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Walter R. Reid

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IMPROVEMENT IN BLOOD TRANSFUSION SERVICE

A DISSERTATION SUBMITTED TO THE
GRADUATE SCHOOL
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REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

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BY

PAUL IRWIN HOXWORTH
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A. B. OHIO STATE UNIVERSITY 1931
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PART I

THE SELECTION OF NATURAL ANTI-A AND ANTI-B TEST SERUMS
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WITH THE DISCOVERY OF THE HUMAN BLOOD GROUPS BY LANDSTEINER¹ AT THE TURN OF THIS CENTURY, THE VAST MAJORITY OF DANGEROUS REACTIONS WERE ELIMINATED AND THE TRANSFUSION OF BLOOD BECAME A RELATIVELY SAFE PROCEDURE. LANDSTEINER OBSERVED THAT THE CELLS OF SOME BLOODS, WHEN PLACED WITH THE SERUMS OF OTHERS, WOULD CLUMP TOGETHER. THIS PHENOMENON WAS CALLED AGGLUTINATION.² THE SERUM FACTOR IN THIS PHENOMENON WAS CALLED THE AGGLUTININ, AND THE CELL FACTOR WAS CALLED THE AGGLUTINOGEN. ON THE BASIS OF THE PRESENCE OR ABSENCE OF SUCH SERUM AND CELL FACTORS ALL HUMAN BLOODS CAN BE CLASSIFIED INTO FOUR GROUPS. LANDSTEINER WAS ABLE TO DIVIDE HUMAN BLOOD INTO THREE GROUPS.³ THE FOURTH AND RAREST GROUP WAS ADDED BY VON DECASTELLO AND STURLI IN 1902.⁴ THREE NOMENCLATURES HAVE BEEN ATTACHED TO THE FOUR GROUPS, THAT OF JANSKY IN 1907, THAT OF MOSS IN 1910, AND THE "INTERNATIONAL" ACCEPTED BY THE HEALTH COMMITTEE OF THE LEAGUE OF NATIONS IN 1927 (TABLE I).

TABLE I

CLASSIFICATION OF BLOOD GROUPS			
INTERNATIONAL	MOSS	JANSKY	
AB	I	IV	
A	II	II	
B	III	III	
O	IV	I	

GROUP AB BLOOD CONTAINS BOTH A AND B AGGLUTINOGENS AND NO AGGLUTININS. GROUP A BLOOD CONTAINS THE A AGGLUTINOGEN AND AGGLUTININ *b*. GROUP B BLOOD CONTAINS THE B AGGLUTINOGEN AND AGGLUTININ *a*. GROUP O BLOOD CONTAINS NO AGGLUTINOGENS AND BOTH *a* AND *b* AGGLUTININS.

BECAUSE OF LANDSTEINER'S OBSERVATIONS WE ARE NOW ABLE TO PREDETERMINE WHETHER OR NOT AGGLUTINATION AND A CONSEQUENT REACTION WILL OCCUR WHEN THE BLOOD OF ONE PERSON IS TRANSFUSED TO ANOTHER. THIS IS DONE BY THE USE OF SERUMS FROM GROUP A AND GROUP B BLOODS AS TEST SERUMS. THE SERUM OF GROUP A BLOOD IS KNOWN AS ANTI-B SERUM AND THAT OF GROUP B BLOOD IS KNOWN AS ANTI-A SERUM. ANTI-B AND ANTI-A SERUMS ARE PLACED ON THE LEFT AND RIGHT ENDS, RESPECTIVELY, OF A GLASS SLIDE. SAMPLES OF THE BLOOD TO BE TESTED ARE PLACED WITH EACH PUDDLE OF TEST SERUM AND OBSERVED FOR AGGLUTINATION. REGARDLESS OF VARIATIONS IN THE TECHNIQUE FOR THIS TEST IN PRESENT USE, THE FOLLOWING INTERPRETATION IS ADVANCED.

IF NO AGGLUTINATION IS NOTED WITH EITHER SERUM, THE BLOOD IS CLASSIFIED AS GROUP O. IF AGGLUTINATION OCCURS WITH THE ANTI-B SERUM ONLY, THE BLOOD IS CLASSIFIED AS GROUP B. IF IT OCCURS WITH THE ANTI-A SERUM ONLY, THE BLOOD IS CLASSIFIED AS GROUP A AND IF IT OCCURS WITH BOTH SERUMS, THE BLOOD IS CLASSIFIED AS GROUP AB.

DESPITE THE ADVENT OF THE KNOWLEDGE OF BLOOD GROUPS AND THE USE OF GROUPING AND COMPATIBILITY TESTS (CF. P. 36) PRIOR TO TRANSFUSION, OCCASIONAL SEVERE REACTIONS DO OCCUR AS

A RESULT OF THE TRANSFUSION OF INCOMPATIBLE BLOOD. THE MORTALITY RATE IN THESE REACTIONS IS APPROXIMATELY 65% (CF. P. 15). SOME OF THE ACCIDENTS MAY BE ATTRIBUTED TO THE FACTOR OF HUMAN ERROR. ONE NEEDS ONLY TO PERUSE THE LITERATURE, HOWEVER, TO REALIZE THAT MANY ARE DUE TO THE FAILURE OF TEST SERUMS IN COMMON USE PROPERLY TO GROUP THE BLOOD OF EITHER THE DONOR OR THE RECIPIENT IN INSTANCES WHERE THE AGGLUTINOGENS ARE UNUSUALLY WEAK. IT IS A WELL RECOGNIZED FACT THAT THERE IS A MARKED VARIATION IN THE POTENCY OF BOTH THE AGGLUTININS AND AGGLUTINOGENS IN THE BLOODS OF DIFFERENT INDIVIDUALS^{5,6,7}. BLOODS DO EXIST IN WHICH THE AGGLUTINOGEN TESTED FOR PRIOR TO TRANSFUSION IS SO WEAK THAT ONLY THE STRONGEST OF TEST SERUMS WILL SHOW DEFINITE CRITERIA OF AGGLUTINATION. THE SAFEGUARD AGAINST ACCIDENTS OF THESE KINDS LIES IN THE USE OF TEST SERUMS OF UNUSUALLY POTENT AGGLUTININ COMPLEMENT, STRONG ENOUGH TO ESTABLISH DEFINITE CRITERIA OF AGGLUTINATION WHEN PLACED WITH ANTI-CELLS OF UNUSUALLY LOW AGGLUTINOGEN COMPLEMENT.

