant.

Non-Significant

Normal

A radiologically significant shadow was one considered to require further investigation clinically and this category included both inflammatory and non-inflammatory lesions. The non-significant group included calcified tuberculous lesions, congenital bony anomalies etc.

Table 12 shows this initial analysis and compares the performances of the individual observers with their combined efforts.

Table 13 shows how the addition of the second reader improved the average yield of radiologically significant shadows, but also how it increased greatly the figures for recalls proving normal or non-significant.

The clinical Advantage of the Second Reader The results so far have been expressed purely in terms of X-Ray findings. In order to assess the true value of dual reading it was necessary to know how many of the extra

Assessment of recall film	No. recalled			Percentage of total recalled		
	Dual reading	Reader A	Reader B	Reader A	Reader B	Average of A and B
Significant ..	108	99	93	92	86	89
Non-significant ..	225	192	165	86	72	79
Normal	243	130	171	53	70	62
Total ..	576	421	429	73	74	74

TABLE 12.

Table 12. Radiological assessment of recall films and the number of recalls by each reader.

Assessment of recall film	Average no. of recalls by a single observer	Average no. of recalls added by second observer	Percentage increase
Significant shadows ..	96	12	12
Normal and non-significant	329	137·5	42
Normal	150·5	92·5	61

TABLE 13.

Table 13. Effect of a second reader on the yield of radiologically significant shadows and number of recalls.

shadows detected by the second reader were clinically significant.

Of the 108 shadows referred for further clinical study, 9 were missed by Reader A and 15 by Reader B. These 24 cases were followed up from records approximately twelve months after detection. Table 14 shows the results of the investigation.

Table 15 shows for comparison the results of followup in the remaining 84 cases detected by both the readers.

21. EARLY DIAGNOSIS OF LUNG CANCER.

Bronchial Carcinoma is the commonest type of cancer in men in Britain. Moreover, it is one of the most fatal. In 1966 it caused 39% of all deaths in men that were attributable to cancer and 8% of all deaths in men from all causes (49).

Investigators have made several surveys to discover if the mortality from Bronchial Carcinoma can be reduced by diagnosing cases before the onset of symptoms.

In the reported series the proportion of cancers that can be resected and the survival rate are both higher when the diagnosis is made by X-Ray in the absence of symptoms than when the patient has been referred for investigation because symptoms are present. E. Posner, et al (50) for example, found that the resectability rate was increased from 33% to 47% and that in those patients in whom the tumour could be resected the two-year survival rate was increased from 37% to 46%.

It is dangerous, however to interpret these and other similar results at their face value, for the cases that are picked up by mass radiography in the absence of symptoms will include a disproportionate number in which the cancers are slow-growing. The slower the growth, the greater

Diagnosis	*No.*	*Follow-up study*
Tuberculous lesions*	15	'Active', requiring treatment
	18	Still under observation at twelve months without treatment
	17	Discharged as 'inactive' by twelve months
Malignant tumours ..	3	Excised
	1	Treated by radiotherapy
	3	Unsuitable for any form of treatment
Benign tumours ..	1	A retrosternal thyroid removed on account of symptoms
	1	Lung cyst – no treatment required
Pneumonia ..	2	Required active treatment
Bronchiectasis ..	14	Required no further action
Hiatus hernia ..	2	
Pneumoconiosis ..	2	

*5 patients presumed tuberculous, possibly 'active', were lost sight of.

TABLE 15.

Table 15 - One-year follow-up of patients referred for further investigation after being detected by both readers.

Diagnosis	*No.*	*Follow-up study*
Tuberculous lesions*	1	Doubtfully 'active'. Chemotherapy given as a precautionary measure
	6	No evidence of 'activity'. Leading normal lives. No treatment. Still under observation after twelve months
	8	All discharged as 'inactive' by nine months after referral. Required no treatment
Bronchial carcinoma	1	Hepatic secondaries. Symptomatic treatment only
Bronchiectasis ..	1	Bilateral, symptoms mild, fully investigated previously. No treatment required
Aspiration pneumonia	1	No symptoms. Cleared up without treatment
Hiatus hernia ..	1	All were symptom free and required no treatment
Substernal thyroid ..	2	
Basal air cyst ..	1	

*2 patients, aged 66 and 69, were lost sight of. Both radiographically had small tuberculous lesions but it was extremely doubtful whether they were 'active'.

TABLE 14.

Table 14 One-year follow-up of patients referred for further investigation after being missed by one or other of the readers.

the chance that the tumour will be recognizable radiographically at a given moment and this fact alone may be sufficient to account for the apparently good results

The resectability rate was higher in groups X-Rayed every six months than in the others and was higher when the tumour was detected during the six-monthly surveys (64%) than those X-Rayed at 3 yearly intervals (51%).

These results provide some modest encouragement for the belief that the widespread use of mass radiography may help to reduce the overall mortality from the disease. Prevention remains the best policy, but in its absence it is estimated that 1,000 five-year survivors above the normal 1,400 might be obtained if men aged 55 years and over who smoked 15 or more cigarettes a day were X-Rayed at six-monthly intervals.

22. SPIROMETORY

The use of the Spirometer is becoming universally accepted as essential in the diagnosis of respiratory disease. It is the simplest means of measuring respiratory function, takes little time and is harmless. It can be easily performed and is remarkably inexpensive. As yet, research in its use in mass or selected surveys, is only beginning.

Chronic respiratory disease has become a major public health problem afflicting an estimated 15,000,000 people in the United States. Specific diagnosis such as "Chronic Bronchitis," "Pulmonary Emphysema" and "Bronchial Asthma" comprise the great majority of chest disease. In 1959, there was a 158% increase over 1954 in the number of deaths reported from pulmonary Emphysema and a 44% increase from Bronchitis. In 1962, 70,000 deaths were attributed to chronic respiratory diseases. (51)

Detection of persons who have a mild obstructive ventilatory syndrome should lead them to earlier treatment. This might delay or prevent the progression of the illness to the stages of disability and death. Also, early diagnosis of these diseases should lead to a better understanding of their prevalence and natural history.

The great majority of chronic respiratory diseases manifest increased resistance to the flow of air from the lungs. Fortunately increased airway resistance produces characteristic slowing of the flow rates of expired air which may be measured on a spirometer. There is definite evidence that mass ventilatory screening is feasible for persons over 40 years of age. (52)

23. DATA PROCESSING IN MULTI TESTING.

Whilst in administration the stress in the use of the computer is on data acquisition and rationalization, the aim in the clinical application of the computer is to make a contribution to better and quicker diagnosis and treatment free from evaluation errors but with greater differentiation thanks to the more manifold possibilities of evaluation. The computer cannot relieve the physician of the task of making a decision. It does, however, present the information obtained from the examinations in a clearer and better process form and relieves the physician from the strain of having to remember too much, apart from the fact that it eliminates the danger of one or the other details of an examination and evaluation of a case from being forgotten. In addition ,of course, there is the advantage of storage of the clinical patient data and the rapid accessibility of the same.

The following summaries briefly sketh the most important possibilit-

ies of using a data processing system clinically. Also for these tasks punched cards have to be used in some cases as an interface between the measuring equipment and the computer. In many cases, however, faultless transmission and, above all, high speed in the transmission of the patient's signals is absolutely necessary so that direct connection of the measuring equipment to the computer is to be preferred in such instances (57)

1. LABORATORY TESTS.

An important field of application for the data processing system as has been demonstrated is the pick-up, calculation and recording of data supplied by equipment in the medical laboratory. As a rule the data supplied by the individual samples is fed directly into the computer where it is tested for accuracy, corrected if necessary, and stored or computed as intermediate results. In conjunction with autoanalyzers, a major part of the laboratory can be made automatic in this way. Unfortunately not all equipment in the medical laboratory can be connected directly to the computer so that some of the data must be fed into the computer by means of punched card or teleprinter. Of course the computer can also be used for controlling and planning the functional operation of the laboratory. Some systems of this kind are in use - but with punched card interfaces - particularly in the USA. It is to be expected, however, that with more modern systems the measuring instruments will be connected as far as possible to the computer.

2. ECG

At the present time the best known application of a data processing system in diagnosis is its use in analyzing and evaluating electrocardiograms. Here the heart potential tracing recorded for one or more heart

beats (electrocardiogram) is divided into 100 to 1000 sections, whose amplitude is measured and stored by the computer. (An analogue tracing is turned into individual digital values). With the aid of measuring programmes the position, height, slope and interval between the individual waves of the ECG relative to one another can be determined and recorded or written out as digital values. These values are then compared with "normal values" and computor write out gives ECG diagnosis.

Similar consideration although not discussed apply to the EEG as with the ECG. The problem of correlating the data measured to certain definite diagnosis or diagnostic groups has, however, hardly been investigated.

3. X- RAY DIAGNOSIS

Here it should be mentioned that with good photometers it is possible to scan radiographs point by point and store in the data processing system the density distribution recorded so that it can be evaluated and reproduced in a similar manner to that used with scan images. However, investigations into this are in the early stages.

4. RESPIRATORY FUNCTION TESTS.

This field is still in its infancy and the "normal values" have not been fully established and until these parameters are decided automatic interpretation of results cannot be achieved so that data can only be fed into the computer by means of punched cards etc. The reliability of these tests is still under examination and patient co-operation is essential in carrying them out.

(54)

24. PRODUCTION AND EFFICIENCY IN MEDICAL LABORATORIES.

In conclusion, medical laboratories face acute shortages of tech-

nical manpower, and the causes are seen to stem from

(a) A rising workload

(b) The acceptance of a prescribed in-service training commitment.

(c) Wastage of personnel.

(d) A reduction in working hours and increased leave.

It is suggested that these are essentially problems of management which come properly within one of its designated functions _ "the efficient use of available resources."

An analysis of the causes contributing to technical staff shortages shows that, apart from wastage of personnel

(1) Student/junior technicians are wastefully employed on non-technical duties.

(2) Available categories of ancillary staffs are not being utilised.

(3) Clerical resources are not being properly utilised.

(4) Mechanisation and the use of commercially prepared materials are not sufficiently exploited.

Most of these problems can be overcome by introducing multiple investigations on admission or pre-admission of patients, as with this system will come new equipment, new duties, different categories of staff and by the utilization of new, automated and sophisticated equipment the proper utilization of human resources.

25. THE KAISER FOUNDATION HOSPITAL

This hospital has introduced a most comprehensive automated multi-

test laboratory. Where possible this centre is used for men and women who are "routine" admissions as a form of pre-admission for medical cases and pre-operative evaluation in surgical cases. (55)

Figure 26 shows how the centre has been constructed. It consists of a series of stations which are connected with an automated multi-test laboratory and all stations are on line to a computer, which not only provides advice but furnishes a final summary report.

The diagram illustrates the flow of patients from Stations 1 to 20. The process takes from 2 - 3 hours. It can process 2,000 cases a month working a 40 hour week.

This hospital has one of the best planned and most modernly equipped units in the world with an overall view of total patient investigation. For this reason it is proposed to elucidate the 20 stages that each individual proceeds through. This done in Appendix II of this Chapter C1/2/1-C1/2/6 Page 105 .

The concept may be considered as more applicable to mass population screening but there is so much sound basic medical investigation that when modified this could be the basis of multiple investigations on admission or on pre-admission.

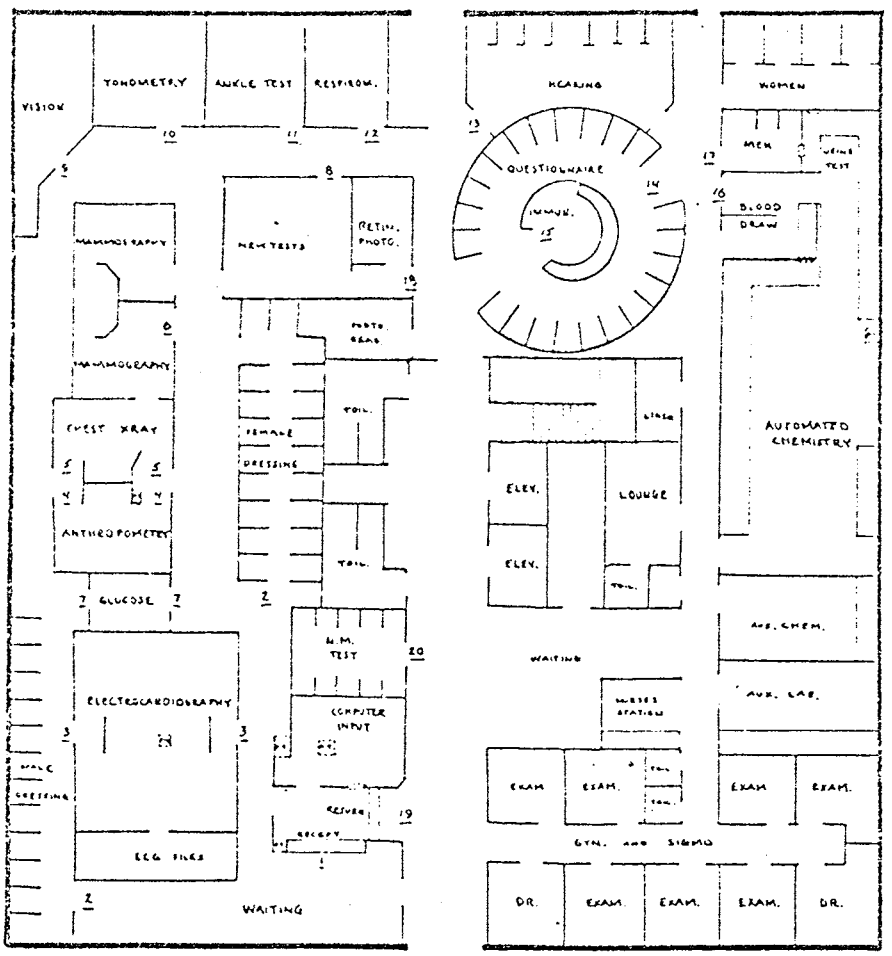

VISION
TONOMETRY
ANKLE TEST
RESPIROM.
HEARING
WOMEN
MEN
QUESTIONNAIRE
IMMUN.
BLOOD DRAW
MAMMOGRAPHY
RETIN. PHOTO.
MEM TESTS
PHOTO. READ.
MAMMOGRAPHY
CHEST XRAY
ANTHROPOMETRY
FEMALE DRESSING
TOIL.
LOUNGE
ELEC.
AUTOMATED CHEMISTRY
GLUCOSE
M.M. TEST
COMPUTER INPUT
ELECTROCARDIOGRAPHY
MALE DRESSING
EEG FILES
WAITING
AUX. CHEM.
AUX. LAB.
EXAM.
GYN. AND SIGMO
DR.

FIG. 26

DISCUSSION.

From the literature reviewed there is an obvious lack of adverse criticism regarding Multiple Investigations on admission or pre-admission to Hospital. The object of this chapter is not to carry out a critical analysis of the literature but to present some of that which is available.

Due to the concept of multiple investigations being comparatively new the procedures and equipment are still undergoing modifications and the reports to-date, although very encouraging, do not reflect an accurate assessment.

APPENDIX IA.

GLOSSARY OF ABBREVIATIONS

Abbreviation	
Na	Sodium
K.	Potassium
Cl	Chloride
HCO_3	Bicarbonate
B.U.N.	Blood Urea Nitrogen
Creat.	Creatinine.
P.	Phosphorus.
S.G.	Specific Gravity.
Ca.	Calcium
Mg.	Magnesium
Alk. Phos.	Alkaline Phosphatase
Alb.	Albumin.
Glob.	Globulin.
S.G.O.T.	Serum Glutamic Oxaloacetic Transaminase
S.G.P.T.	Serum Glutamic Pyruvic Transaminase
L.D.H.	Lactic Dehydrogenase.
C.P.K.	Creatine Phospho Kinase
Thymol Turb.	Thymol Turbidity.
$ZnSO_4$ Turb.	Zinc Sulphate Turbidity.
Br.	Bromide
Fe.	Iron

GLOSSARY OF ABBREVIATIONS (contd.)

I.B.C.	Iron Binding Capacity
P.B.I.	Protein Bound Iodine.
Acid Phos.	Acid Phosphatase
B.S.P.	BromSulphthalein.
Met. Hb.	Met Haemoglobin
Sulph. Hb.	Sulph Haemoglobin
Cu. Oxidase	Copper Oxidase
Cu.	Copper
SIA Test	Sia's Test.
G.T.T.	Glucose Tolerance Test.
Time Hr. Min.	Time, Hours, Minutes.
Vol.	Volume
U.N.	Urea Nitrogen.
17-KS	17 Keto Steroids
17-OHCS	17 Oxogenic Steroids.
D-XYLOSE	Dextro Xylose
5-OHIAA	5 Hydroxy Indole Acetic Acid.
B.J. Prot.	Bence Jones Protein.
L.E. Cells	Lupus Erythematous Cells.
R.H. Factor	Rhesus Factor.
Hb.	Haemoglobin

GLOSSARY OF ABBREVIATIONS (contd.).

Total WCC.	Total White Cell Count.
MCV.	Mean Corpuscular Volume.
MCH.	Mean Corpuscular Haemoglobin.
MCHC.	Mean Corpuscular Haemoglobin Concentration.
ESR.	Erythrocyte Sedimentation Rate
PI.	Prothrombin Index.
Differential WCC.	Differential White Cell Count.
BP.	Blood Pressure.
ECG.	Electrocardiograph.

C1/1/1

APPENDIX I

THE USE OF PUNCHED CARDS IN LABORATORIES

The system in the Pathology Department, Conemaugh Valley Memorial Hospital, U.S.A. is as follows:

Requisitions:

"The requisition itself is a single part form on which are listed the most commonly ordered tests in chemistry, haematology, serology and coagulation (Fig. 14). Frequency analysis of laboratory tests showed that tests comprised over 99% of laboratory volume in these areas. These tests were arranged in a clinically significant sequence and assigned sequential numbers for data processing purposes and then rearranged alphabetically to facilitate selection by nursing personnel. Clinicians can also order batteries of tests (Fig. (15))."

To use the requisition

"The nurse stamps the sheet with an addressing machine plate to provide patient identification and location and simply checks the procedures desired."

"The bottom 6 inches of the requisition form may also be used as an interim reporting form. Emergency tests must be performed at any time of the day or night, and unless we wished to staff the data processing facility 24 hours a day, seven days a week, a machine report could not be produced. Furthermore, as in most community hospitals, admissions are heavy in the late afternoon, often for surgery the following morning, and the results of admission studies should be on the medical record before

UNIT TESTS (see reverse side)

CHEMISTRY

10000 ☐ Electrolytes	00534 ☐ Barbiturates	00100 ☐ Globulin	00120 ☐ pO2
[illegible] ☐ Liver Function A	[illegible] ☐ Bilirubin,	[illegible] ☐ Glucose	[illegible] ☐ Inorganic Phosphorous
[illegible] ☐ Liver Function B	[illegible] ☐ Bilirubin, Micro	[illegible] ☐ Glucose Tolerance	[illegible] ☐ Potassium
[illegible] ☐ Myocardial Infarct	[illegible] ☐ Bromide	[illegible] ☐ 5-HIAA	[illegible] ☐ PSP
00001 ☐ Renal Function	00007 ☐ BSP	00040 ☐ Icterus Index	00130 ☐ Salicyl.
00002 ☐ Bone Joint	00024 ☐ BUN	00055 ☐ Iron	00148 ☐ SGOT
00018 ☐ Acetone	00032 ☐ Calcium	00058 ☐ Iron Bind. Cap.	00141 ☐ SGPT
00100 ☐ A/G Ratio	00572 ☐ Carb. Dioxide	00046 ☐ 17 Ketosteroids	00057 ☐ Sodium
00120 ☐ Albumin	00042 ☐ Chloride	00053 ☐ 17KGS	00064 ☐ Thymol Turb.
00013 ☐ Alcohol	00235 ☐ Cholesterol	00331 ☐ LAP	00174 ☐ Tot. Protein
00020 ☐ Acid Phosph	00273 ☐ Chol Esters	00158 ☐ LDH	00299 ☐ Triglycerides
00315 ☐ Alk. Phosph	00075 ☐ CO2 Content	00206 ☐ Lipase	00400 ☐ Urea Cl.
00257 ☐ Ammonia	00114 ☐ Creatinine	00231 ☐ Lipids, Total	00105 ☐ Uric Acid
00349 ☐ Amylase	00422 ☐ Creat. Clear	00504 ☐ PBI	00550 ☐ Urobilinogen
	00547 ☐ Electrophor. Hemogl.	00081 ☐ pCO2	00503 ☐ VMA
	00539 ☐ Electrophor. Protein	00083 ☐ pH	☐ Others

UNIT TESTS (see reverse side)

HEMATOLOGY

51000 ☐ Complete Blood Count	00001 ☐ Bleeding Time	01010 ☐ Hematocrit	00430 ☐ Retic.
51003 ☐ Anemia Unit	00497 ☐ Blood Types	01024 ☐ Hemoglobin	01101 ☐ Sickle Cells
☐	01149 ☐ Clot Retraction	00276 ☐ LE Preparation	00105 ☐ Sed. Rate
☐	00572 ☐ Coag. Time	01313 ☐ Platelets	01191 ☐ Thrine Test
☐	01009 ☐ Differential	00471 ☐ RBC	01003 ☐ WBC
☐	00521 ☐ Eosinophile Count	01130 ☐ RBC Fragility	☐ Others

SEROLOGY

99005 ☐ Febrile Agglutin.			
03105 ☐ Brucella Abortus	02053 ☐ ASO Titer	03123 ☐ FTA	03070 ☐ Reiter Protein
03160 ☐ Para A	00512 ☐ BUR	03210 ☐ Gravindex (Prog)	03137 ☐ TPI
03170 ☐ Para B	03046 ☐ Cold Agglutin.	03137 ☐ Heterophile (Slide)	03202 ☐ UCG
03151 ☐ Proteus OX19	03038 ☐ Collodial Gold	03095 ☐ Heterophile (Tube)	03996 ☐ VDRL
03145 ☐ Typhoid H	03051 ☐ C-Reactive Protein	03020 ☐ Kolmer	☐ Others
03150 ☐ Typhoid O	03103 ☐ Davidsohn Diff.	03111 ☐ Latex Fixation	☐

UNIT TESTS (see reverse side)

COAGULATION

61002 ☐ Hemorrhagic, Screening	03509 ☐ Factor V	03509 ☐ Lee White	03533 ☐ Thrombopl.Gen.
71001 ☐ Hemorrhagic, Definitive	03574 ☐ Factor VII	03525 ☐ Prothrom. Consump.	03517 ☐ Part. Thrombo.
☐	03589 ☐ Fibrinolysis	03541 ☐ Prothrom. Time	☐ Others

04002 ☐ Routine Urinalysis

99994 ☐ Laboratory Admissions Baseline Studies (LABS)
99995 ☐ LABS with S & C

Comments:

INTERIM LABORATORY RESULTS

Do not write in this space for laboratory use only

Acetone	_____	mgm%
Glucose	_____	mgm%
BUN	_____	mgm%
Na	_____	mEq/L
K	_____	mEq/L
CO2	_____	mEq/L
Chloride	_____	mEq/L
pH	_____	
pCO2	_____	mm
SGOT	_____	units
SGPT	_____	units
LDH	_____	units
Amylase	_____	units
Calcium	_____	mgm%
Phosphorus	_____	mgm%
Uric Acid	_____	mgm%

Hemoglobin	_____	gm/100 ml
Hematocrit	_____	%
Sed. Rate	_____	mm/hr
Bleeding Time	_____	min
Coag. Time	_____	min
Lee-White Coag. Time	_____	min
Proth. Time	_____	sec.
	_____	%
	_____	control

WBC _____

Diff: meta stab seg lymph mono eos baso

FIG. 14.

UNIT TESTS

CHEMISTRY

ELECTROLYTE UNIT

Sodium
Potassium
Chloride
Carbon Dioxide Content
pH
pCO2
BUN

LIVER UNIT A

BSP
Bilirubin, Total & Ind.
Alkaline Phosphatase
Protein, A/G Ratio
Cephalin Flocculation
Thymol Turbidity
Prothrombin Time
Transaminase, SGOT, SGPT

LIVER UNIT B

(Clinical Jaundice)
Bilirubin, Total & Ind.
Alkaline Phosphatase
Protein, A/G Ratio
Total Cholesterol, Esters
Cephalin Flocculation
Thymol Turbidity
Transaminase, SGOT, SGPT

BONE-JOINT UNIT

Sedimentation Rate
Calcium
Phosphorous
Alkaline Phosphatase
Total Protein, A/G Ratio
Uric Acid
Rheumatoid Factor
LE x3
C Reactive Protein

RENAL FUNCTION

Urea Clearance
Creatinine Clearance
Electrolyte Unit
Calcium
Phosphorous
PSP

MYOCARDIAL INFARCT

(Request on 3 consecutive days)
SGOT
LDH
Sedimentation Rate
WBC & Differential
Prothrombin Time
Lee White Coag. Time

HEMATOLOGY

CBC

Hemoglobin
Hematocrit
White Blood Cell Count
Differential

ANEMIA UNIT

CBC
Blood Indices, MCV, MCH, MCHC, CI
RBC Fragility
Reticulocyte Count
LDH
Bilirubin, Total & Ind.
Coombs, Direct & Ind.
Peripheral Blood Smear examined by Pathologist

COAGULATION

HEMORRHAGIC UNIT—SCREENING

CBC
Bleeding Time
Lee-White Coag Time
Prothrombin Time
Partial Thromboplastin Time
Clot Retraction
Platelet Count

HEMORRHAGIC UNIT—DEFINITIVE

Hemorrhagic Unit—Screening
Prothrombin Consumption Time
Thromboplastin Generation Test
Fibrinogen
Factor V
Factor VII

ADMISSION STUDIES

LABS (Laboratory Admission Baseline Studies)

CBC
Glucose
BUN
VDRL
Urinalysis

LABS WITH B & C (for surgical patients)

Routine LABS
Bleeding Time
Coagulation Time

FIG. 15.

APPENDIX I (contd)

patient goes to the operating room. Telephone reporting of laboratory data is notoriously unsuccessful since the person receiving the call may record the result incorrectly, assign it to the wrong patient, or lose the message entirely. The hospital's policy therefore of providing a hard copy to the medical record as soon as possible after the test has been completed and the bottom section of the requisition forms fill that need. On it are listed the tests most commonly requested on a non-routine basis, together with the units in which the result is expressed. The test is performed, the results written in the proper location, and the entire sheet duplicated on an electrostatic copier. The bottom section of the requisition is then detached and sent to the nursing station. The copy is sent to the data processing facility where the results are transferred to punched cards for inclusion in a machine-produced report and for billing purposes. This same reporting method is used on Sundays and holidays."

Preparation of Result Cards

"Laboratory results are recorded on standard 80-column cards by the technician performing the test. Routine requisitions for tests to be performed the following day are in the laboratory by 11 p.m. The requisition sheets are arranged in patient number order and quickly scanned for duplications or errors. The patient number and the test number are then keypunched into requisition cards. The keypunch is operated under the control of a programme card which permits the rapid entry of this data. A separate card is produced for each test required. The programme card permits duplication of the patient number if more than one test is requested per patient, thereby reducing the opportunities for error."

APPENDIX I (contd)

" Since approximately 50% of the laboratory volume is comprised of test batteries, decks pre-punched for these are prepared and stored in a tub-file. When a batter is requested, the key-punch operator needs to punch the patient and battery number into only one card, together with a code punch; the decks of pre-punched cards are collated by hand, and the patient identification and date information is intersperse gang punched into the pre-punched cards."

"The requisition cards are then sorted into patient number order and collated with a patient master deck. The patient master deck is made up of cards that contain the patient identification information. These cards are prepared when the patient is admitted and contain name, number, location and a physician code. These patient master cards are collated in front of the requisition cards, and the information they contain is intersperse gang punched into the requisition cards and the test master cards are then sorted out for later reference. "

"Result cards are then reproduced from the requisition cards on the reproducing punch. Three types of result cards are used:

1. General, on which may be written the result of any single tests.
2. Haematology, on which may be entered a complete blood count, i.e. white blood cell count, haematocrit and haemaglobin values, and differential count, and
3. Comment, on which may be written any comment the technologist may care to make regarding a test, e.g. protein-bound iodine-contaminated."

APPENDIX I (contd)

"The result cards contain the patient's name, number, location, test name, test number, dimensions data, time of sample collection, and space for recording of results."

Preparation of Lists.

" Blood Collection List. In this institution, blood specimens are collected by a team made up of technologists, students, part-time employees and only rarely by interns or residents. To inform the team of the specimens to be collected that day, a collection schedule is printed from the requisition cards. The cards are sorted, first into patient number order and then by nursing station and the schedule is generated on the accounting machine. The machine is programmed to skip to a new form when the nursing station changes so that a separate sheet is obtained for each area. The schedule is prepared in duplicate, one copy is returned to the laboratory with the specimens and the second is left at the nursing station to show that the specimens have been collected."

" Work List. After the printing of the collection schedule, the cards are sorted by work group, and a work list is prepared. These lists are delivered to the laboratory with the result cards and serve as a schedule of work to be done at that station that day, as well as a log and laboratory record. These lists are separated along lines of activity, e.g. glucose and blood urea nitrogen analyses, potassium, sodium, carbon dioxide and chloride determination, pH and arterial carbon dioxide pressure (Pco_2)."

Entering of Results.

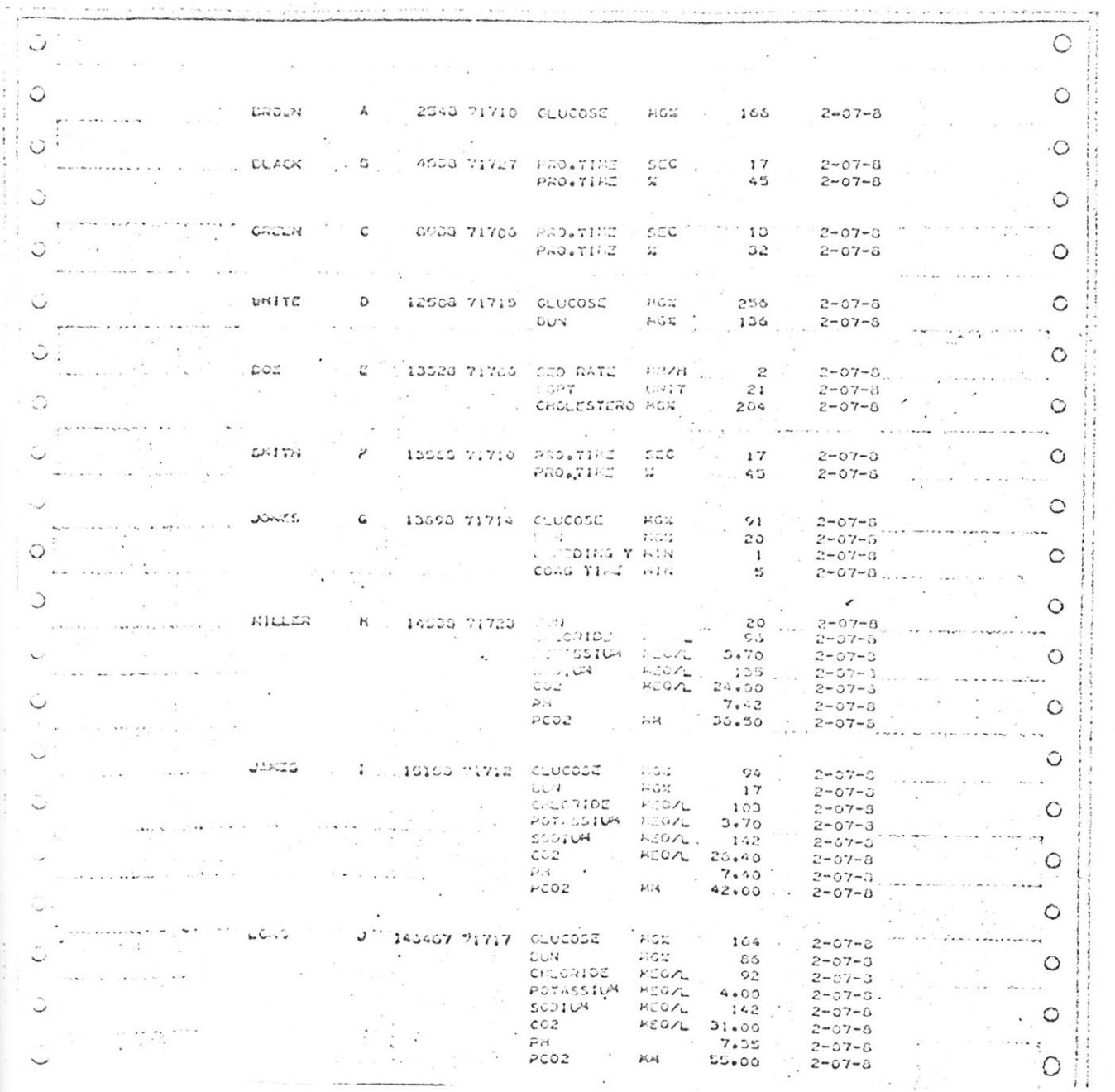
"Results are written on the cards and also mark sensed in the proper bubbles. Originally it was planned to perform a double punch blank column

APPENDIX I (contd)

detection in this field but the difficulties encountered with zero suppression made this impossible. This procedure, therefore, serves only as a check on the technologist since he must write the result twice. All cards are verified with another technologist before being returned to the data processing facility. There, the results are key-punched into the cards and again visually verified."

"Interim Reports. Since a goal of the new system was to have results available as soon as possible, several types of reports were designed. Mention has already been made of the report form for emergency work. A second type of report is the interim, or ward report (Fig. (16)). This report is a listing of tests performed on patients at each nursing unit and is made available as soon as a significant block of work is complete, e.g. prothrombin time, electrolyte levels, glucose values. The first of these reports is sent to the nursing unit at about 9.15 a.m. and contains the prothrombin times and early glucose analyses. The second report is produced at about 10.30 a.m. and updates the first with electrolyte and other glucose values. The third report is produced about noon and contains all work done until that time, again as a simple list."

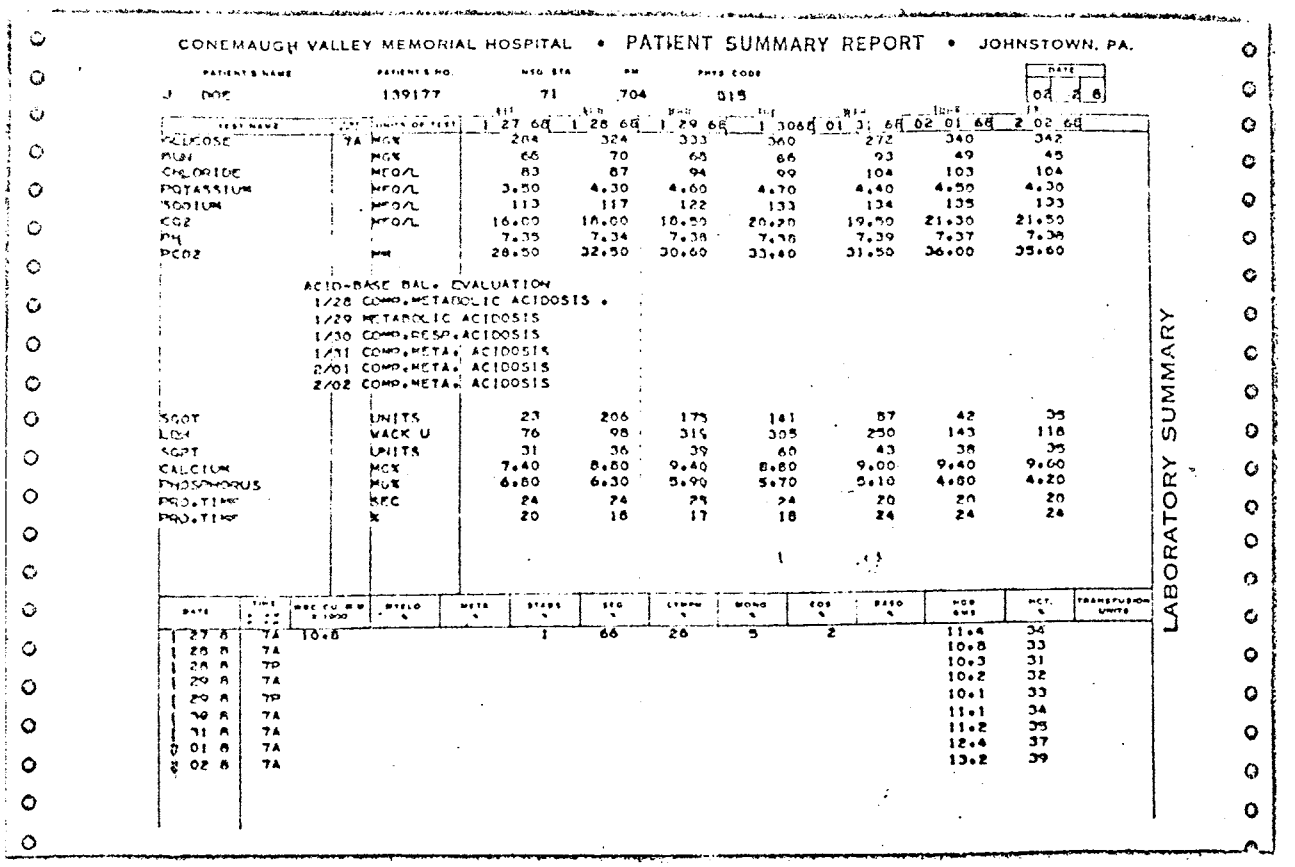
"Summary Reporting Summary reports (Fig. (17)) are prepared each day except Sunday and contain all reports during any one calendar week. The report is updated each day with new results and replaces any previous summary that was on the medical record. At the end of each week, the final report is left as a permanent part of the patient's chart and a second summary sequence is started. Since the average length of stay is ten days, most patients have two summaries on their record by the time of discharge. The



BROWN	A	2548 71710	GLUCOSE	MG%	166	2-07-8	
BLACK	B	4558 71727	PRO.TIME	SEC	17	2-07-8	
			PRO.TIME	%	45	2-07-8	
GREEN	C	6958 71706	PRO.TIME	SEC	18	2-07-8	
			PRO.TIME	%	32	2-07-8	
WHITE	D	12508 71715	GLUCOSE	MG%	256	2-07-8	
			BUN	MG%	136	2-07-8	
DOE	E	13528 71708	SED RATE	MM/H	2	2-07-8	
			SGPT	UNIT	21	2-07-8	
			CHOLESTERO	MG%	204	2-07-8	
BRITN	F	13558 71710	PRO.TIME	SEC	17	2-07-8	
			PRO.TIME	%	45	2-07-8	
JONES	G	13698 71714	GLUCOSE	MG%	91	2-07-8	
			BUN	MG%	20	2-07-8	
			BLEEDING T	MIN	1	2-07-8	
			COAG TIME	MIN	5	2-07-8	
MILLER	H	14538 71733	BUN		20	2-07-8	
			CHLORIDE		95	2-07-8	
			POTASSIUM	MEQ/L	5.70	2-07-8	
			SODIUM	MEQ/L	135	2-07-8	
			CO2	MEQ/L	24.50	2-07-8	
			PH		7.42	2-07-8	
			PCO2	MM	36.50	2-07-8	
JAMES	I	15103 71712	GLUCOSE	MG%	99	2-07-8	
			BUN	MG%	17	2-07-8	
			CHLORIDE	MEQ/L	103	2-07-8	
			POTASSIUM	MEQ/L	3.70	2-07-8	
			SODIUM	MEQ/L	142	2-07-8	
			CO2	MEQ/L	26.40	2-07-8	
			PH		7.40	2-07-8	
			PCO2	MM	42.00	2-07-8	
LONG	J	143467 71717	GLUCOSE	MG%	164	2-07-8	
			BUN	MG%	86	2-07-8	
			CHLORIDE	MEQ/L	92	2-07-8	
			POTASSIUM	MEQ/L	4.00	2-07-8	
			SODIUM	MEQ/L	142	2-07-8	
			CO2	MEQ/L	31.00	2-07-8	
			PH		7.35	2-07-8	
			PCO2	MM	50.00	2-07-8	

FIG. 16

Fig. 16. Interim, or ward reports. Copy is posted at each nursing station as results become available.



CONEMAUGH VALLEY MEMORIAL HOSPITAL • PATIENT SUMMARY REPORT • JOHNSTOWN, PA.

PATIENT'S NAME: J DOE | PATIENT'S NO.: 139177 | MED. STA.: 71 | RM: 704 | PHYS CODE: 015 | DATE: 02 2 68

LABORATORY SUMMARY

TEST NAME	TIME	UNITS OF TEST	1 27 68	1 28 68	1 29 68	1 30 68	01 31 68	02 01 68	2 02 68
GLUCOSE	7A	MG%	204	324	333	340	272	340	342
BUN		MG%	66	70	68	66	93	49	45
CHLORIDE		MEQ/L	83	87	94	99	104	103	104
POTASSIUM		MEQ/L	3.50	4.30	4.60	4.70	4.40	4.50	4.30
SODIUM		MEQ/L	113	117	122	133	134	135	133
CO2		MEQ/L	16.00	18.00	18.50	20.20	19.50	21.30	21.50
PH		PH	7.35	7.34	7.38	7.38	7.39	7.37	7.38
PCO2		PH	28.50	32.50	30.60	33.40	31.50	36.00	35.60

ACID-BASE BAL. EVALUATION
1/28 COMP.METABOLIC ACIDOSIS •
1/29 METABOLIC ACIDOSIS
1/30 COMP.RESP.ACIDOSIS
1/31 COMP.META. ACIDOSIS
2/01 COMP.META. ACIDOSIS
2/02 COMP.META. ACIDOSIS

SGOT		UNITS	23	206	175	141	87	42	35
LDH		WACK U	76	98	315	305	250	143	118
SGPT		UNITS	31	36	39	60	43	38	35
CALCIUM		MG%	7.40	8.80	9.40	8.80	9.00	9.40	9.60
PHOSPHORUS		MG%	6.80	6.30	5.90	5.70	5.10	4.80	4.20
PRO.TIME		SEC	24	24	29	24	20	20	20
PRO.TIME		%	20	18	17	18	24	24	24

DATE	TIME	WBC CU.MM X 1000	MYELO %	META %	STABS %	SEG %	LYMPH %	MONO %	EOS %	BASO %	HGB GMS	HCT. %	TRANSFUSION UNITS
1 27 8	7A	10.8			1	66	26	5	2		11.4	34	
1 28 8	7A										10.8	33	
1 28 8	7P										10.3	31	
1 29 8	7A										10.2	32	
1 29 8	7P										10.1	33	
1 30 8	7A										11.1	34	
1 31 8	7A										11.2	35	
2 01 8	7A										12.4	37	
2 02 8	7A										13.2	39	

FIG. 17

APPENDIX I (contd)

summary report is the most difficult to produce on unit record equipment. Since our accounting machine has essentially no memory except for digital information that can be stored in counters, all information that appears on the reports must be presented to the machine on a card. "(24)

C1/2/1

APPENDIX 2.

THE KAISER FOUNDATION HOSPITAL.

The following are the 20 stations used in the Multi-screening procedures carried out at the above hospital.

Station 1. The patient registers at the reception desk. He receives a clipboard containing a medical questionnaire form and a deck of cards (pre-punched for computer input with his medical record number) upon which are to be recorded the test results at each station. The patient's electrocardiogram card is dispatched by pneumatic tube from the reception desk to Station 3.

Station 2. The patient removes the upper body garments in a dressing booth and puts on a disposable paper gown.

Station 3. Six electrocardiogram leads (AVR. AVL. AVF. VI. V3. V5) are simultaneously recorded by means of a direct optical recording oscillograph. The ECGs are subsequently read by a cardiologist who records his interpretations on a "mark sense" card using pencil marks that can be sensed directly by a card-reading machine for input to the computer.

Station 4. Weight and skinfold thickness (subscapular and triceps are measured with a caliper) and this data is key punched into the patient's anthropometry test card. By means of an automated anthropometer, 12 height and transverse body measurements are recorded directly into the patient's punched card within three minutes.

Station 5. A 70 mm posterioanterior chest X-Ray is obtained, to be read subsequently by a radiologist who records his interpretations on a mark sense punch card.

APPENDIX 2.(Contd.)

Station 6. Mammography is performed on women 48 years of age and over. Cephalacaudal and lateral views of each breast are taken. Mammograms are subsequently read by a radiologist who records his interpretations on a mark sense card. The patient then returns to the booth in Station 2 and redresses.

Station 7. The patient ingests 75 gm of glucose solution in 240 ml of cold carbonated water dispensed from a vending machine. The time of glucose ingestion is recorded by an automatic time stamp on the back of the card and the patient is assigned a sequencing number from 1 to 24 for control purposes and for later assignment to a booth in Station 14.

Station 8 Supine pulse rate and blood pressure are measured by an automated instrument and recorded on a mark sense card.

Station 9. Visual acuity is tested by reading a wall chart, and a pupillary light reflex is tested. The results of these tests are recorded on a mark sense card.

Station 10. Ocular tension is measured by a tonometer, and the reading is recorded on a mark sense card. A drop of phenylephrine hydrochloride is placed in the right eye to dilate the pupil for later retinal photograpy.

Station 11. The Achilles reflex one-half relaxation time is measured to screen for hypothyroidism. An experimental pressure tolerance test is also performed on the ankle tendon at this station.

Station 12. A one-second, two-second, and total forced expiratory vital capacity and peak flow is measured with a spirometer and is recorded on a mark sense card.

Station 13. Hearing is tested with an automated audiometer for six frequencies in each ear, and the graphed readings transferred to a mark sense card.