IN 1931 COCA⁸ REVEALED THE INDIFFERENT QUALITY OF COMMERCIAL GROUPING SERUMS AND DEFINED GRADE 1 SERUM AS ONE WHICH WOULD IN A 1:4 DILUTION AGGLUTINATE A 1:4 SALINE SUSPENSION OF SENSITIVE ANTI-CELLS MACROSCOPICALLY IN ONE MINUTE. SINCE THEN MOST COMMERCIAL SERUMS HAVE BEEN LABELED AS CONFORMING TO THIS STANDARD. BECAUSE OF DISSATISFACTION WITH THE TEST SERUMS IN USE AT THE TIME AND THE RESULTS OF THE TITRATIONS OF TWO COMMERCIAL SERUMS AS COMPARED TO COCA GRADE 1 STANDARD (TABLE II), A SEARCH WAS BEGUN FOR HIGH TITERED ANTI-

A AND ANTI-B SERUMS TO BE SELECTED AND USED FOR FUTURE GROUP-
ING TESTS AT THE CINCINNATI GENERAL HOSPITAL.

PROCEDURE

SAMPLES OF BLOOD WERE DRAWN FROM LARGE NUMBERS OF
VOLUNTEERS AND TESTED ACCORDING TO THE COCA METHOD OF SLIDE
TITRATION FOR SERUM AGGLUTININS.⁸ EACH SERUM WAS DILUTED 1:10
WITH NORMAL SALINE. A 1:4 SALINE SUSPENSION OF EACH OF KNOWN
A AND B CELLS WAS MADE. A MEASURED DROP OF EACH OF THE SUS-
PENSIONS WAS ADDED TO A DROP OF EQUAL VOLUME OF EACH DILUTED
ANTI-SERUM ON A GLASS SLIDE. THE TIME TO FIRST MACROSCOPIC
CLUMPING WAS CAREFULLY NOTED IN EACH INSTANCE.

DATA

ANTI-A AND ANTI-B SERUMS WERE FOUND WHICH WOULD,
WHEN DILUTED 1:10 WITH NORMAL SALINE, AGGLUTINATE A 1:4 SUS-
PENSION OF KNOWN SENSITIVE ANTI-CELLS IN 5 SECONDS MACROSCOP-
ICALLY⁹ (TABLE II). THE POTENCY OF THE SERUMS IN FURTHER
DILUTION IS SHOWN IN TABLE III. THE COMPARATIVE TITER OF THE
TEST SERUMS WITH THREE COMMERCIAL SERUMS BOUGHT ON THE OPEN
MARKET IN 1938 IS SHOWN IN TABLE IV. THE METHOD OF SERIAL
TITRATION WAS USED. HERE PROGRESSIVELY DOUBLED DILUTIONS OF
0.2 CC. OF THE SERUMS ARE MIXED WITH A FIXED AMOUNT (0.2 CC.
OF A 2.5 PERCENT SUSPENSION) OF SENSITIVE ANTI-CELLS. THE
TITER OF THE SERUM IS GIVEN BY THE RECIPROCAL OF THE HIGHEST
DILUTION AT WHICH AGGLUTINATION OCCURS AT THE END OF TWO HOURS.

THE TESTS WERE MADE SIMULTANEOUSLY AND THE SAME ANTI-CELL SAMPLES WERE USED AGAINST ALL SERUMS.

TABLE II

		SERUM DILUTION	CELL DILUTION	TIME TO FIRST MACROSCOPIC CLUMPING
GRADE I (COCA)		1-4	1-4	11 SEC.
COMMERCIAL (1)	ANTI-A	1-5	1-4	NO AGGLUTINATION
		NONE	1-4	14 SEC.
	ANTI-B	1-5	1-4	NO AGGLUTINATION
		NONE	1-4	8 SEC.
COMMERCIAL (2)	ANTI-A	1-5	1-4	NO AGGLUTINATION
		NONE	1-4	16 SEC.
	ANTI-B	1-5	1-4	NO AGGLUTINATION
		NONE	1-4	10 SEC.
SERUM AT CINCINNATI GENERAL HOSPITAL	ANTI-A	1-10	1-4	5 SEC.
	ANTI-B	1-10	1-4	5 SEC.

TABLE III

	SERUM DILUTION	CELL DILUTION	TIME TO FIRST MACROSCOPIC CLUMPING
ANTI-A	1-14	1-2	20 SEC.
	1-16	1-2	60 SEC.
ANTI-B	1-14	1-2	15 SEC.
	1-16	1-2	50 SEC.

TABLE IV

SERUM TITRATIONS - AGGLUTINATION AT END OF TWO HOURS										
DILUTION		2	4	8	16	32	64	128	256	512
COMMERCIAL (1)	ANTI-B	+++	++	++	+	±				
	ANTI-A	++	++	+	+	±				
COMMERCIAL (2)	ANTI-B	++ ++	++ ++	+++	+	+				
	ANTI-A	++ ++	+++	+	±					
COMMERCIAL (3)	ANTI-B	++ ++	++ ++	++ ++	++ ++	++ ++	+++	+++	++	+
	ANTI-A	+++	++	+	+	± -				
C.G.H.	ANTI-B	++ ++	++ ++	++ ++	++ ++	++ ++	+++	+++	++	+
AGE 3 MO.	ANTI-A	++ ++	++ ++	++ ++	++ ++	++ ++	+++	++	+	± -