APPENDIX 2. (contd)

Station 14. The self-administered medical questionnaire form that the patient received at Station 1, and which had been completed during any waiting periods between stations, is now audited by a nurse. The patient is then assigned to one of 24 questionnaire booths in accordance with the sequencing number received at Station 7. In this booth, the patient receives a letter box containing a deck of 207 pre-punched cards, each having a single dichotomous question printed on the card. The patient responds to each question by taking the card from the top section of the divided letter box and dropping the card into the middle section if his answer to the question is "yes", or into the bottom section if his answer is "no". The procedure automatically sorts "yes" responses for direct input to the computer by means of a card-reading machine.

Station 15. As a part of the preventive medical programme, the patient may here receive a booster dose of tetanus toxoid with a high pressure jet injector.

Station 16. When an hour has elapsed since ingestion of the glucose challenge dose, the patient is called from his assigned questionnaire booth and is sent to the laboratory where blood samples are drawn for haemoglobin, which blood cell count, veneral disease, research laboratories test for syphillis (VDRL), rheumatoid factor (latex fixation slide test), and blood grouping. The test values are recorded on mark sense cards. From a single 2 ml. sample of serum, eight blood chemistry determinations (serum glucose, creatinine, albumin, total protein cholesterol, uric acid, calcium and transaminase) are simultaneously done within 12 minutes by a multi-channel automated chemical analyzer; test results are directly punched into cards.

APPENDIX 2. (contd.)

Station 17. A urine specimen is collected and tests are done for bacteriuria (cultured six hours with triphenyltetrazolium chloride), and for pH, blood, glucose, and protein (paper strip tests). The results are entered on the patient's test card.

Station 18. The patient returns to his questionnaire booth: when he has completed all his questions, he proceeds to Station 18, where a photograph is taken of the right retina with a fundus camera. Retinal photographs are subsequently read by an opthalmologist, who records his interpretation on a mark sense card.

Station 19 The patient returns to the registration area and gives the receptionist the clipboard containing the marked and punched cards and the questionnaire form. He now receives a second box of questionnaire cards, which isapsychological test.

Station 20. The patient again sits in a booth in this station, and he sorts 155 psychological questions into "True and False" responses using a sort box in the same manner as he did with the medical questionnaire in Station 14.

By the time the patient has completed the psychological questionnaire the "on-line" computer processing has been completed, and supplemental tests and appointments "advised" by the programmed rules of the computer, are arranged for the patient.

Routinely advised are a sigmoidoscopy for all patients aged 40 or more. For women, a gynaecological examination with cervical smear for cancer detection is advised.

APPENDIX 2. (contd)

DATA PROCESSING REQUIREMENTS.

Most of the data generated in the automated multi-test laboratory is recorded on prepunched or mark sense cards to permit its immediate introduction into the data processing system. As on "on-line" procedure while the patient is in Station 20, the computer processes the information from

1) The punched cards from anthropmetry and chemistry

2) The prepunched sorted cards from the medical questionnaire box and

3) The reproduced mark sense cards from respirometry, hearing, vision, urine paper strip tests, haemoglobin determination, and white cell count. The punched cards are read into a data communication system, and the data are transmitted via telephone line to the central computer in a separate building.

The computer processor goes through a programme routine containing various test limits and decision rules, and prints out a report constituting "advice" as to any additional procedures.

When all information has been received and stored, the computer produces a printed summary of all test reports and questions answered "yes".

At the time of the patient's first office visit, the internist reviews the summary report and directs further history toward elaborating upon the questions to which the patient has answered "yes" and to the test abnormalities reported from the automated multi-test laboratory. The doctor with these reports completes his physical examination, records the

APPENDIX 2 (contd)

findings and diagnoses on a preprinted form, which can be automatically scanned by an optical mark reader, and then proceeds to arrange whatever medical care is necessary for his patient in the usual way.

CHAPTER II.

INTRODUCTION.

Medical equipment has become more sophisticated, especially in recent years. Computers, electronic and improved instrumentation, has had a far-reaching impact on patient-care.

The effect of improved equipment on laboratory efficiency has allowed the pathology department to meet the ever-increasing work load. There does not appear to be any sacrifice of quality of results at the expense of quantity of work performed. Because of the equipment available, hospitals in various countries are now producing bio-chemical profiles on admission.

Methods exist for controlling the quality of test performance in bio-chemistry, haematology and to a lesser extent in micro-biology, blood banks and anatomic pathology. Standard solutions and reagents are more consistent and widely available and quality control procedures have been refined and simplified.

In cardiology new machines have minimised electrical interference and because of improved standardization procedures, ECG tracings are of a better technical quality giving a truer and more reliable write out which allows for easier interpretations. Machines may be of the standard type giving a normal read-out or the machine may be linked to a computer which has been programmed to read ECGs. The reading may be on line using an Analogue-Digital Converter, or may involve the use of a Dacta-phone or similar transmitter linked to a computer. Alternatively the ECG may be manually measured and the figures feed into the computer and the computer reading obtained.

Similarly programmes for measuring respiratory function using Spirographs may or may not be linked with computers.

In the field of Cytology, Cervical Smears, are now being screened by automated machinery - but this is only in its initial stages. Readers are still generally being used to screen these tests.

The usage of computers in medicine covers mainly 5 areas - Administration, the processing Laboratory investigations and Clinical data, Medical Records, Medical Research and Information Retrieval In considering multiple investigations upon admission the processing of investigations, the storage of results, their retrieval and the presentation of results are most important.

MULTI-TEST EQUIPMENT.

The following are the tests that are most commonly used in multi-screening on admission and the equipment that is used to carry them out. (86) The Appendix of this chapter will elaborate on specific items of equipment.

1) Chest X-Ray

This is done by a 70 m.m or 100 m.m. film postero-anterior projection and requires to be read by a Radiologist.

2) Electrocardiogram.

The ECG may be a conventional 12 lead or a modified 6 lead tracing. In some centres it is combined with a phonocardiogram. The results can be recorded by Mark-sense cards. The ECG can then be evaluated by computer analysis. However, in Australia it is probable that for some time cardiologists will fulfill this function and the reading can be entered via an input metnod into a computer onto the patient's profile.

3) X-Ray Mammography.

This is recommended to be carried out on women over 45 years of age. Special views of each breast are taken; mammographs are read by a radiologist.

4) Visual Acuity

This is performed by reading an ordinary wall-chart.

5) Tonometry

The intra-ocular pressure is measured by an electric tonomograph.

6) Respiratory Function Tests.

Vital capacity and other respiratory ratios are measured on a spirograph and recorded manually. These can be then entered on Mark-sense cards.

7) Hearing Tests.

These are recorded by automated audiometers. The graphed reading transferred to a Mark-sense card.

8) Urine Tests.

These can be carried out manually using paper-strip tests or by automated laboratory tests.

9) Retinal Photograph.

Retinal photography is done by a special camera through a dilated left pupil. The results are read by an Opthalmologist. Unless contra-indicated this test is usually performed on all admissions.

10) Questionnaires.

These are self administered in the form of pre punched cards each with a single question. The patient drops the cards into yes/no boxes and a card reading machine records the results.

11) Body Measurements.

Special machines have been built to measure height and transverse body measurements which can be automatically recorded on punch-cards.

12) Blood Tests.

Haematological investigations VDRL, Rheumatoid factor, blood groups and various chemical tests can be carried out by multi-channel autoanalysers and the results directly punched on cards.

13) Sigmoidoscopy

This is a simple piece of equipment and is recommended on all people over the age of forty.

14) Cervical Smear.

This examination still requires the evaluation of a trained reader.-

Major items of equipment can be considered as

a) Biochemical and Haematological.

b) Electrocardiographs.

c) Chest X-Rays.

d) Computers.

The minor items mentioned in the above series will not be described.

The whole concept of multi-screening on admission to hospital must be considered as an application of automated data-processing into which the items of equipment fit as integral part.

ADVANCED AUTOMATED BIOCHEMICAL AND HAEMATOLOGICAL EQUIPMENT - GENERAL PRINCIPLES.

Biochemical

Since 1957 there have been rapid advances in automated equipment in this branch of Medicine. This was due mainly to the realization that only through such advances could medicine keep abreast with the increasing number of specific tests requested per patient, the increasing number of patients and the decreasing number of technicians. By manual methods the increasing work-load upon laboratories would never have been able to be managed by the technicians available.

The increased reliability in testing and the decrease of human errors to a minimum have been important features of this new equipment.

Auto-analysers which were at first single unit analysers have now been produced as multi-unit complexes usually in groups of 6, 12 or 24.

The following general principles are involved in the use of auto-analyser equipment.

1) Request Form

2) Collection of the Samples

3) Reagents.

4) Method of Determination

   a) Calorimetric Methods.

   b) Fluorometric Methods.

   c) Flame Photometric Methods.

5) Presentation of Results.

   a) Graphic Form

   b) Digital Write Out.

6) Computer Linkage giving:-

a) Intermittent Daily Ward Reports.

b) Daily Patient Reports.

c) Summary Format.

1) Request Form

The request form are usually of a special type produced to meet the requirements of the individual machine and to fulfill the needs of the hospital concerned. However certain basic principles are required on each form. In chapter 5 Appendix 7 page 393 shows the request form which has been adopted at RGH(C).+ This Request Form consists of 4 tear-off strips which are used for patient identification. On this strip or stub is the patient's identification number and the tests requested. This stub is attached to the Sample and the same identification number appears on the results chart when produced by the Auto-analyser. The Requisition Form which has spaces for other information is demonstrated in Appendix 7 C5/7/1 Page 393.

2) Collection of Samples.

The Request Form is filled in by the Ward Doctor or Admission Doctor and sent to the laboratory with or without the Sample. If there is no Sample this is then collected and attached to the appropriate slip.

The blood is collected and placed in a special container with the Identification Tag and placed in a turntable which allows the material (Serum) to be fed into the Auto-analyser.

3) Reagents.

These are produced by the individual firms themselves and they have achieved a high degree of consistency. Each cartridge has its own reagent.

+ RGH(C) = Repatriation General Hospital, Concord

4) Method of Determination

The Auto-analyser consists of a number of analytical cartridges which carry out various bio-chemical analyses using one of three principles.

a) Colorimetric Methods.

b) Fluorometric Methods.

c) Flame Photometric Methods.

The various typesof tests that can be performed by these methods and the actual chemical combinations used in performing the tests is illustrated in Appendix 4 Page 166

5) Presentation of Results.

The results are usually produced in an Analogue Form on graph paper as shown in Fig. (6) on Page 26 . At the same time there may be a Digital Write-out which may also be incorporated in the system or Punch-Cards or Punch-Tapes may be produced. The Autoanalyser may be itself connected directly on-line to a computer. Fig. 27.)

6) Computer Linkage.

In order to achieve full advantage of automated bio-chemical tests computer linkage is desirable not only because of the method of storage of results and their accessibility but also because of intermittent daily ward reports. daily patient reports and summary formats can be produced.

Diagrammatic layout of an on-line real time computer system for Biochemistry Department.

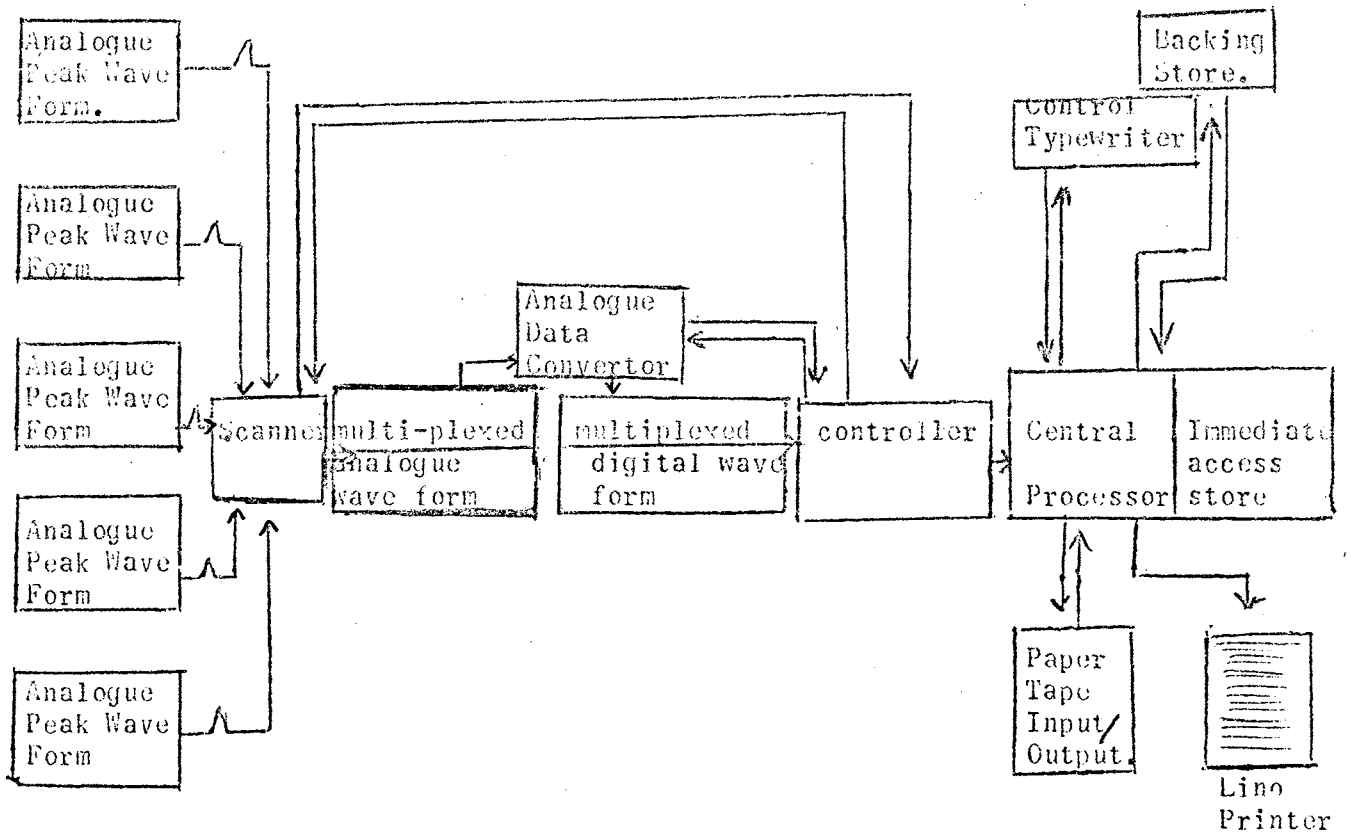


Figure 27.

The General Concept of Multi-Channel Auto-Analyser "Continuous Flow Concept"

One manufacturer of Multi-channel Auto-analysers developed the concept of "continuous flow analysis". In this system each sample is subjected to identical analytical conditions. Samples and Reagents, segmented by air bubbles flow through the system. Samples follow each other continuously through a system of tubes, these are brought together with Reagents under controlled conditions. Progress from one module or capsule is completely automatic. The resultant reaction is then measured by one of the three methods. The results being automatically measured and recorded.

In the concept of "continuous flow analysis" a relevant factor is the machine's ability to achieve and record a steady state condition e.g. when concentration in the flow cell is contant with time. The characteristic shape of the curve produced, or steady state portion, representing the time period during which concentration is in a state of equilibrium. When this steady state is achieved it can be assumed that all effects of possible sample interaction have been eliminated and that the recorded signal gives a true reflection of the constituent of the sample being measured.

The air bubbles which flow through the machine do so at a constant rate and serve three purposes.

a) Separation of the Sample.

b) Mixing of Samples and Reagents.

c) Cleaning of the tubes between Samples.

Haematology

This section of the Pathology Department has undergone automation but to a lesser extent than in Bio-chemistry. Automated procedures are now widely used in major institutions for several determinations e.g. Hb., RBC, WBC, MCH, MCHC, MCV, and Haematocrit. Other equipment is also available for blood groupings and Rh determinations.

There are two major manufacturers of equipment[+] in the automated Haematological field, they are the SMA 7A and the Coulter S. These are considered in detail in the Appendices of this Chapter. Both give the same determinations. The original SMA gave a graphic write-out whilst the Coulter S. gave a digital print-out. The SMA can now be attached to its own analogue digital converter which gives a digital write-out.

The Coulter S. is considered by many as a less complicated machine but it requires a technician to hold the blood sample in front of the machine input. The digital write out appears at the output end. Approximately 1000 samples a day can be handled by the machine. Errors as regard sample identification are rare for the write-out is for the sample that the technician is holding in front of the input section of the machine. Human error as regards collection of the sample or transcribing the name from the sample to the write-out is the factor which cannot be eliminated. Technically the machine is extremely accurate.

The SMA 7A is similar to the SMA 12/60. It can be used with all the attachments as with other SMA machines e.g. Turntable, Technilogger 11. etc. It is equally as efficient as the Coulter S.

It requires 1 ml. of blood to produce the 7 determinations. The time

+ 1) Technicon Corporation, New York, USA, Manufacturers SMA 7A/4A
2) Coulter Electronics Limited, Bedfordshire, England Manufacturers Coulter S

for processing a sample is 4 minutes. The sample rate is 60 per hour and the turntable holds 40 samples.

The auto-analyser uses the "continuous flow concept" and the recordings are made at "steady-state conditions", as with the other SMA units.

A smaller machine, the SMA 4A, has a more limited use and produces a graphic write-out of Hb, Red Blood Cells, White Blood Cells and Haematocrit.

Automation in Haematology is limited mainly to the above determinations. However Blood Groupings and Rh Factor may be determined by automated equipment. This is being performed in Overseas units and at present in one hospital in Australia. Folic Acid assays and B_{12} assays are at present being introduced into overseas hospitals on an automated basis.

Skilled technicians and pathologists are still performing many of the Haematological tests. A simple example of this is the Differential White Cell Count. The Haematological field is not as automated as the Bio-chemical one where approximately 95% of the tests can be automated.

Some immune antibodies are now being determined by automated equipment, however this is still in the research stages.

Preliminary screening of Carcinoma Cells such as in Cervical Smears are being carried out by automated processes. However this is only a screening procedure to differentiate between a normal smear and a possible abnormal one. The possible abnormal smears are then read by specially trained technicians or Pathologists.

ELECTROCARDIOGRAPHIC EQUIPMENT.

Electrocardiographs are usually performed as part of a pre-admission profile in oversea's units. The standard 12-lead Cardiograph is the one of choice; however, the value of a 6-lead Cardiograph as a screening procedure has merits which are still being evaluated.

The Electrocardiograph may be performed on a conventional machine and the tracings interpreted by a Physician. His reading can then be treated as a narrative report and entered into a computer complex via a Punch-card or any of the other conventional methods to be programmed into the patient's profile.

A second method is the use of a conventional machine which records the normal 12-lead tracings. Technicians using measurement cards record exact measurements of the various components of the tracing. Punch-cards are then completed and are ready to be used as Data input. Section 14 Page 48 in Chapter 1 describes this method of instrumentation and the computer complex used . A schematic outlining computer logic sequence is seen in Fig. (18) Page 52.

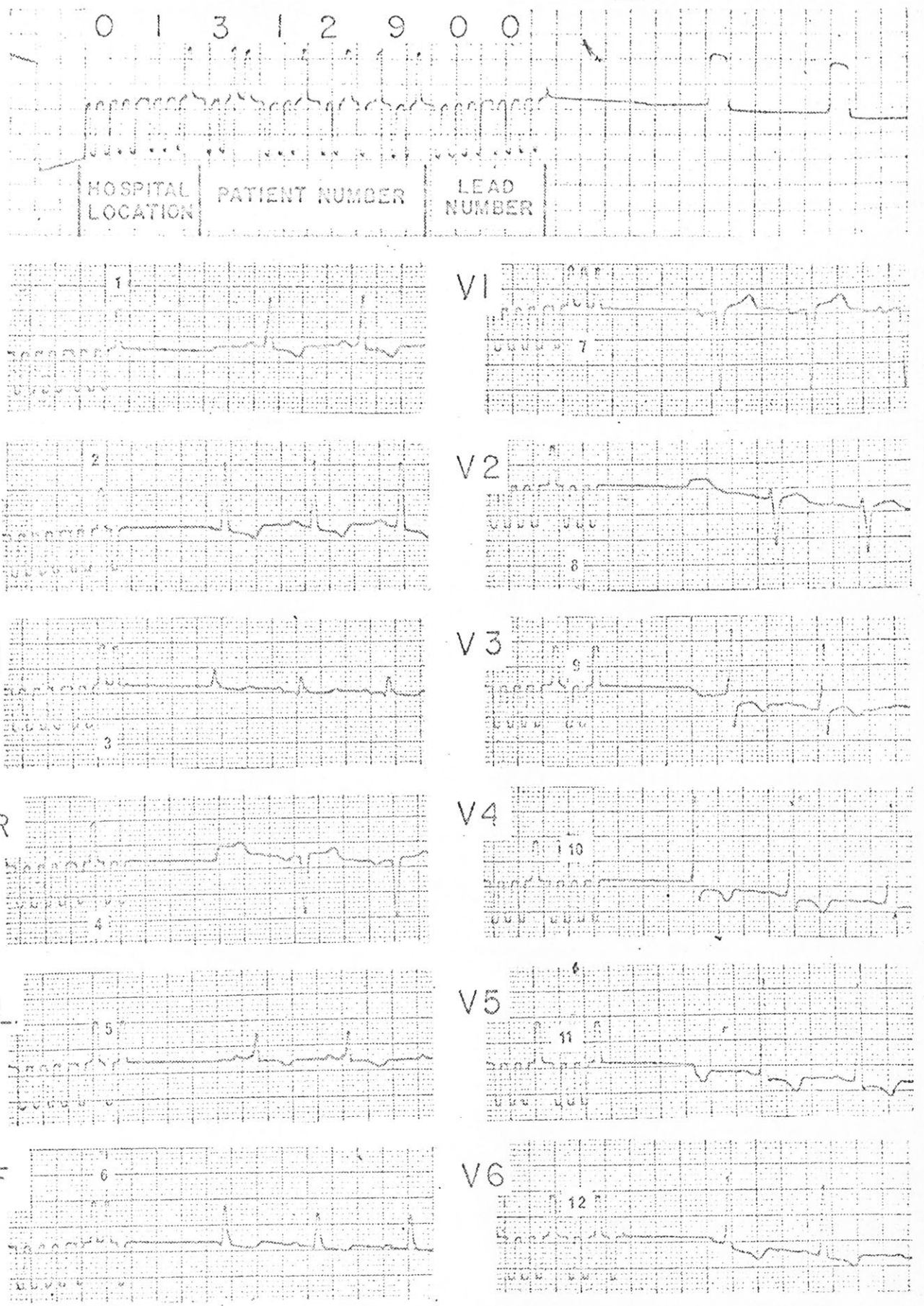
A third method represents a complete system with capabilities to provide automatic clinical evaluations of standard 12-lead electrocardiograms. The basic equipment includes a magnetic tape ECG machine and a medium-sized digital computer. The computer accepts data directly by telephone or by tape playback. Each of the 12 leads is converted to digital samples, measured, and stored. A three-step programme then recalls the measurements to be condensed, combined, and refined to one or several diagnostic statements. (79)

The ECG can be taken in the conventional manner. It is then converted into a frequency modulated signal and recorded on magentic tape on a special data acquisition device which contains a tape recorder, a conventional electrocardiograph, and a patient coding circuit.

Automatic identification codes are important in fully automated systems. The first item recorded on tape is a patient code number or other identifying data for the function being recorded Fig. (28). Calibration and other patient data, such as height and weight, are also added by the data acquisition device.

Transmission of the ECGs from the data acquisition device to the computer may be accomplished by the use of tapes, telephone transmission of the signal as it is being taken, or by tape playback (78), (82) & (83)

In the processing system at the heart station the analogue signal is converted to digital computer's core memory for electrocardiographic wave-form identification, recognition, and measurement of the standard clinical amplitudes, durations and intervals. (84) (85) This manipulation currently takes approximately four minutes. On completion of these procedures, each measurement is stored and clinical interpretation by inter-relation of wave morphology from any number of leads follows as a three-step diagnostic procedure to arrive at a standardized electrocardiographic diagnosis. This takes five seconds on the computer used. Data retention and recall is facilitated by storage of measurements in coded form on the computer's internal digital magnetic tape Fig. (29). The three steps involved in diagnosis are data condensation, data combination and diagnosis. These are illustrated in Figs. (30) (31) (32)



Typical ECG as played back from FM magnetic tape. Binary coding system for patient identification is read electronically by computer to identify physiological signal that follows. Calibration and 12 standard electrocardiographic leads are shown with code partially eliminated from all except standardization.

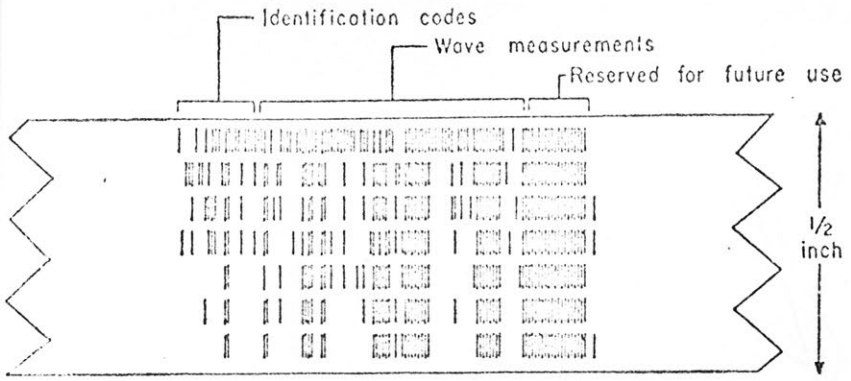


Fig. 29

Measurements of lead II tracing from Fig. 28; they are stored in coded form on computer's internal digital magnetic tape. Tape can be recorded at 200 or 556 characters per inch. One vertical line represents one character.

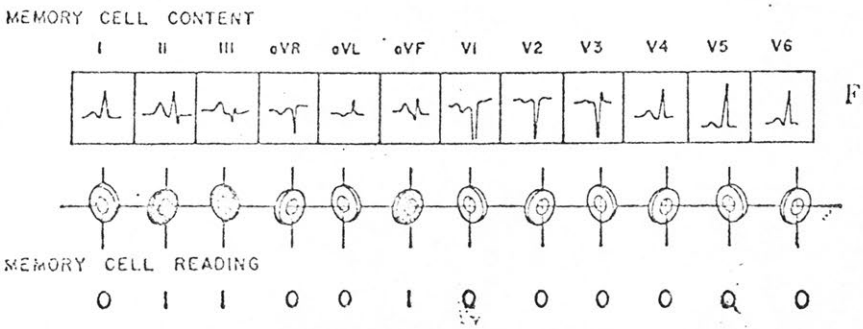


Fig. 30 Computer's method of determining in which leads P wave exceeds 0.20 mv. Darkened bits, the "1" state, represent those leads in which P wave has met defined criteria.

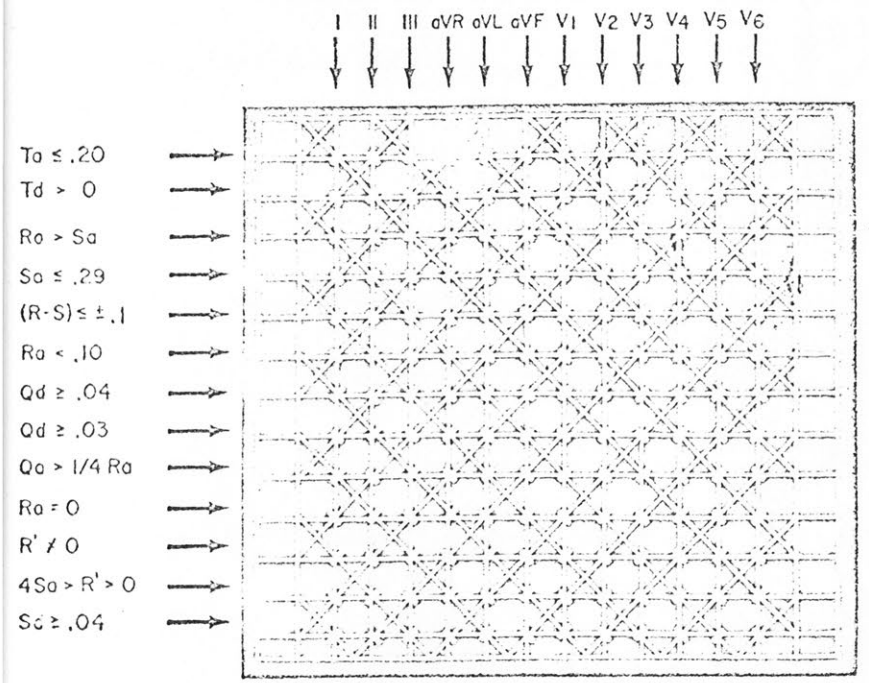


Fig. 31

Computer memory arrangement of a few of measurement interrogations. Each single core is assigned a parameter and limits for specific electrocardiographic lead. Entire morphology of a 12-lead ECG is represented at 0/1 states in this manner.

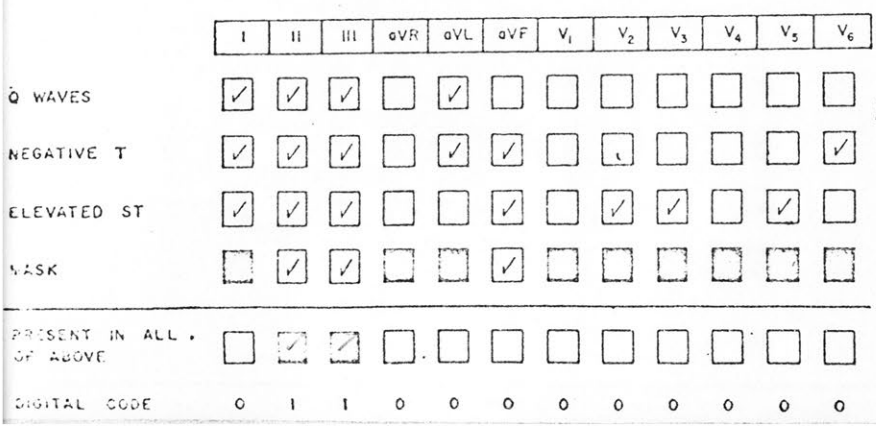


Fig. 32

Successful computer diagnosis of acute diaphragmatic myocardial infarction based on existence of two columns containing four checks. Mask (*fourth row*) can be shifted to pick up infarctions in other areas.

CHEST X-RAYS.

Photofluorography (or radiophotography) is the common method used for mass chest radiography.[91] The usual films used have been 35 mm., 45 mm., 70 mm., and 100 mm.. The 100 mm. film produces a picture of 90 x 90 mm.. The larger films cost more than the smaller. The 100 mm. films are only available as separate sheets for each exposure, apparently because technical factors make roll film unsatisfactory.

There is some loss of fine detail in the 100 mm. photofluorograph as compared with the full-sized radiograph. Loss of details in 35 mm. film is mainly due to the size of the granules of silver of the film. This factor is of minor importance for the 70 mm. film, and of even less importance for the 100 mm. film. In both of these the major loss of detail is due to the granularity of the fluorescent screen.[75] The 100 mm. camera has 20% better resolving power than the 70 mm.[76]

The screen granularity appears to be the main limiting factor at the present state of technology. A screen providing more detail would require a greater dose of X-rays to the patient. Image intensifiers can provide photographs whose details is comparable with that of the photofluorographs of larger sizes, but their input diameter is limited at present.

It has generally been accepted that the 35 mm. and similar small photofluorographs are for the detection of chest diseases in mass surveys, the diseases then being identified with the assistance of radiographs.[77] On the other hand, the 100 mm. photofluorographs provide so much detail as to be nearly as effective as radiographs for the detailed study of many diseases of the chest. This is the reason for choice of 100 mm. for

screening on admission.

The X-ray exposure to the patient is about 1.6 to 2 times that required for a radiograph, but less than that required for lens cameras that have been used. For a postero-anterior photofluorograph of the chest, the dose to the gonads of an adult is no more than 0.1 millirontgen.

Main Advantages.

The cost of a 100 mm. film is about 12% that of 35.6. x 43.2 cm. film.

There is less storage and filing space required.

Radiographers are relieved of much carrying and handling of cassettes.

THE COMPUTER.

GENERAL PRINCIPLES.

Reference has been made to the computer itself in automated data processing. Consideration has been given to the methods by which material may be fed into a computer and how it may be retrieved. Reference has also been made to the use ofAnalogue digital converters and the methods of online and offline input.

Multi-screening on admission to hospital would beextremely difficult without a computer. The screening would have to be limited in volume, both as to the number of patients handled and the number of tests performed. The overall value would be similarly effected.

Fig (33) briefly diagramatically represents the basic functions of a computer.

Some of the terms used in connection with computers are found in Appendix IA Chapter 5 Page 383. Chapter 5 itself gives a typical example of the method by which a computer can be used in Multi-screening. It describes the use of Visual Display Units, the use of a 1080 System and the IBM 360/50 computer complex.

In some systems the input and output devices are combined in a single unit such as a keyboard-teletype unit through which information can be sent to the memory unit by using the keyboard and information can come back through the key-typer or on the cathode ray tube monitor which can be combined with a light pen and keyboard and allows the operator to receive information in graphical, symbolic, numeric or pictorial form. The former is relatively slow and cheap the latter (C.R.P. monitor) fast (90) and expensive. The memory unit varies in word capacity with the size of

BASIC FUNCTIONS OF A COMPUTER.

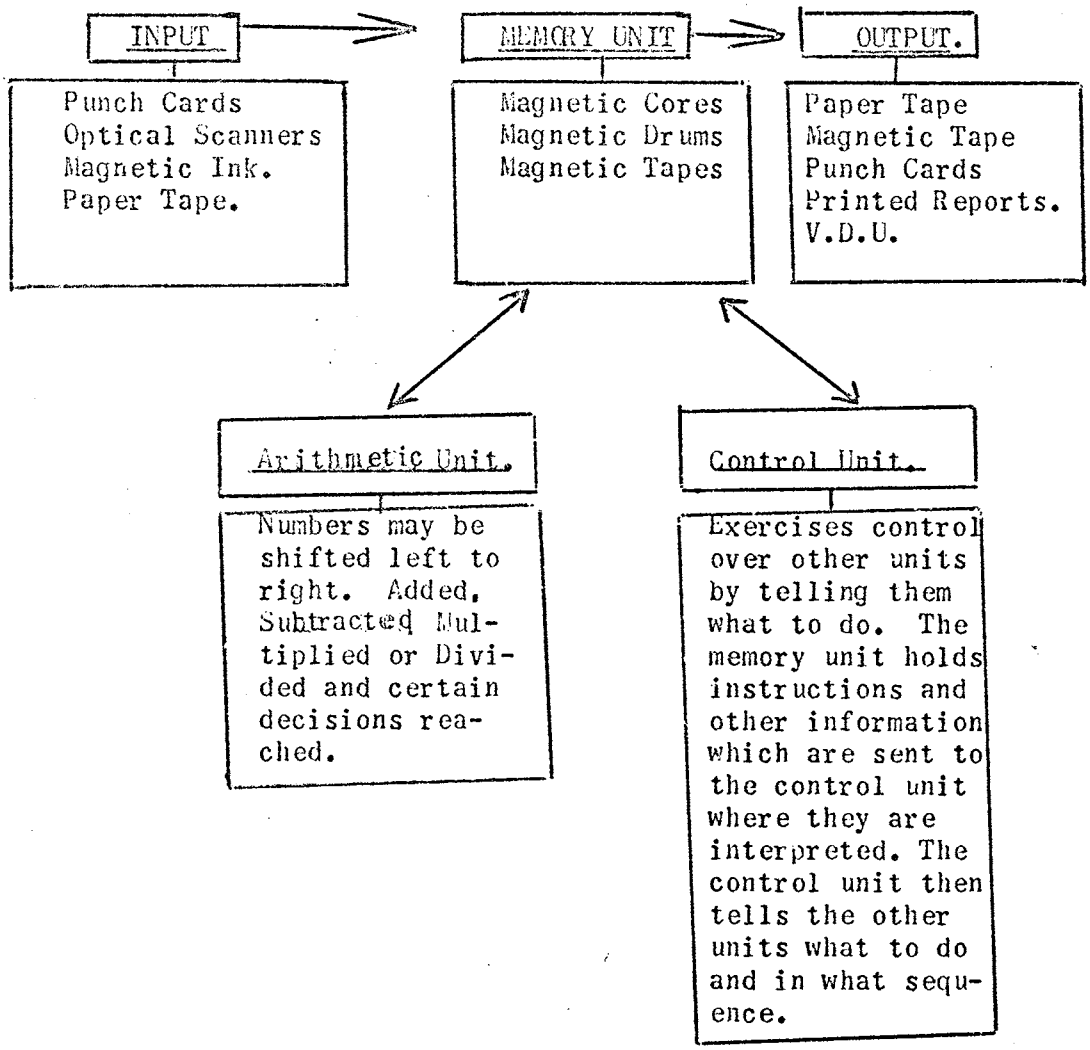


Figure 33

the computer.

Adapting computer techniques to multi-test screening is mainly a problem of selecting the proper methods for the practical work. The basic components are collecting, manipulation, and storing of data. (86)

Data Collection

The problems inherent in data handling for screening are concerned with the collection of data and with obtaining the information in a form suitable for machine processing.

Punch cards, paper tape or magnetic tape are the usual means of recording information. The choice of which method is dependent to a large extent on the machinery available.

The Punch Card.

The Punch Card is easy to handle - can be punched, checked and sorted by simple machines. For screening, highly effective combinations can be used by combining the uncoded text with the punched holes. A definite advantage is the Punched cards allowing new information to be added whenever needed.

There are many ways of changing punch cards to adapt them for special needs that are of interest for screening purposes. For instance a combination card - the dual card - offers the possibility of connecting visual information etc. to the coded punch card.

Punching is somewhat tedious work and needs well-trained personnel; it also introduces errors. Duplicate punching is often necessary, because errors in digital information may be misleading and dangerous. The checking of duplicates can be done automatically by machine (a "verifier").

Another technique of special interest in primary data collection for screening is the use of Mark-sensing cards. Instead of punching holes, marks are made on special areas by ordinary lead pencils, or by special ferrite pencils. The marks can then be read by machine. The Mark-sensing cards have less capacity, since the marks need more space. They are easy to handle, but it is easy to make faulty notations. For certain purposes, the IBM "Port-A-Punch" is useful. The cards are partly perforated, and a clear hole can easily be made with a pencil. The error inherent in Mark-sensing must always be borne in mind. However, the technique has been adapted for laboratory work, etc., with highly satisfactory results.

Paper tape as a medium is increasing in popularity. However, a special punch is needed, which is inconvenient. One of the main drawbacks is that, of their nature, paper tapes store sequentially arranged information. Therefore, addition of data (or sorting, etc.) cannot usually be done without retyping.

There are also paper tapes with extra space for adding for example, the uncoded text and identification. Paper tape is somewhat unwieldy to handle in quantity. It is nevertheless a cheap and convenient way of storing information, especially for later data processing.

Electric typewriters combined with punch and reader for paper tape (flexowriter, teletypewriter etc), constitute self-contained equipment. Such equipment can serve as a "terminal", and is handy and not too costly. Simultaneously, it gives the uncoded text for visual checking of the information stored on the paper tape. When needed, the information can then be sent to a distant computer centre by using a modulating unit and ordinary

telephone connections.

Magnetic tape and other magnetic media, such as discs, will presumably dominate the future. The advantages are striking, with high capacity and readily available information. On a large scale, they are economical. (For multi-screening however, the use of these media is of interest only for the processing and storage of information in a data centre where factors other than screening needs will be decisive)(86). However recording on magnetic tape is somewhat complicated, and requires special equipment.

Data Processing.

There is a discernible trend to use large and fast computers centrally located, instead of smaller ones working at a lower speed. By means of a time-sharing technique, a large computer can perform many different operations concurrently, and is more economical. It is true that small desk-size computers are now available, which are comparatively inexpensive and not too slow. However, they are used mostly for data collection on-line and as terminals, or for data reduction . They will presumable not replace large computers to any appreciable extent, especially since the development of data-transmission technique has been very rapid.

Data Storage

Generally speaking, extremely large memory capacity can be achieved today only by magnetic tape. This is a comparatively cheap method and not too space-demanding, but it has the disadvantage of a long access time. The production of large disc memories with a very high capacity and a very short access time is an important development.

Computer centres are now able to store enormous amounts of data

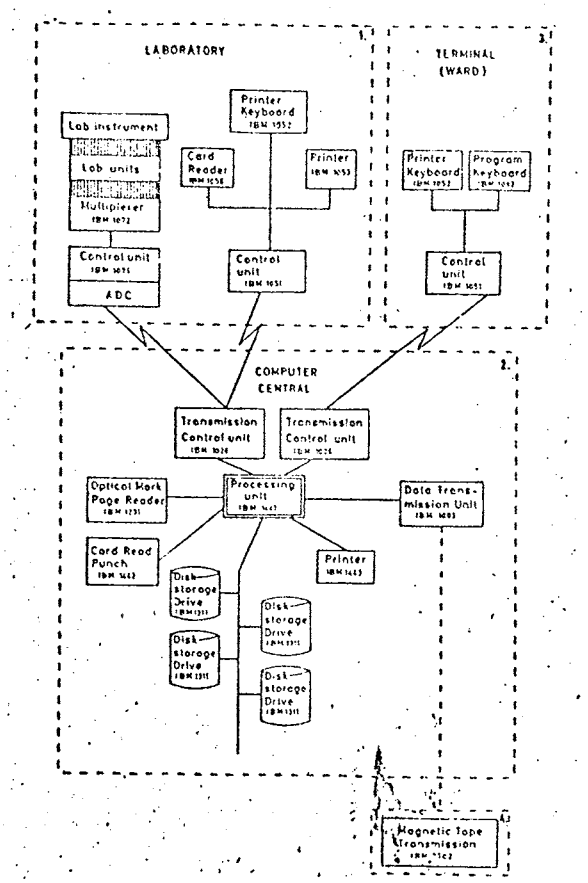


Fig34 Uppsala University Hospital computer set-up.

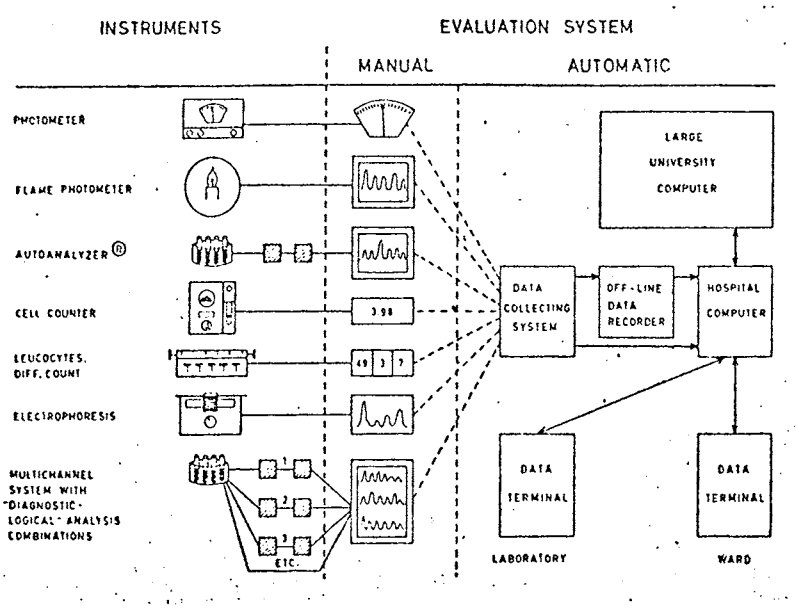


Fig 35 All types of analytical equipment can be connected to the data collecting system, but at the same time they display their output in the conventional manner.

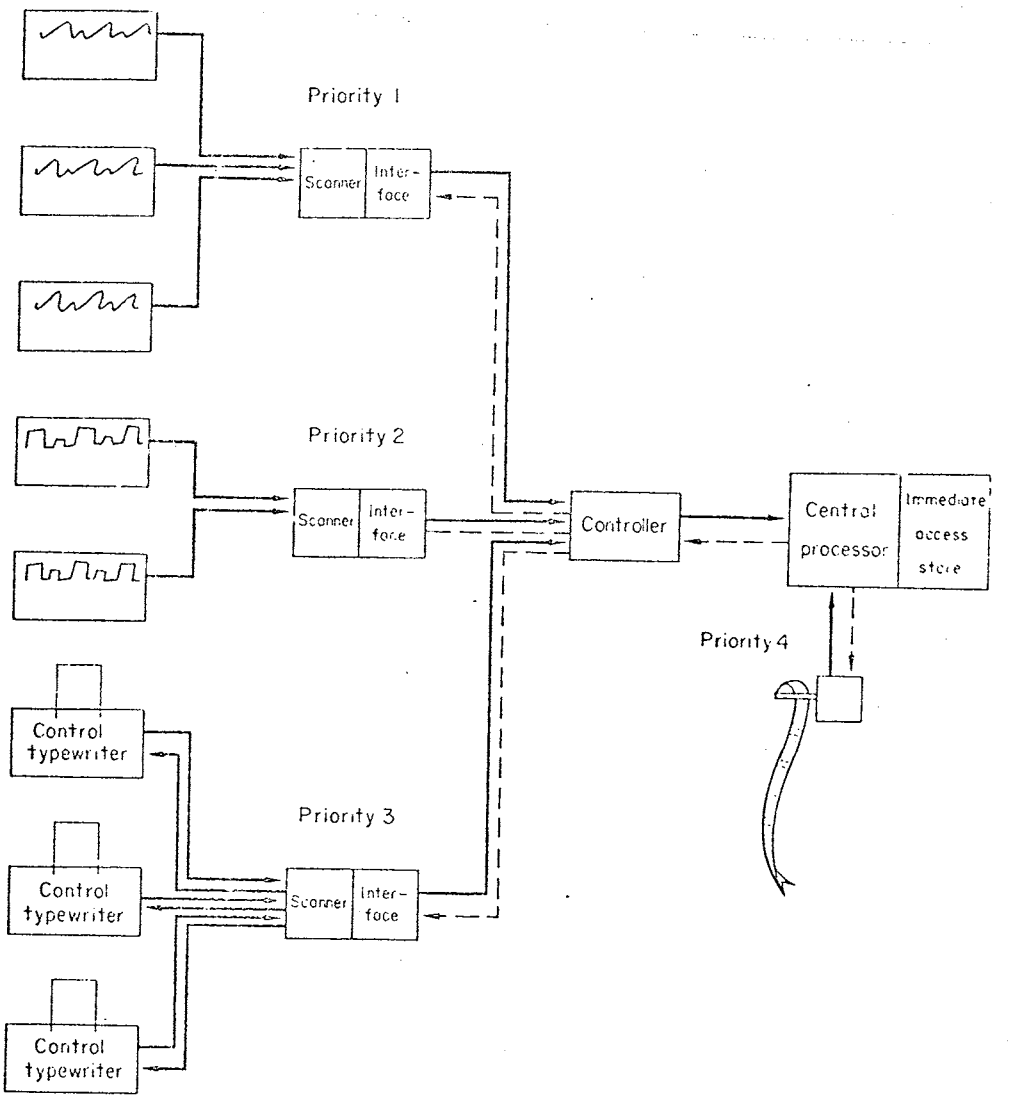


Fig. 36 Multiple inputs with priority gradings.