RESULTS

TEST SERUMS OF THIS POTENCY HAVE BEEN ADOPTED FOR REGULAR USE DURING THE PAST FOUR YEARS AT THE CINCINNATI GENERAL HOSPITAL. RELIANCE HAS BEEN PLACED UPON MACROSCOPIC GROUPING (CF. P. 37). IN MORE THAN 12,000 CONSECUTIVE TESTS PRIOR TO TRANSFUSION. A RECHECK ON THE RESULTS OF EACH TEST AT THE END OF FIFTEEN MINUTES HAS BEEN ROUTINE PRACTICE AND IN NO CASE HAS LATER AGGLUTINATION APPEARED WHICH WAS NOT PRESENT DURING THE FIRST ONE MINUTE. FIGURE 1 IS A PHOTOGRAPH WHICH SHOWS GROUP A AGGLUTINATION FIFTEEN SECONDS AFTER ORDINARILY SENSITIVE ANTI-CELLS WERE MIXED WITH THE TEST SERUMS NOW IN USE.

OCCASIONALLY, HOWEVER, CELLS ARE ENCOUNTERED IN WHICH THE AGGLUTINOGEN IS VERY WEAK. THIS IS PARTICULARLY TRUE OF THE A AGGLUTINOGENS IN BLOODS OF GROUPS A₂ AND A₂B.

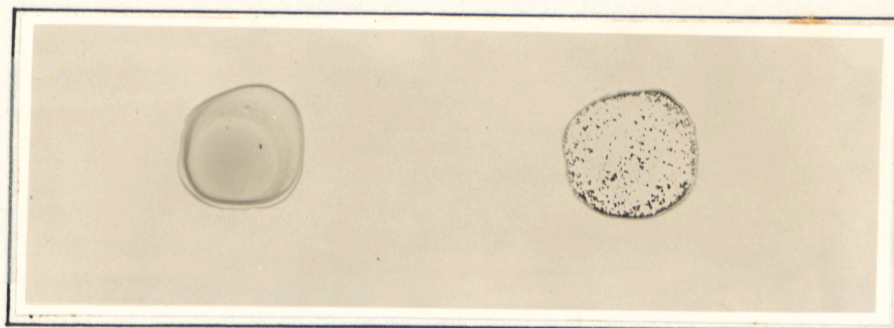


FIG. 1. -- GROUP A AGGLUTINATION FIFTEEN SECONDS AFTER BLOOD WAS MIXED WITH SERUMS.

IN TABLE V THE ACTION OF THREE COMMERCIAL TEST SERUMS IS COMPARED WITH THE ACTION OF ANTI-A SERUM NOW IN USE AT THE CINCINNATI GENERAL HOSPITAL, WHEN PLACED WITH A SAMPLE OF GROUP A CELLS OF LOW AGGLUTINOGEN TITER.

THE NECESSITY FOR USE OF TEST SERUMS OF UNUSUAL AGGLUTININ TITER IN ORDER TO PREVENT ERRONEOUS GROUPING AND CONSEQUENT TRANSFUSION ACCIDENTS CANNOT BE OVERSTRESSED. FURTHER EMPHASIS WILL BE GIVEN TO THIS SUBJECT IN SUCCEEDING PARTS OF THIS REPORT.

THESE SERUMS WERE REGULARLY PROVIDED FOR ALL DEPARTMENTS AT THE CINCINNATI GENERAL HOSPITAL, THE CHILDREN'S HOSPITAL, AND THE CHRISTIAN R. HOLMES HOSPITAL FOR A PERIOD OF THREE YEARS AT A TOTAL COST OF \$200.00 FOR A QUANTITY OF 1500 CC. OF SERUMS USED. THE COST FOR COMMERCIAL TEST SERUMS IN

THE SAME QUANTITY WOULD RANGE FROM \$2250 TO \$6000. BEGINNING DECEMBER 10, 1938 THE SERUMS HAVE BEEN SELECTED IN THE SURGICAL LABORATORIES AT THE CINCINNATI GENERAL HOSPITAL AND ARE

TABLE V

GROUP A ₂ BLOOD WITH CELL FACTOR OF LOW TITER (EQUAL PARTS WHOLE BLOOD AND SERUM)							
ANTI-A COMMERCIAL SERUM	TIME TO MACROSCOPIC AGGLUTINATION IN MINUTES						
	1	2	3	4	5	10	15
1	0	0	0	0	0	0	±
2	0	±	+	+	+	+	++
3	0	0	0	0	±	±	+
C.G.H. ANTI-A SERUM	+	+	++	++	++	++	+++

DISTRIBUTED BY THE WM. S. MERRELL COMPANY ON A NON-PROFIT BASIS THROUGH AGREEMENT WITH THE BOARD OF TRUSTEES OF THE UNIVERSITY OF CINCINNATI. THIS ARRANGEMENT WAS MADE IN ORDER TO INSURE A PERMANENT SUPPLY OF THE TEST SERUMS IN THE FUTURE.

ARTIFICIAL CONCENTRATION OF TEST SERUMS USED IN BLOOD GROUPING¹⁰

FOR THE PAST FOUR YEARS THE SAME TWO DONORS HAVE SUPPLIED ALL THE ANTI-A AND ANTI-B TEST SERUMS USED FOR THE DETERMINATION OF BLOOD GROUPS IN THE UNIVERSITY HOSPITALS. HOWEVER, DONORS WHOSE SERUMS EXCEL THE REQUIREMENTS OF COCA'S GRADE I AND PARTICULARLY THOSE WHO MEET THE ABOVE MENTIONED STANDARDS ARE RARE, AND FINDING THEM IS ACCOMPLISHED ONLY AFTER CONSIDERABLE SEARCH.