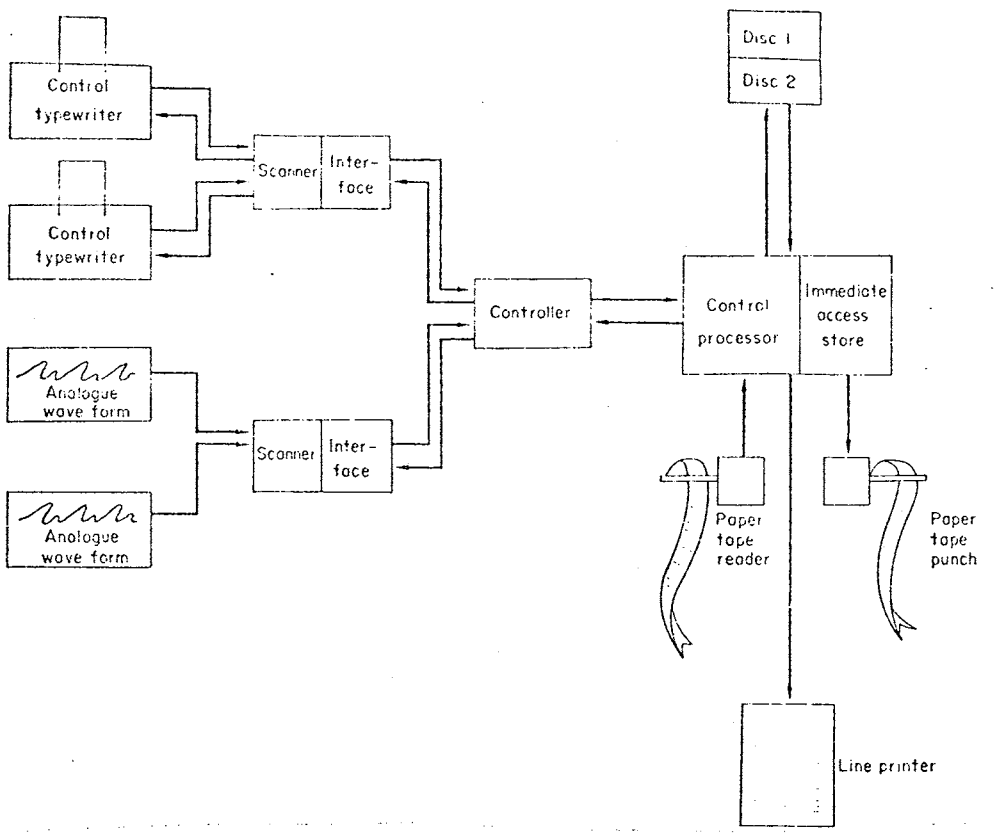


Figure 37

Mixed format multiple on-line inputs together with off-line inputs

and also to distribute them automatically to desired terminals, which may be as a write-out or on a Visual Display Unit.

General Hospital Computers.

These are large units usually servicing various areas in the hospital and fulfilling a number of functions. They may, for example, store, sort and up-date medical records, perform various accounting functions, carry out inventory procedures, roster staff, programme work in areas such as X-Rays, Pathology, Operating Theatres etc., allocate beds as well as other general hospital procedures. They have a memory bank depending upon the size of the computer. The retrieval rate is dependant upon the method of storage of material and the size of the computer.

Depending on the time available and allocated to a section on the computer that section may be on-line or off-line. This would be largely related to the volume and importance of the work performed in that section.

Small Laboratory Computers.

These are usually small on-line computers connected to the laboratory equipment. Some laboratory equipment has its own small computer incorporated in it, other items of equipment have an optional small computer which may be attached to that specific piece of equipment.

A small laboratory computer is usually situated in the immediate laboratory area and is on-line to the equipment and gives an immediate digital write out.

The computer does have a limited storage capacity and usually gives a punch-card, punch-tape, or other method by which material may be fed into a larger computer for storage.

The advantage in small laboratory computers is that the results are obtained immediately within the laboratory area and are available for checking and immediate distribution.

DISCUSSION.

The following Discussion is incorporated in this chapter for it incorporates important considerations directly related to the effects of equipment and automation on human relationships. The following points are considered:-

1) The effects of the Human Factor in Using Automated Equipment.will be one of the main determining influences in its successful implementation.

2) An important consideration is the transition from manual methods to a fully automated system.

3) The effects of automation and improved equipment on laboratory quality control.

The above three points are now presented as being relevant in this section as they deal directly with the success of automated equipment and its implementation.

THE HUMAN FACTOR IN USING AUTOMATED EQUIPMENT.

Hospital administrators believe that above all else, they must retain a focus upon the unique physical and emotional needs of the individual patient. They sometimes have had difficulty in reconciling this focus with their conception of computer operations as a vast, impersonal, and dehumanizing phenomenon.

To the medical and nursing staff, it may be a threat to status or authority, while to housekeeping, clerical and other personnel, it may appear to be an immediate threat to their jobs.

In any event, experience has shown that unless these threats are dispelled, hospital personnel will not co-operate willingly with a data processing programme. If they do not, the system probably will not work effectively. Therefore, as many people as possible should be informed about what is contemplated in their area and their future role in the plans and the machinery being used. In this way, not only do personnel feel a part of the plans, but many gross misconceptions about the computer are dispelled.(58)

Wertz predicted that "within the lifetime of most of us, every major hospital will be using computers and allied automated equipment as basic tools in diagnosis, as monitors of patients' conditions in the crucial hours after surgery and as compilers and analyzers of patient history information."(59) To-day no one hospital computer is accomplishing all these functions, but at certain hospitals, research and development activities on these functions are progressing and certain of them are now realities.(60)

Wertz also predicted that "Centralized hospital data processing should be achieved within a community by 1970". As has happened frequently when predictions have been made concerning future developments in data processing, Wertz overestimated the time frame. Such systems are already in operation in several communities.(61)

(57)

THE TRANSFER FROM MANUAL TO AUTOMATED METHODS.

The stage by stage transformation of various procedures from a manual system to a completely automated analytical system is shown diagramatically in Fig. (38).

"Manual System"

In the conventional way, manually performed methods are employed as well as a manual collection of manual data, manual calculation with the slide rule etc. and a manual listing of results.

"Semi-Automated System"

In the semi-automated system the manually listed basic data are manually punched into punch-cards for automatic data processing and listing by a computer.

"Automated System"

The basic data from partially mechanised chemical channels are automatically collected by a multi-plexing and signal conditioning unit and are automatically punched onto cards for "off-line" processing by the computer or the basic data are feed "on-line" into the computer for processing and listing.

At the automated stage of development advanced systems for automatic process control can be introduced.

In a working hospital laboratory all stages of sophistication must be run in parallel if there is to be maximum benefit.

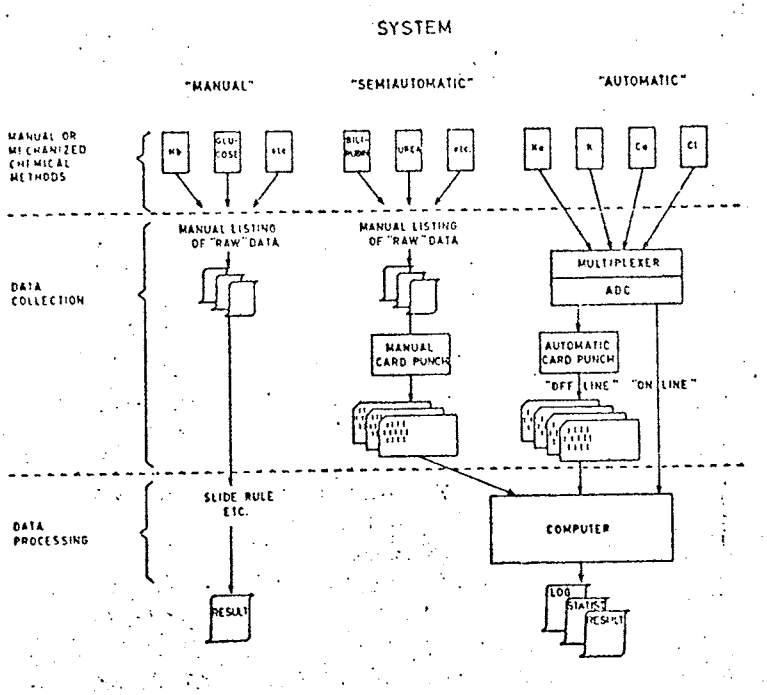


Fig 3 The transformation from a manual system towards a fully automated procedure.

THE BENEFITS OF BETTER EQUIPMENT.

By using automated test equipment and the collection of test results by computer the following benefits can be achieved.

1) Improved reliability results.

2) Possibilities for displaying the result in an improved manner.

3) Shorter time lag between test samplings and report of results.

4) Better "Book-keeping" of laboratory data in the patient's record.

5) Automatic up-dating of an "immediate access" patient's file in the hospital computer.

6) Automatic up-dating of various patient data registers by data transmission to the main computer centre, eventually containing all medical information about the patient. From these registers data can be retrieved for studies of case histories, scientific work, patient's statistics etc.

In order to make full use of three and four the communication between the laboratory and the wards should be integrated into a computer system. The logical sequence would be that each ward would eventually have its own terminal equipped with various input-output devices.

THE EFFECT OF AUTOMATION AND IMPROVED EQUIPMENT.

Laboratory Quality Control.

More precise equipment and a greater degree of automation have grown together, since improved precision minimises instrument errors while increased automation lessens the risk of operator error. Newer instruments also reduce the amount of handling steps for many specimens, thereby eliminating opportunities for error that accompany each step.

Equally important is the awareness of quality control that has been developed amongst and accepted by physicians, pathologists, laboratory personnel and hospital staff in general. In considering quality control it is a serious mistake to consider that it begins and ends in the laboratory.

Errors can occur at any particular point in the multiple stages through which the process travels from the ordering of the test to its result being filed in the patient's record.

Errors such as drawing samples from the wrong patients or transcribing the wrong results are rare but they are often most serious. Cross checking is the simplest way to eliminate the risk of drawing the wrong sample e.g. name on wrist band, hospital number ward or bed number, age and sex.

To eliminate errors due to variation in collection procedures, written procedure manuals on sampling are most effective. These serve as orientation aids for new members of the staff and for training aids for technicians. Cross checking should also apply to the clerical work of reporting and transcribing results.

In the laboratory, the central element of most quality control programmes is the concept of statistical quality control. The concept embodies the theory of mathematical probability. Its implementation has been simplified by automation but there is still the human error in tests where technicians themselves do most of the figuring and plotting.

Bio-chemistry is perhaps the simplest area in which quality control programmes can be applied, for it is here that much of the work is repetitive and the results are quantative. It is also one of the most important areas since it usually accounts for a major portion of test volume.

Bio-chemistry lends itself to frequent checking with "blind" specimens. A useful technique for spot checking and for monitoring new employees.

Quality control in haematology is more difficult. Although the tests are still quantative in the majority of cases technician's skill and human judgement plays a large role e.g. differential blood counts.

However automated machinery as in bio-chemistry has greatly simplified areas in which quality control programmes can be used.

Micro-biology is a difficult area in which to apply quality control in the strictest sense of the word. Tests are almost exclusively qualitative, human judgement is the decisive factor and risk of contamination always exists.

Cross-typing and cross-matching of blood is especially important since any error here can result in the death of an individual. This is an area in which the human element must be checked and cross-checked in order to reduce the possibility of mistakes to a minimum.

Anatomic pathology is the most difficult area to control systematically, so quality will depend upon how carefully the work is done.

Automated equipment with standardized reagents and procedures has done much towards improving quality control in Australia. Methods of identification of samples has been improved and made almost foolproof by new automated procedures.

Quality control can be expensive, statistical quality control methods, top quality equipment and supplies can cost 10 per cent or more of total billings in a large laboratory. The cost may be even higher for a small laboratory. Fortunately, however, improved quality control can help build laboratory test volume which, in turn, may increase hospital income since, on the average hospital laboratories contribute 10 to 15 per cent of hospital income and account for only 7 to 9 per cent of costs.(56) +

+ The figures quoted relate to American Hospitals and may not necessarily be applicable to the Australian situation.

APPENDIX

A REVIEW OF AUTOMATED BIOCHEMISTRY EQUIPMENT.

1) AutoAnalzer

The Autoanalyzer consists of a series of interconnected modules. Samples are drawn off into a multiple-channel proportioning pump, which serves to propel forward sample and reagents in correct proportions. They are then brought together, dialysed, incubated and passed through a colorimeter to give a chart readout.

Air bubbles are continuously drawn into the flow, both to separate successive samples and to segment each sample stream. These bubbles not only provide a barrier between samples, but also cleanse the system between samples and assist in mixing sample with reagent.

Later developments of this basic scheme are the Sequential Multiple Analysis systems which carry out a complement of tests on each sample. The SMA 12/60 carries out 12 different analyses on each of 60 samples per hour. A pre-calibrated strip chart gives a direct presentation in concentration terms. The physician can then see at a glance where results deviate from normal.

Technicon can also be incorporated for a complete online computer controlled analyser system.

2) Bionalyst.

Evans Electroselenium Limited (EEL) and Griffen and George Ltd. make the "automated chemistry module". It is unusual in that the sample cups proceed along the straight sides of the unit instead of revolving. Sample cups of 0.5 ml capacity and reaction tubes of 5 ml capacity are

moved round by a conveyor system. They may spend a predetermined section of their journey moving through a thermostatically controlled incubator trough.

The system will handle from two to sixty samples, which may be processed at the rate of 120 per hour. Although this automatic system uses methods not very different from those executed manually, it uses smaller volumes of sample and reagents. As with all these automatic systems, it also has the advantage over manual methods of increased accuracy and reproducibility ofmethod and results.

Optional with the Griffin module is the EEL automatic measuring and print-out colorimeter module. The cuvetter of the colorimeter is filled from the chemistry module just described. The module provides waveband coverage from 340 to 700 mp. and self adjustment to reference standards. Concentration is printed out in digital form.

3) Autolab.

Grant Instrument of Cambridge have used the Linsom system, called Autolab.

Sample tubes for the specimens are drawn through the machine in magazines linked together to form a chain. A measured quantity of specimen is drawn from the tube in the sample chain and transferred to the analysis chain. The specimen tube may therefore be fed through again for different analyses.

The tube holder of each magazine has an identification number, which is printed out with the analysis result. In urgent cases it is possible to insert extra magazines in the middle of the chain, and still identify them in the printed record.

Specimens are processed at the rate of 240 an hour. If incubation is required, the analysis chain can be led through a water bath. Any suitable print out unit may be used. The analyser is a photo-meter of range 340 to 700 mu wave-lenght. Specimen is dispensed into a 10 mm cuvette, which is rinsed before each analysis.

4) Built-in Centrifuge.

Quickfit and Quart have also developed a new automatic analyser. This analyser is novel in that it includes a centrifuging stage as part of the normal automatic sequence. This is accomplished by a built-in micro centrifuge, capable of separating any precipitate encountered in traditional analytical procedures and also of handling liquid/liquid systems. This permits the use of whole blood as starting material, consequently cutting out several sample preparation stages during which there is a risk of accidentally mixing samples.

Batches of up to 32 samples of whole blood, plasma, serum and other specimens are passed through at a rate of approximately 100 per hour.

5) Mecolab

This system consists of a number of preparation units, each of which accepts a batch of 15 samples, an automatic photometering unit and a digital printer. As with many of these systems, the output can be obtained in a form suitable for computer processing. It can produce refined statistical information such as normal values and standard deviation.

6) Clinomak

This unit can handle 300 samples per hour in batches of 90. It has

a built-in automatic colorimeter, where each sample is viewed in it own reaction cuvetter. As with most of these systems, it can handle these types of biochemical analysis but cannot carry out deproteinisation.

The machine can automatically measure by a flame photometer sodium, potassium and calcium.

7) Multichannel 300

Vickers Ltd. have produced the Multichannel 300. Twelve analysing units are arranged in series, each coping with one type of analysis at the rate of 300 samples per hour. Samples are introduced into the system in special cuvettes, each labelled with a number to identify the patient A quantity of specimen for each analysis is withdrawn as the sample passes the appropriate analysing unit, and the complete list of results for each patient is printed out at the end.

8) Autochemist.

This machine, produced by the Swedish Company, A.G.A., is designed for integration with a totally automated hospital system including communication with wards, other laboratories and hospitals as well as with its own central computer.

Requiring a free floor space of 18 x 7 feet, and rising to a height of 9 feet the central chemical processor accepts 18 samples per hour, which along the conveyor system of 24 different analyses channels represents 3,000 determinations per hour. Satellite stations handle these analyses which are required only occasionally.

Results from all analysers are fed on-line to a computer which comes with the installation where they are correlated on magnetic tape records of patient's history. These can be connected by telephone line with

wards for the automatic ordering of tests and reporting of data. The computer works in real time and results are printed out by teletypewriter Fig. (39).

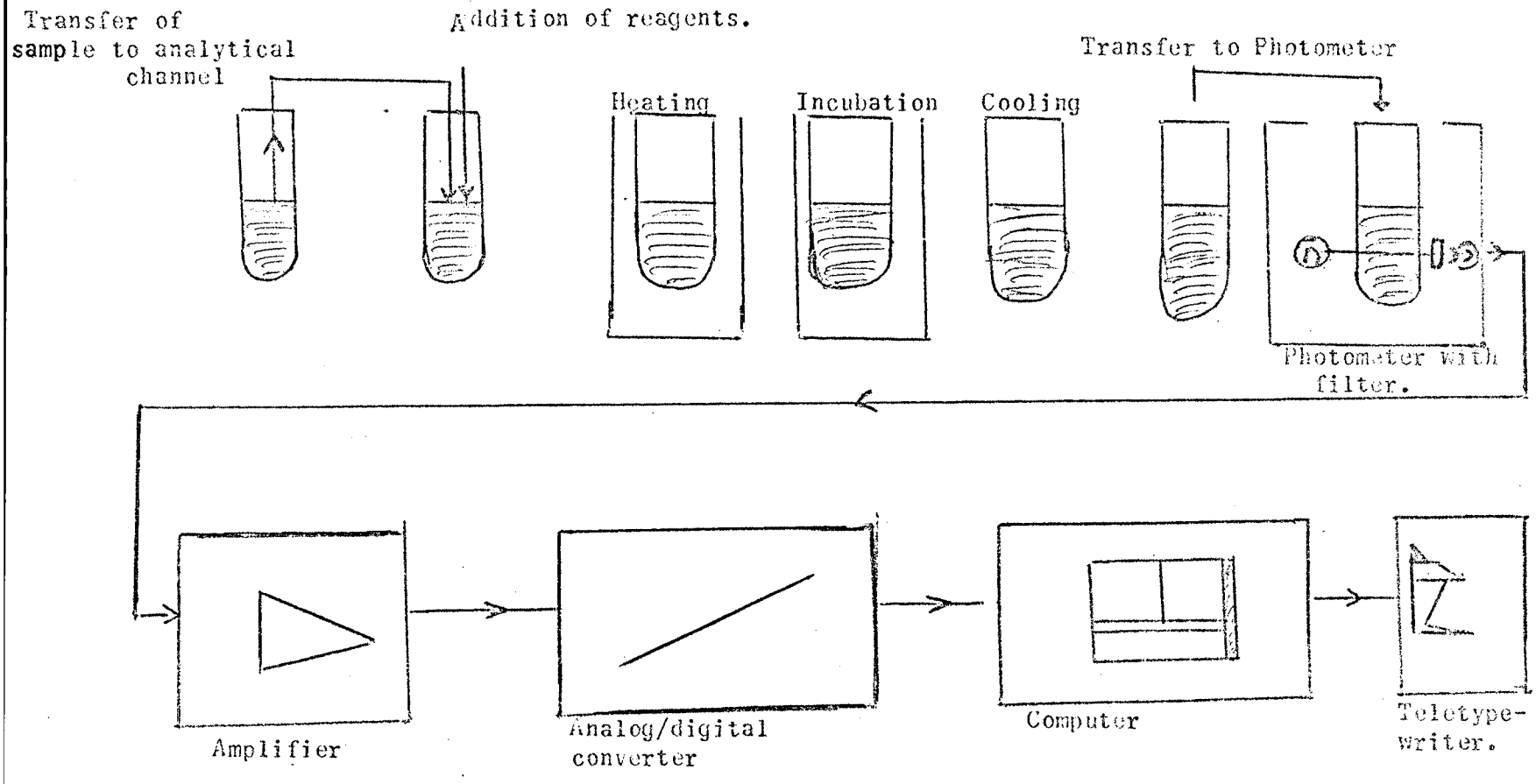


Fig. 39.
Cycle of events along one channel.

APPENDIX I

SMA 12/60 (66)
TECHNICON.

Fully automated chemical analyzers were first used in chemical laboratories in 1957. Technicon developed the sequential multiple analyses system which was capable of performing several chemical tests simultaneously. By achieving what they termed a "steady state" i.e. a condition in which concentration of the sample in the flow-cell remains constant through time, the machine attained a high degree of efficiency. Results can be directly reported in concentrated terms in an immediately usable form.

Many test may be run at a rate of 60-80 samples per hour at a "steady state" with single point calibrations and digital print-outs of results. Using multiple points standardization rates up to 120 per hour may be run.

Test Flexibility of the SMA 12/60

This machine is designed to provide any 12 (+ blank channels where applicable) of the following bio-chemical procedures.

SGOT	Carbon Dioxide
L.D.H. (including blank)	Calcium
Total Bilirubin (including blank)	Inorganic Phosphate
Uric Acid	Total Protein (including Blank)
Urea Nitrogen	Albumin (including Blank)
Sodium	Glucose
Potassium	Cholesterol
Chloride	Creatinine
	Acid Phos. CPK

Each of the chemistries is performed in an individual, compact, "plug-in" analytical cartridges. Each cartridge contains all the hardware needed for one specific procedure mixing coils, phasing coils, dialyzer, heating units if needed and all requisite connections.

As all cartridges have exactly the same outer dimensions, they are interchangeable.

All 12 test results for each sample are reported in directly readable concentration units on a single strip of precalibrated chart paper. The normal ranges for each parameter are printed as shaded areas. The SMA System may be connected to their Technilogger II which will provide a digital result.

Accuracy

In continuous flow analysis, the colour intensity of the air segmented analytical stream (s) is continuously measured in a Colorimeter, and, at the same time, continuously recorded on a strip chart record. On the SMA 12/60, in addition to the primary recording on the Serum Chemistry Graph (SCG), the complete analytical curve for each of the twelve to sixteen channels is visually displayed on a Function Monitor.

Four blank correction channels are standard with the SMA 12/60 for use with those test procedures which require them. Lipemic or icteric sera no longer pose a problem for accurate biochemical analyses. Any of the blank channels can, of course, be utilized for other procedures which might require them.

Actual measurements are made only after the analytical curve reaches it steady-state plateau, (which may be defined as an equilibrium condition in the system at which there are no changes in concentration with time.)

At this steady-state plateau, all effects of possible sample interaction have been eliminated, and the recorded signal gives a true reflection of the concentration of the constituent being measured.

Precise Air Segmentation.

The importance of segmenting each of the sample and reagent streams with air bubbles is due to the fact that the air bubbles act as barriers to divide each sample (and reagent stream) into a large number of discrete liquid segments. Equally important, the air bubbles continually "scrub" the walls of the tubing. This sequential wiping of the walls diminishes the possibility of contamination in succeeding segments of the same sample. Thus, should there be any interaction between two samples, it can easily be seen that the effects of this interaction will occur only in the first few segments of the second sample. In the middle segments, the air bubbles immediately preceding will have effectively cleansed the system and prevented further interaction.

It is these middle and final segments, free from interaction, which are recorded as the steady-state plateau and appear as flat lines on the SCG. This assurance of freedom from contamination is accomplished by continuous flow analytical techniques.

The air bubbles are added to the flow-stream in a precise and timed sequence by a proportioning pump. The importance of the air bubbles has already been stressed.

Built-in Refrigeration.

The Sampler table includes a built-in refrigeration unit with enough space for six large reagent containers and two plates of samples.

Sample.

1.8 ml. of untreated serum is required for simultaneous performance of 12 biochemical tests.

Sampler II or T40

Either a Sampler II or a Technicon Sampler T40 may be used on the SMA 12/60. Both hold up to 40 sample cups or standards. The T40, is the system of choice for use with Auto-analyser systems. By printing an identifying number on each Serum Chemistry Graph, the T40 eliminates errors that can occur in identifying patient test results.

The unit electronically "reads" a 6-digit identification card that accompanies a patient's sample from the time it is drawn, through serum separation by centrifugation, to loading on the sampler turntable. Appropriately phased with sample entry into the system, the signal is fed to an electronic buffer which converts the information into printable form. A printing device in the recorder then registers the six-digit number on each patient record.

Analytic Cartridge.

Each test has its own removable analytical cartridge to perform such analytical techniques such as mixing, dialysis, heating, time delay and phasing.

Monitor

The Oscilloscope is divided down the centre with eight complete test curves on each side (including the four blank channels).

Each sample curve is recorded in its entirety, and enables the operation to see sixteen curves for each sample at all times.

Colorimeters.

The colorimeter flow cells are located as close as possible to their analytical cartridges. This is accomplished by a system design incorporating four photo-tube Colorimeters, each consisting of four analytical channels and one reference channel, and positioning them immediately above four of the analytical cartridges.

Flame Photometer.

SMA 12/60 system is designed to include electrolyte determinations, by a Flame Photometer module for Na and K.

Flow System of Individual Chemistries.

After the sample is aspirated, it is split six ways:

Stream 1 (SGOT) is incubated with substrate. The mixture is dialyzed and diazo dye added to the recipient stream. After incubation for colour development, the mixture goes to the colorimeter.

Stream 2 (Alkaline Phosphatase.) is incubated with paranitrophenylphosphate substrate, dialyzed into a recipient stream of aminomethylpropanol buffer, and phased to the colorimeter.

Stream 3 (Uric Acid) is treated with sodium hydroxide, dialyzed into a recipient stream of sodium tungstate and hydroxylamine. Phosphotungstic is then added for colour development and the stream is phased to the colorimeter.

Stream 4 (Inorganic Phosphate) is diluted with sulfuric acid and dialyzed into sulfuric acid. After dialysis, ammonium molybdate and stannous chloride hydrazine are added, and the stream is phased to the colorimeter.

Stream 5 (Cholesterol) is mixed with Lieberman-Burchard reagent and phased to the colorimeter.

Stream 6 (T.P. Albumin, Calcium, Glucose, BUN, LDH, and Bilirubin) is diluted with water, and then this "main" sample stream is further split into sub-streams:

(Glucose) Stream is diluted with saline, and dialyzed into and treated with sodium carbonate. Copper neocuproine is added, the mixture is heated to 90°C., and phased to the colorimeter.

(BUN) Stream is diluted with water, and dialyzed into a receipient stream of diacetyl monoxine and thiosemicarbazide. It is then treated with acid ferric chloride, heated to 90°C., and phased to the colorimeter.

(LDH) Stream is mixed with substrate DPN diaphorase, and then tetrazolium dye. After incubation, and the addition of HCl to stop the reaction, the stream is phased to the colorimeter.

(LDH BLANK). Same as assay except that a blank solution issued in place of DPN diaphorase.

(Calcium) Stream is mixed with HCl and 8-hydroxy-quinoline and dialyzed into a solution of HCl, 8-hydroxyquinoline, and cresolphthalein complexone. After dialysis, base is added, and the stream is phased to the colorimeter.

(Total Bilirubin) Stream is mixed with caffeine diazo and tartrate, and phased to the colorimeter.

(Total Bilirubin Blank) Stream is mixed with caffeine sulfanilic acid, and tartrade, and phased to the colorimeter.

(Total Protein) Stream is treated with biuret and phased to the colorimeter.

(Total Protein Blank) Stream is treated with alkaline iodide solution and phased to the colorimeter.

(Albumin) Stream is treated with HABA reagent and phased to the colorimeter.

(Albumin Blank) Stream is treated with phosphate buffer and phased to the colorimeter.

Programmer.

The Programmer is the control module of the SMA 12/60. It contains solid-state electronic circuitry for measuring the output of the twelve analytical channels and for conditioning the signals so that a direct recording of concentration is printed on the recorder chart. It may also be used to perform blank, sensitivity, and linearity checks. Finally, there is the clot alarm light which indicates the presence of a clot or blockage in the main sample line.

Specifications of SMA 12/60

Dimensions: L-shaped. 8'6" long x 62" wide x 547/8" high.

Allow access room of 3' all around.

Weight: 1200 pounds.

Power requirements: 115VAC, 50/60 CPS.

System draws 1800 watts. Two 15 ft. power cords are supplied.

Fuel requirements (if Na and/or K are selected): Piped or bottled compressed air. Piped or bottled natural gas or propane (line pressure of 4 in water to 1 psi).

Volume of sample 1.8 ml.

Rate of Analysis: 60 samples (and standards) per hour.

Analysis Lag Time: 8 minutes.

Drain: System drains into self-contained waste bottle. However, connecting waste into a permanent floor drain is preferred.

APPENDIX 2

S. M. A. 4A/7A (68)

S.M.A. 4A

This is for recording R.B.C, W.B.C. Haematocrit, Hb simultaneously at 60/hours.

1.0 ml of blood is required.

The results are sequentially presented in concentrated terms on a precalibrated chart.

S.M.A. 7A

Carries out the above tests in addition to M.C.V, M.C.H. and M.C. H.C., on the same chart.

The above two machines are based on the same principle of continuous flow analysis as the S.M. A. 12/60

SPECIFICATIONS:

Dimensions:

System occupies bench space 6' long x 2' deep

Weight:

200 pounds; shipping weight 350 pounds.

Power Requirements:

115 Vac: 60 cps (50 cps. available);

1 phase; 300 watts.

Operating Temperature:

15°C. to 40°C.

Reproducibility (Average coefficient of variation):

RBC Count ± 2%

WBC Count ± 2%

Hemoglobin ± 1%

Hematocrit ± 1.5%

Rate of Analysis:

60 samples per hour.

No. of Samples/Tray: 40.

Sample: Wash Ratio.

53:7

Time Interval: Sampling to recording: 4 min.

Sample Volume (min): 1 ml.

Anticoagulant:

K_3EDTA.

Sample Volume Used:

RBC/Hemoglobin	0.05 ml.
WBC.	0.15 ml.
Hematocrit	0.23 ml.
Total:	0.43 ml.

Drain: System drains into sink.

APPENDIX 3 (69)
TECHNILOGGER II.

TECHNICON.

Used with either SMA 12/60, SMA 6/60, SMA 4A, or SMA 7A Auto Analyzer. The Technilogger II will provide as output a directly readable typewritten tabulation of the test results - without further data processing.

In addition to printing a tabulation of the results, the Technilogger II, can also store the results on either magnetic tape, punched paper tape, or punched cards for further statistical analysis by a computer.

SPECIFICATIONS:

Data Input: 16 channels of analog information.

Input Level: 0 to + 15V.

Input Impedance: 1 Megohm.

Digitizer

Performance: Accuracy: ± 0.1% ± 1 count LSD.

Precision: 4 decimal digits.

Encode Rate: 12 ms max.

Logic Levels: CV ± 0.75; logical 0

+ 5V ± 1: logical 1.

Clock Rate: 100 KHZ.

Output Code:

Output # 2.8 channel binary coded decimal code 24 volts @ 500 ma 50-150 ms.

Output # 2.8 channel binary coded decimal code 24

volts @ 500 ma.

Start Input: Contact closure or internal clock

Dimensions:

Height: 7 inches.

Width: 20 inches.

Depth: 20 inches.

Power.

Requirements: 115 volts 50/60 cps single phase.

Operating Temp: 15° C @ 45° C

Power Drain: 50 watts.

Weight: 50 lbs.

APPENDIX. 4

TECHNICON AUTOANALYZER.

CLINICAL METHODS AVAILABLE.

A. COLORIMETRIC METHODS.

Acid Phosphatase	Phenol is estimated with 4-aminoantipyrine following hydrolysis of phenyl-disodium phosphate at PH 5.0.
Alkaline Phosphatase	As above but at PH 10.0
Blood Urea Nitrogen	Estimated by diacetyl monoxine in the presence of thiosemicarbazide under acid conditions.
Micro Urea Nitrogen	As above.
Bilirubin	Bilirubin is reacted with diazotised sulphanilic acid.
Calcium	Calcium is dialysed under acidic conditions into cresolphthalein complexone and diethylamine is added.
Carbon Dioxide	Carbonate, bicarbonate and carbon dioxide are released by acid, and the gas caused a change in the colour of a phenolphthalein buffer.
Micro CO_2	As above.
Chloride	Ferric thiocyanate is formed by reaction of Cl with mercuric thiocyanate and thence ferric nitrate.
Cholinesterase	Thiocholine is determined by reaction with DTNB following hydrolysis of Acetylthiocholine.
Cholesterol	An isopropanol extract is reacted with ferric chloride-sulphuric acid.
Cholesterol	(continuous filter) Eliminates manual extraction.
Creatinine	Estimated following dialysis with alkaline Picric acid.

Creatine Phosphokinase	The reaction can be measured either by the estimation of creatine or phosphate.
Free Fatty Acid	Following extraction a copper soap is formed. This is subsequently complexed with diethyldithiocarbonate to form a coloured product.
Glucose	Determined by the potassium ferricyanide - potassium ferrocyanide reduction reaction.
Micro-Glucose	As above.
Glucose Oxidase	For the determination of true glucose.
Haemoglobin	Estimation as cyanmethaemoglobin.
Hydroxyproline	Estimation with P-dimethyl amine benzaldehyde following oxidation with Chlormine T.
L.D.H.	Lactate is converted to pyruvate which is estimated by a tetrozolium salt as chromogenic indicator.
Inorganic Phosphate	An adaptation of the method of Fiske and Subborow.
17-Ketosteroids 17-Hydroxyketosteroids.	) Following manual extractions, the methods) predominately parallel manual procedures.)
Protein bound Iodine	Estimated following digestion by reduction of ferric salt with arsenic as catalyst.
Protein	Lowry or Biuret methods.
Serum Iron	Is estimated in ferrous state by T.P.T.Z.
S.G.O.T.	The oxalacetate produced is dialysed and reacted with the diazonium, salt Azoene Fast. Red!.
S.G.P.T.	An automated version of the Reitman - Frankel colorimetric method.
Albumin	Estimated by the reaction of sera with either HABA or Brom Cresol Green.
Uric Acid	Estimated by reduction of Phosphotungstate in either a cyanide or carbonate method.

B. FLUOROMETIC METHODS.

Calcim	A fluorescent complex is produced when calcium is added to a strongly alkaline solution of calcein.
Catecholamines	Following a purification step the method is an adaptation of the trihydroxyindole method.
L.D.H.	The reaction followed is lactate - Pyruvate and activity is determined by following the fluorescence of NADP.
Magnesium	The test is based on the fluorescent complex formed by the reaction of magnesium with 8 - hydroxyquinoline.
Phenylalanine	Is determined by estimation of the fluorescent complex formed when it is heated in the presence of ninhydrin and L-leucyl-L-alamine.
SCOT, SGPT	These methods depend on the native fluorescence of NADP.
Triglycerides	Are saponified to glyceroland free fatty acids. The glycerol is oxidised to formaldehyde which condenses with acetylacetone to yield a fluorescent complex.

C. FLAME PHOTOMETRIC METHODS.

Sodium & Potassium	Are determined on serum or urine samples by comparing flame colour to a standard lithium solution.

D. HAEMATOLOGICAL AND IMMUNOLIGICAL METHODS.

Antibody Screening	Cells are enzyme treated and reacted with specimens.
Automated reagin Test.	An automated VDRL test giving permanent results.

Complement fixation and Haemogglutination systems for a variety of antibodies.

Cell Counting

Blood Typing.

N.B. This list included most of the commonly used clinical methods, however, many other methods have been automated.

APPENDIX. 5

ZYMAT 340.(72)

The Zymat 340(R) Enzyme Analyzer is a completely automatic instrument which analyzes Lactate dehydrogenase (LDH) Alanine aminotransferase (GOT), and other enzymes in biological fluids.

Minimum Preparation: Interchangeable syringe and dispensing assembly eliminates possibility of cross-contamination. Disposable sample cups and cuvettes.

High Volume: After incubation, the Zymat 340 analyzes one sample every two minutes, with a sample load capacity of up to 47 samples.

Permanent Record: Paper tape printout is in International Enzyme units with a serial number to identify each sample.

Minimum Sample Size: 0.2 ml. sample size permits multiple determinations on typical 3 cc sample.

SPECIFICATIONS:

Electrical System: 120 Volts AC, 50/60 HZ nominal
230 Volt Model Available.
Power requirement of 800 watts.

Incubation Period: Approximately 12 minutes.

Throughput: Sample every 2 minutes.

Water Bath Temperature: 23.37°C ± 0.1° C

Photometric System: Double Beam Interference Filter

Wheel Capacity: Up to 47 samples.

Printout: International Enzyme Units

Finish: Resistant to sample and reagent stains.

APPENDIX. 6

(88)

ATOMIC ABSORPTION - SPECTROPHOTOMETER.

ATOMSPEK:

By atomic absorption Spectrophotometry over 60 elements can be determined. The most important ones are: Calcium, Copper, Iron, Lithium, Lead, Potassium and Sodium.

SPECIFICATIONS:

Wavelength Range	193 - 853 nm
Wavelength Accuracy	better than 0.5 nm below 500 nm
Inverse Dispersion	1.7 nm/mm at 200 nm 44.6 nm/mm at 500 nm
Absorbance Range	0.1; linear in absorbance with continuously variable scale expansion up to x 10.
Absorbance Range Presentation.	125mm (5 in.) meter or 200 mm (8 in.) recorder
Response Time.	2.15 or 40 seconds, selected by switch 9 on either meter or recorder).
Flames.	Air/acetylene Nitrous oxide/acetylene Air/propane
Flame Path Length	120 mm (air/acetylene and air/propane) 50 mm (nitrous oxide/acetylene)

Sample Take-up Rate.	2ml/min.
Power Requirements	250 W: 190/260V, 50 Hz.
	or 100/135V, 60 Hz.
Dimensions	1100 mm. wide x 460 mm.
	deep x 380 mm.high
	(43 x 18 x 15½ in).
Weight	64 kg (141½ lb.) approx.

APPENDIX. 7

ELECTROCARDIOGRAPHS.

(73)

MODEL 1500A AND MODEL 1511A - MANUFACTURED BY

HEWLETT & PACKARD.

DESCRIPTION:

The 1500A Electrocardiograph is designed for E.C.G. monitoring and recording. Its design places special emphasis on patient protection and on its use with defibrillators.

Special patient protection provisions include isolation circuitry which reduces leakage current from any 120 volt AC source to 4 microamperes or less. During defibrillation, the 1500A may remain connected to the patient without damage to the instrument - allowing recording of the E.C.G. immediately following.

A switch provides instant selection of standard 25 mm/second chart speed for recording of fast heart rates. Similarly, any one of 4 Sensitivities (¼,½, 1, 2) may be selected, depending on signal strength variation between leads or between patients. The ½ and ¼ sensitivity positions are recommended for large V leads that are frequently encountered, particularly in pediatric electrocardiography.

The 1500A, in addition to E.C.G. input, provides a floating AC and DC input circuit which permits its use as a single-channel amplifier/recorder. An output jack is available for use with an oscilloscope or with the Bell Telephone 603 series Data Phone

The Model 1511A provides the same features as the 1500A except that it is built in to a rugged mobile cart. A large compartment in lower front section of the cart serves as handy storage space for accessories, supplies and completed records.

SPECIFICATIONS.

Chart: 50 mm. rules width, 6 cm. total width, with 1 mm. vertical and horizontal divisions. Chart length 150 ft. per roll.

Paper Drive: Speeds 25 and 50 mm/sec.

Lead Marker: Manual, marks solid black line 1 mm. wide in top margin.

Power requirement: 115 volt 60 Hz, 45 watts maximum Optional, at extra cost, other voltages for either 50 or 60 Hz. Choice of 2 wire or 3 wire detachable power cord [illegible].

Patient Circuit: Leads STD, 1,11,111, AVR, AVL, V, CF. manually selected by rotary switch.

Instomatic action and automatic paper stop between lead positions.

Isolation of patient from chassis: 30 megohms at 60Hz, Electrode Input impedance: Greater than 40 megohms, shunted by 1500 pF with 8-foot patient cable.

Sensitivity: ECG and AC input: 2, 1, ½ and ¼ cm/mV.

DC input: (selected by switch) 25, 50, 100 and 200mV/cm. via patient cable socket.

Standardization: 1 mV (± 1%) calibration signal derived from zener diode.

Frequency response: Two ranges: Not more than 3 db down

at 100 Hz on the high range.

Controls: SENSITIVITY (¼,½,1,2) switch, stylus POSITION, 9 position lead selector switch with instomatic stylus stabilizing and automatic paper stop between positions, OFF-ON-RUN switch, polarity TEST, lead MARK, SPEED selector switch (25 and 50 mm/sec), STD (1MV) push-button STYLUS HEAT Screwdriver control.

CARDIOTRACE 3000 E.C.G.(74)

General: This is another example of a single-channel two-speed, direct-writing electrocardiograph.

SPECIFICATIONS.

Power: Push on-Push off mains supply switch. Adjacent lamp indicates when power is switched on.

Chart Speed: Interlocked push buttons marked 25 mm/Sec and 50 mm/Sec.

Filter: Push on-Push off high frequency filter switch. Adjacent lamp clearly indicates when filter is on.

Sensitivity: Interlocked push buttons used to select preset recording sensitivity.

Marked 1 - standardised, 1 mV = 1 cm. deflection.

½ - ½ standardisation, 1 mV = cm deflection

Position: Thumb-operated rotary control used to set recording base line.

Chart: Three-position rotary switch used to control chart. Marked STOP - chart stationary, tracing blanked.

VIEW - chart stationary, tracing unblanked.

RUN - chart running, tracing unblanked.

CAL. 1. mV: Push button produces 1 mV square wave input to pre-amplifier. Used for checking standardising in lead selector CAL. position or for adding 1 mV calibration pulses to any lead while recording.

Lead Selector: 15-position rotary switch includes CAL, and leads 1, 2, 3, AVR.AVL, AVF.V. A reset position is provided between each lead in which the tracing is permanently blanked (no signal). Automatic blanking for 300mm/sec. also occurs whenever a new lead is selected.

APPENDIX 8.

(89)

THE ODELCA 100.

The Odelca 100 photofluorographic unit appears to be the most suitable type of Chest X-Ray Unit for multi-screening on admission.

CAMERA:

The Odelca 100 Camera with straight hood, type 100-XVII-S, equipped with Standard Roller Separator cassette RSS 100; unexposed film magazine capacity 50 100 mm. cut films, is recommended.

If the camera stand is of a suitable design, the Odelca 100 Camera with angle hood, type 100-XVIII-S, again with the RSS cassette may be used.

In both cases the camera has a cardholder by means of which the data on the patients' card are recorded on the film. A safety device - electrically interlocked - prevents operator's errors, such as double exposures, or exposure without patient's identification, in which case no exposure can be made.

A Phototimer for exposure control is available.

Processor:

The Odelcamatic fully automatic processing machine for 100 mm. films is recommended when coping with large numbers of phtofluorographs. In this machine, the photofluorographs are optimally processed automatically. The Odelcamatic may be used as a separate machine, but can also be coupled to the Odelca 100 camera. With this continuous flow system, the films are exposed (in the camera) and automatically transported to the processor where they are processed and dried at a rate of 120 films per hour.

Viewers:

The Helio Contrastor 100 viewer presents the Odelca 100 photofluoragraph on a high acuity, high definition 25 x 35 cm. viewing screen. This special screen permits group viewing so that the photofluorograph can be read in exactly the same manner as a large size radiograph. The light intensity onf the screen can be varied by a foot switch; placing and removal of films is extremely simple. Also available are viewers with a low-power magnifier, such as Trioscope, Soliscope and Miniscope.

X-Ray Apparatus.

Generally the same procedures apply to Odelca photo-flurography as with normal radiography. The modern X-ray generator has several high tension outlets, one of which may be assigned to photofluorography. By a switch-over the apparatus is adapted to Odelca work, the supply being fed to the roller separator, interlock system, safety monitor, program selector, etc. An Odelca camera can be combined with an existing X-ray apparatus. For single exposure with the standard roller separator cassette, the output of a simple half wave X-ray apparatus will suffice.

APPENDIX. 9

VITALOGRAPH.

The Vitalograph provides physiological values which may be read directly, or which can be measured without requiring time-consuming calculations. The tracings present each value optimally and measurable separately. Its recording mechanism operates automatically as soon as the patient commences breathing into the instrument. The operator has an over-riding control button and colour-coded lamps signal the correct operational sequences. Printed chart graphs record the various respiratory functions.

Physiological Parameters Measurable with the Vitalograph

Forced Expiratory volume, $F.E.V._T$ (also known as Timed Vital Capacity) i.e. the volume of air exhaled over a given time - usually the first second or ¾-second-after maximal inspiration, expiration being as rapid and as forced as possible. (The 2-or-3 second FEV, or any desired intermediate time value up to 6 seconds may also be measured).

The FEV_T value is readable from the calibrated grid of the Vitalograph chart.

Forced Vital Capacity, F.V.C.(also known as Fast Vital Capacity), i.e. the volume of air expired after full inspiration, expiration being as rapid and as complete as possible, viz. forced.

Vital Capacity, may also be measured, i.e. the volume of air expired after full inspiration, expiration being as complete as possible but the subject is allowed to take his own time for complete expiration. Provision is made also to record expirations considerably in excess of 6

seconds' duration, viz. 20-30 seconds.

The F.V.C. and V.C. values are readable from the calibrated grid of the Vitalograph chart.

Percentage F.E.V. i.e. the Forced Expiratory Volume expired in a given time interval - usually at the first second or ¾-second-expressed as a percentage of the measured Forced Vital Capacity or the Vital Capacity; $F.E.V._{T}\%$ if suitable qualified, may also be related to the predicted or estimated normal V.C. or F.V.C.

The Vitalograph Percentage Ruler, enables reading of these or other percentage values from the chart.

Expiratory Flow Rates. are measurable at any point of the Vitalogram.

The Vitalograph is especially suitable for the rapid measurement of the following parameters as accurate and sensitive detectors of obstructive airways defects.

Forced Expiratory Flow .e.g. $F.E.F._{200-1200}$ the average rate of gas flow for a specified volume segment, during a forced expiratory effort.

The Vitalograph chart grid is especially marked at 200 ml and 1200 ml volume levels to enable rapid reading of this value with the aid of a transparent Flow Rate Protractor which may be superimposed on the chart. The F.E.F. may also be calculated graphically from the chart grid. The F.E.F. may also be measured at other volume segments if qualified accordingly, e.g. $F.E.V._{V.I.V.2.}$ or $F.E.F._{0-25\%}$

It is recommended to express this test value in litres per minute.

Forced Mid-Expiratory Flow, e.g. F.M.F. or $F.E.F._{25-75\%}$, the average rate of gas flow prevailing over the middle two quarters of the volume segment of the forced expiratory Vitalogram, usually expressed in terms of litres per second.

Indirect Maximum Breathing Capacity Ind. M.B.C., i.e. the volume of air which a subject can breathe in one minute, as predicted from the Forced Expiratory Volume, expressed in terms of litres per minute.

Specification

Volume Calibration	Linear; a displacement of the stylus by 2.92 mm equals an air volume of 100 ml. at an Ambient Temperature of 20° Centigrade, Normal Barometric Pressure, Saturated (A.T.P.S.).
Volumetric Accuracy	Max. mean error ± 1.0% at ATPS 20°C.
Recorder Speed	Constant speed of 30.00 mm per second ±2.0% not affected by voltage fluctuations of less than ±25 volts. With facility for stop-start operation, if desired.
Recorder Drive	Special synchronous motor providing equal starting as well as running torques; driving chart carrier via precision-cut rack and nylon pinion. Chart carrier runs friction-and inertialess on self-lubricating bearing. Automatic, volumetric, patient-

	triggered starting mechanism outside the breating circuit, of highest response and sensitivity, with adjustable sensitivity and over-riding push-button controls.
Recorder Stylus	Spring-loaded, precision-ground inkless stylus with quick-adjustment for accurate centering. It produces a clear, non-smudging and permanent tracing in dark red, suitable for photographic reproduction.
Dead Space	Plastic measuring bag, 42 ml. compensated for in chart calibration. The volumes of tubes, mouthpieces, etc., are displaced truly and therefore do not rate as functional dead-space.
Measuring Bag	Made of non-toxic plactic material. The bag is constructed and made of a special configuration to provide an adequate pen travel per millilitre over the physiological range, to have the high frequency response, and to have a negligible functional dead space. It is rated to record 6000 ml of air at ATPS 20^{o}C., viz 6612 ml of

	expired gas at BTPS (i.e. at Body Temperature, normal barometric Pressure and completely saturated with water vapour at B.T.)
Inertia Eliminator	Precision-spring counter balance with dual action. To eliminate inertia of the stylus arm and platform at the start of the displacement, and to eliminate the forces of mass acceleration over the subsequent displacement.
Inner Diameters	Breathing duct into measuring bag, 1" (25 mm) minimum bore throughout. Mouthpiece, 1 1/16" (27 mm) bore, circular shape to conform anatomically with airways structive in order to minimise turbulence of gas flows.
Current Consumption	Less than 15 watts.
Control Lamps	Three neon types, with built-in resistors.
Vitalograph Chart	Overall size 20x20 cms., with precision-printed grid. Size and grid variations with varying humidity and temperatures are less than 0.1% Accuracy of ruling and imprinting

within ± 0.005" (±0.127 mm).

Chart Calibration

Horizontal volume rulings of different thickness, at every 1-litre, 500 ml. 100 ml & 50 ml mark; special broken rulings at the 200-ml and 1200-ml marks (see measurement of Maximum Expiratory Flow Rate). Total volume range of 0 to 6000 ml at A.T.P.S. 20° Centigrade - A zero point and line as well as a pen starting point and line are provided also; the distance between zero and starting lines represents the functional dead space of the instrument, which is allowed for in the calibreation.

Vertical time rulings of different thicknesses at every 1-second, 0.5-second and 0.1-second mark; with a special broken ruling at the ¾-second mark. Total time scale from 0 to 6.0 seconds. It should be noted that the instrument has control facilities also for recording Vital capacities requiring considerably longer time intervals, i.e. 10 - 30 seconds.

APPENDIX10.

(63)

A Clinical Laboratory Computer System.

One Company (Digital Equipment) has recently produced a clinical laboratory computer system capable of interpreting and recording data simultaneously from 15 clinical analysers. It can be used on line or off, in conjunction with automatic clinical biochemistry. It gives automatic readouts, files, stores results and does all the result calculations.

The new integrated hardware/software computer system allows the technician to define his own testing parameters such as the rate of sampling, the number of readings desired per sample, the observational tolerance allowed and the type of report wanted.

The system features build-in interfacing to permit future accommodation of up to 24 analytical instruments or to further increase laboratory throughput.

The basic system configuration includes a 4,096 word core memory computer, teleprinter with paper tape punch and reader, analogue-to digital converter, oscilloscope and a dual magnetic tape unit.

The system performs one of the technician's most time consuming tasks - test monitoring and data recording. Once the analysis methods are established and the samples inserted into the analysing apparatus, the computer will automatically collect and analyse the data, format it, and print out a report.

System errors and retesting are minimised by the computer's quality control checks of the analytical instruments prior to initiation of tests on unknown samples.

Among its on-line functions, the system picks peaks based on the highest of two to seven (user specified) points sampled at regular intervals, converts to proper units referring to customer-defined control blocks, and print out diagnostic warnings when deviations from standards warrant.

Off-line, the system can display or print out histograms of the monthly range and values distribution of a particular test type, generate monthly reports of the number of each test type performed, and compute averages and standard deviations of result data by test type.

It will print out a periodic summary, also a summary on a particular patient upon demand, even while logging data. The system will allow for a separate file for each patient where all laboratory results can be sorted: instant response to file queries interim report during the day upon demand, and complete summary reports for any or all patients at any time.

NAME:		FLOOR:
Date 02 --23--68.		Cup No. 91
Chol	R.	MG7
Calcium	0.2.	MG7
Phos	0.1	MG7
Tot-Bil	0.1.	MG7
Albumin	0.1.	MG7
Tot-Prot	0.1.	MG7
Uric	0.2.	MG7
Bun	1.	MG7

NAME:		FLOOR:
Gluc	8.	MG7
LDH	6.	Wacker
Alk-Phos	0.	King-A
S.G.O.T.	4	Kamen

CHAPTER 3.

INTRODUCTION.

In 1969 I decided to prepare a Questionnaire to be sent to a sample of Doctors to investigate certain considerations regarding multiple investigations on patients on admission to hospital.

The purpose of the project was to establish principles in considering the following points.

a) What tests or investigations a doctor considered desirable on a patient being admitted to a general hospital?+

b) What would be the initial "acceptance" by the medical profession?

c) The effect of the different professional status of doctors in the acceptance or rejection of the principle of multiple investigations on admission to hospital.

d) What effect the doctor's age had on his attitude towards multiple investigations on admission to hospital?

In August, 1969 the Questionnaire was sent out to 1,500 doctors, practising in Capital Cities throughout Australia. The doctors were divided into three groups. These groups comprised 500 Physicians, 500 Surgeons and 500 Hospital Residents and Registrars of over two years Graduate standing. The Questionnaires were distributed by Permail, a direct mail-

+A General Hospital is defined in Chapter 4 of this Thesis as any Hospital of over 500 beds which is classified as accepting "General" adult cases.

ing service. The Organisation has a list of all the doctors in Australia. From the list a random sample of doctors in each group was drawn and to these a Questionnaire was sent. The age or sex was not known of the doctors to whom the Questionnaire was sent. Apart from the distribution being based on the number of doctors by proportion to the number practising in each of the three groups in the Capital Cities in Australia no other criteria were placed on those to whom the Questionnaire was sent.

As well as the Questionnaire there was enclosed a pre-addressed envelope to be returned to a G.P.O. Box number in Sydney but it was not pre-paid.

The purpose of this chapter is to show an analysis of the returns and an evaluation of their significance.

THE QUESTIONNAIRE.

The Questionnaire was introduced by a general letter to the doctors explaining that I was engaged on a Post-Graduate Research Project involving the introduction of a series of admission or pre-admission investigation. It requested them to complete the attached Questionnaire and return it in the enclosed envelope.

Page 2 was headed "Admission Profile Questionnaire". The doctor was asked to fill in his status in one of the four squares.

Specialist	Registrar	Senior RMO	Junior RMO

On the same line he was asked to fill in his Speciality and age Group:

Your Speciality	Your Age Group	
	Under 50	50 and Over.

The reason for these questions was that variations were expected in the type of tests that would be requested by doctors of various status and between the various types of Specialists especially between the Senior Doctors and between those practicing at a relatively low level but of recent Graduation and within a modern hospital complex.

The section on age was also considered as being relevant to the degree of training and orientation towards Multi-screening that the doctor may have had. The dividing line of 50 years represented roughly those who were trained pre-war or post-war. The War brought with it changes in the practice of clinical medicine involving far greater use of biochemical tests and investigations. The under 50's were educated for and graduated into this type of practice.

When filling in the Questionnaire the doctors were requested not to consider the cost or complexity of tests but what is best as regards improved patient care:-

> "earlier diagnosis, rapid institution of appropriate treatment, evaluation of treatment, prognosis and discovery of unsuspected conditions."

The comments of some of the doctors indicated that they were unable to dissociate cost from patient care and they would not fill in the Questionnaire as they did not consider that the cost would warrant routine admission or pre-admission profiles. Others did not fill in the Questionnaire as they considered it a reflection on their medical acumen and would not improve patient care and considered that tests should be done at the discretion of the doctor and not routinely. This will be elaborated upon later under "General Comments."

The instructions to filling in the Questionnaire were then given

Part One

1. "From the tests listed in PART ONE, select the <u>forty</u> (40) tests you consider to be most appropriate as routine examinations of all admissions - mark each of them 'A' putting the A's in the 'boxes' of the tests you have selected".

This section seemed to cause considerable mathematical problems. The number of doctors who could not count to forty was high and was one of the major factors in invalidating 22% of the Questionnaires returned. This was not due to the fact that the Doctors did not consider forty tests

necessary as they only filled in thirty-eight or thirty-nine. Those that considered forty tests excessive did not hesitate to express their views.

2. "also from PART ONE select a further ten (10) tests if you think these are desirable, marking each of these B in the appropriate box."

Only a small number of doctors selected these extra tests and from the general comments it appears that forty tests are probably adequate. This will be elaborated on later in this chapter.

Part Two

3. "In PART TWO enter any tests which you consider should be part of an admission testing programme but which have not been included in PART ONE. Write those additional tests you consider desirable for all admissions in the upper space; and those tests you think appropriate only to all admissions within your own speciality to be entered in the lower space"

The portion of the questionnaire created no problems and most doctors practicing in a particular Speciality filled in additional tests specifically related to their field in which they practiced.

Part Three

4. "Please indicate YES or NO as to your answer to the question in PART THREE"

This section caused no problems.

QUESTIONNAIRE CONTENT.

(See Appendix I)

Part 1 of Questionnaire

This section of the Questionnaire was devoted to specific tests and questions regarding tests on specific systems.

Biochemical Analysis

The first battery of tests under this heading was classified as "Serum Analysis" and comprised fifty tests.

The second section was on Urine Analysis and comprised twenty-four investigations.

The third section was on Cerebro Spinal Fluid Analysis and comprised four tests.

The fourth section was Faeces Analysis and comprised two tests.

The fifth section was on General Pathology and comprised five tests.

Haematology Analysis

This section comprised eleven tests.

Respiratory System Examination

This section comprised two tests.

Cardio-Vascular System Examination

This section comprised two tests.

Gastro-Intestinal System Examination

This section comprised one test.

Part 2 of Questionnaire

This was a section that allowed the doctor to add any additional tests which he considered should have been covered by part 1. He was asked for general tests or those related to the speciality which he practiced.

Part 3 of Questionnaire.

This section is to ascertain the attitude of the doctors towards "Admission Profiles" on hospital admissions. The actual wording used in the Questionnaire was:

"Do you agree in Principle to Multi-Test Screening on Hospital admission"

It was anticipated that the doctor would understand that this question would not relate directly to the type of tests selected or the number of tests selected either in Part One or Part Two but related to the principle of the concept, not necessarily to the form that was considered in the Questionnaire.

Some of the unsolicited comments, that were added to this part, indicated that the doctors did not, in some instances, understand that this Section referred to the principle of Multi-Screening in general rather than being specifically related to the previous two Sections.

The Total Response Rate.

As indicated 1,500 Questionnaires were circulated. The total number returned were 458. Table 15A indicates the distribution of the returns divided into four groups.

TABLE 15A.

TOTAL NUMBER OF QUESTIONNAIRES RETURNED.

N = 458.

Classification	Number Returned from Group	Total Number Sent to Group	Percentage Returned from Group.
Physicians	136	500	27%
Surgeons	103	500	21%
Registrars & Residents	119	500	24%
Invalid Returns (not correctly completed).	100		
Totals	458	1,500	31%

From Table 15A it can be seen that 100 returns were invalid. These were invalidated due to various reasons which are discussed later. This represents 22% of all the returned Questionnaires.

Table 15A illustrates that 31% (458/1500) of the Questionnaires were returned. It is a matter of conjecture as to why the remaining 69% were not returned. The following analysis is based on the 458 questionnaires which were returned.

The total number of replies in each group, not taking into consideration the age factor, were of a similar order as shown in the above Table.

Physicians returned more valid Questionnaires than the other groups (27%). The Registrars and Residents were next, 3% less (24%), whilst the Surgeons were 3% less than Registrars and Residents (21%). The difference between the number returned by Physicians (Maximum) and the Surgeons (minimum) of the valid returns was 6% and on the limited survey carried out I do not consider this figure as being an important variation.

Age Distribution of Returns.

Table 15B shows that of the valid Questionnaires returned the under-50 age group comprised 88% and the over-50 age group 12%

TABLE 15B.

NUMBER OF VALID RETURNS DIVIDED INTO STATUS AND AGE GROUPS.

N = 358

Age of Group	Status of Group						
	Physicians		Surgeons		Residents		Total.
	No.	%	No.	%	No.	%	
Under 50 Years	117	33%	79	22%	117	33%	88%
Over 50 Years	19	5%	24	7%	2	negligible	12%
Combined Total of Returns	136	38%	103	29%	119	33%	100%

The inferences that might be made from the above Table are:-

a) That there is a substantial proportion of younger

doctors interested in Multi-Screening and prepared to take an active interest in the subject - even to the extent of filling in a Questionnaire and

b) that the Doctors who returned the Questionnaire did so at their own expense by buying a 5 cent stamp.

ANALYSIS OF VALID QUESTIONNAIRES.

The following section of this Chapter examines the 350 valid returns.

Part One

This section consists of a numerical study of the tests recommended by the doctors who answered the Questionnaire. Table 16+ is a composite Table to give an overall survey of the total number of Tests considered desirable by the doctors in the various groups. The Table also indicates where there is over 80% agreement by all the doctors on any particular Test.

Tables 21, 22, 23, 24, 25, 26, 27, 28, 29, 30 & 31, in Appendices 2, 3, 4 of this Chapter, show the number of Tests recommended divided into Physicians, Surgeons, Residents and Registrars categories and if over or under fifty years of age and whether in favour or against Multiple Screening on admission to hospital.

The figure of 80% agreement of all doctors on any particular test was selected using no special criteria except that I considered that 80% would represent a very high degree of agreement.

In Table 16 the Tests marked with an "X" (indicating 80% or greater agreement) could form the basis of a suggested group of multi-tests to be used on admission to hospital. The following charts illustrate diagramatically the distribution of the most common tests requested.

This section is completed by a list of suggested multiple investigations or test battery to be used on patients on admission to hospital which is based on the Questionnaire answers - Table 16A.

+ A Glossary of Abbreviations (medical) is to be found on Page 95A Appendix 1.

TOTAL NUMBER OF EACH TEST REQUESTED BY ALL DOCTORS.

N = 358

TABLE 16

BIOCHEMICAL ANALYSES.

Symbols used in ALL Tables are in Appendix 4A Page 95A - Glossary of Abbreviations.

		SERUM ANALYSIS			
Type of Test.	No. of Drs requesting Test.	80% agreement marked by "X"	Type of Test.	No. of Drs request-ing Test.	80% agreement marked by "X.
Na.	342	X	Bilirubin	298	X
K.	346	X	S.G.O.T.	289	X
Cl	317	X	S.G.P.T.	192	
HCO_3	321	X	L.D.H.	127	
B.U.N.	317	X	C.P.K.	53	
Creat	183		Thymol Turb.	95	
P.	159		ZNSO Turb[4]	77	
Uric Acid	278				
S.G.	74		Choles-terol	303	X
Ca	287	X	Barbitone	35	
Mg.	55		Hapto-globin	5	
Amylase	143				
Alk. Phos	322	X	Schumm's Test	6	
Alb.	326	X	Br.	46	
Glob.	312	X	Fe	155	
Total Pro-tein	283		I.B.C.	65	
			P.B.I.	198	
			Acid. Phos	177	
Van den Berg	61.		B.S.P.	73	

80% of the total number of valid returns (358) = 286.
286 was therefore the cut off figure for inclusion of the tests in the theoretical profile.

TABLE 16 (Contd)

Type of Test.	No. of Drs. requesting Test.	80% agreement marked by "X"	
Met. Hb.	20		
Sulph Hb.	37		
Aldolase	4		
Cholin-esterase	16		
Ca Oxidase	3		
Pyruvate	11		
Lactate	8		
Salicylate	332		
Carotene	6		
Cu	3		
Cortisol	51		
Cyro-globulin	8		
SIA Test	4		
Fibrinogen	49		
Random Blood Sugar	307	X	
G.T.T.	74		

TABLE 16 (contd.)

URINE ANALYSIS.

Type of Test	No. of Drs. requesting Test.	80% Agreement marked by "X"	Type of Test	No. of Drs. requesting Test.	80% Agreement marked by "X"
Time Hr. Min.	58		5-OHIAA	15	
Vol	192		Bilirubin	191	
Na.	59		Urobilinogen	135	
K.	44		Porphyrins	111	
Cl.	32		Porphobilinogen	48	
Ca.	50		B.J. Prot	53	
Mg.	/3				
P.	10				
Uric Ac.	29				
U.N.	21				
Creat.	39				
Protein	308	X			
pH	243				
Glucose	316	X			
Cystine	29				
17-KS.	34				
17-OHCS	28				
D-XYLOSE	9				

T A B L E. 16 (Contd.)

HAEMATOLOGY ANALYSIS.

Type of Test.	No.of Drs requesting Test	80% Agreement marked by "X"	Type of Test	No. of Drs requesting Test	80% Agreement marked by "X"
Hb.	318	X	P.I.	121	
Red Cell Count.	155		Differential W.C.C.	324	X
Total WCC	306	X	Platelet Count	248	
Haematocrit.	250				
M.C.V.	124				
M.C.H.	83				
M.C.H.C.	143				
E.S.R.	331	X			

RESPIRATORY SYSTEM EXAMINATIONS.

Chest X-Ray.	342	X	Spirometry.	145	

CARDIOVASCULAR SYSTEM EXAMINATION.

B.P.	334	X	E.C.G.	282	

T A B L E. 16 (Cont'd)

C. S. F. ANALYSIS.

Type of Test.	No. of Drs requesting Test.	80% Agreement marked by "X".	Type of Test.	No. of Drs requesting Test.	80% Agreement mared by "X".
Glucose.	62		CI.	42	
Protein.	71		Lange.	45	

FAECES ANALYSIS.

Occult Blood.	252		Faecal Fat (3 days).	75	

GENERAL PATHOLOGY.

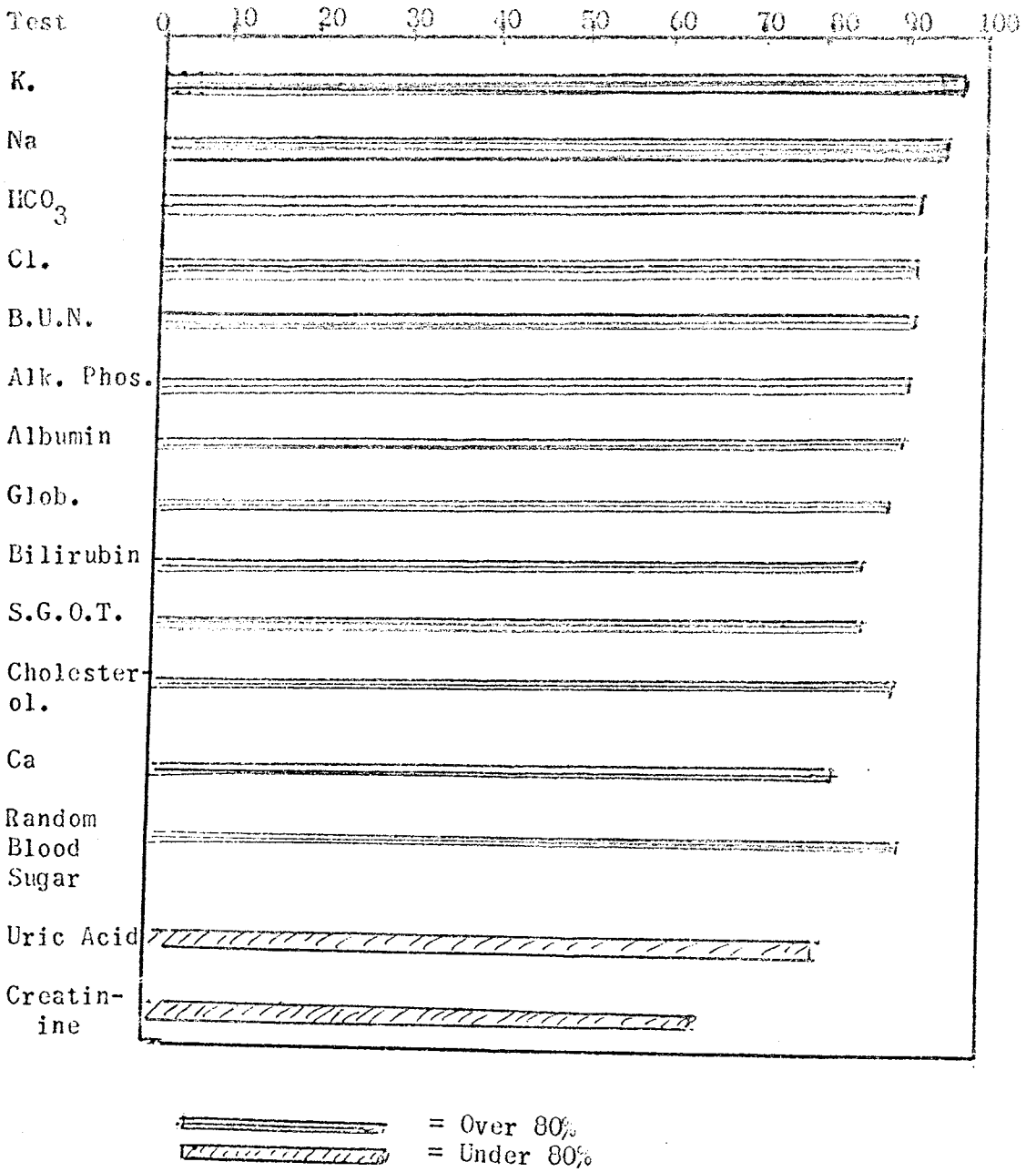
L.E. Cells.	87		Blood Group.	306	X
Cervical Smear.	281				
Latex Test.	102		Rh Factor	269	

GASTRO INTESTINAL SYSTEM EXAMINATION.

Sigmoidoscopy if over 40 years.	212				

BIOCHEMICAL TESTS.

Percentage of Doctors in Favour of Most Requested Tests in Admission Profile Battery.



HAEMATOLOGY ANALYSIS.

Percentage of Doctors in Favour of Most Requested Tests in Admission Profile Battery.

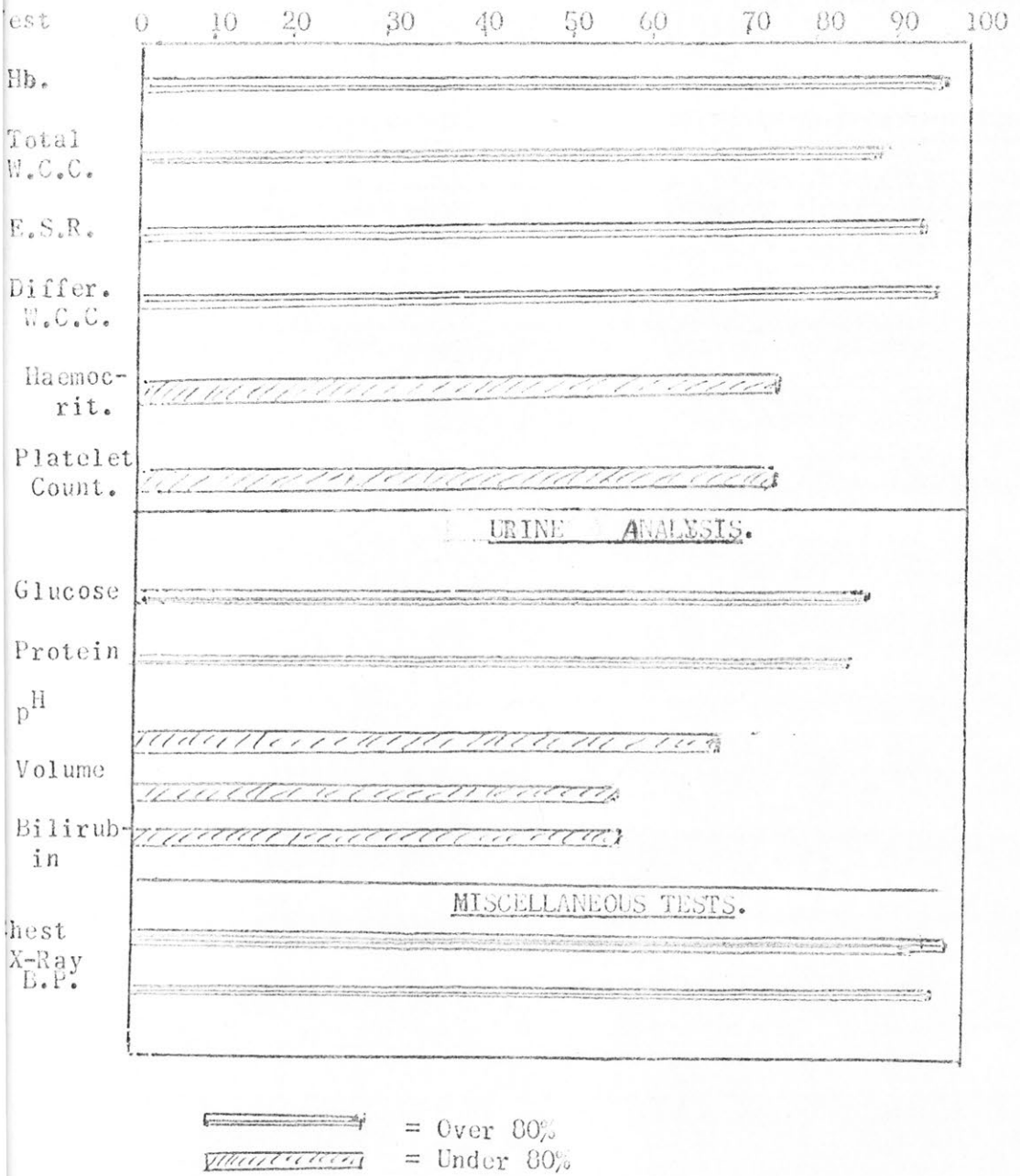


TABLE 16A.

SUGGESTED TEST BATTERY.

Bio-Chemical.

Na.

K.

Cl.

HCO_3

B.U.N.

Ca.

Alk.Phos.

Alb.

Glob.

Bilirubin

S.G.O.T.

Cholesterol.

Random Blood Sugar.

Haematological.

Hb.

Total WCC

Differential WCC

Blood Group.

Urine Analysis.

Protein

Glucose.

Respiratory System.

Chest X-Ray.

Cardio-Vascular System.

Blood Pressure
(this is actually part of a normal physical examination).

Part Two.

This section comprised two questions related to tests not covered in Part 1. The answers were divided into..

1. General - this was to cover any test that the doctor considered should have been included but was left out.
2. Special - this was to cover tests related to the area in which the doctor specialised.

In order to analyse the additional tests requested the Section was divided into the three status groups.

a) Physicians.

b) Surgeons.

c) Residents and Registrars.

a) Physicians.

A detailed analysis of the additional tests requested by this group is shown in Appendices 5, 6, 7, 8, which contain Tables, 32, 33, 34 and 35. In these Appendices the Physicians are divided into over and under 50 age groups and whether in favour of or against multiple investigations on admission to hospital.

The under 50 age group of physicians had the second highest request rate for additional tests of all the groups studied. 65 Doctors out of 117 in this group requested additional tests.

The most common tests requested were

Micro-Urine.	Blood Film
WR	Blood Gases.

Only the under 50 Residents and Registrars had a higher request

The additional tests requested by these Physicians reflected the Speciality in which they were interested. This is illustrated by the various types of tests requested and in any of the additional tests there is only a small agreement in any particular one apart from the Micro-Urine.

The over 50 age group of physicians requested the same types of additional tests as the under 50 group, but the total response being less in number the figures are numerically less. Seven doctors out of nineteen requested additional tests.

The additional tests which were generally considered desirable by all groups of Physicians were therefore :-

Micro-Urine	Blood Film
WR	Blood Gases.

b) Surgeons.

In Appendices 9, 10, 11, 12, which contain Tables, 36, 37, 38, and 39 a detailed analysis of the additional tests requested by the Surgeons of all groups both for and against multiple screening on admission to hospital and divided into the over and under 50 age groups is shown.

The number of additional tests requested was again higher in the under 50 age group but not as marked as with the Physicians.

Additional tests requested in the over 50 age group of Surgeons was comparatively less than the Physicians. Due to the negligible number of replies in the over 50 age group in the Residents and Registrars any comparison would be invalid. However in the under 50 age group the Registrars and Residents requested more tests than did either the Physicians or Surgeons. The most common tests requested by the Surgeons were the same as the Physicians

c) Residents and Registrars.

Appendices 13, 14, 15 contain Tables 40, 41 and 42 which show a detailed analysis of the additional tests requested by the doctors in this group. The under 50 age group had the highest request rate for additional tests of the three groups studied. 76 doctors out of 117 doctors in this group requested additional tests.

The Residents and Registrars requested the same four additional tests that were most commonly requested by the Physicians and Surgeons.

Part 3.

Tables 17, 18, 19, and 20 give a statistical analysis of the number of doctors for and against multiple screening on admission to hospital.

The Physicians under 50 were mostly in favour of the concept (94 out of 117) . A similar situation existed amongst the Residents and Registrars (84 out of 117).

Surgeons under the age of 50 were not as in favour of the concept as the other two groups (49 out of 79)., that is proportionally speaking" fewer Surgeons were in favour.

In the over 50 age group only a small group of Physicians and Surgeons answered the Questionnaire. (As only two Residents and Registrars over the age 50 answered the Questionnaire they need not be considered). The returns of both the Physicians and Surgeons in this group showed similar results (Physicians 13 out of 19, Surgeons 16 out of 24).

From Table 17, which gives a statistical summary of all the valid Questionnaires completed, the number of Doctors in favour of the general principle of Multiple Screening on admission to hospital can be seen. The overall figure was that 72% of all groups irrespective of age were in favour of multiple screening.

TABLE 17

STATISTICAL SUMMARY OF ALL COMPLETED QUESTIONNAIRES.

PART 3. N = 358

	Yes +		No. +		
STATUS	Number	%	Number	%	TOTAL
PHYSICIANS	107	30%	29	8%	38%
SURGEONS	65	18%	38	10.7%	28.7%
RESIDENTS & REGISTRARS	86	24.1%	33	9.2%	33.3%
TOTALS	258	72.1%	100	27.9%	100%

+Yes refers to the number or percentage of doctors in favour of multi-screening on admission to hospital.

+No refers to those not in favour.

TABLE. 18 N = 136

STATISTICAL ANALYSIS OF SURVEY.

PHYSICIANS.

PART 3.

STATUS.	Number in favour of Multi-Screening.	Number not in favour of Multi-Screening.	Total.
Physicians under 50.	94	23	117
Physicians over 50.	13	6	19
Total:	107	29	136

PHYSICIANS.

STATUS.	% in favour of Multi-Screening.	% not in favour of Multi-Screening	Total.
Physicians under 50	26%	6%	32%
Physicians over 50	4%	2%	6%
Total:	30%	8%	38%

The above figures are expressed as a percentage of the valid replies to the Questionnaire - 358.

TABLE. 19 N = 103

STATISTICAL ANALYSIS OF SURVEY.

SURGEONS. - PART 3.

STATUS.	Number in favour of Multi-Screening.	Number not in favour of Multi Screening.	Total.
Surgeons under 50	49	30	79
Surgeons over 50	16	8	24
TOTAL:	65	38	103

SURGEONS.

STATUS.	% in favour of of Multi-Screening	% not in favour of Multi-Screening.	Total.
Surgeons under 50	13.5%	8.5%	22%
Surgeons over 50	4.5%	2.2%	6.7%
TOTAL:	18%	10.7%	28.7%

TABLE. 20

N = 119

STATISTICAL ANALYSIS OF SURVEY.

REGISTRARS & RESIDENTS.

PART 3.

STATUS	Number in favour of Multi-Screening.	Number not in favour of Multi-Screening.	TOTAL:
Registrars & Residents under 50	84	33	117
Registrars & Residents over 50	2	-	2
TOTAL:	86	33	119

TABLE: 20 (contd.)

STATISTICAL ANALYSIS OF SURVEY.

REGISTRARS & RESIDENTS.
PART 3.

STATUS	Percent in favour of Multi-Screening	Percent not in favour of Multi-Screening.	Total.
Registrars & Residents under 50	23.5. %	9.2 %	32.7%
Registrars & Residents over 50	0.6. %	0 %	0.6%
TOTAL:	24.1. %	9.2 %	33.3 %

Unsolicited Comments on Valid Questionnaires.

The unsolicited comments added after Part 3 in the valid Questionnaires are shown in Appendices 16, 17, 18, 19, 20, 21, 22, 23, 24, and 25, of this chapter. These are included because all comments are considered of interest as they reflect what the Doctors are actually thinking.

Additional Tests Marked "B".

In the introduction to the Questionnaire the Doctors were requested to mark an additional 10 Tests with "B" in addition to the 40 Tests marked "A" if they considered such Tests necessary on Multi-Screening on admission to Hospital. These tests were not examined, for after reviewing the Questionnaire answers, 40 selected Tests of those in Part 1. were considered adequate to cover all fields of Medicine.

SUMMARY OF FINDINGS.

Part 1.

From the analysis of the tests recommended in this Section a proposed Multi-Screening set of Tests has been drawn up and is composed of those Tests where there was an 80% agreement by all doctors who returned valid Questionnaires. This list does not include any of the additional tests which are considered in part 2. The section shows that there is little difference in the tests selected either as regards groups of doctors based on age or status. The following is the battery of tests drawn up from the Questionnaire answers.

Bio-Chemical

- Na.
- K.
- Cl.
- HCO_3
- B.U.N.
- Ca.
- Alk. Phos.
- Alb.
- Glob.
- Bilirubin
- S.G.O.T.
- Cholesterol
- Random Blood Sugar.

Haematological

- Hb.
- Total WCC
- Differential WCC
- Blood Group

Urine Analysis.

- Protein
- Glucose.

Respiratory System

- Chest X-Ray

Cardio-Vascular System.

- Blood Pressure (This is actually part of a normal physical examination.)

Part 2.

The following tests were the only ones in this Section that appeared to be relevant in both the general section and those related to the particular speciality in which the doctor practised.

WR.	Blood Film
Micro-Urine	Blood Gases.

If the above had been included in the body of the Questionnaire they may have recorded an 80% agreement. In my opinion the most likely tests in which this would have been achieved are

Micro-Urine

Blood Film

Therefore in considering the tests recommended in Parts 1 and 2 of this section point a) in the introduction of this Chapter is answered.

Part 3.

Of all the doctors who answered the Questionnaire correctly 72% were in favour of Multiple Screening on admission to hospital. However of the total number of doctors to whom the Questionnaire was sent only 31% returned it and of these 22% were correctly completed. This does not really answer point b) in the introduction of this Chapter. In order to answer this question a more extensive survey would have to be carried out.

Point c) in the introduction of this chapter considers the effect of the different professional status of doctors in the acceptance or rejection of the principle of multiple investigations on admission to hospital.

The return rate indicated that of the valid questionnaires returned Physicians returned 38%, Residents and Registrars 33.3% and Surgeons 28.7%

(Table 17). Of the number of Physicians who answered the Questionnaire 30% were in favour of multi-screening and 8% not in favour (Table 18). Of the Residents and Registrars 24.1% were in favour and 9.2% not in favour (Table 20). The Surgeons were 18% in favour and 10.7% not in favour (Table 19). These results refers to the views of a small sample of doctors who answered the Questionnaire, and as such does not allow any definite findings to be reached.

Point d) in the introduction of this chapter considers the age factor of the doctors who answered the Questionnaire. The findings in this section indicates that a greater proportion of younger doctors to whom the Questionnaire was sent are liable to return it. There is no way of comparing the number of doctors in the over and under 50 years age groups to whom the Questionnaire was sent as the age proportion of the various groups of doctors in Australia is not known.

In review of the above considerations, based on a limited sample and the small response rate, one cannot reach definite "conclusions" on the basis of this survey.

One can suggest hypotheses which could, if tested, on a more representative sample and by the use of personal interviews, provide data of value in planning and introducing a battery of tests which could be used as the basis for multiple investigations on patients on admission to hospital.

INCORRECTLY COMPLETED QUESTIONNAIRES.

One hundred questionnaires were returned incorrectly completed and therefore invalid due to the following:

74% of these were invalid due to the following:-

1. The appropriate number of tests requested were not filled in.
2. The status or age group was not marked.
3. No decision was given as regarding agreement or disagreement to multi-screening.

26% were invalid as they were not completed in any section but the Doctor passed general comments on the Questionnaire.

The total of all the above returns represent 7 1/3% of all the questionnaires sent out and 22 % of the number of questionnaires returned by Doctors.

UNSOLICITED GENERAL COMMENTS OF THE INVALID QUESTIONNAIRES.

1. My hospital has on the advice of the medical staff decided that multi-testing on hospital admissions is not to be established at this stage and have advised against it in principle - (This comment represented the views of a major Melbourne teaching hospital.).
2. I disagree with the need for more than about 15-16 routine tests.
3. A bit too complex for me - I feel that a good social profile might be more useful.
4. Cost and complexity cannot be ignored in any practical scheme.
5. Multi-test screening should only be introduced when many more important facets of patient care at present being neglected have been given proper attention. At present multi-screening would be a misuse of public and private money.

6. I fail to see that this will serve any useful purpose except to waste time and money. I suggest you become involved in a more useful project.
7. I cannot answer this as set out. I doubt that one can meaningly select forty most appropriate tests than ten desirable tests. The problem of multi-test screening seems to be an organizational one and not a medical one im most of its aspects.
8. If it is to be done one cannot reduce the number to forty. Equally significant ones are deleted.
9. In my opinion, there is not even one test, yet alone forty, which should be done routinely on every admission - even a Chest X-Ray may be inadvisable if a normal one has been performed within 12 months.
10. It is with considerable regret that I have to inform you that I cannot fill out your questionnaire as requested, I don't think I could put down forty tests that I would consider to be most appropriate as routine examinations on all admissions. I feel that it is far too many for this purpose. I agree with multi-test screening on hospital admissions but not this multiple.
11. I may have mucked up your sheet but even with enthusiasm, under any circumstances, I could not find more than 15 As that I could countenance as routine tests on admission.
12. As you can see I have only answered part 3 of your questionnaire (No.). This is deliberate but is not intended to sabotage your research. I don't hold for routine tests on any patient

admitted to hospital for whatever complaint. This does not apply to public health screening campaigns conducted outside hospitals.

I believe that every investigation inflicted upon a patient warrents a valid reason even if the tests be simple, cheap and of no inconvenience physically to the patient. I guess I might be termed old-fashioned but I firmly believe in Clinical acumen foremost. Investigations valuable and necessary when indicated, should be recognised for what they really are - auxiliary aids - to confirm or deny a clinical diagnosis or to make a diagnosis when this is impossible by physical means.

13. I feel that 2 or 3 tests are usually sufficient and consequently I cannot find 40 appropriate tests for ALL admissions.
14. This idea is appallingly alarming. Tests should be indicated on medical evidence only.
15. I could bring myself to mark 35 tests only, which is already too many, in my opinion, for routine testing.
16. I agree only with appropriate tests - not routine tests on hospital admissions.
17. In paediatrics a venipuncture is not undertaken lightly, and I would not regard the likelihood of a significant abnormality being uncovered would justify this.
18. What nonsense - forty routine Tests !! Who pays the taxpayer ?
19. (a) I do not agree that screening is a good thing for the patient.
    (b) Cost should be considered. Otherwise medical care will become as expensive as in the U.S.A.

(c) Minor abnormalities can lead to further detailed investigations and even operations which are unnecessary and we then leave the patient worse than we start.

(d) Let us think before doing "blind investigations"

(e) Just because something is "done overseas" does not mean we have to follow.

(f) I would be interested in the cost of your investigation.

20. In my opinion the first step in clinical medicine is a careful history and a full general examination. I would not have any tests done at all or even a routine chest X-Ray until that had been satisfactorily completed. Then I would select such tests as seem appropriate (if any) - a limited and highly selected group (sometimes on an acute surgical condition such as an acute appendix in a young soldier - none at all. Operation forthwith. No tests except the normal clinical examination). This is the essence of good medical practice and the routine performances of 40 bio-clinical tests without discrimination as a routine at the time of admission is the negation of it. Trusting that you will give a fair account of this viewpoint in any contribution you may make to the literature or otherwise.

21. I do not hold with the principle of routine performance of a set of biochemical and haematological tests and it is seldom indeed that there is a need for such an extensive screening. Consequently, I have consigned the questionnaire to the waste basket and I shall continue to instruct my students and

residents in the use of common sense in the ordering of tests.

22. I really think you must be joking !

23. Totally unconvinced about the usefulness or economic justification of biochemical profiles.

24. Although I agree in principle of routine Multi-Test Screening in my opinion it is bad medicine if not lunacy to have forty tests as a minimum. Even the 20 odd I have filled in are more than is necessary and no benefit will accrue to the patient by having forty or more done.

25. I cannot in all honesty think of 40 or 50 tests. I would want in a general screening procedure. In part this is - that because of my speciality - I am now out of touch with general hospital procedures but also it seems overwhelming to me to consider such a screening programme.

26. My Secretary made me chop this comment off as inappropriate to H.M. Post Office and any receptionist. Phrased in a more restrained way, the proposal is ludicrous from more than one point of view. One physician was extremely dogmatic about the format of the Questionnaire considering it structurally poor and a waste of his time and considered that the time of the person doing the research could be better spent on other projects.

DISCUSSION ON ABOVE COMMENTS.

These general comments are exact extracts as they appeared on the Questionnaire. The English has not been corrected. Some comments have not been included as the writing was undecipherable. It must be realized that this Questionnaire was done in August, 1969, and I consider that if the same questionnaire was sent out now, some of these doctors would have altered their views. The comments indicate that there is some lack of understanding in the principles involved in mulü-screening procedures and the equipment available and the type of tests that are automated and can be performed on this equipment. This I will elaborate on when discussing the admissions profile which has been selected, based on the answers in the Questionnaire and what I consider reasonable and practicable under Australian conditions, Chapter 4 Page 346.