CONSEQUENTLY A METHOD FOR CONCENTRATING THE HEMAGGLUTININS IN SERUM IS HIGHLY DESIRABLE TO INSURE AN UNLIMITED FUTURE SUPPLY. ARTIFICIAL CONCENTRATION BY ALTERNATE FREEZING AND THAWING HAS BEEN PROPOSED BY TERRY.¹¹ THE LYOPHILE METHOD OF DRYING SERUM AS REPORTED BY FLOSDORF AND MUDD¹² APPEARED TO US AS A POSSIBLE METHOD FOR ACCOMPLISHING THE SAME PURPOSE. WE HAVE BEEN ABLE TO DRY SERUM BY THIS METHOD AND REDISSOLVE THE RESIDUE IN LESS THAN THE ORIGINAL VOLUME. THE RESULTING PRODUCT WAS FOUND TO HAVE A HEMAGGLUTININ TITER GREATER THAN THE UNPROCESSED SERUM AND TO BE SUITABLE FOR USE AS TEST SERUM.

TECHNIC

UNDER STERILE PRECAUTIONS 200 CC. OF ANTI-B SERUM WAS DRIED BY THE LYOPHILE METHOD. THE SOLID WAS THEN COMPLETELY DISSOLVED IN 50 CC. OF STERILE DISTILLED WATER AND THE SOLUTION WAS FOUND TO CONTAIN ACTIVE ANTI-B HEMAGGLUTININS WHEN PLACED WITH KNOWN SENSITIVE ANTI-CELLS. SAMPLES OF THE UNPROCESSED AND PRO-

CESSED PLASMA WERE THEN COMPARED FOR ANTI-B HEMAGGLUTININ POTENCY ACCORDING TO THE METHOD OF SLIDE TITRATION DESCRIBED BY COCA⁸. THE RESULTS OF THE TITRATIONS ARE GIVEN.

DATA

SERUM WHICH WOULD AGGLUTINATE MACROSCOPICALLY AN EQUAL VOLUME OF ANTI-CELLS IN WHOLE BLOOD IN TWENTY SECONDS WAS PROCESSED, RESULTING IN A SERUM WHICH UNDER THE SAME CONDITIONS AGGLUTINATED THE SAME CELLS IN FOUR SECONDS (TABLE VI).

TABLE VI

COMPARISON OF AGGLUTININ TITER OF PROCESSED AND UNPROCESSED SERUM			
SERUM	AMOUNT, CC.	ANTI CELLS WHOLE BLOOD CC.	MACROSCOPIC AGGLUTINATION TIME
UNPROCESSED	0.05	0.05	20 SECONDS
PROCESSED	0.05	0.05	4 SECONDS
(ONE FOURTH OF ORIGINAL VOLUME)			
PROCESSED	0.05	0.05	20 SECONDS
(REDILUTED TO ORIGINAL VOLUME)			

THIS INDICATES THAT THE HEMAGGLUTININ TITER OF THE SERUM WAS INCREASED IN INVERSE PROPORTION TO THE VOLUME. THE PROCESSED SERUM WAS THEN REDILUTED TO THE ORIGINAL VOLUME AND THE HEMAGGLUTININ POTENCY WAS THE SAME AS THAT OF THE UNPROCESSED SERUM. SIMILAR RESULTS WERE OBTAINED WITH THIS SERUM IN VARIOUS DILUTIONS AND WITH OTHER SERUMS, BOTH AS TO RETENTION OF GROUP

SPECIFICITY AND AS TO THE CONCENTRATION OF AGGLUTININS. IN MOST INSTANCES IT WAS POSSIBLE TO OBTAIN, WITHIN TWO MINUTES, COMPLETE SOLUTION OF THE DRIED PRODUCT IN ONE FIFTH OF THE ORIGINAL VOLUME OF THE SERUM. IMPERFECT DRYING RESULTED IN A GUMMY PRODUCT WHICH RESISTED SOLUTION, AND THE HEMAGGLUTININ ACTIVITY OF THE SUPERNATANT LIQUID WAS MARKEDLY LOWERED OR ABSENT.

SUMMARY AND CONCLUSIONS

UNUSUALLY HIGH TITERED TEST SERUMS MUST BE EMPLOYED IN ORDER TO DETECT CLEARLY WEAK A AND B CELL FACTORS. SERUMS OF INADEQUATE TITER MAY BE ARTIFICIALLY CONCENTRATED BY THE LYOPHILE METHOD. THIS WILL PROVIDE A LESS LIMITED SOURCE OF SUPPLY THAN HAS BEEN PREVIOUSLY AVAILABLE FOR USE IN THE GROUPING OF BLOODS PRIOR TO TRANSFUSION.

THE CAUSE AND PREVENTION OF HEMOLYTIC BLOOD TRANSFUSION REACTIONS

MANY OF THE UNTOWARD ACCIDENTS WHICH FOLLOW THE TRANSFUSION OF INCOMPATIBLE BLOOD ARE OF THE DELAYED OR HEMOLYTIC TYPE, RESULTING FROM HEMOLYSIS OF THE CELLS OF THE DONOR OR THE RECIPIENT IN THE BLOOD STREAM. THE CLINICAL AND PATHOLOGICAL FINDINGS IN CASES OF HEMOLYTIC TRANSFUSION REACTION HAVE BEEN LUCIDLY DESCRIBED BY BORDLEY¹³ AND BY BAKER AND DODDS.²³ THE SYNDROME IS USUALLY CHARACTERIZED BY A SHARP FEBRILE REACTION WITHIN A FEW HOURS OF THE TRANSFUSION. THIS MAY OR MAY NOT BE DISTINGUISHED BY SIGNS OF IMMEDIATE REACTION OR FOLLOWED BY JAUNDICE. HEMOGLOBINURIA AND OLIGURIA OR ANURIA FOLLOW. SUPPRESSION OF URINE CONTINUES FOR SEVERAL DAYS ACCOMPANIED BY SIGNS, SYMPTOMS, AND LABORATORY FINDINGS OF PROGRESSIVE UREMIA. A UREMIC DEATH OCCURS OR A DIURETIC RECOVERY BEGINS ON THE FOURTH TO THE 18TH DAY. THE MORTALITY RATE IS APPROXIMATELY 65 PERCENT IN 42 REPORTED CASES. THE AUTOPSY FINDINGS ARE CENTRAL LOBULAR NECROSIS OF THE LIVER AND PALE EDEMATOUS KIDNEYS WITH DEGENERATIVE CHANGES IN ALL TUBULAR EPITHELIUM.