APPENDIX I.

UNIVERSITY OF NEW SOUTH WALES.

SCHOOL OF HEALTH ADMINISTRATION.

P.O. Box 1.
Kensington.
N.S.W. 2033.

Dear Doctor,

I am engaged upon a post-graduate research project at the University of New South Wales.

As you are aware, "biochemical profiles" are prepared routinely on admission to many hospitals overseas - biochemical investigations being relatively easily adaptable to multiple analysis methods.

I am investigating the introduction of a more comprehensive admission or pre-admission series of investigations. I will not discuss the pros and cons of this concept for I am sure you have your own views. However, I would be most grateful if you would fill in the form attached to this letter.

Please return the completed questionnaire in the enclosed envelope.

Looking forward to your co-operation in this project.

Yours sincerely,

J.I. DAVIS, M.B, B.S.

APPENDIX I.

PART ONE
BIOCHEMICAL ANALYSIS

SERUM ANALYSIS.

Na	K	Cl	HCO_3	B.U.N.	Creat.	P.	Uric Acid.
Alk. Phos.	S.G.	Ca	Mg	Amylase	Alb.	Glob.	Total Protein.
Van den Berg	Bilirubin	S.G.O.T.	S.G.P.T.	L.D.H.	C.P.K.	Thymol Turb.	$ZnSO_4$ Turb
Cholesterol	Barbitone	Haptoglobin	Schumm's Test	Br	Fe	I.B.C.	P.B.I.
Acid Phos.	B.S.P.	Met. Hb	Sulph Hb	Aldolase	Cholinesterase	Cu Oxidase	Pyruvate
Lactate	Salicylate	Carotene	Cu	Cortisol	Cryoglobulin	SIA Test	Fibrinogen.
Random BLOOD SUGAR		G.T.T.					

URINE ANALYSIS.

Time Hr. Min.	Vol.	Na	K.	Cl	Ca	Mg	P
Uric Acid.	U.N.	Creat.	Protein	P^H	Glucose	Cystine	17-KS
17-OHCS	D-XYLOSE	5-OHIAA	Bilirubin	Urobilinogen	Porphyrins	Porphobilinogen	B.J. Protein.

Part One continued on next Sheet.

Part One continued

APPENDIX I.

C.S.F. ANALYSIS					
Glucose	Protein	CI	Lange		
FAECES ANALYSIS					
Occult Blood		Faecal Fat (3 days)			
GENERAL PATHOLOGY					
L.E. Cells	Cervical Smear	Latex Test	Blood Group	Rh Factor	
HAEMATOLOGY ANALYSIS					
Hb	Red Cell Count	Total WCC		Haema-tocrit	M.C.V.
M.C.H.	M.C.H.C.	E.S.R.	P.I.	DIFFEREN-tial W.C.C.	Platelet Count.
RESPIRATORY SYSTEM EXAMINATION.					
Chest X-Ray		Spirometry			
CARDIOVASCULARY SYSTEM EXAMINATION					
B.P.		E.C.G.			
GASTRO INTESTINAL SYSTEM EXAMINATION					
Sigmoidoscopy if over 40 years.					

Parts Two & Three on next sheet.

APPENDIX I.

PART TWO

Tests not covered by marking appropriate squares in Part One.

1. General.

2. In your Speciality

PART THREE

Do you agree in principle to Multi-test Screening on Hospital Admissions. YES ____ NO ____

THANK YOU FOR YOUR CO-OPERATION.

PHYSICIANS UNDER THE AGE OF 50 - YES.

TABLE 21

N = 94

BIOCHEMICAL ANALYSES.

SERUM ANALYSES.

Type of Test	No. of Drs requesting Test.	80% Agreement marked by "X".	Type of Test.	No. of Drs requesting Test.	80% Agreement marked by "X"
Na	91	X	Bilirubin	80	X
K.	92	X	S.G.O.T.	76	X
Cl	80	X	S.G.P.T.	44	
HCO_3	85	X	L.D.H.	42	
B.U.N.	87	X	C.P.K.	21	
Creat.	62		Thymol Turb.	19	
P.	47		ZNSO Turb^4	20	
Uric Acid.	82	X	Chole-sterol	86	X
S.G.	15		Barbitone	13	
Ca.	78		Hapto-globin	3	
Mg.	13		Schumm's Test	2	
Amylase.	33		Br.	13	
Alk Phos.	87	X	Fe	55	
Alb.	88	X	I.B.C.	28	
Glob	84	X	P.B.I.	58	
Total Protein	71		Acid Phos.	43	
Van den Berg	11		B.S.P.	21	

Yes = Those Physicians in favour of an Admission Profile

PHYSICIANS UNDER THE AGE OF 50 - YES.

Type of Test.	No. of Drs requesting Test.	80% Agreement marked by "X".	Type of Test.	No. of Drs. requesting Test.	80% Agreement marked by "X".
Met. Hb.	5				
Sulph Hb.	3				
Aldolase	1				
Cholin-esterase	4				
Ca Oxidase	-				
Pyruvate	4				
Lactate	4				
Salicylate	12				
Carotene	3				
Cu	-				
Cortisol	19				
Cryo-globulin	2				
SIA Test	1				
Fibrinogen	11				
Random BLOOD SUGAR	77	X			
G.T.T.	24				

PHYSICIANS UNDER THE AGE OF 50 - YES.

TABLE 21

URINE ANALYSIS.

Type of Test	No. of Drs requesting Test.	80% Agreement marked by "X"	Type of Test.	No. of Drs requesting Test.	80% Agreement marked by "X"
Time Hr. Min.	12		5-OHIAA.	7	
Vol.	41		Bilirubin.	46	
Na.	12		Urobilinogen.	36	
K.	11		Porphyrins.	26	
Cl.	3				
Ca.	17		Porphobilinogen.	22	
Mg.	1				
P	4		B.J.Prot.	13	
Uric Ac.	9				
U.N.	5				
Creat.	12				
Protein.	83	X			
P^H.	60				
Glucose.	82	X			
Cystine.	12				
17-KS.	5				
17-OHCS.	5				
D-XYLOSE.	2				

PHYSICIANS UNDER THE AGE OF 50 - YES.

TABLE. 21

HAEMATOLOGY ANALYSIS.

Type of Test.	No.of Drs requesting Test	80% Agreement marked by "X"	Type of Test	No. of Drs requesting Test	80% Agreement marked by "X"
Hb.	91	X	P.I.	28	
Red Cell Count.	29		Differential W.C.C.	83	X
Total WCC	84	X	Platelet Count	70	
Haematocrit.	65				
M.C.V.	30				
M.C.H.	19				
M.C.H.C.	42				
E.S.R.	91	X			
RESPIRATORY SYSTEM EXAMINATIONS.					
Chest X-Ray.	90	X	Spirometry.	37	
CARDIOVASCULAR SYSTEM EXAMINATION.					
B.P.	90	X	E.C.G.	70	

PHYSICIANS UNDER THE AGE OF 50 - YES.

TABLE 21

C. S. F. ANALYSIS.

Type of Test.	No. of Drs requesting Test.	80% Agreement marked by "X".	Type of Test.	No. of Drs requesting Test.	80% Agreement mared by "X".
Glucose.	11		CI.	8	
Protein.	16		Lange.	12	

FAECES ANALYSIS.

Occult Blood.	64		Faecal Fat (3 days).	15	

GENERAL PATHOLOGY.

L.E. Cells.	18		Blood Group.	70	
Cervical Smear.	70				
Latex Test.	28		Rh Factor	61	

GASTRO INTESTINAL SYSTEM EXAMINATION.

Sigmoidoscopy if over 40 years.	42				

PHYSICIANS UNDER THE AGE OF 50 - NO.

No = Those not in favour of an Admission Profile

TABLE 22

N= 23

BIOCHEMICAL ANALYSES.

SERUM ANALYSES.

Type of Test	No. of Drs requesting Test.	80% Agreement marked by "X".	Type of Test.	No. of Drs requesting Test.	80% Agreement marked by "X"
Na	22	X	Bilirubin	20	X
K.	22	X	S.G.O.T.	20	X
Cl	19	X	S.G.P.T.	12	
HCO_3	21	X	L.D.H.	4	
B.U.N.	20	X	C.P.K.	5	
Creat.	10		Thymol Turb.	7	
P.	9		ZNSO Turb	6	
Uric Acid.	18	X	Chole-sterol	23	X
S.G.	3		Barbitone	7	
Ca.	17		Hapto-globin	1	
Mg.	2		Schumm's Test	1	
Amylase.	4		Br.	1	
Alk Phos.	23	X	Fe	11	
Alb.	21	X	I.B.C.	3	
Glob	21	X	P.B.I.	17	
Total Prot-ein	14		Acid Phos.	9	
Van den Berg	3		B.S.P.	5	

TABLE 22.

PHYSICIANS UNDER THE AGE OF 50 - NO.

Type of Test.	No. of Drs requesting Test.	80% Agreement marked by "X".	Type of Test.	No. of Drs. requesting Test.	80% Agreement marked by "X".
Met. Hb.	1				
Sulph Hb.	-				
Aldolase	1				
Cholin-esterase	-				
Ca Oxidase	-				
Pyruvate	-				
Lactate	-				
Salicylate	3				
Carotene	1				
Cu	1				
Cortisol	3				
Cryo-globulin	1				
SIA Test	1				
Fibrinogen	2				
Random BLOOD SUGAR	21	X			
G.T.T.	5				

PHYSICIANS UNDER THE AGE OF 50. - NO.

TABLE 22

URINE ANALYSIS.

Type of Test	No. of Drs requesting Test.	80% Agreement marked by "X"	Type of Test.	No.of Drs requesting Test.	80% Agreement marked by "X"
Time Hr. Min.	5		5-OHIAA.	-	
Vol.	12		Bilirubin.	9	
Na.	3		Urobilinogen.	6	
K.	3		Porphyrins.	8	
Cl.	2				
Ca.	4		Porphobilinogen.	4	
Mg.	-				
P	1		B.J.Prot.	5	
Uric Ac.	3				
U.N.	-				
Creat.	2				
Protein.	22	X			
P^H.	11				
Glucose.	21	X			
Cystine.	3				
17-KS.	1				
17-OHCS.	3				
D-XYLOSE.	1				

PHYSICIANS UNDER THE AGE OF 50 - NO.

T A B L E. 22

HAEMATOLOGY ANALYSIS.

Type of Test.	No.of Drs requesting Test	80% Agreement marked by "X"	Type of Test	No. of Drs requesting Test	80% Agreement marked by "X"
Hb.	23	X	P.I.	6	
Red Cell Count.	7		Differential W.C.C.	21	X
Total WCC	21	X	Platelet Count	15	
Haematocrit.	17				
M.C.V.	8				
M.C.H.	8				
M.C.H.C.	11				
E.S.R.	23	X			

RESPIRATORY SYSTEM EXAMINATIONS.

Chest X-Ray.	23	X	Spirometry.	6	

CARDIOVASCULAR SYSTEM EXAMINATION.

B.P.	22	X	E.C.G.	19	X

PHYSICIANS UNDER THE AGE OF 50 - NO.

TABLE -9-

C. S. F. ANALYSIS.

Type of Test.	No. of Drs requesting Test.	80% Agreement marked by "X".	Type of Test.	No. of Drs requesting Test.	80% Agreement mared by "X".
Glucose.	2		CI.	1	
Protein.	4		Lange.	1	

FAECES ANALYSIS.

Occult Blood.	16		Faecal Fat (3 days).	7	

GENERAL PATHOLOGY.

L.E. Cells.	6		Blood Group.	21	X
Cervical Smear.	17				
Latex Test.	16		Rh Factor	18	X

GASTRO INTESTINAL SYSTEM EXAMINATION.

Sigmoidoscopy if over 40 years.	11				

PHYSICIANS OVER THE AGE OF 50 - YES+

TABLE 23

N= 13

BIOCHEMICAL ANALYSES.

SERUM ANALYSES.

Type of Test	No. of Drs. requesting Test.	80% Agreement marked by "X".	Type of Test.	No. of Drs requesting Test.	80% Agreement marked by "X"
Na	12	X	Bilirubin	12	X
K.	12	X	S.G.O.T.	10	X
Cl	12	X	S.G.P.T.	7	
HCO_3	10	X	L.D.H.	7	
B.U.N.	11	X	C.P.K.	-	
Creat.	9		Thymol Turb.	5	
P.	6		ZNSO Turb	5	
Uric Acid.	13	X	Chole-sterol	12	X
S.G.	3		Barbitone	2	
Ca.	9		Hapto-globin	-	
Mg.	-		Schumm's Test	-	
Amylase.	3		Br.	3	
Alk Phos.	11	X	Fe	7	
Alb.	13	X	I.B.C.	2	
Glob	13	X	P.B.I.	9	
Total Prot-ein	11	X	Acid Phos.	7	
Van den Berg	3		B.S.P.	1	

+ In the following Tables Yes or NO indicates the answer to Part3.

TABLE 23.

PHYSICIANS OVER THE AGE OF 50 - YES

Type of Test.	No. of Drs requesting Test.	80% Agreement marked by "X".	Type of Test.	No. of Drs. requesting Test.	80% Agreement marked by "X".
Met. Hb.	1				
Sulph Hb.	-				
Aldolase	1				
Cholin-esterase	-				
Cu Oxidase	-				
Pyruvate	2				
Lactate	1				
Salicylate	1				
Carotene	-				
Cu	-				
Cortisol	3				
Cryo-globulin	3				
SIA Test	1				
Fibrinogen	1				
Random BLOOD SUGAR	11	X			
G.T.T.	1				

PHYSICIANS OVER THE AGE OF 50 - YES

TABLE 23

URINE ANALYSIS.

Type of Test	No. of Drs requesting Test.	80% Agreement marked by "X"	Type of Test.	No.of Drs requesting Test.	80% Agreement marked by "X"
Time Hr. Min.	-		5-OHIAA.	1	
Vol.	5		Bilirubin.	8	
Na.	-		Urobilinogen.	9	
K.	-		Porphyrins.	5	
Cl.	1				
Ca.	-		Porphobilinogen.	2	
Mg.	-				
P	-		B.J.Prot.	1	
Uric Ac.	-				
U.N.	-				
Creat.	-				
Protein.	11	X			
p^H.	4				
Glucose.	12	X			
Cystine.	-				
17-KS.	1				
17-OHCS.	1				
D-XYLOSE.	-				

PHYSICIANS OVER THE AGE OF 50 - YES

T A B L E. -23-

HAEMATOLOGY ANALYSIS.

Type of Test.	No.of Drs requesting Test	80% Agreement marked by "X"	Type of Test	No. of Drs requesting Test	80% Agreement marked by "X"
Hb.	11	X	P.I.	2	
Red Cell Count.	8		Differential W.C.C.	11	X
Total MCC	9		Platelet Count	7	
Haematocrit.	10	X			
M.C.V.	7				
M.C.H.	5				
M.C.H.C.	5				
E.S.R.	13	X			

RESPIRATORY SYSTEM EXAMINATIONS.

Chest X-Ray.	11	X	Spirometry.	3	

CARDIOVASCULAR SYSTEM EXAMINATION.

B.P.	11	X	E.C.G.	10	X

PHYSICIANS OVER THE AGE OF 50 - YES.

TABLE 23

C. S. F. ANALYSIS.

Type of Test.	No. of Drs requesting Test.	80% Agreement marked by "X".	Type of Test.	No. of Drs requesting Test.	80% Agreement mared by "X".
Glucose.	4		CI.	3	
Protein.	4		Lange.	4	

FAECES ANALYSIS.

Occult Blood.	10	X	Faecal Fat (3 days).	3	

GENERAL PATHOLOGY.

L.E. Cells.	6		Blood Group.	9	
Cervical Smear.	9				
Latex Test.	7		Rh Factor	7	

GASTRO INTESTINAL SYSTEM EXAMINATION.

Sigmoidoscopy if over 40 years.	4				

PHYSICIANS OVER THE AGE OF 50 - NO

No = Those Doctors not in favour of an Admission Profile

TABLE 24

N = 6.

BIOCHEMICAL ANALYSES.

SERUM ANALYSES.

Type of Test	No. of Drs requesting Test.	80% Agreement marked by "X".	Type of Test.	No. of Drs requesting Test.	80% Agreement marked by "X"
Na	5	X	Bilirubin	5	X
K.	5	X	S.G.O.T.	6	X
Cl	4		S.G.P.T.	4	
HCO_3	5	X	L.D.H.	2	
B.U.N.	4		C.P.K.	-	
Creat.	3		Thymol Turb.	3	
P.	1		ZNSO Turb	3	
Uric Acid.	5	X			
S.G.	1		Chole-sterol	6	X
Ca.	2		Barbitone	3	
Mg.	-		Hapto-globin	-	
Amylase.	1		Schumm's Test	-	
Alk Phos.	5	X	Br.	1	
Alb.	3		Fe	1	
Glob	3		I.B.C.	1	
Total Prot-ein	6	X	P.B.I.	1	
			Acid Phos.	1	
Van den Berg	2		B.S.P.	1	

TABLE 24.

PHYSICIANS OVER THE AGE OF 50 - NO.

Type of Test.	No. of Drs requesting Test.	80% Agreement marked by "X".	Type of Test.	No. of Drs. requesting Test.	80% Agreement marked by "X".
Met. Hb.	1				
Sulph Hb.	1				
Aldolase	-				
Cholin-esterase	-				
Ca Oxidase	-				
Pyruvate	-				
Lactate	-				
Salicylate	1				
Carotene	-				
Cu	-				
Cortisol	1				
Cryo-globulin	-				
SLA Test	-				
Fibrinogen	1				
Random BLOOD SUGAR	5	X			
G.T.T.	3				

PHYSICIANS OVER THE AGE OF 50 - NO.

TABLE 24.

URINE ANALYSIS.

Type of Test	No. of Drs requesting Test.	80% Agreement marked by "X"	Type of Test.	No.of Drs requesting Test.	80% Agreement marked by "X"
Time Hr. Min.	2		5-OHIAA.	-	
Vol.	4		Bilirubin.	4	
Na.	-		Urobilinogen.	4	
K.	-		Porphyrins.	3	
Cl.	-				
Ca.	-		Porphobilinogen.	3	
Mg.	-				
P	-		B.J.Prot.	2	
Uric Ac.	1				
U.N.	-				
Creat.	-				
Protein.	6	X			
P^H.	3				
Glucose.	6	X			
Cystine.	-				
17-KS.	-				
17-OHCS.	2				
D-XYLOSE.	-				

PHYSICIANS OVER THE AGE OF 50 - NO.

T A B L E. 24

HAEMATOLOGY ANALYSIS.

Type of Test.	No.of Drs requesting Test	80% Agreement marked by "X"	Type of Test	No. of Drs requesting Test	80% Agreement marked by "X"
Hb.	6	X	P.I.	-	
Red Cell Count.	2		Differential W.C.C.	5	X
Total WCC	6	X	Platelet Count	2	
Haematocrit.	5	X			
M.C.V.	2				
M.C.H.	2				
M.C.H.C.	3				
E.S.R.	4				

RESPIRATORY SYSTEM EXAMINATIONS.

Chest X-Ray.	6	X	Spirometry.	3	

CARDIOVASCULAR SYSTEM EXAMINATION.

B.P.	6	X	E.C.G.	6	X

PHYSICIANS OVER THE AGE OF 50 - NO.

TABLE 24

C. S. F. ANALYSIS.

Type of Test.	No. of Drs requesting Test.	80% Agreement marked by "X".	Type of Test.	No. of Drs requesting Test.	80% Agreement mared by "X".
Glucose.	2		CI.	2	
Protein.	2		Lange.	1	

FAECES ANALYSIS.

Occult Blood.	4		Faecal Fat (3 days).	4	

GENERAL PATHOLOGY.

L.E. Cells.	3		Blood Group.	5	X
Cervical Smear.	4				
Latex Test.	1		Rh Factor	5	X

GASTRO INTESTINAL SYSTEM EXAMINATION.

Sigmoidoscopy if over 40 years.	3				

SURGEONS UNDER 50 - YES.

Yes = Those doctors in favour of an Admission Profile

TABLE 45.

N = 49

BIOCHEMICAL ANALYSES.

SERUM ANALYSES.

Type of Test	No. of Drs requesting Test.	80% Agreement marked by "X".	Type of Test.	No. of Drs requesting Test.	80% Agreement marked by "X"
Na	48	X	Bilirubin	43	X
K.	47	X	S.G.O.T.	39	X
Cl	47	X	S.G.P.T.	19	
HCO_3	46	X	L.D.H.	10	
B.U.N.	45	X	C.P.K.	1	
Creat.	17		Thymol Turb.	21	
P.	19		ZNSO Turb	10	
Uric Acid.	34		Chole-sterol	38	
S.G.	5		Barbitone	1	
Ca.	43	X	Hapto-globin	-	
Mg.	7		Schumm's Test	-	
Amylase.	26		Br.	2	
Alk Phos.	45	X	Fe	16	
Alb.	44	X	I.B.C.	1	
Glob	42	X	P.B.I.	23	
Total Prot-ein	41	X	Acid Phos.	26	
Van den Berg	9		B.S.P.	6	

TABLE 25.

SURGEONS UNDER 50 - YES.

Type of Test.	No. of Drs requesting Test.	80% Agreement marked by "X".	Type of Test.	No. of Drs. requesting Test.	80% Agreement marked by "X".
Met. Hb.	5				
Sulph Hb.	1				
Aldolase	-				
Cholin-esterase	2				
Ca Oxidase	-				
Pyruvate	-				
Lactate	-				
Salicylate	2				
Carotene	-				
Cu	-				
Cortisol	5				
Cryo-globulin	-				
SIA Test	-				
Fibrinogen	4				
Random BLOOD SUGAR	45	X			
G.T.T.	8				

SURGEONS UNDER 50 - YES.

TABLE 25

URINE ANALYSIS.

Type of Test	No. of Drs requesting Test.	80% Agreement marked by "X"	Type of Test.	No.of Drs requesting Test.	80% Agreement marked by "X"
Time Hr. Min.	10		5-OHIAA.	2	
Vol.	31		Bilirubin.	38	
Na.	10		Urobilinogen.	30	
K.	3		Porphyrins.	17	
Cl.	8				
Ca.	8		Porphobilinogen	5	
Mg.	1				
P	-		B.J.Prot.	8	
Uric Ac.	3				
U.N.	6				
Creat.	3				
Protein.	38				
pH.	38				
Glucose.	39	X			
Cystine.	3				
17-KS.	3				
17-OHCS.	2				
D-XYLOSE.	-				

SURGEONS UNDER 50 - YES.

T A B L E. 25

HAEMATOLOGY ANALYSIS.

Type of Test.	No.of Drs requesting Test	80% Agreement marked by "X"	Type of Test	No. of Drs requesting Test	80% Agreement marked by "X"
Hb.	47	X	P.I.	17	
Red Cell Count.	30		Differential W.C.C.	45	X
Total WCC	40	X	Platelet Count	37	
Haematocrit.	40	X			
M.C.V.	22				
M.C.H.	12				
M.C.H.C.	17				
E.S.R.	44	X			
RESPIRATORY SYSTEM EXAMINATIONS.					
Chest X-Ray.	45	X	Spirometry.	20	
CARDIOVASCULAR SYSTEM EXAMINATION.					
B.P.	45	X	E.C.G.	37	

SURGEONS UNDER 50 - YES.

T A B L E.25

C. S. F. ANALYSIS.

Type of Test.	No. of Drs requesting Test.	80% Agreement marked by "X".	Type of Test.	No. of Drs requesting Test.	80% Agreement mared by "X".
Glucose.	6		CI.	4	
Protein.	6		Lange.	4	

FAECES ANALYSIS.

Occult Blood.	36		Faecal Fat (3 days).	12	

GENERAL PATHOLOGY.

L.E. Cells.	14		Blood Group.	47	X
Cervical Smear.	42	X			
Latex Test.	13		Rh Factor	45	X

GASTRO INTESTINAL SYSTEM EXAMINATION.

Sigmoidoscopy if over 40 years.	34				

SURGEONS UNDER 50 - NO

No = Those Doctors not in favour of an Admission Profile

T A B L E 26

N = 30

BIOCHEMICAL ANALYSES.

SERUM ANALYSES.

Type of Test	No. of Drs requesting Test.	80% Agreement marked by "X".	Type of Test.	No. of Drs requesting Test.	80% Agreement marked by "X"
Na	30	X	Bilirubin	26	X
K.	30	X	S.G.O.T.	21	
Cl	30	X	S.G.P.T.	15	
HCO_3	27	X	L.D.H.	4	
B.U.N.	23		C.P.K.	-	
Creat.	12		Thymol Turb.	9	
P.	9		ZNSO Turb[4]	8	
Uric Acid.	21		Chole-sterol	22	
S.G.	5		Barbitone	1	
Ca.	23		Hapto-globin	-	
Mg.	4		Schumm's Test	1	
Amylase.	18		Br.	1	
Alk Phos.	24	X	Fe	13	
Alb.	24	X	I.B.C.	3	
Glob	24	X	P.B.I.	17	
Total Prot-ein	26	X	Acid Phos.	22	
Van den Berg	6		B.S.P.	6	

TABLE 26.

SURGEONS UNDER 50 - NO.

Type of Test.	No. of Drs requesting Test.	80% Agreement marked by "X".	Type of Test.	No. of Drs. requesting Test.	80% Agreement marked by "X".
Met. Hb.	-				
Sulph Hb.	-				
Aldolase	-				
Cholin-esterase	3				
Ca Oxidase	-				
Pyruvate	-				
Lactate	1				
Salicylate	4				
Carotene	1				
Cu	-				
Cortisol	2				
Cryo-globulin	-				
SIA Test	-				
Fibrinogen	10				
Random BLOOD SUGAR	26	X			
G.T.T.	4				

SURGEONS UNDER 50 - NO.

TABLE 26

URINE ANALYSIS.

Type of Test	No. of Drs requesting Test.	80% Agreement marked by "X"	Type of Test.	No.of Drs requesting Test.	80% Agreement marked by "X"
Time Hr. Min.	10		5-OHIAA.	1	
Vol.	17		Bilirubin.	20	
Na.	4		Urobilinogen.	14	
K.	1		Porphyrins.	12	
Cl.	3				
Ca.	4		Porphobilinogen.	2	
Mg.	-				
P	-		B.J.Prot.	5	
Uric Ac.	5				
U.N.	1				
Creat.	1				
Protein.	23				
P^H.	24	X			
Glucose.	27	X			
Cystine.	3				
17-KS.	4				
17-OHCS.	2				
D-XYLOSE.	2				

SURGEONS UNDER 50 - NO.

T A B L E. 26

HAEMATOLOGY ANALYSIS.

Type of Test.	No.of Drs requesting Test	80% Agreement marked by "X"	Type of Test	No. of Drs requesting Test	80% Agreement marked by "X"
Hb.	30	X	P.I.	6	
Red Cell Count.	22		Differential W.C.C.	30	X
Total WCC	23		Platelet Count	23	
Haematocrit.	16				
M.C.V.	5				
M.C.H.	6				
M.C.H.C.	7				
E.S.R.	27	X			
RESPIRATORY SYSTEM EXAMINATIONS.					
Chest X-Ray.	30	X	Spirometry.	10	
CARDIOVASCULAR SYSTEM EXAMINATION.					
B.P.	27	X	E.C.G.	27	X

SURGEONS UNDER 50 - NO.

TABLE 24.

C. S. F. ANALYSIS.

Type of Test.	No. of Drs requesting Test.	80% Agreement marked by "X".	Type of Test.	No. of Drs requesting Test.	80% Agreement mared by "X".
Glucose.	5		CI.	3	
Protein.	7		Lange.	2	

FAECES ANALYSIS.

Occult Blood.	25		Faecal Fat (3 days).	7	

GENERAL PATHOLOGY.

L.E. Cells.	11		Blood Group.	30	X
Cervical Smear.	24	X			
Latex Test.	7		Rh Factor	28	X

GASTRO INTESTINAL SYSTEM EXAMINATION.

Sigmoidoscopy if over 40 years.	21				

SURGEONS OVER THE AGE OF 50 - YES.

Yes = Those doctors in favour of an Admission Profile

TABLE 27

N = 16.

BIOCHEMICAL ANALYSES.

SERUM ANALYSES.

Type of Test	No. of Drs requesting Test.	80% Agreement marked by "X".	Type of Test.	No. of Drs requesting Test.	80% Agreement marked by "X"
Na	16	X	Bilirubin	15	X
K.	16	X	S.G.O.T.	13	X
Cl	16	X	S.G.P.T.	9	
HCO_3	16	X	L.D.H.	1	
B.U.N.	13	X	C.P.K.	-	
Creat.	5		Thymol Turb.	5	
P.	6		ZNSO Turb	4	
Uric Acid.	12		Chole-sterol	13	X
S.G.	3		Barbitone	2	
Ca.	9		Hapto-globin	-	
Mg.	-		Schumm's Test	-	
Amylase.	12		Br.	3	
Alk Phos.	13	X	Fe	3	
Alb.	14	X	I.B.C.	-	
Glob	14	X	P.B.I.	8	
Total Prot-ein	14	X	Acid Phos.	9	
Van den Berg	4		B.S.P.	2	

TABLE 27.

SURGEONS OVER THE AGE OF 50 - YES.

Type of Test.	No. of Drs requesting Test.	80% Agreement marked by "X".	Type of Test.	No. of Drs. requesting Test.	80% Agreement marked by "X".
Met. Hb.	2				
Sulph Hb.	2				
Aldolase	-				
Cholin-esterase	-				
Ca Oxidase	1				
Pyruvate	-				
Lactate	1				
Salicylate	-				
Carotene	-				
Cu	-				
Cortisol	1				
Cryo-globulin	-				
SIA Test	-				
Fibrinogen	5				
Random BLOOD SUGAR	13	X			
G.T.T.	1				

SURGEONS OVER THE AGE OF 50 - YES.

TABLE 37

URINE ANALYSIS.

Type of Test	No. of Drs requesting Test.	80% Agreement marked by "X"	Type of Test.	No.of Drs requesting Test.	80% Agreement marked by"X"
Time Hr. Min.	2		5-OHIAA.	-	
Vol.	7		Bilirubin.	11	
Na.	2		Urobilinogen.	7	
K.	-		Porphyrins.	7	
Cl.	2				
Ca.	-		Porphobilinogen.	3	
Mg.	-				
P	-		B.J.Prot.	1	
Uric Ac.	1				
U.N.	-				
Creat.	-				
Protein.	14	X			
P^H.	14	X			
Glucose.	16	X			
Cystine.	-				
17-KS.	2				
17-OHCS.	1				
D-XYLOSE.	-				

SURGEONS OVER THE AGE OF 50 - YES.

T A B L E. 27

HAEMATOLOGY ANALYSIS.

Type of Test.	No.of Drs requesting Test	80% Agreement marked by "X"	Type of Test	No. of Drs requesting Test	80% Agreement marked by "X"
Hb.	15	X	P.I.	4	
Red Cell Count.	12		Differential W.C.C.	15	X
Total WCC.	12		Platelet Count	12	
Haematocrit.	8				
M.C.V.	3				
M.C.H.	2				
M.C.H.C.	4				
E.S.R.	14	X			
RESPIRATORY SYSTEM EXAMINATIONS.					
Chest X-Ray.	16	X	Spirometry.	7	
CARDIOVASCULAR SYSTEM EXAMINATION.					
B.P.	15	X	E.C.G.	14	X

SURGEONS OVER THE AGE OF 50 - YES.

T A B L E. 27

C. S. F. ANALYSIS.

Type of Test.	No. of Drs requesting Test.	80% Agreement marked by "X".	Type of Test.	No. of Drs requesting Test.	80% Agreement mared by "X".
Glucose.	5		CI.	4	
Protein.	5		Lange.	3	

FAECES ANALYSIS.

Occult Blood.	15	X	Faecal Fat (3 days).	8	

GENERAL PATHOLOGY.

L.E. Cells.	5		Blood Group.	15	X
Cervical Smear.	12				
Latex Test.	3		Rh Factor	14	X

GASTRO INTESTINAL SYSTEM EXAMINATION.

Sigmoidoscopy if over 40 years.	12				

SURGEONS OVER 50 - NO.

No = Those Doctors not in favour of an Admission Profile

TABLE 29

N = 8

BIOCHEMICAL ANALYSES.

SERUM ANALYSES.

Type of Test	No. of Drs requesting Test.	80% Agreement marked by "X".	Type of Test.	No. of Drs requesting Test.	80% Agreement marked by "X"
Na	6	X	Bilirubin	7	X
K.	7	X	S.G.O.T.	6	X
Cl	6	X	S.G.P.T.	2	
HCO_3	6	X	L.D.H.	2	
B.U.N.	6	X	C.P.K.	1	
Creat.	1		Thymol Turb.	3	
P.	1		ZNSO Turb[4]	2	
Uric Acid.	8	X	Chole-sterol	5	
S.G.	1		Barbitone	-	
Ca.	6	X	Hapto-globin	-	
Mg.	1		Schumm's Test	-	
Amylase.	7	X	Br.	1	
Alk Phos.	8	X	Fe	1	
Alb.	7	X	I.B.C.	-	
Glob	6	X	P.B.I.	3	
Total Prot-ein	8	X	Acid Phos.	4	
Van den Berg	3		B.S.P.	-	

TABLE 28

263

SURGEONS OVER 50 - NO.

Type of Test.	No. of Drs requesting Test.	80% Agreement marked by "X".	Type of Test.	No. of Drs. requesting Test.	80% Agreement marked by "X".
Met. Hb.	1				
Sulph Hb.	-				
Aldolase	-				
Cholin-esterase	-				
Ca Oxidase	-				
Pyruvate	-				
Lactate	-				
Salicylate	-				
Carotene	-				
Cu	-				
Cortisol	-				
Cryo-globulin	-				
SIA Test	-				
Fibrinogen	-				
Random BLOOD SUGAR	8	X			
G.T.T.	1				

SURGEONS OVER 50 - NO.

TABLE 28

URINE ANALYSIS.

Type of Test	No. of Drs requesting Test.	80% Agreement marked by "X"	Type of Test.	No.of Drs requesting Test.	80% Agreement marked by "X"
Time Hr. Min.	-		5-OHIAA.	-	
Vol.	5		Bilirubin.	6	X
Na.	1		Urobilinogen.	3	
K.	1		Porphyrins.	3	
Cl.	-				
Ca.	1		Porphobilinogen.	1	
Mg.	-				
P	-		B.J.Prot.	2	
Uric Ac.	1				
U.N.	1				
Creat.	-				
Protein.	5				
P^H.	7	X			
Glucose.	8	X			
Cystine.	-				
17-KS.	-				
17-OHCS.	-				
D-XYLOSE.	-				

SURGEONS OVER 50 - NO.

TABLE. 28

HAEMATOLOGY ANALYSIS.

Type of Test.	No.of Drs requesting Test	80% Agreement marked by "X"	Type of Test	No. of Drs requesting Test	80% Agreement marked by "X"
Hb.	8	X	P.I.	3	
Red Cell Count.	5		Differential W.C.C.	8	X
Total WCC.	7	X	Platelet Count	5	
Haematocrit.	6	X			
M.C.V.	4				
M.C.H.	2				
M.C.H.C.	3				
E.S.R.	8	X			
RESPIRATORY SYSTEM EXAMINATIONS.					
Chest X-Ray.	8	X	Spirometry.	4	
CARDIOVASCULAR SYSTEM EXAMINATION.					
B.P.	8	X	E.C.G.	8	X

SURGEONS OVER 50 - NO.

TABLE 28

C. S. F. ANALYSIS.

Type of Test.	No. of Drs requesting Test.	80% Agreement marked by "X".	Type of Test.	No. of Drs requesting Test.	80% Agreement mared by "X".
Glucose.	3		CI.	1	
Protein.	3		Lange.	2	

FAECES ANALYSIS.

Occult Blood.	8	X	Faecal Fat (3 days).	4	

GENERAL PATHOLOGY.

L.E. Cells.	2		Blood Group.	8	X
Cervical Smear.	6	X			
Latex Test.	1		Rh Factor	8	X

GASTRO INTESTINAL SYSTEM EXAMINATION.

Sigmoidoscopy if over 40 years.	7	X			

REGISTRARS & RESIDENTS UNDER THE AGE OF 50 - YES.

Yes = These Doctors in favour of an Admission Profile

TABLE 29

N = 84.

BIOCHEMICAL ANALYSES.

SERUM ANALYSES.

Type of Test	No. of Drs requesting Test.	80% Agreement marked by "X".	Type of Test.	No. of Drs requesting Test.	80% Agreement marked by "X"
Na	79	X	Bilirubin	68	X
K.	80	X	S.G.O.T.	68	X
Cl	74	X	S.G.P.T.	55	
HCO_3	72	X	L.D.H.	48	
B.U.N.	77	X	C.P.K.	20	
Creat.	53		Thymol Turb.	12	
P.	44		ZNSO Turb^4	11	
Uric Acid.	63		Chole-sterol	69	X
S.G.	26		Barbitone	10	
Ca.	69	X	Hapto-globin	1	
Mg.	23		Schumm's Test	1	
Amylase.	26		Br.	11	
Alk Phos.	77	X	Fe	31	
Alb.	79	X	I.B.C.	22	
Glob	75	X	P.B.I.	45	
Total Prot-ein	62		Acid Phos.	34	
Van den Berg	11		B.S.P.	24	

TABLE 29.

REGISTRARS & RESIDENTS UNDER THE AGE OF 50 - YES.

Type of Test.	No. of Drs requesting Test.	80% Agreement marked by "X".	Type of Test.	No. of Drs. requesting Test.	80% Agreement marked by "X".
Met. Hb.	2				
Sulph Hb.	-				
Aldolase	1				
Cholin-esterase	4				
Ca Oxidase	2				
Pyruvate	4				
Lactate	2				
Salicylate	6				
Carotene	-				
Cu	2				
Cortisol	13				
Cryo-globulin	1				
SIA Test	-				
Fibrinogen	9				
Random BLOOD SUGAR	69	X			
G.T.T.	23				

REGISTRARS & RESIDENTS UNDER THE AGE OF 50 - YES.

TABLE - 29

URINE ANALYSIS.

Type of Test	No. of Drs requesting Test.	80% Agreement marked by "X"	Type of Test.	No.of Drs requesting Test.	80% Agreement marked by "X"
Time Hr. Min.	11		5-OHIAA.	2	
Vol.	49		Bilirubin.	34	
Na.	21		Urobilinogen.	18	
K.	19		Porphyrins.	17	
Cl.	11				
Ca.	11		Porphobilinogen.	4	
Mg.	1				
P	3		B.J.Prot.	10	
Uric Ac.	4				
U.N.	2				
Creat.	17				
Protein.	71	X			
P^H.	58				
Glucose.	72	X			
Cystine.	4				
17-KS.	15				
17-OHCS.	10				
D-XYLOSE.	3				

REGISTRARS & RESIDENTS UNDER THE AGE OF 50 - YES.

TABLE 29

HAEMATOLOGY ANALYSIS.

Type of Test.	No.of Drs requesting Test	80% Agreement marked by "X"	Type of Test	No. of Drs requesting Test	80% Agreement marked by "X"
Hb.	83	X	P.I.	40	
Red Cell Count.	31		Differential W.C.C.	76	X
Total WCC	75	X	Platelet Count	56	
Haematocrit.	60				
M.C.V.	25				
M.C.H.	10				
M.C.H.C.	34				
E.S.R.	77	X			

RESPIRATORY SYSTEM EXAMINATIONS.

Chest X-Ray.	81	X	Spirometry.	40	

CARDIOVASCULAR SYSTEM EXAMINATION.

B.P.	79	X	E.C.G.	64	

REGISTRARS & RESIDENTS UNDER THE AGE OF 50 - YES.

T A B L ... 29

C. S. F. ANALYSIS.

Type of Test.	No. of Drs requesting Test.	80% Agreement marked by "X".	Type of Test.	No. of Drs requesting Test.	80% Agreement mared by "X".
Glucose.	18		CI.	13	
Protein.	20		Lange.	11	

FAECES ANALYSIS.

Occult Blood.	50		Faecal Fat (3 days).	9	

GENERAL PATHOLOGY.

L.E. Cells.	15		Blood Group.	69	X
Cervical Smear.	69	X			
Latex Test.	17		Rh Factor	55	

GASTRO INTESTINAL SYSTEM EXAMINATION.

Sigmoidoscopy if over 40 years.	53				

REGISTRARS & RESIDENTS UNDER THE AGE OF 50 - NO.

No = Those Doctors not in favour of an Admission Profile

TABLE 30

N = 33

BIOCHEMICAL ANALYSES.

SERUM ANALYSES.

Type of Test	No. of Drs. requesting Test.	80% Agreement marked by "X".	Type of Test.	No. of Drs requesting Test.	80% Agreement marked by "X"
Na	31	X	Bilirubin	26	X
K.	33	X	S.G.O.T.	28	X
Cl	27	X	S.G.P.T.	23	
HCO_3	31	X	L.D.H.	17	
B.U.N.	29	X	C.P.K.	5	
Creat.	19		Thymol Turb.	10	
P.	16		ZNSO Turb	7	
Uric Acid.	20		Chole-sterol	27	X
S.G.	11		Barbitone	6	
Ca.	29	X	Hapto-globin	-	
Mg.	5		Schumm's Test	1	
Amylase.	12		Br.	9	
Alk Phos.	27	X	Fe	15	
Alb.	32	X	I.B.C.	5	
Glob	29	X	P.B.I.	15	
Total Prot-ein	28	X	Acid Phos.	20	
Van den Berg	8		B.S.P.	7	

TABLE 30

REGISTRARS & RESIDENTS UNDER THE AGE OF 50 - NO.

Type of Test.	No. of Drs requesting Test.	80% Agreement marked by "X".	Type of Test.	No. of Drs. requesting Test.	80% Agreement marked by "X".
Met. Hb.	2				
Sulph Hb.	-				
Aldolase	-				
Cholin-esterase	2				
Ca Oxidase	-				
Pyruvate	-				
Lactate	1				
Salicylate	3				
Carotene	-				
Cu	-				
Cortisol	4				
Cryo-globulin	-				
SIA Test	-				
Fibrinogen	2				
Random BLOOD SUGAR	30	X			
G.T.T.	4				

REGISTRARS & RESIDENTS UNDER THE AGE OF 50 - NO.

T A B L E 30

URINE ANALYSIS.

Type of Test	No. of Drs requesting Test.	80% Agreement marked by "X"	Type of Test.	No.of Drs requesting Test.	80% Agreement marked by "X"
Time Hr. Min.	6		5-OHIAA.	2	
Vol.	20		Bilirubin.	14	
Na.	6		Urobilinogen.	8	
K.	6		Porphyrins.	12	
Cl.	2				
Ca.	5		Porphobilinogen.	2	
Mg.	-				
P	2		B.J.Prot.	6	
Uric Ac.	1				
U.N.	2				
Creat.	5				
Protein.	28	X			
P^H.	23				
Glucose.	31	X			
Cystine.	4				
17-KS.	3				
17-OHCS.	2				
D-XYLOSE.	1				

REGISTRARS & RESIDENTS UNDER THE AGE OF 50 - NO.

TABLE 30

HAEMATOLOGY ANALYSIS.

Type of Test.	No.of Drs requesting Test	80% Agreement marked by "X"	Type of Test	No. of Drs requesting Test	80% Agreement marked by "X"
Hb.	32	X	P.I.	15	
Red Cell Count.	8		Differential W.C.C.	30	X
Total WCC	28	X	Platelet Count	20	
Haematocrit.	22				
M.C.V.	8				
M.C.H.	7				
M.C.H.C.	10				
E.S.R.	30	X			
RESPIRATORY SYSTEM EXAMINATIONS.					
Chest X-Ray.	31	X	Spirometry.	14	
CARDIOVASCULAR SYSTEM EXAMINATION.					
B.P.	30	X	E.C.G.	26	

REGISTRARS & RESIDENTS UNDER THE AGE OF 50 - NO.

T A B L E. 30

C. S. F. ANALYSIS.

Type of Test.	No. of Drs requesting Test.	80% Agreement marked by "X".	Type of Test.	No. of Drs requesting Test.	80% Agreement mared by "X".
Glucose.	6		Cl.	3	
Protein.	4		Lange.	5	

FAECES ANALYSIS.

Occult Blood.	22		Faecal Fat (3 days).	6	

GENERAL PATHOLOGY.

L.E. Cells.	7		Blood Group.	30	X
Cervical Smear.	26	X			
Latex Test.	8		Rh Factor	26	X

GASTRO INTESTINAL SYSTEM EXAMINATION.

Sigmoidoscopy if over 40 years.	19				

REGISTRARS & RESIDENTS OVER 50 - YES.

Yes = Those doctors in favour of an Admission Profile

TABLE 31

N = 2.

BIOCHEMICAL ANALYSES.

SERUM ANALYSES.

Type of Test	No. of Drs requesting Test.	80% Agreement marked by "X".	Type of Test.	No. of Drs requesting Test.	80% Agreement marked by "X"
Na	2	X	Bilirubin	1	
K.	2	X	S.G.O.T.	2	X
Cl	2	X	S.G.P.T.	2	X
HCO_3	2	X	L.D.H.	-	
B.U.N.	2	X	C.P.K.	-	
Creat.	2	X	Thymol Turb.	1	
P.	1		ZNSO Turb[4]	1	
Uric Acid.	2	X	Chole-sterol	2	X
S.G.	1		Barbitone	-	
Ca.	2	X	Hapto-globin	-	
Mg.	-		Schumm's Test	-	
Amylase.	1		Br.	1	
Alk Phos.	2	X	Fe	2	X
Alb.	1		I.B.C.	-	
Glob	1		P.B.I.	2	X
Total Prot-ein	2	X	Acid Phos.	2	X
Van den Berg	1		B.S.P.	-	

TABLE 31.

REGISTRARS & RESIDENTS OVER 50 - YES.

Type of Test.	No. of Drs requesting Test.	80% Agreement marked by "X".	Type of Test.	No. of Drs. requesting Test.	80% Agreement marked by "X".
Met. Hb.	-				
Sulph Hb.	-				
Aldolase	-				
Cholin-esterase	1				
Ca Oxidase	-				
Pyruvate	1				
Lactate	1				
Salicylate	-				
Carotene	1				
Cu	-				
Cortisol	-				
Cryo-globulin	1				
SIA Test	1				
Fibrinogen	-				
Random BLOOD SUGAR	2	X			
G.T.T.	-				

REGISTRARS & RESIDENTS OVER 50 - YES.

TABLE 31

URINE ANALYSIS.

Type of Test	No. of Drs requesting Test.	80% Agreement marked by "X"	Type of Test.	No.of Drs requesting Test.	80% Agreement marked by "X"
Time Hr. Min.	-		5-OHIAA.	-	
Vol.	1		Bilirubin.	1	
Na.	-		Urobilinogen.	1	
K.	-		Porphyrins.	1	
Cl.	-				
Ca.	-		Porphobilinogen.	-	
Mg.	-				
P	-		B.J.Prot.	-	
Uric Ac.	1				
U.N.	-				
Creat.	-				
Protein.	2	X			
P^H.	1				
Glucose.	2	X			
Cystine.	-				
17-KS.	-				
17-OHCS.	-				
D-XYLOSE.	-				

REGISTRARS & RESIDENTS OVER 50 - YES.

T A B L E. 31

HAEMATOLOGY ANALYSIS.

Type of Test.	No.of Drs requesting Test	80% Agreement marked by "X"	Type of Test	No. of Drs requesting Test	80% Agreement marked by "X"
Hb.	2	X	P.I.	-	
Red Cell Count.	1		Differential W.C.C.	-	
Total WCC	1		Platelet Count	1	
Haematocrit.	1				
M.C.V.	-				
M.C.H.	-				
M.C.H.C.	-				
E.S.R.	-				
RESPIRATORY SYSTEM EXAMINATIONS.					
Chest X-Ray.	1		Spirometry.	1	
CARDIOVASCULAR SYSTEM EXAMINATION.					
B.P.	1		E.C.G.	1	

REGISTRARS & RESIDENTS OVER 50 - YES.

T A B L E. 31

C. S. F. ANALYSIS.

Type of Test.	No. of Drs requesting Test.	80% Agreement marked by "X".	Type of Test.	No. of Drs requesting Test.	80% Agreement mared by "X".
Glucose.	-		CI.	-	
Protein.	-		Lange.	-	

FAECES ANALYSIS.

Occult Blood.	2	X	Faecal Fat (3 days).	-	

GENERAL PATHOLOGY.

L.E. Cells.	-		Blood Group.	2	X
Cervical Smear.	2	X			
Latex Test.	1		Rh Factor	2	X

GASTRO INTESTINAL SYSTEM EXAMINATION.

Sigmoidoscopy if over 40 years.	1				

APPENDIX 5
TABLE 32

PHYSICIANS - UNDER 50 - IN FAVOUR OF MULTI-SCREENING.

ADDITIONAL TESTS REQUESTED.	
General	Related to Speciality in which physician practices.
1) Micro-Urine	1)
2) SG Urine	2)
3) Breast X-Rays	3) Eye Tests - Acuity, Glaucoma
4) SG of Urine	4) T_3 Resin
5) Micro-Urine & Culture	5) Blood Film
6) Blood, Slide, WR	6) BEG, Skull & Wrist X-Rays
7)	7) Colecholamines
8) Serum Oxmolality, EPG, Blood Gases	8)
9) EPG, WR	9)
10) Micro-Urine, Blood Film	10)
11) Micro-Urine, Blood Film	11)
12) Pulse, Temperature, Weight, Blood Film, EPG	12)
13) Mantoux, Sputum Smear & Culture, Blood Gases.	13)
14) Micro-Urine, Culture & Sensitivity, EPG, X-Ray Hands & Feet, Rose Waller Test, Anti-Nuclear Factor, Immune Factor.	14)
15) Micro-Urine, WR, Throat Swab	15)
16)	16) Psychometrics
17) Urine Culture & Sensitivity WR., Weight.	17)
18) Sputum Culture	18) Bronchial Cytology
19) Blood Film	19)
20)	20) EPG
21) WR., Micro-Urine Culture & Sensitivity, Chromosone Count	21)
22) IgG, IgA, IgM	22) Marrow Biopsy
23)	23) Blood Gases, Radio Nuclids.
24) EPG, Micro-Urine, Sputum Culture, Cytology.	24) Bone Marrow, Bleeding Time & Clotting Time
25) Blood Film	25)
26) Micro-Urine	26)
27) Blood Alcohol, Micro-Urine	27) Skull X-Ray, EEG
28) Blood Alcohol	28)
29) Height, Weight, Blood Alcohol, SG of Urine	29) Serum Lipids.
30) Urine, Temperature, Pulse.	30) EPG
31) Micro Urine	31) Blood Gases, IVP
32) Micro Urine & Culture WR	32) Blood Culture, Agglutinins, Mycoplasma Antibodies.
33) Blood Smear.	33)
	34)
	35) Anti-Nuclear Factor
	36)
	37) Skull X-Ray, EEG
	38) EPG
	39) Serum Folate and B_{12}
	40)
	41) B_{12}

The number in the bracket refers to the identification number of the case in the group. The same number refers to general and special tests.

APPENDIX 5 (contd)
TABLE 32

PHYSICIANS - UNDER 50 - IN FAVOUR OF MULTI-SCREENING.

ADDITIONAL TESTS REQUESTED.	
General	Related to Speciality in which physician practices.
33) Blood Smear	42) Optic Fundi.
34) Blood Film	43) Sputum Cytology, Culture Blood Gases
35) Urine Cytology & Culture	44)
36) X-Ray Renal Areas, EPC, IVP, Urine Culture	45)
37)	46)
38)	47)
39)	48) Blood Gases, Mantoux, Sputum Culture
40) Micro-Urine	49)
41)	50) Serum B_{12}, WR, EEG.
42) Colour of Urine, Colour of Faeces, Reticulocytes, EPG.	51) IQ, Serum Phenylolinisine. Urinary Phenylphyruvic Acid.
43) Blood Film	52) Phenlyphyruvic Acid, Urinary Amphetamines.
44) EPG	53) Serum Ammonia, Abdomen X-Ray.
45) Micro Urine & Culture	54)
46) SG of Urine	
47)	
48) Urine Culture, Blood Culture T_3 Resin	
49) EPG, Micro-Urine & Culture Blood Gases	
50)	
51) Barium Meal	
52) Temperature, Pulse, WR,	
53) WR,	
54) Micro-Urine & Culture.	

The above requests have not been altered in any way.

PHYSICIANS UNDER 50 - NOT IN FAVOUR OF MULTI-SCREENING.

ADDITIONAL TESTS REQUESTED.	
General	Related to Speciality in which Physician Practices.
1) WR, GFT	1)
2)	2) Triglycerides
3)	3) WR, Skull X-Ray, X-Ray abdomen.
4)	4) T_3 Resin, Tests for Auto Antibodies.
5) WR	5)
6)	6) Serum B_{12} Assay and Folate, X-Ray Abdomen.
7)	7) Blood Gases
8) Micro-Urine & Culture	8) X-Ray Skull, Karryotype.
9) Height, Weight, Fat.Fold, Girth.	9)
10) WR	10)
11) Thyroxine	11)
The above requests	have not been altered in any way.

APPENDIX 7
TABLE 34.

PHYSICIANS OVER 50 - IN FAVOUR OF MULTI-SCREENING.

ADDITIONAL TESTS REQUESTED.	
General	Related to Speciality in which physician practices.
1) Micro-Urine 2) SPG, Total Serum Lipoids, Triglycerides. 3) Weight & Height. 4) Blood Gases, Micro-Urine & Culture. 5) Screening Chest & Barium Swallow.	

APPENDIX 8.
TABLE 35.

PHYSICIANS OVER 50 - NOT IN FAVOUR OF MULTI-SCREENING.

ADDITIONAL TESTS REQUESTED.	
General	Related to Speciality in which Physician Practices.
1) Body Weight and Height. 2) WR.	

The above request have not been altered in any way.

SURGEONS UNDER 50 - IN FAVOUR OF MULTI-SCREENING.

ADDITIONAL TESTS REQUESTED.	
General	Related to Speciality in which Surgeon Practices.
1) Micro-Urine Sensitivity	1)
2) Gastric Acidity, Lipase Activity	2)
3) SG of Urine, Serum Thyroxins	3) Ba Meal and follow through
4) WR	4) Coagulation Defects
5) WR	5) Micro-Urine
6) Weight	6)
7) SG of Urine	7)
8) Blood Smear	8)
9) X-Ray of Abdomen	9)
10) Photograph of Relevant Lesion	10)
11) Micro-Urine Culture & Sensitivity	11)
12) Micro-Urine Culture & Sensitivity, X-Ray of Abdomen.	12)
13)	13) Bleeding & Clotting Time
14)	14) Breast, Skin & Mouth Examination.
15) Creatinine Clearance, Micro-Urine, Sputum Cytdogy, Blood Gases.	15)
16) Blood Film, EPG, WR	16)
17) SG of Urine, Blood Gases	17)
18)	18) Urine Cytology, PR.

SURGEONS UNDER 50 - NOT IN FAVOUR OF MULTI-SCREENING.	
1) SG of Urine, Bleeding Time Clotting Time, Reticulocyte Count, Blood Film	1) X-Ray of Abdomen.
2) Blood Gases	2)
3) 24 Hour Urinary Amalyse	3)
4) Bleeding Time, Clotting Time Patient's Weight.	4)
5) Hydatids, WR, Sigmoidoscopy for all over the age of 20	5)
6) SG of Urine	6)
7) Faeces for Worms & Cysts	7)
8) X-Ray of Abdomen	8)
9) Nose & Throat Swab	9)
10)	10) X-Ray Hips and Long Bones.
11)	11) LER, Bacilluria Screening Test

The above requests have not been altered in any way.

The number in the bracket refers to the identification number of the case in the group. The same number refers to general and special tests.

APPENDIX 11.
TABLE 38

SURGEONS OVER 50 - IN FAVOUR OF MULTI-SCREENING.

ADDITIONAL TESTS REQUESTED.	
General	Related to Speciality in which Surgeon Practices.
1) 2) SG of Urine 3) Blood Alcohol 4)	1) X-Ray of Abdomen. 2) Height, Weight. 3) 4) Blood Volume.

C3/12/1

APPENDIX 12.
TABLE 39

SURGEONS OVER 50 :- NOT IN FAVOUR OF MULTI-SCREENING.

1) WR, Nose & Throat Swab Paul Bunnell, Micro-Urine & Sensitivity, Casoni 2) SG of Urine, FTM	1) Blood Alcohol. 2)

The above requests have not been altered in any way.

APPENDIX 13.
TABLE 40.

REGISTRARS & RESIDENTS UNDER 50 - IN FAVOUR OF MULTI-SCREENING

ADDITIONAL TESTS REQUESTED.	
General	Related to Speciality in which Resident practices.
1) W.R.	1)
2) Examination of Blood Film	2)
3) Micro Urine & Sputum Cultures	3) Blood Gases
4) V.D.R.L., W.R.	4) Vitamin B_{12}, Assay
5) Blood Film Examination	5) Fasting Serum Total Lipids.
6) Blood Film Examination	6)
7) Blood Film Examination	7)
8) Stools for Ova	8)
9) EPG, Micro-Urine	9) Blood Gases.
10) Blood Film Examination, Micro Urine, Reticulocyte Count.	10) X-Rays of Hand and Abdomen
11) Micro-Urine	11)
12) Cytology	12)
13) X-Ray of Abdomen	13)
14) WR	14)
15) Micro-Urine	15)
16) WR, Pregnancy Test	16)
17) Weight, Micro-Urine & Culture	17)
18) EPG, WR,	18) EEG
19) Micro-Urine, Blood Film	19) EEG, Echo Encephalogram.
20) Micro-Urine & Culture	20) Mamography, Cervical Smear
21) Micro-Urine	21)
22) Urinary Eostriols	22)
23) T_3Resin, EPG, Micro-Urine	23) Visual Acuity with Glasses.
24) Urine Culture & Sensitivity, Mantoux Test.	24) Serum Pseudo Cholinesterase.
25) VDRL	25)
26) Micro-Urine	26)
27)	27) Guthrie Test, Aminociduria.
28) Tests for Lead & Arsenic Poisoning, WR.	28) Urinary Amphetimines, EEG.
29) SG Urine	29)
30) WR	30) Serum B_{12}
31) VDRL	31)
32)	32) X-Ray Skull
33) Schilling Test, Serum Folate SG Urine	33)
34) Blood Smear, T_3 Resin, Reticulocyte Count.	34)
35) Blood Smear	35)
36) PR Examinations in Adults.	36)
37)	37) Blood Gases, EPG, Blood Lead.
38) Specific Gravity of Urine	38)

The number in the bracket refers to the identification number of the case in the group. The same number refers to general and special tests.

REGISTRARS & RESIDENTS UNDER 50- IN FAVOUR OF MULTI-SCREENING.

ADDITIONAL TESTS REQUESTED.	
General	Related to Speciality in which Resident Practices.
39) Micro-Urine, Blood Film, EPG	39) X-Ray Skull, EEG.
40) EPG	40)
41) VDRL	41)
42) Weight, Height	42) EPG, Blood Film, Cytology
43) Blood Gases	43)
44) Nose Swab, Urine Culture	44)
45) EPG, Urine & Serum Osmolality	45)
46) Urine Cytology & Culture	46)
47)	47) Micro-Urine, EPG
48) Serum & Urine Osmolality	48)
49) WR, Blood Gases,	49) Urine Amphetamine, EEG, Skull X-Ray
50)	50) EEG, Master's Test.
51) Weight	51)
52) Blood Film, EPG, Blood Gases	52)
53) WR	53)
54) Micro-Urine & Culture	54)
55) VDRL, Micro-Urine	55)
56) Weight & Height	56) Triglyserides.

The above requests have not been altered in any way

~~APPENDIX 14 — TABLE 41~~ C3/14/1

REGISTRARS & RESIDENTS OVER 50 -	IN FAVOUR OF MULTI-SCREENING.
1) VDRL	1)
2)	2) EEG

The above requests have not been altered in any way

APPENDIX 15.
TABLE 42.

REGISTRARS & RESIDENTS UNDER 50 - NOT IN FAVOUR MULTI_SCREENING

ADDITIONAL TESTS REQUESTED.	
General	Related to Speciality in which Resident Practices.
1) Height & Weight	1)
2)	2) Cerebral Scan, EEG.
3)	3) Blood Gases
4) Plan Ray of Abdomen	4)
5) Micro Urine, Culture & Sensitivity	5)
6) Micro Urine, Culture & Sensitivity, Mantoux Test.	6) Urine Amino Acids.
7) Blood Film Examination	7) EEG, Psychological Testing.
8) Blood Film Examination	8)
9)	9) EEG, Skull X-Rays, Urine Amphetamine.
10)	10) WR, EEG, PKV, Bone Age By X-Ray, Fasting Blood Sugar.
11)	11) Skull X-Ray, EEG.
12)	12) Blood Gases & Blood Volume
13)	13) Rose-Waller Test.
14) Urine Specific Gravity, Blood Smear.	14)
15) Urine Specific Gravity	15) FeV, V.C.
16) Fasting Blood Sugar	16) EEG, Skull X-Ray
17) F.D.R.L., Mantoux Test	17)
18) Micro-Urine	18)
19) Micro Urine, Culture & Sensitivity, EPG	19)
20) Weight, Special Blood Gases.	20)
The above requests	have not been altered in any way

APPENDIX. 16

PHYSICIANS UNDER 50

IN FAVOUR OF MULTI-SCREENING.

Unsolicited Comments.

1) Surely not a Lumber Puncture as a Routine.

2) Only if economically sound.

3) If not too costly to patient, clinical pathology is no substitute for history taking and physical examination.

4) Should be limited to less than 40.

5) I must qualify this (answer Yes) the list in part I includes data which require the action of the doctor or a part of even the least comprehensive examination and do not qualify for screening (e.g. Sigmoidoscopy, B.P.) While examination of CSF as a routine would come under the heading of malpractice in my view particularly as it implied to be data to go to the doctor as he completes his history and examination and therefore not done by him.

The above have not been altered in any way and represent the views of the Doctors.

APPENDIX 17

PHYSICIANS UNDER 50

NOT IN FAVOUR OF MULTI-SCREENING.

Unsolicited Comments.

1) Surely CSF examination will never be a routine admission procedure

2) Fasting blood sugars are more reliable than random blood sugars.

3) I agree in principle in the taking of desirable tests but not to routine multi-tests.

The above have not been altered in any way and represent the view of the Doctors.

APPENDIX. 18

PHYSICIANS OVER 50

IN FAVOUR OF MULTI-SCREENING.

Unsolicited Comments.

1) I feel that the number could be reduced a little, if used as a completely routine screening for every patient admitted (hence the absence of sigmoidoscopy - it would be undesirable to symoidoscope all cardiac patients). Similarly the following tests may at least partially act as screening exclusives for those following them in brackets - the latter should only be done if doubt still exists - Serum Uric Acid (Urinary ditto) SGOT & LDH (CPK), $ZnSO_4$ Turb (Thymol Turb), Cortisol (Urinary OH corticords), Blood Sugar (GTT), Urinary Porphylbilinogen (Porphyrins), LE cells, Hb & FBC (MCV etc).

   Certain other tests may well only need to be done in special circumstances and not completely routinely - e.g. CPK, Cholesterol, Bromide, Barbiton, BSP, Cryoglobulin, Fibrinogen, many of the Urinary Tests, CSF Tests, Blood Gasses and Sigmoidoscopy - I personally should prefer to select, patients for most of this group. In a much less ambitious way, we have had similar discussion in Brisbane recently and have had widely varying opinions.

2) An intelligent RMO.

The above have not been altered in any way and represent the view of the Doctors.

APPENDIX.19

PHYSICIANS OVER 50.

NOT IN FAVOUR OF MULTI-SCREENING.

No unsolicited comments.

APPENDIX. 20.

SURGEONS UNDER 50

IN FAVOUR OF MULTI-SCREENING.

Unsolicited Comments.

1) I find it very difficult to consider forty seperate investigations for a Multi-Screening test.

2) This depends on cost and a multiple of other factors.
In certain large hospitals and for dubious medical conditions Yes.
For the common run of Hernias and other clear-cut cases I can't see any point unless the expense was negligible.

3) I do not wish this to be construed that I advocate 40 tests in the screen.

4) Information on Age, Sex, Race, Socio-Economic Status, Occupation, Current Drugs Taken, Immunization and their status, Allergies detected and previous transfusions. Agree not "equal Test" but part of screen.

The above have not been altered in any way and represent the view of the Doctors.

APPENDIX 21. C3/21/1

SURGEONS UNDER 50

NOT IN FAVOUR OF MULTI-SCREENING.

No unsolicited comments.

APPENDIX 22

SURGEONS OVER 50

IN FAVOUR OF MULTI-SCREENING.

Unsolicited Comments.

1) Serum Bulldust.

The above have not been altered in any way and represent the view of the Doctors.

APPENDIX-23 C3/23/1

SURGEONS OVER 50

NOT IN FAVOUR OF MULTI-SCREENING.

Unsolicited Comments.

1) Routine CSF - Heaven forbid.

2) Means Test.

The above have not been altered in any way and represents the view of the Doctors.

APPENDIX. 24.

REGISTRARS & RESIDENTS UNDER 50

IN FAVOUR OF MULTI-SCREENING.

Unsolicitated Comments.

1) Yes - provided cost is cheaper than hospital Specialists' time who can be more selective in his choice of investigation.

The above have not been altered in any way and represent the view of the Doctors.

APPENDIX. 25 C3/25/1

REGISTRARS & RESIDENTS UNDER 50

NOT IN FAVOUR OF MULTI-SCREENING

Unsolicited Comments.

1) In view of present cost structure and the fact that 20 tests would be enough.

2) To list As & Bs requires knowledge of individual patients.

The above have not been altered in any way and represent the view of the Doctors.

CHAPTER 4.

This chapter considers the various implications that selected multiple investigations on admission or pre-admission would have had if carried out on the series of cases studied. The following points are evaluated.

1. What type of patient should have multiple investigations on admission or pre-admission?
2. What investigations should be carried out which are applicable to Australian conditions?
3. When, where and how are those investigations to be carried out?
4. The advantages and disadvantages in patient care and if by multi-investigations on admission new or earlier diagnosis is possible.

In considering the above, a series of case histories were studied and the results compiled so as to show the following effects which were related back to the above:-

(a) The effect of length of stay in hospital of patients.

(b) Staff problems

(c) New equipment

(d) Acceptance by the Medical Profession

(e) Possibility of more rapid diagnosis

(f) The use of computers with adequate programming.

(g) The incidence of undiagnosed disease

(h) Better patient care by improved standardization of investigations.

(i) Overall financial review from a hospital and patient aspect.

CASE HISTORIES.

Case Histories.

One hundred consecutive cases, males and females were studied. The material needed from the histories were correlated using the following methods.

1. Conversion Table Appendix I.
2. Tabulation Form. Appendix II.

1. Conversion Table.

This was used to convert all the investigations carried out on the patient into a number for easy processing. The Appendix indicates that each system was given a group of numbers and the tests for investigations relevant to that system were given a number in that group.

2. Tabulation Form.

This was drawn up to have an easy visual method of seeing the various tests used in establishment of diagnosis. The left hand column showed Page , this was the number of the page for that particular case, each page had sufficient columns for 10 days.

Under the page is patient identification number (1 to 100). The reason for an identification number was to preserve anonymity of patients in the series.

Under this was age, then sex.

The next two squares were for Surgical and Medical Cases. Because of difficulties that arose during the series, it was decided not to investigate surgical cases as there arose too many variables.

The next square - total number of days in hospital.

The final square in Column 1 was left blank and was used to note

the date of discharge.

The second column had Square 1 for diagnosis on admission.

The next space was Final Diagnosis.

Underneath this one, four squares for additional diagnosis:-

D.M. = Day Made.)
) this refers to the
D.C. = Day confirmed.) diagnosis.

The page then comprised 10 columns representing the first 10 days of admission. In these columns the converted number of tests was entered on the appropriate day.

Page 2 represented days 11-20 etc.

The final column was used for treatment evaluations. This was to record on what day after admission the correct treatment was instituted for both primary and additional diagnosis. This was not used as the assessment would have been a completely subjective evaluation and not one which could generally be accepted as valid. This section was not used.

The bottom section in this column was used for additional data which would contain any information to help in the project.

Factors Considered in Determining Test Date.

The day the test was dated and signed as reported on was considered the day the test was reported on by the Specialist, back in the ward or file, and known to the ward doctor. This is an assumption that had to be made. There are obvious fallacies:

(i) The test may have been verbally reported to the ward doctor earlier.

(ii) The Specialist doctor may have signed the report and

it may not have been sent immediately to the ward.

(iii) The date on the report as indicated in (ii) may not necessarily be the date the report is placed in the file, and known to the ward doctor, although at RGH(C), the report is not placed in the file until the ward doctor has sighted it.

(iv) The report may be inadvertently put in the file without the ward doctor sighting it.

However, for this exercise, it is considered that the date on the report is the date on which the report is known to the Ward doctor.

Consecutive Cases

In using 100 cases in this series, the term "Consecutive" must be clearly defined; the cases had to be selected on the following conditions, otherwise the results would be completely unacceptable.

(i) The case had to have a new provisional diagnosis on admission.

(ii) Re-admissions for the same complaint were not considered, i.e. exacerbations of existing conditions were ruled out.

(iii) Cases admitted to surgical wards were not considered.

It is important to realize that these cases did not come through a Casualty Department but were all screened by a private Medical Practitioner prior to admission, some also by Specialists at the Out-Patient Department. The admissions were arranged through an Admissions Officer and as well as requiring medical admission there had to be eligibility for admission under the Repatriation Act.

Eligibility for Admission.

Two criteria had to be established.

1. Eligibility for Admission.

2. Medical necessity for admission.

1. Patients were admitted under the Repatriation Act 1920-1968 whereby "The Repatriation Commission is responsible, subject to the control of the Minister, for the administration of the Repatriation Act and associated legislation designed for the care and welfare of ex-servicemen and women andof the dependants of those who died as a result of war service."+

Eligibility for Treatment.

Medical treatment is provided for all disabilities which have been accepted as related to war service, and, subject to certain limitations, for disabilities not accepted for the following classes:

- ex- servicemen and women who have been assessed at the maximum general rate (100%) or a higher rate;
- Nurses who served in the 1914-18 War;
- Widows and certain dependants of ex-servicemen whose deaths have been accepted as related to war service, or who died from causes not related to war service but were receiving at the time of death the special (T.P.I.) rate or the rate for amputation of two or more limbs;
- Service pensioners, including service pensioners of the Boer War but not those qualifying solely because of the "tapered" means test.

The limitations in treatment for disabilities not related to war service are that in-patient treatment is not provided for:

+/ Repatriation Commission Annual Report 1969-1970. P. 5

- Chronic or incurable diseases requiring in-patient treatment for a prolonged period, although in-patient treatment for an acute or sub-acute phase of a chronic or incurable disease may be provided under certain conditions;
- Infectious or contagious disease where admission to an infectious diseases hospital is required by health laws; or
- conditions caused by alcoholism or drug addiction

Special provision exists for treatment of ex-servicemen and women suffering from pulmonary tuberculosis not accepted as related to war service. +

Patients are admitted to Repatriation Institutions under the following regulations, which are explained in detail in Appendix 3

Regulations 64
Regulations 65
Regulations 66
Regulations 72
Regulations 73.

2. Medical necessity for admission is decided by the Admitting Medical Officer after discussion with the referring Doctor or after receipt of a Report requesting admission.

Limiting Factors

The selection of patients admitted under the Repatriation Act causes severe limitations on the type of individual in the series. These should be considered as representing a select abnormal group of the pop-

+ Ibid , p. 26

ulation as shown by the following facts:-

(1) Each individual male had attended at least one World War, each female was either a war widow or had attended at least one World War.+ Therefore the people would not represent a normal cross-section of the community found in the average hospital catering for the adult population.

(2) A high majority of the patients had been exposed to a period of abnormal conditions of stress and strain, diet, living conditions etc, during the period of war.

(3) The high age group of the hospital patients - the youngest in the series was 38 years old and the eldest 84.

(4) The abnormal distribution of males to females. (96-4)

(5) The selection of cases prior to admission by the local medical officer or by a specialist.

(6) The length of stay of patients is different from that in an acute general hospital as social, political and economic considerations are factors.

(7) The total patient care concept is of paramount importance and the patients' return to the community is carefully considered.

Other limiting factors not restricted to the group being selected but affecting results are:-

(1) Some additional diagnosis were complicated in diagnosis

+ World War in this context refers to any area of conflict as defined as a war area under the Repatriation Act.

by the underlying condition for which the patient was admitted.

(2) Some conditions occurred whilst the patient was in hospital unrelated to the condition for which the patient was admitted or perhaps as a complication of the condition for which the patient was admitted.

(3) Some conditions would not have been diagnosed by multi-screening on admissions.

(4) There is an unknown number of conditions not diagnosed in the series because they were not obvious clinically - no tests were done that would have discovered their existence - This number is unknown.

When is a Diagnosis Confirmed?

The confirmation of a diagnosis is a matter of individual interpretation and could represent an area of conflict. However, I consider there are two methods by which a diagnosis can be confirmed.

1) A Clinical Diagnosis

This is one in which the doctor has made a diagnosis based on symptoms and signs of the particular condition from which he considers the patient is suffering. It is a clinical diagnosis, which is considered a confirmed diagnosis, when the Clinician states the patient is suffering from a specific disease, irrespective of whether it has been, or could be, confirmed by a tests. The majority of cases in which a clinical diagnosis is made are those where a test is not necessary as the condition is considered clinically obvious or one in which tests may not confirm or in which there are not applicable tests.

2. A "Mechanical" Diagnosis

This is a diagnosis which can only be confirmed by scientific tests.

Examples of the above are that a diagnosis of dermatitis needs no tests for its establishment whilst that of a Duodenal Ulcer can usually only be demonstrated by a Barium Meal or Gastric Camera.

One of the purposes of this study is to establish if by multiple investigations on admission new or earlier diagnoses in each particular case investigated could have been made. The average time from the date of admission to the confirmation of the diagnosis was established in the series. However, as discussed, when considering the problem of when a diagnosis is confirmed can be a matter of interpretation.

The confirmation of a diagnosis by tests, as previously stated, is taken as the date appearing on the test result in the patient's file but it may not necessarily be the date when the result is known to the Ward Doctor. The confirmation of a diagnosis by clinical means is when the specialist has confirmed the diagnosis in the file based on his interpretation of the patient's symptoms, signs and his own physical examination.

Possibility of Earlier Diagnosis and Days That May Have Been Saved By Multi Screening on Admission

Table 42 shows that of the 40 cases not diagnosed on Day 1, using the criteria laid down for multi-screening+ in this series then 19 of the cases could have been diagnosed on Day 1. This indicates that it is possible and probable that a more rapid diagnosis could have been made

+ The Multi-Screening Test Batteries considered for the studied series is set out on P. 346 as an Appendix No. 4 to this chapter

TABLE 42.

THE 40 CASES NOT DIAGNOSED ON DAY 1.

Case No.	Diagnosis on admission.	Final Diagnosis.	Possibility of earlier Diagnosis.	Days that may have been saved.	Diagnosis confirmed on.	Total No. of Days in Hospital.
1	Haematemesis	Gastric Erosion	No	Nil	5th day	7
2.	Lumbar Spondylosis	Lumbar Spondylosis	No	Nil	3rd day	27
3.	Myocardial Infarction	Ischaemic Heart Disease	Yes	4	4th day	19
4.	Glomerulonephritis	Glomerulonephritis	No	Nil	17th day	29
5.	Myocardial Infarction	Myocardial Infarction.	Yes	4	4th day	46
6.	Pneumonia	Carcinoma of Osephagus	No	Nil	36th day	54

Definition of Day 1. For this Investigation Day 1. considered the actual day of Admission till midnight.

TABLE 42 (contd.)

Case No.	Diagnosis on admission.	Final Diagnosis	Possibility of earlier Diagnosis	Days that may have been saved	Diagnosis confirmed on.	Total No. of Days in Hospital.
7.	Cirrhosis of Liver	Cirrhosis of Liver	Yes	9	9th day	39
8.	Ischaemic Heart Disease	Ischaemic Heart Disease	Yes	3	3rd day	19
9.	Ischaemic Heart Disease	Ischaemic Heart Disease.	Yes	3	3rd day	27
10.	Sacro Iliac Arthritis	Sciatica	No	Nil	4th day	17
11.	Duodenal Ulcer	Duodenal Ulcer	No	Nil	3rd day	28
12.	Duodenal Ulcer (Dermatitis)	Duodenal Ulcer (Dermatitis)	No	Nil	7th day	25

TABLE 42 (contd.)

Case No.	Diagnosis on admission.	Final Diagnosis	Possibility of earlier Diagnosis	Days that may have been saved	Diagnosis confirmed on.	Total No. of Days in Hospital.
13.	Peptic Ulcer	Dyspepsia	No	Nil	4th day	25
14.	Duodenal Ulcer	Duodenal Ulcer	No	Nil	5th day	21
15.	Gastritis	Gastritis	No	Nil	7th day	29
16	Malabsorption Syndrome	Malabsopption Syndrome	No	Nil	14th day	20
17	Pneumothorax	Pneumothorax	Yes	2	2nd day	46
18	Peptic Ulcer	Peptic Ulcer	No	Nil	2nd day	25
19	Duodenal Ulcer	Duodenal Ulcer	No	Nil	3rd day	38

TABLE 42 (contd.)

Case No.	Diagnosis on admission.	Final Diagnosis.	Possibility of earlier Diagnosis.	Days that may have been saved.	Diagnosis confirmed on.	Total No. of Days in Hospital.
20.	Duodenal Ulcer	Duodenal Ulcer	No	Nil	3rd day	12
21.	Lumbar Spondy-litis.	Lumbar Spondy-litis.	No	Nil	8th day	12
22.	Chronic Bronchit-is	Chronic Bronch-itis	Yes	2	2nd day	38
23.	Duodenal Ulcer	Duodenal Ulcer	No	Nil	6th day	19
24	Ischaemic Heart Disease.	Ischaemic Heart Disease	Yes	2	2nd day	33
25.	Ischaemic Heart Disease.	Ischaemic Heart Disease	Yes	3	3rd day	59

TABLE 42 (Contd.)

Case. No	Diagnosis on admission.	Final Diagnosis	Possibility of earlier Diagnosis	Days that may have beem saved	Diagnosis confirmed on	Total No. of Days in Hospital.
26.	Ischaemic Heart Disease	Ischaemic Heart Disease	Yes	2	2nd day	27
27.	Ischaemic Heart Disease	Ischaemic Heart Disease.	Yes	2	2nd day	18
28.	Chronic Bronchi-tis	Chronic Bronchi-tis	Yes	2	2nd day	82
29.	Left Homonymous Hemianopia	Cerebral Thrombosis.	No	Nil	9th day	29
30	Cardiac Failure	Atrial Fibrill-ation.	Yes	2	2nd day	32
31.	Duodenal Ulcer	Duodenal Ulcer	No	Nil	16th day	36

TABLE 42 (cond)

Case No	Diagnosis on admission.	Final Diagnosis	Possibility of earlier Diagnosis	Days that may have been saved	Diagnosis confirmed on	Total No. of Days in Hospital.
32.	Coronary Occlusion	Coronary Occlusion.	Yes	2	2nd day	29
33.	Headaches	Cerebral Thrombosis	No	No	10th day	45
34	Congestive Cardiac Failure & Cirrhosis	Congestive Cardiac Failure & Cirrhosis	Yes	2	2nd day	41
35.	Chronic Bronchitis	Chronic Bronchitis	Yes	3	3rd day	36
36.	Ischaemic Heart Disease.	Ischaemic Heart Disease	Yes	3	3rd day	25
37.	Chronic Obstructive Airways Disease	Chronic Obstructive Airways Disease	Yes	2	2nd day	27

TABLE 42 (contd)

Case No	Diagnosis on Admission.	Final Diagnosis	Possibility of earlier Diagnosis	Days that may have been saved	Diagnosis confirmed on	Total No. of Days in Hospital.
38.	Carcinoma of Lung	Carcinoma of Lung	No	Nil	17th day	75
39.	Myocardial Infarction	Myocardial Infarction	Yes	2	2nd day	28
40.	Gastric Carcinoma	Achlorhydria	No	Nil	13th day	15
			Total:	54 days		

in 48% of cases not diagnosed within 24 hours of admission.

The specific investigation which could have been used in considering the method of confirmation of the diagnosis is shown in Table 43. In these cases this test would have been performed as part of the Multi-screening on admission and the report immediately available. This represents that there is a potential saving of 54 days using the criteria for a "mechanical" diagnosis as previously defined. This can be interpreted in two ways:

1. That 54 hospital days might not have elapsed between admission and confirmation of diagnosis if Multi-screening had been carried out. or
2. 54 actual hospital days may have been saved.

Patient care is one of the factors to be considered in this study and the earlier a diagnosis is confirmed the better the standard of patient care. Because of the difficulty of evaluation of treatment that involve personal interpretation and an assessment that could vary with each investigator the section on evaluation of treatment was discarded. In consideration of this the number of days taken from the date of admission to the date of confirmation of diagnosis was considered to be the number of hospital days that <u>may</u> have been saved in the considered cases not diagnosed on day 1.

Table 42 which considered the 40 cases in the series not diagnosed on Day 1 indicates that the confirmation of diagnosis took on an average of 6.1 days. The average time taken to diagnose all cases was 3.5 days. (in the series of 100 selected cases)

<u>Additional Diagnoses</u>

Table 44 shows that 1 in every 4 cases had an additional diagnosis.

TABLE 43

Case No.	Diagnosis on admission	Final Diagnosis	Days that may have been saved	Diagnosis confirmed on	Multi-screening test which could have confirmed diagnosis on Day 1.
3	Myocardial Infarction	Ischaemic Heart Disease	4	4th Day	(E.C.G.) Electrocardiograph & Pathology Tests
5	Myocardial Infarction	Myocardial Infarction	4	4th Day	E.C.G. & Path. Tests.
7	Cirrhosis of Liver	Cirrhosis of Liver	9	9th Day	Pathology Tests
8	Ischaemic Heart Disease	Ischaemic Heart Disease	3	3rd Day	E.C.G. & Path. Tests.
9	Ischaemic Heart Disease	Ischaemic Heart Disease	3	3rd Day	E.C.G. & Path. Tests.
17	Pneumothorax	Pneumothorax	2	2nd Day	Chest X-Ray & Spirometry
22	Chronic Bronchitis	Chronic Bronchitis	2	2nd Day	Chest X-Ray & Spirometry
24	Ishaemic Heart Disease	Ischaemic Heart Disease	2	2nd Day	E.C.G. & Path. Tests.
25	Ischaemic Heart Disease	Ischaemic Heart Disease	3	3rd Day	E.C.G. & Path. Tests.

TABLE 43. SPECIFIC INVESTIGATION USED TO CONFIRM DIAGNOSIS.

The case numbers are related to Table 42.

TABLE 43 (contd.)

Case No.	Diagnosis on admission	Final Diagnosis	Days that may have been saved	Diagnosis confirmed on	Multi-screening test which could have confirmed diagnosis on Day 1.
26	Ischaemic Heart Disease	Ischaemic Heart Disease	2	2nd Day	E.C.G. & Path. Tests.
27	Ischaemic Heart Disease	Ischaemic Heart Disease	2	2nd Day	E.C.G. & Path. Tests.
28	Chronic Bronchitis	Chronic Bronchitis	2	2nd Day	Chest X-Ray & Spirometry
30	Cardiac Failure	Atrial Fibrillation	2	2nd Day	E.C.G.
32	Coronary Occlusion	Coronary Occlusion	2	2nd Day	E.C.G. & Path. Tests.
34	Congestive Cardiac Failure & Cirrhosis	Congestive Cardiac Failure & Cirrhosis	2	2nd Day	E.C.G. and Pathology Tests.
35	Chronic Bronchitis	Chronic Bronchitis	3	3rd Day	Chest X-Ray & Spirometry.
36	Ischaemic Heart Disease	Ischaemic Heart Disease	3	3rd Day	E.C.G. & Path. Tests.

TABLE 43 (contd.)

TABLE 43 (Contd.)

Case No	Diagnosis on Admission	Final Diagnosis	Days that may have been saved	Diagnosis confirmed on	Multi-screening test which could have confirmed diagnosis on Day 1.
37	Chronic Obstructive Airways Disease	Chronic Obstructive Airways Disease	2	2nd Day	Chest X-Ray & Spirometry
39	Myocardial Infarction	Myocardial Infarction	2	2nd Day	E.C.G.& Path Tests.

TABLE 43 (contd.)

TABLE 44.

ADDITIONAL DIAGNOSIS

Disease.	Days on which Diagnosis Made.	Diagnosis Confirmed.	Possible Day when Diagnosis could have been confirmed.
Chronic Obstructive Airways Disease.	3rd	3rd	1st
Carcinoma of Oesophagas.	31st	36th	36th
Diabetes.	7th	9th	1st
Anxiety State.	9th	9th	9th
Pulmonary Embolism.	1	1	1
Pleural Effusion.	1	1	1
Gout.	14	17	1
Prostatitis.	3	3	3
Diabetes.	3	6	1
Anxiety State.	1	1	1
Urinary Tract Infection.	7	7	7
Chronic Obstructive Airways Disease.	2	5	1
Anaemia.	1	5	1
Pulmonary Embolism.	33	33	33
Diabetes.	11	13	1
Pneumothorax.	5	5	5
Hiatus Hernia.	2	6	6
Myocardial Infarction.	14	14	14
Cirrhosis of Liver.	1	2	1
Right Inguinal Hernia.	1	1	1
Carcinoma of Prostate.	30	30	1
Spondylitis.	17	30	30
Diabetes.	3	3	1
Cerebro Vascular Accident.	17	17	17
Chronic Obstructive Lung Disease.	1	1	1

TABLE 44.

ADDITIONAL DIAGNOSIS.

Disease.	Days on which Diagnosis Made.	Diagnosis Confirmed.	Possible Day when Diagnosis could have been confirmed
Prostatitis	1	1	1

The above shows that 26 additional diagnoses were made on the 100 cases surveyed.

as well as the primary one. In some cases the additional diagnosis was a complication of the original diagnosis or a new medical condition which developed whilst the patient was in hospital. One diagnosis that of an inguinal hernia, was an incidental one and only medical in the broadest sense.

Of the additional diagnosis 10 could have been diagnosed on admission by Multi-screening.

Additional Diagnosis that could have been found on multi-screenin on Admission.

TABLE 45

Multi-screening on Admission	No	Method.
Chronic Obstructive Airways Disease	2	Chest X-ray
Diabetes	4	Biochemical Test
Carcinoma of Prostate	1	Biochemical Test
Anaemia	1	Haematology
Gout	1	Biochemical Test
Cirrhosis of Liver	1	Biochemical Test.
	10.	

The following table shows the number of days it took confirm the additional diagnosis.

TABLE 46.

Chronic Obstructive Airways Disease	3
" " " "	5
Diabetes	9
"	6
"	13
"	3

Gout	17
Cirrhosis of Liver	2
Anaemia	5
Carcinoma of Prostate	30
	93 Days

The average length of time to confirm an additional diagnosis was 9.3 days on those cases in which the diagnosis may have been confirmed by Multi-Screening on admission. A limiting factor must be that it is unknown to what extent the additional diagnosis affected the length of stay of a patient because of the primary diagnosis, for in all of these cases the primary condition for which the patient was admitted was confirmed.

For the purpose of this project, I will assume that if Multi-screening had been carried out on admission then 10% of cases admitted would have had an additional diagnosis established on admission as a result of 1 in 10 having an abnormal finding. If additional tests had been done on other cases the number of other additional diagnosis that may have been made is completely unknown.

In consideration of the above the following can be considered possible - that in the 100 cases studied, 93 hospital days could have been saved if each additional diagnosis was considered to have prolonged the patients length of stay, by the time it took to confirm the additional diagnosis. The 93 days must be considered a hypothetical figure. The cases considered in determining this figure are listed in Table 45. which indicates what method of investigation included in the recommended

Admission profile may have and probably would have discovered the additional diagnosis on Day 1. The other sixteen diagnosis not included would probably not have been confirmed earlier by this method.

In my opinion the above hypothesis has not been substantiated but it can be considered that by Multi-Screening a potential of 93 hospital days per 100 admissions could be saved.

Potential Hospital Days Which May Be Saved.

Additional Diagnosis	93 Days.
Primary Diagnosis	54 Days.
	147 Days.

This would represent a potential saving of 147 patient hospital days per 100 admissions on the criteria used. This figure is hypothetical and based on various assumptions that have been considered. Nevertheless it is valid enough to indicate the trend and potential in hospital days that may be saved.

Possible Savings and Improvements in Patient Care Through the Use of Multiple-Screening on Admission.

A. Primary Diagnosis.

As shown in Table 47+ 9,679 admissions occurred in 12 months - 1969/1970. Assuming that 54 days per 100 admissions (selected in the studied series) could be saved by multi-screening then 96.8 x 54 days could represent the potential number of days that may have been saved this equals 5,200.

This relates only to the primary diagnosis and is based on the assumption that earlier or more rapid diagnosis would have in fact led to an earlier discharge. However this would probably be effected by

+ See Table 47/Chapter 4/ Appendix 5.

an additional diagnosis.

The mean length of stay in general medical beds was 22.9 days and using the above figure as the possible number of days saved then an extra 227 patients (5200/22.9 =227) could have been admitted over the 1969/1970 period. This represents an extra 0.6 (227/365) patients per day.

The net cost of an inpatient day was $25.39c. Therefore $132,000 (5200 x $25.39) would possibly have been saved on inpatient days.

B. Additional Diagnosis.

Using the hypothesis that 93 hospital days per 100 admissions (selected in the studied series) could be saved by multi-screening on admission, then 96.8 x 93 days could represent the potential number of days that may have been saved. This equals, 9,000.

As considered above, this related only to the additional diagnosis and represents an extra 393 (9,000/22.9) patients which could have been admitted over the 1969/1970 period or an extra 1.1 patients per day. (393/365 = 1.1).

Financially, the net cost on inpatient's days which may have been saved was a total of $228,500 (9,000 x $25.39).

C. Combined Primary and Additional Diagnosis Savings.

The following figures represent the possible savings resulting from a combination of the above A and B.

Total Potential Hospital Days Saving per 100 Admissions = 147.

Total number of extra patients per day which may have been admitted = 1.7 (1.1 + 0.6 = 1.7)

Total number of patient hospital days saved = 14,200 (9,000 + 5,200)

Total Saving on inpatient days = $360,500.

The number of cases not diagnosed on Day 1, which, if Multi-screening could have been used would have been reduced from 40 cases to

21 cases. This represents 19 cases or 48% in which the diagnosis was not confirmed on the first day of admission but which may have been if Multi-screening had been used. These cases took on an average of 3 days to diagnose and represent a waste of 2 days in the confirmation of a diagnosis and possible reduction of standard of patient care.