IT HAS BEEN SHOWN IN THE LABORATORY THAT ISO-HEMOLYSINS CORRESPOND IN SPECIFICITY TO THE ISO-AGGLUTININS WHICH ARE NORMALLY PRESENT IN SERUM. HEMOLYSINS OCCUR IN ABOUT 30 PERCENT OF THE CASES WHERE IT WOULD BE EXPECTED ACCORDING TO THE LANDSTEINER RULE OF THE BLOOD GROUPS, IF FRESH TESTING SERUM IS USED.⁶¹ IF THE TESTING SERUM USED, HOWEVER, HAS BEEN STORED

IN AN ICEBOX FOR ABOUT TWO WEEKS IT WILL BECOME INACTIVATED AS FAR AS HEMOLYSINS ARE CONCERNED.⁶¹ ON THE TEST SLIDE AGGLUTINATION ALWAYS PRECEDES HEMOLYSIS, BUT THE ONE PHENOMENON MAY BE MORE APPARENT THAN THE OTHER. AGGLUTINATION USUALLY PREDOMINATES, BUT IN RARE INSTANCES HEMOLYSIS MAY BE THE MORE PRONOUNCED, PRECEDED ONLY BY A VERY TRANSIENT AGGLUTINATION PHASE. HEMOLYSINS HERE ARE OF PRACTICAL IMPORTANCE BECAUSE THEY MAY MASK TRUE AGGLUTINATION AND LEAD TO ERRORS IN BLOOD GROUPING. IT HAS BEEN SHOWN THAT IT IS THE SERUM FACTOR WHICH DETERMINES THE PREDOMINANCE OF AGGLUTINATION OR HEMOLYSIS WHEN INCOMPATIBLE CELLS ARE ADDED.⁶¹ THEREFORE WE CAN BY THE SELECTION OF A HIGH TITERED TEST SERUM FREE OF HEMOLYSINS PREDETERMINE MOST INCOMPATIBILITIES, WHETHER THE INCOMPATIBILITIES BE AGGLUTINATION OR HEMOLYSIS.

THE PRESENCE OF ATYPICAL AGGLUTININS IN THE SERUM OF EITHER THE DONOR OR THE RECIPIENT WILL BE DETECTED UPON THE CAREFUL PERFORMANCE OF A DIRECT MATCH TEST AFTER THE GROUPS OF THE BLOODS TO BE MIXED IN TRANSFUSION ARE DETERMINED. ATYPICAL AGGLUTININS NOT CONFORMING TO THE BEHAVIOR OF THE BLOOD GROUPS OF LANDSTEINER MUST BE EXTREMELY RARE, SINCE IN THE LAST 3000 CONSECUTIVE BLOODS EXAMINED PRIOR TO TRANSFUSION AT THE CINCINNATI GENERAL HOSPITAL, THERE HAS NOT BEEN A SINGLE INSTANCE IN WHICH THE TWO BLOODS OF THE SAME GROUP DID NOT SHOW PERFECT COMPATIBILITY WHEN THE DIRECT MATCH WAS MADE. FORTYTWO CASES OF HEMOLYTIC TRANSFUSION REACTION ARE ANALYZED IN THE FOLLOWING STUDIES; THE PRESENCE OF ATYPICAL AGGLUTININS

HAS BEEN ADEQUATELY DEMONSTRATED IN ONLY FOUR. IN THIRTY-EIGHT CASES, AS WILL BE SHOWN TO BE TRUE IN THE CASE REPORTED BY McCANDLESS FROM THIS CLINIC, THE ACCIDENTS MAY HAVE RESULTED FROM THE FAILURE OF THE TEST SERUMS IN USE PROPERLY TO DETECT WEAK AGGLUTINOGENS, THEREBY LEADING TO ERRORS IN GROUPING, OR TO ATYPICAL HEMOLYSINS.

IN 1930 BORDLEY¹³ PRESENTED A SERIES OF 17 CASES OF HEMOLYTIC TRANSFUSION REACTION, THREE OF WHICH WERE HIS OWN. McCANDLESS³⁹ COLLECTED NINE ADDITIONAL CASES FROM LATER LITERATURE AND ADDED ONE, MAKING A TOTAL OF 27. FIFTEEN CASES REPORTED SINCE THEN ARE ADDED HERE, MAKING A TOTAL OF 42 CASES IN WHICH LABORATORY DATA ARE ANALYZED. MANY OF THESE CASES ARE ADMITTEDLY DUE TO ERRORS IN GROUPING AND COMPATIBILITY LATER DISCOVERED ON RECHECK BY THE AUTHORS. IF THE CRITERIA OF AGGLUTINATION HAD BEEN MORE PROMPTLY AND CLEARLY DEFINED AT THE TIME OF THE FIRST TEST, MOST OF THESE WOULD HAVE BEEN PREVENTED. IN OTHER CASES RECHECK BY ORDINARY METHODS OF GROUPING AND COMPATIBILITY SHOWS THE DONOR'S AND THE RECIPIENT'S BLOOD TO BE OF THE SAME GROUP. IN THESE INSTANCES THE REACTIONS ARE EITHER UNEXPLAINED OR ATTRIBUTED TO THE PRESENCE OF AGGLUTININS AND HEMOLYSINS WHICH ARE ATYPICAL IN THEIR BEHAVIOR.