There is no doubt that Multi-screening must provide better patient care by establishing the confirmation of the primary diagnosis in some cases at an earlier date. Also, as previously recorded, of the 26 additional diagnosis 10 could have been established on admission. Not only does this represent a potential saving of 9.3 patient days in these cases but a great benefit in patient care by their early diagnosis.

DISCUSSION.

1) Effect on Length of Stay.

If the proposed scheme using Multi-screening on admissions or pre-admissions to the hospital studied had been used during 1969/1970 than a possible 14,200 bed days could have been saved, which is equal to approximately a saving of 1.7 days per admission.

2) Staff Problems.

In considering staff problems there are 2 major aspects.

a) Acceptance.

b) Expertise and its availability.

a) Acceptance.

One of the problems in this area is the fear of computerization and automation. This has been a world-wide problem based mainly on job insecurity. However it is becoming increasingly obvious in a society such as exists in Australia that an employed individual is merely transferred from one position to another, there is no real threat of unemployment. In the recent introduction of computerization and automation in the Pathology Department at the Repatriation General Hospital, Concord there is no indication of a decrease in staffing. The overseas literature regarding staff saving has not, as yet, been proven valid with the introduction of ADP in this area (Personal communication, 1970+)

+From a recent communication it appears that it may be necessary to increase the Pathology staff at RGH(C). This could be partly due to automation, new equipment and increasing scope of tests performed. The statement in Chapter 5, which considers that there would be a staff saving by introducing ADP can be questioned. Dr. Constance RGH (C).

b) Expertise

The introduction of Multi-screening has called for greater expertise in the use of more sophisticated and intricate automated machinery. This has opened a new field in which our already highly trained technicians+ have had to develop new talents, undergo new training schemes, and instead of becoming mere automated mechanics have had to develop more understanding and acquire greater knowledge to deal with the more complicated electrical and electronic problems. In this area there is a definite shortage of skilled labour which has the potential to be trained in this field.

3) New Equipment

Progress cannot be made without the necessary equipment. This has been discussed in some detail in Chapter 2. Considerable capital expenditure will have to be invested in computers and automatedequipment. It is unfortunate that one must talk in millions of dollars in entering this field. Maintenance is also a financial factor which has to be considered.

4. Acceptance by the Medical Profession.

The medical profession is still in a large percentage of cases (28% according to my questionnaire) in considerable doubts regarding the value of multi-screening on admission to hospital. If there is any doubt it must surely be one of their own ability to rely on their clinical judgement when proven wrong by laboratory or other tests. Tests are merely aids to establish a diagnosis - they are not meant to be diagnostic in themselves. The Physician's acumen should not be impaired but

+ The Technicians referred to are those employed in Pathology Laboratories at RGH(C).

improved by having more information available on which to establish a firm diagnosis on admission. From the Survey it is clearly shown that of the cases not diagnosed on the first day of admission, 48% would have been if multi-screening had been used on admission. Similarly of the additional diagnosis discovered in 1 in 4 cases during their stay in hospital 40% of these would have been discovered on the first day of admission (10 out of 26) by using the proposed scheme.

5) Possibility of a More Rapid Diagnosis

There is no doubt that this is a fact. In certain cases the primary diagnosis will be established earlier by multi-screening. This is especially related to those diseases which are associated with abnormal pathological findings, Electrocardiographs or Chest X-rays.

6) The Use of Computers with Adequate Programming.

For Multi-screening on admission to be adequately carried out a computer is essential. This is because of the volume of work to be handled, the number of calculations, the storage of results, the distribution of results and the presentation of results. Without computers the implementation of such a scheme would be impracticable.

7) The Incidence of Undiagnosed Disease.

Although the study carried out does not help to establish the incidence of undiagnosed disease it does show that additional diagnosis would have been made earlier in 1 in 10 cases by multiple screening on admission. There is no doubt that abnormal tests would result from multiple screening in an unknown percentage of cases (as shown in Chapter 1) but whether these would indicate disease would have to be assessed in the individual case.

8) Better Patient Care by Improved Standardization on Investigations

Standardization on investigations is an important aspect of patient care. If procedures are standardized throughout hospitals in different areas the result of tests would be more meaningful and the transfer of patient records from one area to another would have greater value.

9) Overall Financial Review.

Capital cost and maintenance would increase and from the limited survey carried out this would not be offset financially by savings in other areas. Staff would increase and although the cost per unit service may decrease the total number of services would increase. The end result would be an increase in the net cost per day for each patient, but the overall cost per patient/day may decrease due to the saving of up to 1.7 days per patient in length of stay. The series shows an average of 29 tests per patient whilst with multi-screening on admission the number of tests performed would be closer to 40 on Day 1 alone.

10) Medical Standards.

The only way medical standards can be maintained is by automation in conjunction with Multi-screening on admissions. This is based on the fact that there is an increased quantity of medical care to be provided associated with an increase in the number of people to whom it is to be provided for.

CONCLUSIONS.

In consideration of all the above facts and the material presented in the survey in this chapter and the information in previous chapters

the following points are presented for consideration.

1) What type of patient should have multiple investigations on admission or pre-admission? Although the study has been limited to medical cases only there is no reason why surgical cases can not also be incorporated:

a) All planned admissions - either medical or surgical.

b) All non-urgent admissions.

c) All admissions whose condition is such that a delay in the admission centre would not jeopordise their welfare.

d) Children have not been considered in this series and represent a select group in which limited Multi-screening on admission would only be applicable.

2) What investigations should be carried out on admission or pre-admission? This has been covered by Table 47A[+]. A complete coverage of what the various groups of Australian Doctors consider should be done is covered in Chapter 3. Their ideas have been correlated into what I consider a reasonable series and is the one which is presented in the above Table.

3) When ? - The tests may be carried out on either of 2 occasions.

1) Pre-admission - these should be performed within 2 weeks of a planned admission. If they are carried out earlier they are not acceptable in some medical disciplines e.g. Anaesthetics. The same battery of tests is used as in the admission profile.

2) Admission - these are performed when cases are admitted to hospital either planned where it has been unpracticable to

+ See Appendix 4

perform them at an earlier date or on unplanned admissions if their medical condition enable them to be carried out safely.

Where?- These are best performed in a hospital-based centre, the reason is to prevent duplication of equipment and because of the lack of availability of technical staff. Centralization of the Multi-screening area is essential; however, the equipment does not have to be in the immediate area. E.G. the computer may be situated elsewhere but the automated pathology section should be in the immediate vicinity.

How? - this represents the manner in which the work flows in a logical sequence through the admission area. This necessitates having the area available and the people available in the area to perform the tests. Adequate distribution of samples from the area to the laboratory and adequate linkage of equipment with computers is essential. Patient identification must be carefully examined and the methods of communicating the results to the wards adequate.

Patient Care

Advantages to patient care are the most important findings that have been shown in these investigations. This is exemplified by the following:

1) The more rapid diagnosis of disease.
2) The possible discovery of pre-symptomatic disease (e.g. 4 cases of Diabetes)
3) The discovery of additional diagnosis at an earlier date which may have seriously affected the course of the primary condition.

4) The possible earlier institution of correct treatment.

5) The saving in number of patient days in hospital per case.

6) As a result of 5)more cases can be admitted as the potential turn-over is greater.

7) Patient diagnosis would become more orientated towards preventive medicine rather than being purely based on curative medicine.

8) By using computers and automated machinery there is a less likelihood of human error.

9) As a result of 8)there would be better standardization of tests and their interpretation and this would allow for better inter-hospital comparisons.

10) The unit cost per test would decrease. However the overall effect on the cost per patient day has not been clearly evaluated but it is possible that this may increase.

The disadvantage in patient care is the possibility and fear of loss of doctor-patient relationship with some dehumanization of patient care. This is a reality as Doctors are becoming more disease orientated and less patient orientated. There is, in my opinion, a tendency to rely on tests and not medical acumen. So long as doctors do not rely on an admission profile to diagnose disease but merely use the profile as an adjunct to confirm their clinical diagnosis patient care can only benefit. Tests are not diagnostic in themselves but merely confirm a medical diagnosis or help in the establishment of it.

APPENDIX 1

TEST CODE — GENERAL PATHOLOGY

Type of Test	Number
Haemoglobin	001
Red Cell Count	002
White Cell Count	003
Differential White Cell Count	004
Mean Corpuscular Haemoglobin	005
Mean Corpuscular Haemoglobin Concentration	006
Mean Corpuscular Volume	007
Platelet Count	008
Blood Group & Rh Factor	009
Blood Uric Acid	011
P.C.V. Packed Cell Volume	012
Urea	013
Sodium	014
Potassium	015
Chloride	016
Carbon Dioxide	017
Erythrocyte Sedimentation Rate	018
Serum Protein	019
Bilirubin	020
Alkaline Phosphase	021
S.G.O.T.	022
Specific Gravity	023
Calcium	024

APPENDIX 1 (contd)

Type of Test	Number
Phosphate	025
Oxygen Saturation	026
pO_2	027
Actual $_p$H.	028
Actual CO_2	029
Prothrombin Index	030
Hematocrit	031
Glucose Tolerance Test	032
Creatinine	033
Urinary Porphyrins	034
Sputum - Smear	035
Culture	036
Fungus Culture	037
Carcinoma Cells	038
A.F.B. Culture	039
Urine _ Microurine	040
Culture	041
Random Blood Sugar	042
P.T.T.K.	043
P.L.T.	044
Calcium	045
Phosphate	046
Urinary Calcium	047
B.I.T.	048

APPENDIX 1 (Contd.)

Type of Test	Number
Blood Cholesterol	049
Glucose	050
Amylase	051
Total Protein	052
Iron	053
T.I.B.C.	054
F.T.M.	055
Gastric Cytology	056
Diagnostic Blue Test	057
Acid Phophatase	058
P.B.I. Protein Bound Iodine	059
T. Resin Uptake	060
Anti Strep. O. Titre	061
Latex Test	062
C.S.F. W.R.	063
Blood W.R.	064
C.S.F. V D L	065
Blood V D L	066
Blook Cline	067
C.S.F. Examination&Culture	068
Saturation	069
Urinary Porphyrins	070
Urinary Porphobilinogen	071

APPENDIX 1 (contd)

Type of Test	Number
B.L.T.	072
L.D.H.	073
C.S.F. Protein	074
C.S.F. Chlotride	075
C.S.F. Glucose	076
Urinary Urobilinogen	077
Uric Acid	078
Direct Coumbs	079
Sucrose Test	080
Swab Culture	081
Reticulocytes	082
Schums Test	083
Hams Test	084
C.P.K.	085
Aldalose	086
Lange's Curve	087
Muscle Biopsy	088
Serum B 12 Assay	089
Bone Marrow	090
Red Cell Mass	091
Histology of Duodenum	092
Bronchial Biopsy	093
Ca Cells in Urine	094

APPENDIX 1 (Contd)

Type of Test	Number
Renal Biopsy	095
Frozen Section	096
Faecal Fats	097
Prostate Pathology (Histology)	098
Liver Biopsy	099
General Histopathology	100
Blood Culture	100 (a)
Bone Marrow A.F.B.	100 (b)
Serum Folate Assay	100 (c)

APPENDIX 1 (Comtd)

TEST CODE

Type of Test - X-RAY	X-RAY Number
Chest	101
Gastrograffin	102
Lumbar Spine	103
I.V.P.	104
Ba Meal	105
Hands	106
Feet	107
Hips	108
Shoulders	109
Abdomen	110
Graham's Test	111
Gastric Camera	112
Skull	113
T-Tube Cholangiogram	114
Pelvis	115
Feumr	116
Cervical Spine	117
Cerebral Angiogram	118
Knees	119
Thoracic Spine	120
Legs	121
Ba Swallow	122

APPENDIX 1 (contd)

Type of Test	Number
Myelogram	123
Barium Enema	124

APPENDIX 1 (contd)

TEST CODE

Type of Test	Number
CARDIO VASCULAR SYSTEM	
E.C.G.	201
RESPIRATORY SYSTEM	
F.E.V.	301
V.C.	302
Fe V_1	303
V.V.	304
Tuberculin Test	305
M.V.I.	306
Ratio PEV/IC/VC	307
O_2 Sat	308
pO_2	309
Actual Ph	310
Actual p CO_2	311
Base Excess	312
Bronchoscopy	313
URINARY SYSTEM	
Cystoscopy	401
ALIMENTARY SYSTEM	
Gastroscopy	451
Oesophagoscopy	476
Sigmoidoscopy	475

APPENDIX 1 (contd.)

CEREBRAL INVESTIGATIONS.

Type of Test	Number
E.E.G.	501
SCANS	
Brain	550
Liver	551
Lungs	552
Renal	553

Page.	Diagnosis on Admission.	Tests Performed.									
		Days after admission to receipt of results.									
Iden. No.		1	2	3	4	5	6	7	8	9	10
Age	Final Diagnosis.										
Sex M. F.	DC										
Sur-gical	Additional Diagnosis										
Med-ical	1. DM										
	DC										
Total No. days in Hosp.	2. DM										
	3. DC										
	4. DM										
	DC										

Treatment Evaluation.					
Day on which correct treatment instituted.					
Day No.	Final Diagnosis.	Additional Diagnosis.			
		1	2	3	4
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
Additional Information.					

APPENDIX 2.

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APPENDIX 3.

MEDICAL TREATMENT AND SUSTENANCE.

64. A Deputy Commissioner may, subject to such conditions as the Commission from time to time determines, provide medical treatment for a member in respect of an incapacity due to war service.

65. A Deputy Commissioner may, subject to such conditions as the Commission from time to time determines, provide medical treatment for a member who is suffering from:-

(a) pulmonary tuberculosis; or

(b) veneral disease contracted during his war service

66. 1. Subject to the succeeding provisions of this regulation and to such conditions as the Commission determines, a Deputy Commissioner may provide medical treatment in respect of a disease or disabling condition that is not due to war service for:-

(a) a member who is receiving:-

(i) a general rate of war pension upon total incapacity under the First Schedule to the Act;

(ii) a rate of war pension under the Second Schedule to the Act; or

(iii) a service pension;

(b) a person to whom paragraph (b) or paragraph (d) of sub-section (2) of section 108 of the Act applies; or

(c) a person, being a person to whom section 120 of the Act applies, who is receiving a service pension.

APPENDIX 3 (contd.)

2. A member who, but for the operation of:-

(a) section 43 of the Act;

(b) paragraph (c) of the proviso to sub-section (1.) of section 24 of the Act;

(c) paragraph (c) of the proviso to sub-section (1.) of section 101 of the Act; or

(d) sub-section (6.) of section 107c of the Act.

would have been entitled to a rate of war pension specified in the last preceding sub-regulation shall, for the purpose of this regulation, be deemed to be in receipt of a rate of war pension specified in the last preceding sub-regulation.

3. A member is not eligible for medical treatment under sub-regulation (1) of this regulation at the expense of the Department if the disease or disabling condition is:-

(a) an infectious or contagious disease;

(b) a chronic or incurable disease requiring treatment in an institution for a prolonged period;

(c) a condition caused by alcoholism or addiction to drugs; or

(d) a disease or disabling condition in respect of which the member:-

(i) is eligible under a law of the Commonwealth or of a State or Territory of the Commonwealth for medical treatment at the expense of his employer;

(ii) is entitled to medical treatment under a scheme of contract medical attention; or

APPENDIX 3 (contd)

(iii) has recovered or received or is entitled to recover or receive, the cost of medical treatment by way of damages or compensation from another person.

4. Where :-

(a) medical treatment in respect of a disease or disabling condition that is not due to war service is provided for a member who is not eligible for such medical treatment at the expense of the Department; or

(b) the Commission considers that the circumstances are such that the expense of medical treatment provided for a member under sub-regulation (1) of this regulation should not be borne by the Department,

the amount of the expense of the medical treatment shall, if the Commission so directs, be deemed to be an amount supplied to the member by way of loan and thereupon that amount is repayable to the Department in a lump sum or in such instalments as the Commission, in its discretion determines.

5. A reference to a member in the last two preceding sub-regulation shall be read as including a reference to a person specified in paragraph (b) or paragraph (c) of sub-regulation (1) of this regulation.

72. 1. A Deputy Commissioner may, subject to such conditions as the Commission from time to time determines, arrange for investigation to be carried out in connection with:-

APPENDIX 3 (contd.)

(a) a claim by a member that he is suffering incapacity due to war service; or

(b) pension in respect of a member.

2. Where, by reason of any such investigation or any treatment found necessary or expedient in connection therewith, the member is prevented from following his usual occupation and is not engaged in any other remunerative occupation, a Deputy Commissioner may, subject to the next succeeding sub-regulation and to the directions of the Commission grant to the member sustenance allowance in accordance with the scale specified in sub-regulation (1) of Regulation 71 of these Regulations.

3. Sustenance allowance under the last preceding sub-regulation shall cease to be payable upon the day immediately following the date of determination by a Board of the matter that necessitated the investigation.

73. 1. Subject to such conditions as the Commission determines, a Deputy Commissioner may provide medical treatment for widows and children of deceased members and for widowed mothers and widowed stepmothers of deceased unmarried members.

2. In this regulation "children" includes any persons who are in receipt of pensions under sub-section (4) of section 39 of the Act.

APPENDIX 4.

ADMISSION OR PRE-ADMISSION PROFILE.

After dissecting the questionnaire in Chapter 3 and considering the admission profiles in overseas hospitals and reviewing what is reasonable and practicable in large Australian Metropolitan Hospitals * at the present time I consider that the tests on admission or pre-admission as shown in the following Appendix should be implemented.

The implementation of these procedures would involve considerable capital investment in equipment and re-education of medical and technical staff as well as availability of space.

* Any General Hospital over 500 beds. At present shared hospital facilities are not considered in the Australian situation.

APPENDIX 4 (Contd.)

TABLE 47A

ADMISSION OR PRE-ADMISSION PROFILE

Pathology Investigations.

Biochemical Battery using SMA 12/60

Na

K

Cl

HCO_3

Urea

Glucose

Total Protein

Albumen

Bilirubin

S.A.P

Cholesterol

Uric Acid.

Using Single Channel Technicon.

S.G.O.T.
or
Zygmat for Enzymes.

L.D.H.

C.P.K

S.G.O.T.

Aldolase.

S.G.P.T.

A single Channel Technicon may be used for doing an S.G.O.T. Test which is an Enzyme Test. However a Zygmat Machine does a series of Enzyme Tests on the one blood specimen as a single procedure of which the S.G.O.T. is one. Some Hospitals may prefer to do the Enzyme Battery rather than a single Enzyme Test for approximately the same price. Medically there is probably greater clinical value in the results from the Zygmat.

APPENDIX 4 (contd).

TABLE 47A.

Haematology Battery Using a Coulter S or S.M.A. 7A.

Hb.

Haematocrit

MCH Concentration

RCC

WCC

MCH

MCV

Automated Blood Typing.

Blood Group

Rh Factor

Urine Analysis

Albumin

Sugar.

Respiratory Investigations

Chest X-Ray

Spirometry

Cardio-Vascular Investigation

BP

ECG

This could become more extensive at a later date and include such tests as:-

1. E.S.R.
2. Blood Smear Examination.
3. W.R. 4. Psychological Testing etc.

APPENDIX 5

STATISTICS OF GENERAL MEDICAL ADMISSIONS +
RGH(C)
1969/1970

TABLE 47

RGH(C)	TOTAL IN-PATIENT DAYS	AVERAGE DAYS TREAT-MENT PER PATIENT	AVERAGE DAILY BEDS OCCUPIED	ADMISS-IONS DURING PERIOD	MEDIAN AGE OF PATIENTS ADMITTED	RE-AD-MISS-IONS	RE-ADMI-SSIONS AS A PERCENT-AGE OF TOTAL ADMISS-IONS	DISCHAR-GES DUR-ING PER-IOD (IN-CLUDING DEATHS)	MEAN DAYS LENGTH OF STAY OF PAT-IENTS DISCHAR-GED. x
TOTAL	191,858	18.5	527	9,679	63.9	3,152	32.6.	9,795	22.9

Net. Cost for In-patient Days = $25.39

+ The above figures are those quoted in the Repatriation Commission's Annual Report 1969/1970 Pps. 73 & 78

x In this Thesis the mean days length of stay of patients discharged is assumed for calculation and comparison purposes to be the average length of stay of general medical cases.

APPENDIX 6

DISTRIBUTION AND TYPE OF CASES.

The following Appendices allow a comparison to be made between the distribution of medical cases for 1969/1970 at RGH(C) and the series studied.

The median age for the patients in RGH(C) over the studied period was 63.7 years this compares with the median age of the studied series of 65 years. The average age in the series was 64.5 years, this is only marginally higher than that of the average in RGH(C). This is due to the criteria used in selecting the cases for the series. The main one being that only patients with a new primary provisional diagnosis were considered and that no re-admissions for the same condition were in the series.

The average length of stay of patients in the series was 27.4 days.. The average length of stay of general medical cases in RGH(C) over a corresponding period was 22.9 days. The difference is again due to the selection of cases in the studied series+

+ The figures quoted for RGH(C) are those out of the Repatriation Commission Annual Report 1969/1970 p. 73

APPENDIX 6 (contd.)

TABLE 48

DISTRIBUTION OF CASES.

Gastric Erosion	2	Varicose Ulcers	4
Duodenal Ulcer	9	Neuralgia	1
Gastritis	1	Glomeurloe Nephritis	1
Malabsorption Syndrom	1	Cirrhosis of Liver	2
Diverticulitis	1	Prostatic Hypertrophy	5
Constipation	1	Sacro Illiac Arthritis	1
Lumbar Spondylitis	5	Dyspepsia	1
Pneumonia	3	Achlorhydria	1
Pneumothorax	1		
Bronchitis	10		
Asthma	1		
Ca. of Lung	2		
Ca. of Oesophagus	1		
Ca. of Brain	1		
Ca. of Breast	1		
Ca. of Stomach	1		
Motor Neurone Disease	1		
Diabetes	1		
Anxiety Depression	3		
Polyartheritis	1		
Hypertension	5		
Coronary Artery Disease	17		
Cardiac Failure	8		
Cerebral Thrombosis	7		

APPENDIX 6 (contd)

TABLE 49

PHYSICAL SYSTEMS INVOLVED.

VASCULAR DISEASES.		
Hypertension	5	
Coronary Artery Disease	17	
Cardiac Failure	8	
Cerebral Thrombosis	7	
		37
GASTRO INTESTINAL DISORDERS.		
Gastric Erosion	2	
Duodenal Ulcer	9	
Gastritis	1	
Malabsorption Syndrome	1	
Constipation	1	
Achlorhydria	1	
Dyspepsia	1	
Diverticulitis	1	
Cirrhosis of Liver	2	
		19
ARTHRITIS.		
Lumbar Spondylitis	5	
Polyarthritis	1	
Sacro Iliac Arthritis	1	
		7
GENITO URINARY.		
Prostatic Hypertrophy	5	
Glomeurlo Nephritis	1	
		6
NEOPLASM.		
Ca. Lung.	2	
Ca. Oesophagus	1	
Ca. Brain	1	
Ca. Breast	1	
Ca. Stomach	1	
		6
ENDOCRINE & METABOLIC		
Diabetes	1	
		1
RESPIRATORY SYSTEM.		
Pneumonia	3	
Pneumothorax	1	
Bronchitis	10	
Asthma	1	
		15
PSYCHIATRIC		
Anxiety Depressive States	3	
		3
MISCELLANEOUS.		
Motor Neurone Disease	1	
Varicose Ulcers	4	
Neuralgia	1	
		6

TABLE 50

Disease	R.G.H.(C)	Studied Series
Tuberculosis	2.7	
Infective and Parasitic Diseases	0.6	
Neoplasms	8.1	6
Allergic, Endocrine, Metabolic and Nutritional Diseases	3.0	1
Blood Disease	1.3	
Mental Disorders	9.8	3
Nervous System and Sense Organs	4.7	
Disease of Circulatory System	20.6	37
Diseases of Respiratory System	15.7	15
Diseases of Digestive System	7.8	19
Genito-urinary Diseases	5.2	6
Skin Disease & Varicose Ulcers	2.2	4
Musculo-Skeletal System	6.9	8
Symptoms, Senility and Ill-defined conditions	3.9	1
Accidents, Poisoning & Violence	6.4	
Not Yet Diagnosed	1.1.	
	100%	100%

Comparison 1969/1970 Cases +

+ The figures for the Repatriation General Hospital are those quoted in the Repatriation Commission's Annual Report 1969/1970 P. 76.

APPENDIX 6 (contd)

TABLE 51

Patient's Age.

Case No	Age	Case No	Age	Case No.	Age
1	70 Years	39	60 Years	77	60 Years
2	79	40	38	78	53
3	61	41	62	79	64
4	74	42	50	80	76
5	62	43	58	81	78
6	58	44	48	82	68
7	50	45	68	83	84
8	53	46	46	84	72
9	76	47	61	85	77
10	69	48	73	86	65
11	83	49	55	87	70
12	71	50	75	88	69
13	85	51	60	89	45
14	69	52	52	90	59
15	58	53	73	91	58
16	54	54	78	92	56
17	65	55	77	93	69
18	59	56	71	94	72
19	56	57	69	95	81
20	82	58	73	96	65
21	50	59	77	97	75
22	69	60	66	98	80
23	67	61	78	99	65
24	64	62	60	100	43
25	48	63	65		
26	44	64	70		
27	42	65	57		
28	57	66	69		
29	49	67	70		
30	58	68	70		
31	72	69	77		
32	63	70	61		
33	54	71	77		
34	64	72	49		
35	48	73	73		
36	69	74	76		
37	57	75	65		
38	53	76	77		

Average Age = 64.5. Years
Median Age = 65 Years

TABLE 52

NUMBER OF DAYS IN HOSPITAL

Case No.	No. of Days	Case No.	No. of Days	Case No.	No. of Days.+
1	7	40	12	79	27
2	27	41	38	80	9
3	19	42	30	81	7
4	18	43	27	82	39
5	16	44	15	83	6
6	17	45	19	84	4
7	25	46	49	85	78
8	14	47	27	86	12
9	46	48	19	87	16
10	16	49	33	88	8
11	18	50	27	89	59
12	54	51	59	90	23
13	13	52	14	91	15
14	11	53	27	92	28
15	23	54	18	93	25
16	39	55	82	94	17
17	19	56	29	95	40
18	27	57	32	96	22
19	17	58	55	97	15
20	12	59	21	98	25
21	28	60	36	99	21
22	14	61	4	100	6
23	17	62	33		
24	25	63	13		
25	8	64	29		
26	25	65	45		
27	21	66	41		
28	29	67	58		
29	20	68	31		
30	31	69	59		
31	46	70	19		
32	62	71	36		
33	25	72	10		
34	38	73	72		
35	35	74	73		
36	60	75	25		
37	26	76	35		
38	12	77	2		
39	8	78	15		

+ Number of Days in each case represents the total number of days that each case spent in hospital.

Average Number of Days = 27.4

APPENDIX 7

STATISTICAL SUMMARY OF TESTS PERFORMED ON SERIES STUDIED.

The following Appendices show the total number of tests performed on all cases in the test series and the number of tests that were performed on the first, second and third days. The average number of tests performed was 25.7 tests per case.

TOTAL NO. OF TESTS	DAY 1	DAY 2	DAY 3.
2573	211	636	290
	8.2%	23.8%	11.6%

The above shows that in the first 3 days in hospital 1137 tests were performed out of a total of 2573 or 43.6% of all tests done were carried out in this period.

APPENDIX 7 (contd) C4/7/2

TABLE 53

TOTAL NUMBER OF TESTS PERFORMED

Case No	No of Tests	Case No.	No. of Tests	Case No.	No. of Tests	Case No.	No. of Tests.
1	23	40	7	79	21		
2	13	41	49	80	29		
3	13	42	23	81	3		
4	7	43	21	82	36		
5	19	44	20	83	1		
6	13	45	15	84	0		
7	29	46	33	85	70		
8	28	47	31	86	21		
9	69	48	21	87	17		
10	18	49	20	88	4		
11	18	50	50	89	23		
12	107	51	39	90	59		
13	8	52	0	91	15		
14	14	53	38	92	18		
15	74	54	42	93	27		
16	32	55	45	94	27		
17	23	56	9	95	61		
18	27	57	33	96	19		
19	2	58	42	97	23		
20	16	59	28	98	19		
21	40	60	22	99	22		
22	12	61	21	100	4		
23	25	62	22				
24	5	63	33				
25	0	64	36				
26	16	65	31				
27	19	66	89				
28	14	67	57				
29	22	68	8				
30	9	69	31				
31	29	70	18				
32	16	71	23				
33	14	72	17				
34	21	73	48				
35	23	74	48				
36	14	75	13				
37	20	76	36				
38	38	77	13				
39	8	78	24				

Average Number of Tests Per Patient
= 25.7.

CHAPTER 5.

INTRODUCTION.

The Repatriation Commission after six years of planning, investigation and trial decided to introduce an A.D.P. System into R.G. H. Concord. A special committee of experts was set up to investigate procedures. These investigations were carried out in the Meteorological Bureau in Victoria. Here the applications and implications of the use of computers in hospital administration was studied.

Many problems were encountered from simple ones such as semantics to complicated electronic and electrical ones. These provided some initial installation problems and represent unexpected and sometimes intricate and time consuming difficulties which are perculiar to the particular type of machinery being used. The A.D.P. System is being introduced in stages into the Repatriation General Hospital, Concord over 1970-71.

Appendix No.1A is a glossary of terms; this is essential and represents the basic jargon of the workers for without this there would be no means of communication.

The object of the Committee was to investigate the implications of the effects of A.D.P. on hospitalization of a patient in selected areas. The two main areas concentrated on were:-

(a) Pathology Sub-system.

(b) Admission and Disposal procedures.

PATHOLOGY SUB-SYSTEM.

This was decided to be the first area into which A.D.P. could be successfully introduced in direct relationship to patient care. The reason was that the available hardware had already been proven in this field and was available. However, a full and complete investigation was carried out by a special committee. A steering committee was the appointed to introduce the whole procedure with a larger Co-opted Committee.

As was discussed in Chapter 1., each country has its own problems and every hospital is individual and the installations, use and programming of equipment has fundamental problems related to the individual situations.

The following indicates the manner in which the problem was approached but, nevertheless, is closely related to overseas methods.

Background Information.

The Pathology Department of the Repatriation General Hospital Concord, provided a service to medical officers who are responsible for the diagnosis and treatment of conditions found inin-patient or out-patients. Because of the diversity of tests undertaken, the Department is sub-divided at present into the following laboratories:

(i) Biochemistry.

(ii) Haematology.

(iii) Microbiology.

(iv) Histopathology.

The method of testing specimens in the Department varies from fully automated analyses to wholly manual procedures and resulting

reports range from simple numeric values to comprehensive narratives

The volume of tests carried out in the Repatriation General Hospital, during the last five years has doubled and for 1969 some 480,000, individual pathological reports were produced at Repatriation General Hospital, Concord. In addition to the normal increase in tests expected over the next 12-18 months, the recent decision by the Repatriation Commission to introduce multiple screening of in-patients will significantly add to the work load of the Pathology Department. To cater for this increase (estimated at approx. 70%), additional automatic analytical instruments are proposed which are suitable for direct connection to a Date Acquisition System (D.A.S.). *

The existing Pathology System is described in detail in paras. 1. et seq. and is based on the following procedures:-

(i) Trained staff from Pathology Department visit wards at regular intervals during the day, collected test requisition forms and obtain the required speciments from the patients;

(ii) On return to the Pathology Department the specimen is assigned a consecutive number which, together with the patient's name, ward number and tests requested, is entered into a register. Depending upon the variety of tests requested the specimen is divided into a number of samples each of which, carry a label containing the previously assigned consecutive number and patient's name;

(iii) Each sample is then subjected to the required tests, the

* See Page. 364

results entered progressively into the register and after all tests are completed the results are transcribed to the requisition form.

(iv) One copy of the requisition form is returned to the ward for attachment to the clinical record. The duplicate is retained in the Pathology Department for statistical and reference purposes.

Existing Problem Areas.

Professional and technical staff spend approximately 30% of their working day on routine clerical work relating to the preparation of sample lists and calculations of results produced by autoanalysers and associated equipment.

The proposed introduction of multiple screening and the purchase of high capacity laboratory instruments will not appreciably increase the problem of result calculation but will significantly increase the work associated with the identification of specimens, collation, dissemination and retrieval of a large volume of test results. As in any system where a large volume of data is involved, the possibility of error is ever present. Errors can occur at any stage from the incorrect identification of the specimen at the time it is taken from the patient, to the final transcription of test results to the appropriate report form.

The time which elapses between the request for a pathological investigation and the return of a result is at present 1 to 2 days for Biochemical and Haematological tests. Whilst this interval is not excessive under a manual system the delay can frequently defer the

commencement of treatment and eventual discharge of the patient.

Investigation of tests results to produce standard ranges for results considered normal within various population groups cannot be undertaken because of the immense clerical task involved.

Tests results are not returned to the ward until all such tests are completed, despite the fact that some results may be available much earlier.

1. EXISTING SYSTEMS.

Requirements of System:

The Pathology Department provides a diagnostic service to clinicians and is responsible for the collection of specimens, conduct of tests, preparation and return of results/reports, maintenance of card files containing copies of all test results returned to clinicians and production of statistics which reflect test volumes within specified categroies.

Record Types:

The main records held in the Department are as follows:-

(i) A sample day book holding the patient's name, ward and results of tests. This gives a quick reference to test results in case of queries or urgent tests.

(ii) A reference file, in alphabetical order, of duplicate request/report forms maintained by each section of the Department.

(iii) Statistics cards held in the pathology office are updated by clerical staff from the request/report form after the required tests have been completed and results recorded.

Requests for Analyses.

Analyses required by clinicians are requested by sending the appropriate form. If the specimen is not forwarded it is obtained by sisters attached to the Department.

Quality Control.

Test results are verified by senior staff and if necessary compared with the patient's previous test results prior to despatch to the clinician. Instrument calibrations are constantly monitored to ensure result uniformity.

Reporting Results.

The request form containing the result(s) is sent via the hospital courier service to the originator of the request - urgent results may be telephoned direct to the clinician.

Volumes.

Approximately 47,000 tests are completed per four week period, a breakdown of this figure into test types within laboratories is given in Appendix. 6.

Evaluation of Present System.

Repatriation General Hospital, Concord extends over some 67 acres and consequently wards may be up to 2,000 ft. from the laboratories. As delivery of the initial request and sample is via a routine collection service provided by the Pathology Department, and the return of the final result is by the internal mail system, lengthy delays may occur.

On receipt of a request form, the specimen is given a consecutive number and this, together with the test details is entered

in a day book for record and control purposes.

Samples are distributed and if processed automatically charts produced by analysers are interpreted, values calculated, and results entered in the day book from which they are copied, to the original request form. These clerical tasks, which are carried out by technical staff, take a high percentage of their useful working time.

During transfer of data between various records errors may occur.

A statistic card for each test type is updated manually by clerical staff on completion of the test reports. At the end of each four week period, these figures are totalled and then transcribed for forwarding to the statistic clerk. The Maintenance of these records requires substantial clerical effort and because of the sheer volume, errors may be introduced into the statistics.

2. MANAGEMENT SUMMARY:

Objectives:

The Pathology sub-system is designed to:-

(i) automatically record signals from a variety of instruments (including auto-analysers) in the Biochemical and Haematological laboratories, perform the required calculations and record results in a computer based file;

(ii) accumulate these results and associate them with their related requests to provide a patient record;

(iii) print (as required) ward reports, patient profiles, management statistics, and control results;

(iv) provide ready access to test results as and when required by clinicians or laboratory staff.

Future objectives of the system are - incorporation into the ADP system of:-

(i) results of tests which are manually performed in the laboratories;

(ii) narrative type test reports.

These objectives can easily be applied as part of the multi screening process on admission to hospital and is being introduced into Repatriation General Hospital, Concord in the preadmission area, early 1971.

Equipment Constraints:

The system is designed for operation on the Repatriation IBM 360/50 computer in Sydney, with the Social Service computer available in case of failure. Laboratory equipment is not connected directly to the computer but instead is linked to an IBM 1080 Data Acquisition System (D.A.S.) at Repatriation General Hospital, Concord.

Card output from the D.A.S., is transmitted to the computer via a card reader (C.R.) which in addition to two Visual Display Units (V.D.U.) one Keyboard Printer (K.P.) and one medium speed Serial Matrix Printer (S.M.P.) is available to the system and connected directly to computer complex via P.M.G. private telephone lines.

Summary of Proposed A.D.P. System.

Irrespective of the type of test required, the following uniform procedures are followed:-

(i) the medical officer completes a test requisition card specifying the tests which are required, the proposed cards for use in biochemistry and haematology are shown in appendix 7 . Each requisition comprised two 80 column machine cards with interleaved carbon, the whole forming a zip-set. Both cards are pre-numbered and the duplicate card incorporates four specimen identification stubs which may be pre-punched with a specimen serial number. Self-adhesive labels (printed during the admission process) are attached to the top requisition card.

(ii) The medical officer records on the patient's case sheet those tests requested.

(iii) the requisition cards are collected at regular intervals by nurses, who also obtain the required specimens from the patients, positively identifying each specimen by removing a stub from the appropriate requisition card and attaching it by an elastic strap to the specimen tube.

(iv) on delivery of requisition cards and specimens to the Pathology Department, information regarding the patient and tests requested is notified to the A.D.P. system via a V.D.U.

(v) Under the preadmission profile system, the specimen could becollected on admission.

Identification of specimens processed on auto-analysers is chieved by a sampler reader, which consists of a stub-card reader and

control assembly associated with the auto-analyser turntable from which the sample is drawn for analysis. Results of tests performed automatically are punched via the card punch attached to the D.A.S.

Results of manual tests which produce numeric results are notified to the A.D.P. system via a V.D.U.

At appropriate intervals, e.g. hourly, all cards produced via the D.A.S.card punch are transmitted to the computer via the remote card-reader. The information is immediately processed to produce:-

(i) quality control information which is re-transmitted to the pathology department and printed via the K.P;

(ii) in the case of automated haematology, a list associating specimen numbers with patients to enable further examinations to be conducted should they be necessary.

(iii) tests results, which are printed in ward summary form at regular intervals during the day (via the S.M.P.) and distributed;

(iv) cumulative patient profiles for one specified period, e.g. 1 week, which are printed each evening and distributed for inclusion in clinical records.

Manual tests which give rise to narrative type reports are identified in a similar manner by attaching the stub card which is endorsed with the test name. The narrative report is manually entered on a separate report form. On completion of the report, the computer record is updated for control and statistical purposes with the date of completion of the test via the V.D.U.

Some manual test results may, however, be coded; these codes are

translated by computer and produced on the patient's profile in full. If tests are required urgently the clinician indicates this when making his request. Irrespective of the type of test, the technician responsible telephones the result to the doctor. With some automated tests this may be an approximation as a final figure cannot be obtained until several samples in a particular batch have been completed and results analysed.

Requests for pathological tests originate in three specific areas within the hospital:

(i) Admissions.

(a) unless the admitting medical officer (AMO) considers it medically inadvisable, all patients on admission will have specimens taken which are subject to some 12 basic biochemical and 7 haematological tests;

(b) the AMO initiates this action by entering the order on the laboratory requisition card immediately following the physical examination of the patient;

(c) the sample is obtained from the patient, identified by a pre-punched stub from the requisition card and forwarded to pathology.

(ii) Wards.

(a) After the arrival of a patient in the ward, any further tests required by resident doctors or specialists are indicated on the requisition card; this could result from the pre-admission tests being already at hand or the tests may be medically indicated.

(b) the required sample is collected by a trained nurse attached to the Pathology Department, who identifies the sample with the appropriate stub.

(iii) Out-Patient Department.

(a) tests required by doctors for out-patients are entered on the normal requisitions card following examination.

(b) the requisition is then taken by the patient to the Pathology Department where the required specimen is obtained and appropriate identification stub is attached;

(c) the formal test request is input via the Pathology Department V.D.U.

(d) The O.P.D. tests may be performed as part of a pre-admission Clinic.

Advantages of the Proposed A.D.P. System.

The connection of the high volume automatic analytical instruments to the Data Acquisition System and subsequent computer calculation of results eliminates several clerical procedures and consequently reduces the time which elapses between receipt of sample and availability of result to approximately three hours.

Results are returned progressively to the clinician in the form of ward reports and are not delayed until the result from the test requiring the longest laboratory procedure becomes available.

The retention of test results on magnetic disk permits the cumulative printing of individual patient profiles (See Appendix 8) for a seven day period.

Laboratory staff have the facility to quickly compare current test results with previous results by requesting a print of all or selected results from the patient's historical record maintained on magnetic disk. A comprehensive summary comprising a copy of each weeks patient profile (See Appendix 8) of biochemical and haematological test results is automatically produced on discharge for attachment to the clinical summary.

As the A.D.P. system relieves skilled laboratory staff of clerical procedures associated with automatic analytical instruments, an increased range or volume of manual tests may be undertaken.

Historical retention of test results enables research to be undertaken to determine current standard test results ranges for selected groups of patients.

Estimated Savings.

The automatic recording of output signals from analytical instruments, combined with calculation of results by the A.D.P. system should permit the volume of tests conducted to increase by some 70% within the next 12-18 months without corresponding increases in staff. The increase of workload results from the proposed introduction of screening tests on admission and the 25% annual increase in tests which is being experienced at R.G.H. Concord. Without the introduction of these techniques up to five additional laboratory staff would be necessary to satisfy this expected increase in test requests.

Under the proposed system, diagnostic test results are returned to clinicians earlier allowing in many cases, a firm diagnosis to be made, and treatment commenced. Apart from the primary result of

improving patient care, the earlier diagnosis, treatment and ventual discharge should lead to either a reduction in the number of beds required to treat a specified number of patients or a significant increase in the number of patients treated within the existing facilities.

Implementation.

Although not essential, it is desirable that the introduction of the full Automated Pathology System should follow the implementation of the Admission and Dispositions Sub-System which is scheduled for late 1970. This latter Sub-System creates and maintains a patient record on magnetic disk which ultimately forms the basic patient indentification for use by the Pathology System. Meanwhile, the linking of the auto-analyser etc., to the IBM 1080 is effected following delivery of this equipment in 1970. The "Off-Line" calculation of test results could be introduced about mid 1970.

The implementation of the pathology Sub-System is progressive, and initially, two auto-analyser channels used for Biochemical tests are connected to the IBM 1080 system. Manual calculation of results is continued for a period of system checking. As staff gain experience with the 1080 system and associated procedures and providing no serious technical problems arise (overseas experience indicates that this is unlikely) further channels will be subsequently connected.

When all auto-analyser channels are successfully operating through their required range of tests on the 1080 system, progressive inclusion of non-automatic electronic test equipment, e.g. Coulter Counter, Colorimeters etc. is undertaken.

Full A.D.P. system support in the form of control results, ward reports, patient profiles, and specimen identification is provided for each test as it is included in the Pathology Sub-System.

The introduction of test results produced by manual processing into the patient A.D.P. file is independent of the 1080 system and is introduced in stages shortly after the 1080 system has been established.

Likewise the ordering of tests or investigations which result in narrative type reports is wholly independent of the automated system and for this reason may be introduced at a time convenient to the Department.

EQUIPMENT:

Computer.

The A.D.P. system is designed for operation on the Repatriation computer situate in Australia House, Sydney, with the Social Service computer, which is located in the same building, to be used in case of machine failure. Terminals inR.G.H. Concord, are linked via P.M.G. transmission wires to the computer so that the remote location of the computer has no detrimental effect on the output for the hospital system.

Visual Display Unit (V.D.U.).

A V.D.U. provides high speed visual access to computer information. It incorporates a television type screen (14" x 9") and an alphanumeric keyboard. Data entered on the keyboard is displayed on the screen for visual checking and is then used to access computer records.

Similarly on request from the V.D.U. information held in the computer is displayed on the screen. Up to 12 lines of 80 characters can be displayed on the screen simultaneously.

Keyboard Printer (K.P.):

The Keyboard Printer features a Selectric Typewriter modified for use as a general purpose communication terminal. Data can be entered into computer records via the terminal but its main use is to provide printed reports and result lists for verbal requests made via the Visual Display Units. All K.P's work independently of the V.D.U's and print at a rate of 14 characters per second.

Serial Printers:

The serial matrix type printer is specially designed for use as a medium speed remote date communication system printer and operates at 66 characters per second with a spacing of 10 characters per inch and up to 132 characters per line. A keyboard is included with the communic- system for input.

Card Reader:

The 80 column punch card reader transmits information contained in standard cards to the computer at a rate of 150 cards per minute. The reader incorporates automatic input and output feeding and stacking.

Direct Access Storage Device (D.A.S.D.),

All information accessed in the system is stored on a disk pack. Up to 30 million characters can be stored on the magnetic surface of each disk. Each record can be accessed in approximately 60 milliseconds.

P.M.G. Modems:

Modems, which are leased from the P.M.G., are used at termination of the communication lines (at R.G.H. and the computer centre). The basic function of modems is the modulation and demodulation of signals for transmission to/from the V.D.U's, from/to the computer.

DESCRIPTION OF THE PROPOSED A.D.P. SYSTEM:

General:

The A.D.P.system holds on magnetic disk a list of:-

(i) requests for diagnostic tests;

(ii) results of analyses (unmatched with requests);

(iii) results of analyses (matched with requests);

(iv) historical results up to 6 months old;

(v) test codes, with test names and statistics.

Access to historical records and the addition or deletion of requests and results is made via a V.D.U.

Quality control reports, specimen identification data and listings of historical records are output from a keyboard printer, ward reports and patient profiles are however, produced by a medium speed serial matrix printer, also sited in the Pathology Department. Should the volume of patient profiles increase beyond the capacity of the output terminals in Pathology, additional printer capacity is available within the hospital.

Requests for Analyses.

All requests for analyses on automated equipment are entered via a visual display unit and recorded on disk.

The member's hospital number, the specimen number and all tests codes are entered at this time. The hospital number and test codes (which incorporate check digits) are validated prior to the member's name, benefit number and the names of the test being displayed for visual verification.

On re-entry, the information is scanned and validated in case of alteration. A record is then written for each individual test code in the request file. These records are held on disk for matching with

the results when a ward report is requested.

On receipt of a request for a test which is not pre-printed on the card but which has been written on the card, the clerk looks up the test from a table, inserts the test code number, enters the request via the V.D.U. then holds the request card for future identification of samples. Tests in this category represent less than 5% of the total tests processed each day.

Results of Automated Analyses.

Results of analyses run on automated equipment attached to the 1080 Data Acquisition System are automatically punched out on cards. These punched cards are then read by a card reader which transmits the data to the computer ready for analysis by the automated chemistry program.

At intervals throughout the day the automated chemistry program is run as a batch program producing a quality control report and storing the results of analyses on disk.

The pathologist or his representative examines the quality control report and deletes (through the visual display unit) all doubtful results.

With the quality control report an identification list is produced for automated haematology requests.

Manual Analyses (Biochemistry):

All results not collected by the 1080 system must be input to the computer via a V.D.U. In this case, the following procedure is followed:-

On completion of manual results, if the whole result can fit

within 12 characters this is entered on a result form (Appendix 9) which is passed to the V.D.U. operator for entry to the computer. If the result requires a narrative report, the narrative form is completed, a short result written in the space provided (this may consist of a date or 'SEE REPORT'). This short result is input via the V.D.U. and the operator writes the patient's name, benefit number and ward, obtained from the request card, on the narrative report to send to the ward.

Manual analyses from other sections are included in the system after the initial automated system is implemented.

Ward Report:

After the automated chemistry program has been run and the doubtful results deleted, a ward report is requested via the visual display unit.

The ward report program is initiated by the computer operator and this program is run concurrently with the "on-line" program so that the visual display units may be used to enter requests and results without interference.

The program strips results, and requests from their respective data sets sorts into specimen and test code order and matches results with their respective requests.

Unmatched results and requests are printed out as an exception report, on a keyboard printer, and printing is in specimen number order. At the end of this report a summary of all out-standing requests is given. Unmatched results and requests are returned to their respective data sets and held.

Matched records are sorted into ward, member and test code order and listed on a keyboard printer in the Pathology Department. At the

end of the ward report, a summary of all tests completed is given together with average time taken between entering the request through the visual display unit and the ward report being prepared. The ward report is distributed by the pathology nurses whilst collecting samples.

Patient Profile:

Overnight a patient profile of all patients who have had analyses performed during the preceding day is produced.

Profiles are listed in ward and member order, tests are listed within the profiles in test code order.

At the end of the patient profile listing, a summary of the tests performed during the preceding day is produced.

The profiles and summary are listed on the serial matrix printer in the Pathology Department.

Enquiries:

Enquiries about the test results are made via the office where the clerk extracts the appropriate request card, obtains the results from the laboratory staff and, if available, conveys them back to the enquirier. If the request is made before the results have been computerized, then the results may be got from the laboratory. If the results have been computerized, then a duplicate would be in the main office of the Pathology Department.

Historical Records:

Results of analyses are retained on a direct access data set and are available for a period of six months.

A request entered in a visual display unit giving the member's hospital or benefit number will produce as required a list of previous results for all tests or specified tests only.

The name and ward of the member, together with the numbers of the results on file are displayed on the visual display unit whilst the results themselves are listed on a keyboard printer within pathology.

Statistics:

The total numbers of each type of test performed, sub-divided by in-patients, out-patients and others, and the average time taken between the request being input through the V.D.U. and the ward report programs run is accumulated for each type of test throughout the month and printed for each 28 day period.

Error Control:

The A.D.P. system, in taking results direct from the auto-analysers, eliminates the risk of incorrect calculation or transcription of data. Invalid data produced by the auto-analysers due to machine malfunctions etc., are displayed on the quality control report and deleted. Incorrect labelling of specimens is greatly reduced by the attachment of a stub card immediately after taking the samples and mechanical reading of this stub card.

The validation of the visual display unit messages includes verification of the check digits on the hospital number and the test codes, displaying the member's name and hospital number, and verifying the specimen number is numeric and within limits. Where the member's benefit number is required this is also verified.

Security of Data Sets.

The A.D.P. system is designed so that, if a malfunction of the computer occurs, the only necessary step is to restart from the beginning of the job-step within which the malfunction occurred. No data sets are

deleted but are overwritten during the next cycle of the system. Where data is being entered by card reader or visual display unit when the malfunction occurs, this data may be lost and may have to be re-entered.

Manual Fall-Back Procedures:

The terminal network and computer complex is designed to continue working even where one or more terminals has failed; it is therefore only necessary to switch visual display units to continue operation.

In the event of a complete failure of the whole system, or of the 1080 Data Acquisition System, results may be obtained directly from the charts produced by automated equipment. These results may later be entered via a visual display unit to appear on ward reports and patient profiles.

ADMISSION AND DISPOSITION OF IN-PATIENTS AT R.G.H. CONCORD.

SUB - SYSTEM.

This section of the A.D.P. System is incorporated to show how the future preadmission investigations could become a routine part of the programme. The present objectives are only described as most of the procedures being introduced are not related to preadmission multi-testing.

In considering admission procedures much consideration was given to what tests should be done routinely on admission and on which patients they should be carried out.

Various factors such as degree of urgency of admission, the age of the patient, the time the tests would take to carry them out, the number of admissions per day, the space available for the tests to be carried out in etc, were considered, the final result was that on admission urgent cases would go straight to the Admission Ward. Non urgent cases would go through a modified preadmission centre to their appropriate wards. Blood tests and Chest X-Rays would be performed in this centre. Other investigations were ruled out mainly on a time factor.

OBJECTIVES:

The objectives of the proposed ADP. System are to:-

(i) provide an efficient method of verifying entitlement details of persons seeking admission;

(ii) automatically produce self adhering labels, containing paitient identification, for attachment to clinical records and administrative documents;

(iii) accumulate and produce statistics and listings relating to admissions, discharges, length of stay medical categories etc., as required by management for the optimization of hospital resources;

(iv) maintain timely and accurate bed availability information, including ward work-load indicators and projected vacancies;

(v) provide an automatic review of length of patient stay, particularly in those cases where statutory limits are placed on duration of inpatiency;

(vi) create and maintain accurate in-patient records; which are readily accessible by medical or administrative staff;

(vii) provide basic information for secondary records which initially contain details of diagnostic procedures, e.g. pathological tests, X-rays etc.,

(viii) maintain accurate lists, by surgeon, or patients awaiting admission for elective surgery;

(ix) produce for the RMO preparing the discharge summary, a basic patient summary which includes personal details and a listing of diagnostic procedures undertaken by the Pathology, X-Ray and Biophysics Departments.

Subject to the satisfactory achievement of the above objectives further refinements would be added at later dates.

The Application of the New System at RGH, Concord, and its Application to Multiple Investigations on Admission.

The procedures discussed in Chapter 5 will be applied to patients on admission to RGH (C). Pathology - especially Bio-Chemistry and Haematology - because of the nature of the specimen used and it's availability was the first area developed. This has been the accepted procedure elsewhere in the world where Bio-chemical and Haematology profiles have been produced routinely as admission or pre-admission procedures.

The following tests are now being carried out as a routine procedure on all admissions to RGH (C):-

a) Bio-Chemical Tests (Using a SMA 12/60)

Total Protein	Albumin
Globulin	Calcium
Cholesterol	Creatinine.
Bilirubin	L.D.H.
S.G.O.T.	C.P.K.

The above do not cover all the tests recommended in the test battery drawn up from the Questionnaire as shown on Page 216 of Chapter 3 or the one recommended in Chapter 4, Page 346. However a second SMA 12/60 is being purchased so that an additional series of 12 tests not covered in the above Bio-chemical battery can be carried out as part of the routine procedure.

b) Haematological Tests (Using a Coulter S.)

Haemaglobin	Total White Cell Count	
Red Cell Count	M.C.H.	
M.C.H.C.	M.C.H.V.	Haematocrit.

The above tests do not cover some of the tests recommended in either test battery (pps. 216, 346). A Differential White Cell Count, Blood Group and Rh Factor are not routinely performed. However the series of Haematological tests performed cover a wider range than those recommended in the test battery (P. 346) , but the above three tests should be included.

When the ADP System in Pathology is completed all the tests - Bio-Chemical and Haematological - will be performed as part of the Multiple Investigation of patients on admission to RGH (C).

The Admission Centre will be completed at RGH (C) in 1971. The other tests recommended in the Battery (P. 346) will then probably be performed as part of the Multiple Investigations on patients on admission to this Hospital.

Chapter 4 considers that in the 100 selected cases studied of the 40 cases that did not have their diagnosis confirmed on Day 1 it may have been possible that 40% of these could have been confirmed by Multiple Investigations on admission. In the same series of 100 selected cases, 26 cases had additional diagnosis. Ten of these additional diagnosis may have been made and confirmed on admission by using Multiple Investigations. It is postulated that by using the recommended test Battery (P. 346) in the proposed Admission Centre at RGH (C) then the results indicated in Chapter 4 may become a reality .

APPENDIX. IA

GLOSSARY OF TERMS.

ADP.	Automatic Data Processing
Back-up.	Facilities available in case of system failure.
Batch processing.	The execution of programs serially .
CPU.	Gentral Processing Unit. The arithmetic unit and control circuitry governing the internal operation of the computer.
Check Digit.	One or more digits carried in a field and computed from the remaining digits of the field. The check digit is recomputed during processing and compared with the origianl check digit, thus acting as a check on the remaining digits of the number.
COBOL.	Common Business Oriented Language. A programm-language used for applications of a commercial type.
	That part of a computer used for communication between the operator and the computer.
Core Storage.	A form of high speed storage using magnetic cores situated within the main frame of the computer.
Data Set .	A related set of records.
Deck .	A collection of punched cards.
Direct Access .	A technique associated with the direct address-ing of a record without recourse to searching

APPENDIX IA (contd.)

	for that record.
Disk Storage.	A storage device where information is recorded on flat disks; used for storing direct access records.
Down Time.	The time interval during which a device is malfunctioning.
Edit.	To modify the form or format of data, for example to insert or delete characters.
Enquiry	Used in the sense of interrogation, by means of a routine or program, or stored information accessible to the computer.
Error.	Any discrepancy between a computed, observed or measured quantity and the true, specified or theoretically correct value or condition.
Exception.	Where information does not conform to specified conditions.
File.	See Data Set.
Flow Chart.	A graphical representation of the definition, analysis or solution of a problem, in which symbols are used to represent operations, data, flow equipment etc.
Format.	A specific arrangement of data.
Hardware.	The mechanical, magnetic and electronic components making up a computer.
Input.	Used to describe data being transferred from an external store or peripheral device to an internal store.

APPDENDIX IA.

Interface.	A mode of connection through which control and data impulses pass from the CPU to a peripheral device and vice versa.
Job Restart.	Provision in a program for recovery from an error without abandoning the job.
Justify.	To align a set of characters horizontally into a prescribed format.
Key.	One or more characters wit in an item of data that are used to identify it or control its use.
Keyboard Printee (K.P.).	A combination of keyboard and printer capable of communication with the computer. A high speed printing device capable of printing a complete line simultaneously .
Magnetic Disk.	See Disk Storage.
Magnetic Tape.	A tape with a magnetic surface on which data can be stored serially by selective polarization of portions of the surface.
Master Data Set'	A data set that is either relatively permanent, or that contains relatively permanent data, or that is treated as an authority in a particular job.
Matrix.	An array of any number of dimensions.
Memory.	See Core Storage.
Microsecond.	One millionth of a second.
Millisecond.	One thousandth of a second.
Modem.	A device which modulates and demodulates

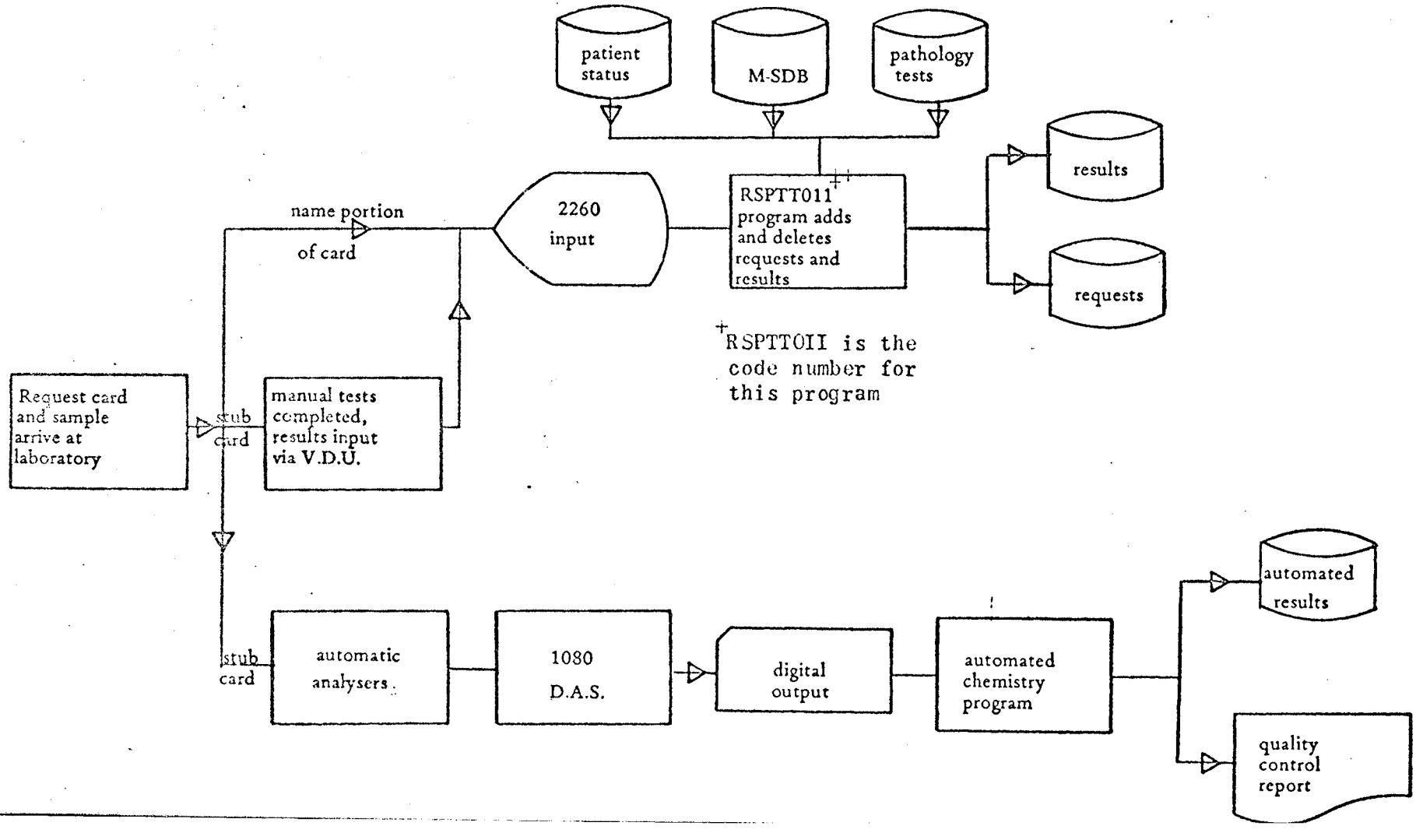
APPENDIX IA (contd)

	signals transmitted over communications facilities
Multiprogramming.	Pertaining to the concurrent execution of two or more programs by a single computer.
Off line.	Pertaining to equipment or devices not under direct control of the CPU.
On line.	Pertaining to equipment or devices under direct control of the CPU.
Serila Matrix Printer (S.M.P.).	A specially designed keyboard printer used as a medium speed remote data communication system printer.
Software.	A set of programs, procedures, rules and possibly associated documentation concerned with operation of a data processing system.
Update.	To apply all additions, deletions and changes to a data set.
Validation.	Computer checking of input data prior to processing to ensure the data falls within defined limits.
Visual Display Unit (V.D.U.).	A combination television-type screen and typewriter keyboard capable of communicating with the computer.
Verify.	To determine whether a transcription of data or other operation has been accomplished accurately.

C5/1/1

APPENDIX 1

PRODUCTION OF RESULTS AND QUALITY CONTROL REPORTS.



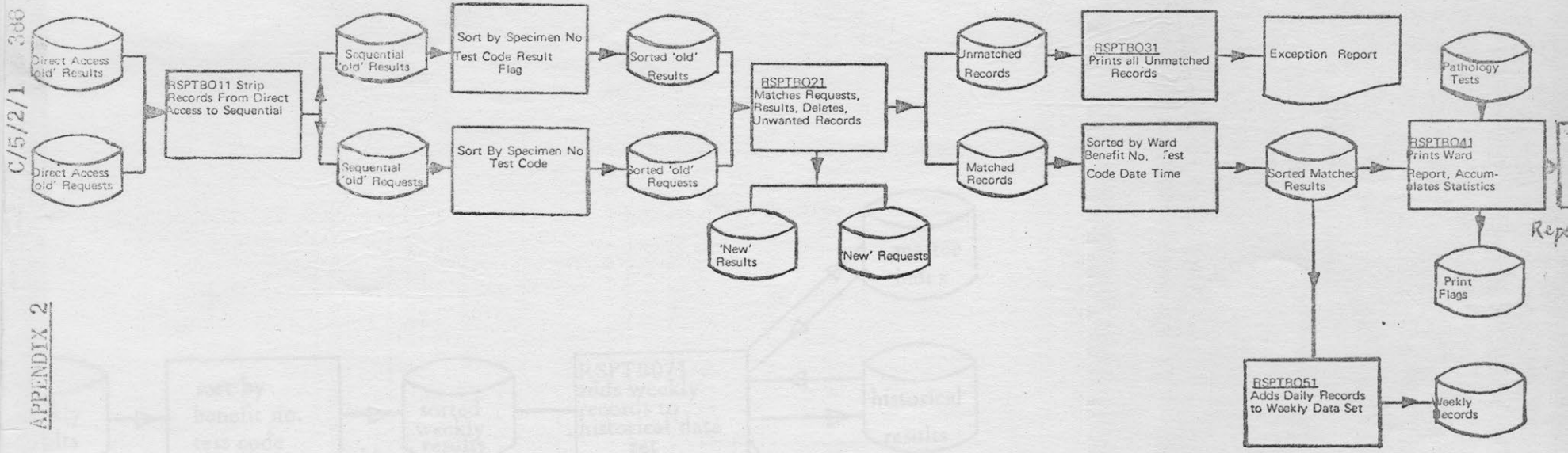
+RSPTTOII is the code number for this program

C/5/2/1 386

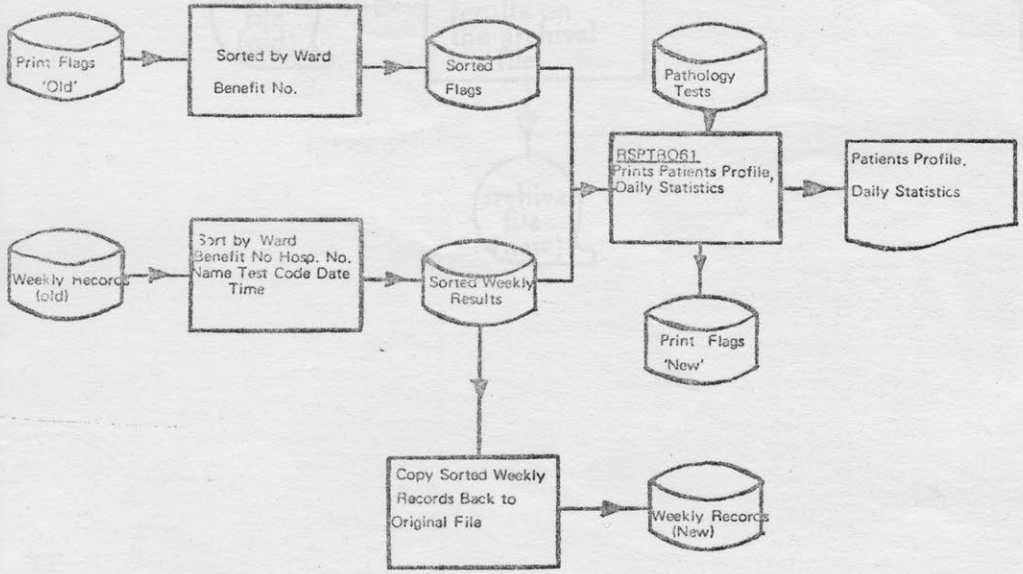
APPENDIX 2

WARD REPORT

PRODUCTION OF WARD REPORTS AND PATIENT PROFILE



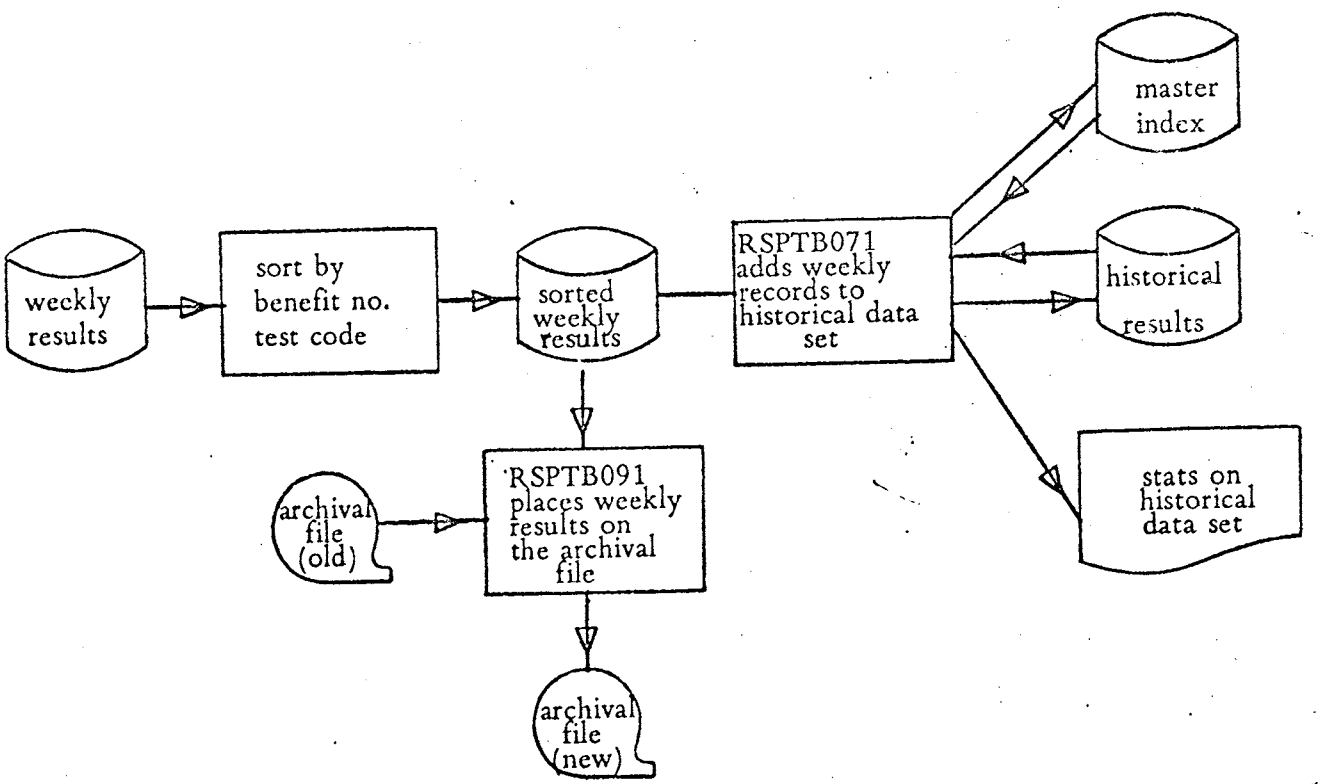
PATIENT PROFILE



APPENDIX 3.

STRIP OF WEEKLY RESULTS FILE.

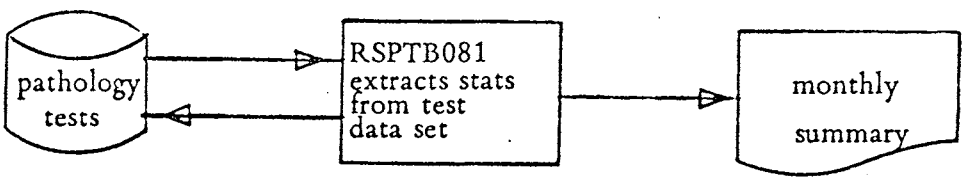
WEEKLY RESULTS - CUMULATIVE REPORTS.



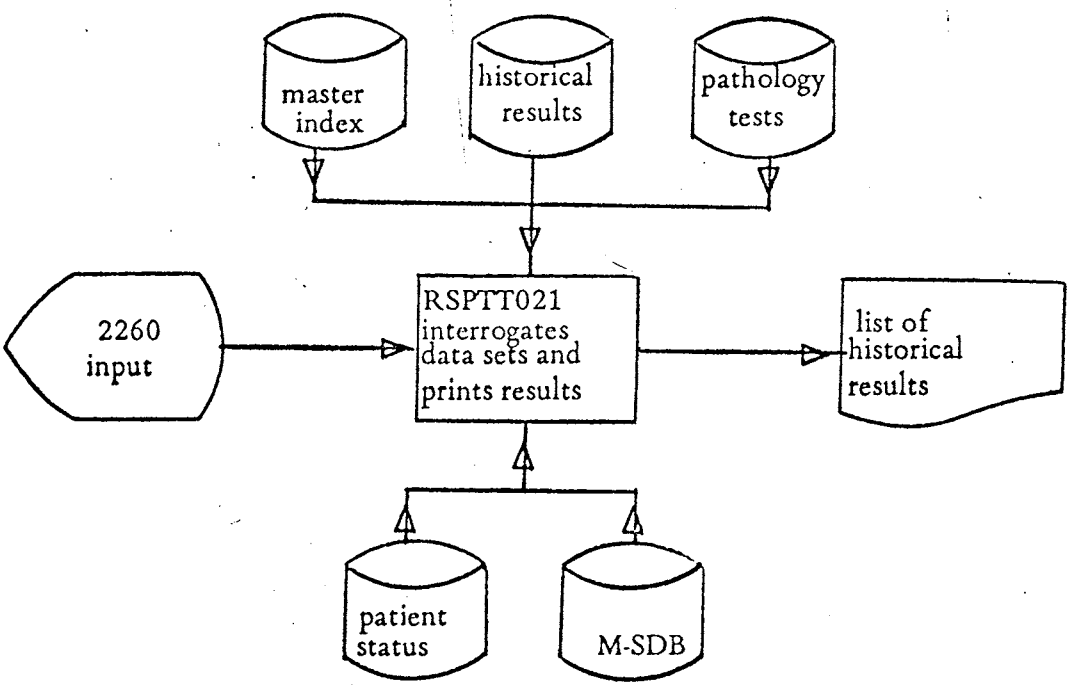
EXTRACTION OF MONTHLY STATISTICS

C5/4/1

APPENDIX 4



APPENDIX 5


master index
historical results
pathology tests
2260 input
RSPTT021 interrogates data sets and prints results
list of historical results
patient status
M-SDB

APPENDIX 6 C5/6/1 392

Nuffield Points are used as a means of comparing the volume of work done in various institutions.
The Points are alloted on a time basis. 1 point for each 10 minutes the test takes.

R.G.H. CONCORD .. PATHOLOGY DEPARTMENT

SUMMARY OF DEPARTMENTAL ACTIVITY - FOUR WEEKS ENDING 28/8/68

DEPARTMENT	TESTS COMPLETED				NUFFIELD POINTS			
	INPATIENTS	OUTPATIENTS	STAFF OP's	TOTAL	INPATIENTS	OUTPATIENTS	STAFF OP's	TOTAL
BIO-CHEMISTRY AUTOMATED TESTS				4,683				4,753
BIOCHEMISTRY	20,184			20,184	40,049			40,049
HAEMATOLOGY	14,670		34	14,704	22,451		61	22,512
HISTOPATHOLOGY	4,660	102		4,762	10,150	234		10,384
MICROBIOLOGY	6,943		7	6,950	11,172		18	11,190
TOTALS	46,457			46,600	83,822	234	79	84,135

APPENDIX 7

BIOCHEMISTRY FRONT CARD

201629

1011 ☐Group B 1147 | Other tests

Na

K

Cl

CO2

BUN

CHEMISTRY

PATIENT LABEL

CLINICAL NOTES

Signature / /19

BIOCHEMISTRY REAR CARD

○ 201629	○ 201629	○ 201629
1011 ☐Group B 1147	other tests	other tests
Na		
K		
Cl		
CO2		
BUN		

Signature / /19

M.O. writes in further chemistry tests required in space provided.

The stubs on the rear card have the number punched in.

HEMATOLOGY FRONT CARD APPENDIX 7 (contd) C5/7/2

6 5 4 3 2 1

1 Group C 5505

HGB MCV MCHC

HCT MCH

PATIENT LABEL

CLINICAL NOTES

UTOMATED HEMATOLOGY

Signature / /19

HEMATOLOGY REAR CARD

6 5 4 3 2 1

1 Group C 5505

HGB MCV MCHC

HCT MCH

This card is for use in Coulter S tests only, a further card will be used for other hematology tests.

WARD G12 CHAPLIN FILE NO. 9X168394 HOSP NO. 26393 24 MAR 70 14:56

TEST	UNITS	SUNDAY 22 MAR	MONDAY 23 MAR	TUESDAY 24 MAR	WEDNESDAY 25 MAR	THURSDAY 26 MAR	FRIDAY 27 MAR	SATURD 28 MAR
SMA-12.SER								
S.G.O.T.	K .	30		36	39		40	
ALK.PHOS	K.A	9		15	14		12	
URIC ACID	MG%	2.5		1.9	2.3		2.9	
PHOSPHATE	MG%	4.9		5.3	5.5		5.1	
CALCIUM	MG%	15.4		14.9	13.6		11.0	
CHOLEST.	MG%	290		**360	*340		*300	
L.D.H	W	15		16	19		14	
BILIRUBIN	MG%	0.5		0.7	0.6		0.6	
PROTEIN	G%	6.9		7.2	7.3		6.6	
ALBUMIN	G%	5.2		15.6	15.4		9.3	
CREATININE	MG%	0.4		0.7	0.6		0.9	
C.P.K.	I.U.	19.6		16.4	16.9		17.3	
SMA-6.ELEC								
SODIUM	MEQ	139	142	140	145		145	
POTASSIUM	MEQ	3.9	3.4	3.6	3.5		3.6	
CHLORIDE	MEQ	100	91	90	94		96	
BICARB	MEQ	27.2	26.4	26.9	26.4		29.0	
UREA	MG%	70	79	76	85		90	
IRON(SER)								
IRON	MIC					16		
L.I.B.C	MIC					20		
T.I.B.C.	MIC					21		
SATURATION	%					51		
FAECES								
FAT	G/24					21.9		
COPROPORPH	MG/G					0.69		
UROPORIH.	MG/G					1.23		
UROBILIN.	MG/G					9.6		

APPENDIX 8.

C5/8/1

REPATRIATION GENERAL HOSPITAL CONCORD

PATHOLOGY DEPARTMENT — PATIENT PROFILE

FILE NO. 9X168394 HOSP NO. 26393 24 MAR 70 14:56

WARD G12 CHAPLIN

TEST	UNITS	SUNDAY 22 MAR	MONDAY 23 MAR	TUESDAY 24 MAR	WEDNESDAY 25 MAR	THURSDAY 26 MAR	FRIDAY 27 MAR	SATU 28 M
HAEMATOLOG								
WBC			32500			32700		
RBC			4600000			4900000		
HGB	GM		14.0			14.4		
HCT	%		39.4			40.2		
MCV	MIC		85			89		
MCA	MMG		30.2			30.5		
MCHC	%		32.5			33.6		

APPENDIX 8 (contd.)

SHORT REPORT FORM

C5/9/1.

APPENDIX 9

PATHOLOGY REPORT

Date /_/_/

SPECIMEN NUMBER	TEST CODE	TEST NAME	RESULT	INITIALS

BIBLIOGRAPHY

1. Whitehead, T.P. — The Use of Laboratory Screening Procedures in Clinical Bio-Chemistry. Bio-Medical Engineering, Oct. 1968.

2. N.H. Kerns — "Casey's Profiles" Expand Diagnostic Role of Pathologist. The Modern Hospital Vol. 108, No. 4. April, 1967.

3. ——— — The Commission on Chronic Illness. Conference on Preventive Aspects of Chronic Disease, 1957, as quoted in (1).

4. Wilson, J.M.G. & Junger, G. — The Principles and Practice of Screening for Disease. World Health Organization, 1967.

5. Eichorn, S. — Moglichkeiten der bessern Organization and Rationalieirung Von Krankenanstalten (Possibilities for improved organization and Rationalization of Hospitals). Osterreichische Krankenhaus-Zeitung. Vol. 8 No. 4, pp. 167-170, 175.-182. Wein, April, 1967.

6. Whitehead, Edwin C. & Khoury Amin. J. — The Role of Multiphasic Screening in the Detection and Prevention of Disease. Technicon Corporation, Tarrytown New York.

7. Skeggs, L.T. Jnr. — Presentdat the Meeting of the International Congress of Clinical Chemists. Barbizon Plaza, New York. 1956.

8. ——— — Technicon Corporation, Ardsley, New York.

9. Forbes, J. — From the works of Edwin C. Whitehead & Amin. J. Khoury. March 15, 1968.

10. Bryan, J.D. — Automation in Analytical Chemistry. Vol. 1., pp 423-426. Mediad Inc. N.Y.C. 1965.

11. Files, James B., Van Peen, Hubert J. Lindberg Donald A.B. — Use of "Normal Range" in Multi-phasic Testing Vol 205 No. 10. Lab. Profiles. JAMA Sept. 2, 1968.

12. C.Z. Williams — Unpublished Thesis.

BIBLIOGRAPHY

13. ———— Daily Test Reports are a Help to Physicians. Montefiore Hospital and Medical Centre Laboratory. Report Sheet. The Modern Hospital Vol 108, No 4. April, 1967.

14. Reece L. Richard — An Analysis of 4000 Chemistry Graphs. Comments on Disease Patterns. Reprinted with permission from the Minnesota Medicine. March, 1968.

15. Rappaport, Arthur E. Gennero, William D. Constandse, William J. — Cybernetics Enters the Hospital Laboratory. The Modern Hospital. Vol. 108, No. 4 April, 1967.

16. MacDonald, L.M. — Computers and Hospitals. A paper presented to the 1967 Residential School, Sydney, in Hospital Administration, Wednesday 11th August, 1967.

17. Brown, P.T.S. — The Computer in Medicine. Data Processing, March-April, 1967.

18. Lindberg, D.A.B., Van Peenen, Files J.B. Lucas, F.V. — Computer Sets Stage for Multi-Testing. The Modern Hospital Vol. 108, No. 4., April, 1967.

19. Lindberg, D.A.B. — The Computer and Medical Care. Springfield Thomas (In Press).

20. Abraham, S. Caceres, C.A. — Statistical Computer Methods for Diagnosis In. K. Enstein (Ed.) Data Acquisition and Processing in Biology and Medicine. pp. 227-284.

21. Rogers, C.A., Balintfy, J.L. & Goldman, A.M. — Computers, Physicians and the Diagnostic Decision Making Process. Human Factors 6: pp. 459-464, October, 1964.

22. Williams, R.J. — Biochemical Individuality John Wiley & Sons Inc. New York, 1956.

23. Baldwin, G., Lamson, Russell, S. William, Glinski, Bernice C. Martz Patricia — A Hospital Wide System for Handling Medical Data. Hospital ADP. Vol. 41, May 1, 1967.

BIBLIOGRAPHY

24. Walsh John. M
Goldblatt Sidney A.
A Punch-Card Laboratory Reporting System with a Cumulative Summary. Format JAMA Vol. 207 No. 9. March 3, 1969.

25. Baird H.W.
Garfunke J.M.
Electronic Data Processing of Medical Records.
New Eng. J. Med. 272: 1211-125
June 10, 1965.

26. Peacock, A.C.
Data Processing in Clinical Chemistry
Clin. Chem II 595-611
May, 1965.

27. Sobota, J.T.
A Data Processing System for Haematology.
American Journal Clin. Path. 44:502-511
November, 1965.

28. Stales L.F.,
Gustafson, C.J.,
Balm, W.A., Tate B.A.
Computer Interpretation of Electro-Cardiograms.
American Heart Journal, Vol. 72.
September 1966.

29. Dowbrow Robert J.,
Fieldman, Arnold,
Page W., Clason C.,
Gorman, Patrick A.,
Reinfrank Ralph F.
Carceres Cesear A.
Transmission of Electrocardiograms from a Community Hospital for remote Computer Analysis.
Amer. Jul. Card. Vol. 21, May 1968.

30. Shoji Yasui, Masashi Yokoi,
Yoshihiko Watanabe,
Kenji Nishijima,
Sadamitsu Azuma, Nobua Aihara,
Noboru Okamoto
Tetsuo Fujion,
Mitsuharu Okajima,
Yasushi Mizuno & Kazuo Yamada.
Computer Diagnosis of Electrocardiograms by means of the Joint Probability.
Japanese Circulation Journal Vol. 32.
April, 1968.

31. Massie E & Walsh T.J.
Clinical Vectorcardiography and Electrocardiography.
Chicago Year Book Medical Publishers Inc. 1960.

32. Grant R.P.
Clinical Electrocardiography, The Spatial Vector Approach.
McGaw Hill Book Co. Inc., New York.
1957.

BIBLIOGRAPHY.

33. Schneider Paul J. Birch, Jr. Alexander A. — Evaluation of Standard ECG Leads for Mass Scanning. JAMA Vol. 204 No. 2. April 18, 1968.

34. Dawber, T.R. — The Electrocardiogram in Heart Disease Detection, Comparison of Multiple and Single Lead Procedures. Circulation 5: 559-566 April, 1952.

35. White, P.D. — Heart Disease, ed. 3. MacMillan & Co., New York, p. 66. 1944.

36. Blackburn H. — Diagnostic Sensitivity and Specificity of the Electrocardiogram in a Random Sample of a Total Population. Circulation 34 (suppl. 3) 57-58. October 1966.

37. Phillips E., Chapman M.M. & Gorke, L.S. — Relative Value of Techniques Used in Detection of Heart Disease. American Heart Journal 45: 319-330 March 1953.

38. Paul, O. — A Longitudinal Study of Coronary Artery Disease. Circulation 28: 20-31. July 1963.

39. Averill K.H. & Lamb L.E. — Electrocardiographic Findings in 67,375 Asymtomatic Subjects: Incidence of Abnormalities. Amer. J. Cardiol 6: 76-83. July, 1960.

40. Manning, G.W. — An Electrocardiographic Study of 17,000 Fit, Young Royal Canadian Air Force Aircrew Applicants. Amer. J. Cardiol. 6: 70-75. July, 1960.

41. Gabriel A. — Analysis of the Electrocardiograms Obtained from 1,000 Young Healthy Aviators. American Heart Journal 27: 524-549. April, 1944.

BIBLIOGRAPHY

42. Blackburn H. — The Electrocardiogram in Population Studies: A Classification System. Circulation 21: 1160-1175. June, 1960.

43. Ostrander, L.D. — Electrocardiographic Findings Among the Adult Population of a Total Natural Community. Circulation 31: 888-898 June, 1965.

44. Rosenman R.H. — A Predictive Study of Coronary Heart Disease: The Western Collaborative Group Study. JAMA 189: 15-22. July 6, 1964.

45. Cooper, J.K. — Role of a Digital Computer in a Diagnostic Centre. JAMA 193: 911-915. September 13, 1965.

46. ———— — Review of Mass Radiography Services. Tubercle, 45.255. London. 1964.

47. Jones J. Spencer — An Investigation in Volunteers Undergoing Mass-Radiography Examinations in the City of Canterbury, 1958. Tubercle 41, 441. London. 1960.

48. Williams R.G. — The Value of Dual Reading in Mass Radiography. Tubercle, 39.367. London. 1958.

49. ———— — Early Diagnosis of Lung Cancer, Leading Articles, 710. British Medical Journal 22 June, 1968.

50. Rosner E., MCDowell L.A. & Cross K.W. — British Medical Journal 21.156 1963.

51. Surprenant Edgar L. Vance John W. — Evaluation of Methods for the Early Detection of Chronic Obstructive Ventilatory Diseases. FCCP Volume 52, No. 6. December 1967.

BIBLIOGRAPHY

52. Barclay, W.R. — The Practicality of Case Finding in Pulmonary Emphysema. American Journal of Public Health 53 (March supplement, Part 11 p. 16.) 1963.

53. R. Schittenhelm — Data Processing Systems in Medicine. Electromedica 3. 1967.

54. Bennett C.H.N. — Production and Efficiency in Medical Laboratories. British Hospital Journal Social Service Review V. 77. 1967.

55. Collin M.F. — The Multi-Test Laboratory is Health Care of the Future Hospitals. J.M.H.A. Vol. 41. May 1, 1967.

56. Hoyt R.S. & Pribor H.C. — Quality Control Saves More Than it Costs. Modern Hospitals Vol. 108 No. 4. April, 1967.

57. Schneider M.A.W. Virille J.C. & Walbruis G. — Automated Acquisition, Screening and Communication of Laboratory Data in a Hospital. World Hospitals Vol. 3. No. 3. July, 1967.

58. Benet W.L. & Hauch J. — A Three Step Plan for Automation. Hospitals J.A.HA. Vol. 41. May 1, 1967.

59. Wartz F.E. — Electronic Data Processing for Hospitals. Hospitals J.A.H.A. May 1, 1962 & May 16, 1962.

60. ———— — Computers Help Evaluate Shock Patients. Modern Hospitals January, 1965.

61. Lane R.A.C. — Success of Shared Facilities Hinges on Adept Planning. Hospitals J.A.H.A. 41:91 May 1, 1967.

62. ——— Automating Biochemical Tests.
Bio-Medical Engineering.
April, 1968.

63. ——— Line 8 Clinical Laboratory System
Bio-Medical Engineering.
January, 1969.

64. ——— Medical Automation.
Data Processing.
March-April, 1967.

65. ——— Punched Cards in the Pathology Laboratory.
Data Processing.
March-April, 1967.

66. ——— SMA 12/60
Technicon Corporation Ardsley/New York.
U.S.A.

67. ——— SMA 6/60
Technicon Corporation Ardsley/New York
U.S.A.

68. ——— SMA 4A/7A
Technicon Corporation Ardsley/New York.
U.S.A.

69. ——— Technilogger II.
Technicon Corporation Ardsley/New York.
U.S.A.

70. Taylor F.P. Automation in Haematology.
Bio-Medical Engineering.
October, 1968

71. ——— Vickers Ltd., Medical Group - Multichannel 300.
Watson Victor Ltd. Sydney.

72. ——— Zymat 340
Bausch and Lamb. New York.

73. ——— Electrocardiographs
Hewlet and Packard. Sydney.

74. ——— Cardiotrace
Watson Victor. Sydney.

BIBLIOGRAPHY.

75. Frank H. & Schuon H. — Fortschritte auf dem Gebiete der Rontgenstrahlen und der Nuklearmedizin 90 392. 1959.

76. Garvagliar C. & Fossati, F. — Radiologica Medica, 44,882. 1958.

77. Enders W. — Tuberkulosearzt, 12, 627. 1958.

78. Cooper J.K. & Caceres C.A. — Transmission of Electrocardiograms to Computers. Milit Med 129: 457-464. May, 1964.

79. Whiteman, J.R. Gorman P.A. Calatayd, J.B. Abraham S. & Caceres, C.A. — Automation of Electrocardiographic Diagnostic Criteria. J.A.M.A. 200: 124. 1967

80. Caceres C.A. — A Basis for Observer Variation in Electrocardiographic Interpretation. Progr. Cardiovas. Dis 5: 521. 1963.

81. Gorman P.A., Calatayd J.B. Abrahan S. & Caceres, C.A. — Observer Variation in Interpretation of the Electrocardiogram. M.Ann. District of Columbia, 33: 97. 1964.

82. Cooper, J.K. — Role of a Digital Computer in a Diagnostic Centre. J.A.M.A. 193: 911-915. September 13, 1965.

83. Balkovic — A Data Communications and Processing System for Cardiac Analysis, AFIPS Conf. Proc. 22:280 December, 1962.

84. Caceres, C.A. — Computer Extraction of Electrocardiographic Parameters. Circulation 25: 356-362. February, 1962.

85. Weihrer A.L, Dobrow R.J., & Caceres C.A. — Pattern Recognition and Identification of Physiological Signals, read before the Second Annual Symposium on Bio-math-

ematics and Computer Sciences in the Life Sciences. Houston, U.S.A. May 13-15, 1964.

86. Wilson, J.M.G. & Jungner, G. — Principles and Practice of Screening for Disease. World Health Organization, Geneva. Public Health Papers No. 34. Pps. 41-43, 143-144.

87. Constance, T. — Personal Communication to author. Consultant Pathologist, Repatriation General Hospital, Concord. Sydney.

88. ——— — Atomspeck, Atomic Absorption Spectrophotometer. Hilger & Watts Ltd.

89. — Adelco 100. Watson Victor Ltd., Sydney

90. Gillam, Robert. — General Consideratinns of Computers in Australian Hospitals. Hospital Administration, Vol. 16 No. 3. March, 1968.

91. Masel, L.F. — The 100 Mirror Camera for Regular Radiography. Australasian Radiology, Vol. ZI, No. 1. February 1967.