WIENER AND PETERS^{53,54} REPORT TWO CASES OF INTRA-GROUP HEMOLYTIC TRANSFUSION REACTION IN WHICH AGGLUTINATION OF THE DONORS' CELLS WITH THE PATIENTS' SERUMS IS DEMONSTRABLE ON

CHILLING BUT NOT AT ROOM TEMPERATURE. FURTHER TESTS OF THESE SERUMS AGAINST CELLS OF GROUP O BLOODS TAKEN AT RANDOM REVEALED AGGLUTINATION REACTIONS COINCIDING WITH THOSE GIVEN BY ANTI-RHESUS IMMUNE RABBIT SERUM AS DESCRIBED BY LANDSTEINER AND WIENER. ON THE BASIS OF THE BEHAVIOUR OF CELLS WHEN PLACED WITH ANTI-RHESUS SERUMS, ALL HUMAN BLOODS ARE CLASSIFIED BY WIENER AS RH+ OR RH-. IN THESE TWO CASES THE HEMOLYTIC TRANSFUSION REACTIONS ARE EXPLAINED BY WIENER AND PETERS AS DUE TO THE TRANSFUSION OF RH+ BLOOD TO INDIVIDUALS WITH RH- BLOOD, RESULTING IN THE FORMATION OF ANTI-RH IMMUNE ANTIBODIES IN THE SERUMS OF THE PATIENTS WHICH HEMOLYSED THE DONORS' CELLS. IN THEIR REPORT METHODS ARE GIVEN FOR THE PREVENTION OF HEMOLYTIC REACTIONS DUE TO RH FACTORS. IN A POSSIBLE HEMOLYTIC TRANSFUSION REACTION WHICH OCCURRED IN THE SERIES OF 3077 TRANSFUSIONS OF BANK BLOOD AT THE CINCINNATI GENERAL HOSPITAL (CF. P. 103), THE BLOOD OF THE RECIPIENT WAS RH+ AND THAT OF THE DONOR WAS RH- AS DETERMINED BY WIENER UPON SAMPLES SENT TO HIM. THE RH COMPLEX COULD NOT THEREFORE HAVE PLAYED ANY PART IN THIS REACTION.

DATA

IN THE FOLLOWING STATISTICAL ANALYSIS OF LABORATORY DATA IN THE 42 CASES REPORTED, TABLES VII TO XIX GROUP THE CASES ACCORDING TO THE DEGREE OF COMPLETENESS WITH WHICH THEY WERE STUDIED FROM THE LABORATORY STANDPOINT. THIS FACILITATES

COMMENT ON THE EVIDENT FACTS. THE NUMBER GIVEN TO EACH CASE CORRESPONDS TO THE REFERENCE NUMBER OF THAT CASE IN THE BIBLIOGRAPHY.

TABLE VII

CASE No.	
16	NO RECORD OF GROUPING OR COMPATIBILITY TESTS BEFORE OR AFTER TRANSFUSION (2 CASES)
21	

COMMENT

IN TWO CASES THERE WAS NO RECORD OF GROUPING OR COMPATIBILITY TESTS HAVING BEEN PERFORMED.

TABLE VIII

ERRORS IN BOTH GROUPING AND COMPATIBILITY FOUND ON RECHECK (7 CASES)		
CASE No.	ERROR	RECHECK
13	A TO A	A TO O
28	O TO O	A TO O
45	O TO O	A TO O
46	O TO O	A TO O
47	O TO O	A TO O
50	O TO O	A TO O
14	O TO O	O TO A

COMMENT

SEVEN WERE ADMITTED BY THE AUTHORS TO BE DUE TO ERRORS IN BOTH GROUPING AND COMPATIBILITY FOUND ON RECHECK. FOUR OF THESE CASES WERE REPORTED IN RECENT LITERATURE AND FROM THE AUTHORS' DESCRIPTION IT IS OBVIOUS THAT MORE IMMEDIATE CRITERIA OF AGGLUTINATION SUCH AS WOULD HAVE BEEN AFFORD-

ED BY THE USE OF TESTING SERUMS OF HIGHER TITER WOULD HAVE
 AVOIDED THESE ACCIDENTS.

TABLE IX

GROUPED AS IDENTICAL PRIOR TO TRANSFUSION AND ON RECHECK. COMPATIBLE BEFORE TRANSFUSION. DONORS' CELLS INCOM- PATIBLE ON RECHECK. (4 CASES)				
CASE No.	GROUP BEFORE TRANSFUSION	RECIPIENT AND DONOR RECHECK	COMPATIBILITY	
			CELLS DONOR, BEFORE	SERUM RECIPIENT RECHECK
*19	0	0	-	
24	0	0	-	
26	0	0	-	
**37	0	0	-	

*AUTHOR BELIEVED HIS ANTI-A TEST SERUM WOULD NOT AGGLUTINATE
 THE CELLS OF THIS "A" DONOR.
 DONOR'S CELLS AGGLUTINATED IN 65 MINUTES ON RECHECK OF COM-
 PATIBILITY.

**SLOW HEMOLYSIS DONOR'S CELLS.

TABLE X

NO GROUPING. COMPATIBLE BEFORE TRANSFUSION. DONOR'S CELLS INCOMPATIBLE ON RECHECK. (2 CASES)	
CASE No.	COMPATIBILITY BEFORE RECHECK
23	-
32	-

TABLE XI

GROUPED BEFORE TRANSFUSION COMPATIBLE BEFORE. DONOR'S CELLS INCOMPATIBLE ON RECHECK. (ONE CASE)		NO RECHECK	
CASE No.	GROUP	COMPATIBILITY DONOR'S CELLS	
51	A TO A	{ BEFORE	-
		{ RECHECK	

COMMENT

THE SEVEN CASES DUE TO ERRONEOUS INTERPRETATION OF COMPATIBILITY TESTS FOUND ON RECHECK MAY HAVE BEEN DUE TO THE FAILURE OF THE TEST SERUM IN USE TO AGGLUTINATE LOW TITERED CELL FACTORS, OR TO ATYPICAL HEMOLYSINS. IT IS SIGNIFICANT THAT IN FOUR OF THESE CASES ALL BLOODS WERE GROUPED AS O. IN NONE OF THE CASES OF THIS GROUP WAS THE TITER OF THE TEST SERUM USED STATED BY THE AUTHORS.

TABLE XII

IDENTICAL GROUPS - RECHECKED. NO COMPATIBILITY TESTS. (TWO CASES)	
CASE No.	GROUP
20	A TO A
44	O TO O

TABLE XIII

GROUP NOT DETERMINED. COMPATIBLE BEFORE TRANSFUSION AND ON RECHECK. (FOUR CASES)				
CASE NO.	DONOR'S CELLS		RECIPIENT'S CELLS	
	PRIOR	RECHECK	PRIOR	RECHECK
22	-	-	-	-
25	-	-	-	-
35	-	-	-	-
52	-	-	-	-
IN EACH OF THESE CASES THE TITER OF TWO UNKNOWN SERUMS WERE DEPENDENT UPON.				

TABLE XIV

ONLY RECIPIENT GROUPED BEFORE TRANSFUSION - NO RECHECK
 COMPATIBLE PRIOR TO TRANSFUSION - NO RECHECK
 (TWO CASES)

CASE No.	GROUP	RECIPIENT	DONOR'S CELLS	COMPATIBILITY RECIPIENT'S CELLS
15		O	-	-
43		O	-	-

TABLE XV

CASE No. 17	NO RECORD GROUPING. BOTH R. AND D. CELLS COMPATIBLE. NO RECHECK.
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COMMENT

IN NINE CASES THE ORDINARY PRECAUTIONS OF PERFORMING BOTH GROUPING AND COMPATIBILITY TESTS PRIOR TO TRANSFUSION WERE NOT OBSERVED. GROUPING ONLY WAS DONE IN TWO OF THESE CASES (TABLE XII). IN SEVEN, ONLY COMPATIBILITY TESTS WERE MADE AND HERE THE TITER OF AN UNKNOWN TEST SERUM WAS DEPENDED UPON. THE TITERS OF THE TEST SERUMS WERE NOT STATED IN THOSE CASES WHICH WERE GROUPED.

TABLE XVI

GROUPS DETERMINED BEFORE TRANSFUSION - NO RECHECK
 COMPATIBLE BEFORE TRANSFUSION - NO RECHECK
 (THREE CASES)

CASE No.	GROUP	DONOR'S CELLS	COMPATIBILITY RECIPIENT'S CELLS
18	"SAME GROUP"	-	-
27	A TO A	-	-
48	O TO O	-	-

COMMENT

THESE THREE CASES MAY BE SUBJECTED TO THE SAME CRITICISM AS THOSE OF TABLE XIX.

TABLE XVII

"UNIVERSAL" DONOR EMPLOYED. DONOR'S CELLS COMPATIBLE.
(ONE CASE)

CASE No.	GROUP RECIPIENT	GROUP DONOR
*42	AB	O

* a AGGLUTININ OF DONOR POTENT IN 1:80 DILUTION. IN THIS INSTANCE THE USE OF A GROUP A OR B DONOR WITH A LOW TITERED SERUM FACTOR WOULD HAVE AVOIDED THE REACTION.

COMMENT

THIS CASE WAS REPORTED IN THE RECENT LITERATURE AND WAS ADMITTEDLY DUE TO THE INDISCRIMINATE USE OF A UNIVERSAL DONOR. THE ROUTINE USE OF THE COCA COMPATIBILITY TEST, AS DESCRIBED LATER IN THIS REPORT AS A METHOD FOR DIRECT MATCHING, AVOIDS SUCH A POSSIBILITY AS OCCURRED HERE. THE FACT THAT THE AGGLUTININS IN THE DONOR'S SERUM WERE POTENT IN A 1:80 DILUTION MEANS THAT A MARKED INCOMPATIBILITY WOULD HAVE REVEALED ITSELF IN THIS QUANTITATIVE TEST.

TABLE XVIII

CASE No.	
40	IDENTICAL GROUPS (O) RECHECKED. ATYPICAL AGGLUTININ DEMONSTRATED IN SERUM OF RECIPIENT.
41	IDENTICAL GROUPS (B). ATYPICAL AGGLUTININ DEMONSTRATED IN SERUM OF DONOR.
53	IDENTICAL GROUPS (O). ATYPICAL AGGLUTININ (ANTI-RH) DEMONSTRATED IN SERUM OF RECIPIENT.
54	IDENTICAL GROUPS (A). ATYPICAL AGGLUTININ (ANTI-RH) DEMONSTRATED IN SERUM OF RECIPIENT.

COMMENT

IN FOUR CASES ATYPICAL AGGLUTININS WERE ADEQUATELY DEMONSTRATED. THE USE OF A COMPATIBILITY TEST PRIOR TO THE TRANSFUSION, INSTEAD OF RELYING SOLELY UPON THE GROUPING TEST, MAY HAVE PREVENTED THE GIVING OF TWO OF THESE TRANSFUSIONS. THE OTHERS COULD HAVE BEEN AVOIDED BY THE METHOD SUGGESTED BY WIENER.^{53,54}

TABLE XIX

GROUPED AS IDENTICAL PRIOR TO TRANSFUSION AND ON RECHECK. COMPATIBLE BEFORE AND ON RECHECK. (NINE CASES)	
CASE No.	GROUP
29	?
30	O TO O
31	A TO A
33	?
34	O TO O
36	O TO O
38	O TO O
*39	O TO O
49	O TO O

*CINCINNATI GENERAL HOSPITAL

COMMENT

NINE CASES WERE LISTED AS UNEXPLAINED BECAUSE IN EACH ONE THE BLOODS OF THE DONOR AND THE RECIPIENT WERE GROUPED AND MATCHED BOTH PRIOR TO AND AFTER TRANSFUSION. THEY WERE FOUND TO BE OF THE SAME GROUP AND COMPATIBLE EACH TIME. IN EACH OF THESE REPORTS THE AUTHORS DID NOT DISCUSS THE TITER OF THE TEST SERUMS USED AND NONE OFFERED EVIDENCE TO CONTRADICT THE EXPLANATION OF A LOW TITERED CELL FACTOR THAT THE TEST SERUMS USED IN THESE CASES MAY HAVE FAILED TO SHOW THE TRUE GROUP OF THE BLOOD DUE TO WEAK AGGLUTINOGENS IS INDICATED BY THE FACT THAT IN ALL EXCEPT THREE CASES, THE BLOODS WERE GROUPED AS O. (THE GROUP WAS NOT STATED IN TWO REPORTS). CASE No. 39 REPORTED BY H. G. MCCANDLESS BELONGS TO THIS GROUP. THE CLINICAL PICTURE WAS TYPICAL OF A HEMOLYTIC BLOOD TRANSFUSION REACTION.

THIS PATIENT, SUFFERING FROM SEVERE SHOCK AS A RESULT OF EXTERNAL HEMORRHAGE, WAS TRANSFUSED SHORTLY AFTER ADMISSION TO THE HOSPITAL. THE BLOOD GROUPS OF THE DONOR AND THE PATIENT WERE PREDETERMINED AS GROUP O. THE TEST SERUMS USED WOULD AGGLUTINATE ORDINARILY SENSITIVE ANTI-CELLS READILY AND WERE IN ROUTINE USE AT THAT TIME FOR THE TESTING OF BLOODS PRIOR TO TRANSFUSION IN ALL CASES ON THE SURGICAL SERVICE AT THE CINCINNATI GENERAL HOSPITAL. A DIRECT MATCH OF THE DONOR'S AND PATIENT'S BLOODS SHOWED NO AGGLUTINATION AT THE END OF ONE-HALF HOUR. FIVE HUNDRED CC. OF CITRATED BLOOD WAS TRANSFUSED. THE PULSE RATE THROUGHOUT THE TRANSFUSION WAS 88. THE PATIENT

MADE NO COMPLAINT AND SHOWED NO SIGNS OF WHAT MIGHT BE INTERPRETED AS AN IMMEDIATE REACTION. THE PATIENT VOIDED FOR THE FIRST TIME 50 HOURS AFTER THE TRANSFUSION. THERE WERE NO SIGNS OF A DISTENDED BLADDER IN THE INTERVAL. THE INITIAL AMOUNT VOIDED WAS 500 CC. AND THE URINE WAS REDDISH-BLACK IN COLOR. FORTY-EIGHT HOURS LATER THE PATIENT AGAIN VOIDED 500 CC. OF REDDISH-BROWN URINE. ON THE NEXT DAY, FOUR DAYS AFTER THE TRANSFUSION OF BLOOD, THE PATIENT VOMITED 500 CC. OF GREENISH MATERIAL AND PASSED 175 CC. OF REDDISH-BROWN URINE. THE BLOOD UREA NITROGEN ON THIS DAY WAS 100 MGS. PERCENT AND THE CARBON DIOXIDE COMBINING POWER WAS 31 VOLUMES PERCENT. DURING THE NEXT FIVE DAYS, COINCIDENT WITH A RISE IN THE BLOOD UREA NITROGEN TO 165 MGS. PERCENT AND A FALL IN THE CARBON DIOXIDE COMBINING POWER TO 17 VOLUMES PERCENT, THE PATIENT WAS FREE OF ANY SUBJECTIVE COMPLAINTS, EXCEPT FOR OCCASIONAL VOMITING, BUT DEVELOPED SIGNS OF INCREASING EDEMA INVOLVING HIS LOWER EXTREMITIES, BACK, AND LOWER ABDOMEN. ASCITES AND A MODERATE RIGHT HYDROTHORAX DEVELOPED. INCREASED URINARY OUTPUT BEGAN ON THE SIXTH DAY WITH A GRADUALLY INCREASING DAILY OUTPUT UP TO AS MUCH AS 3500 CC. IN 24 HOURS. COINCIDENT WITH THE DIURESIS CAME RECOVERY. THE EDEMA DISAPPEARED, THE ASCITES AND HYDROTHORAX CLEARED AND THE BLOOD UREA NITROGEN AND CO₂ COMBINING POWER CAME TO A NORMAL LEVEL 7 DAYS AFTER THE ONSET OF POLYURIA. EIGHT DAYS AFTER THE FIRST AND ONLY BLOOD TRANSFUSION GIVEN TO THIS PATIENT, SAMPLES OF BLOOD FROM THE DONOR AND THE PATIENT WERE TAKEN AND AGAIN

GROUPED AS O. A RECHECK ON THE BLOOD GROUPS OF THESE TWO PEOPLE WAS ALSO MADE TWELVE DAYS AFTER THE TRANSFUSION. THE SAME TEST SERUMS WERE USED IN BOTH RECHECKS AS WERE USED IN THE ORIGINAL TEST. DIRECT MATCH DURING THE RECHECK EXAMINATIONS SHOWED NO CROSS AGGLUTINATION AT THE END OF EIGHT HOURS.

IN HIS REPORT, McCANDLESS CONCLUDED THAT THIS HEMOLYTIC TRANSFUSION REACTION WAS DUE TO AN ANOMALOUS OR ATYPICAL HEMOLYSIN PRESENT IN THE SERUM OF THE RECIPIENT WHICH DID NOT OBEY THE RULE OF THE LANDSTEINER BLOOD GROUPS AND CAUSED HEMOLYSIS OF THE DONOR'S CELLS IN THE RECIPIENT'S BLOOD STREAM.

TWO YEARS LATER, AFTER THE SELECTION AND ADOPTION FOR ROUTINE USE OF UNUSUALLY HIGH TITERED ANTI-A AND ANTI-B TEST SERUMS IN THE GROUPING OF BLOOD PRIOR TO TRANSFUSION (CF. P. 9), THE BLOODS INVOLVED IN McCANDLESS' CASE WERE RE-STUDIED. THE BLOOD OF THE PATIENT WAS GROUPED AS O, SHOWING NO AGGLUTINATION WITH EITHER THE ANTI-A OR ANTI-B TEST SERUM. THE BLOOD OF THE DONOR WAS GROUPED AS A, AGGLUTINATION OCCURRING WITH THE ANTI-A TEST SERUM IN 50 SECONDS TO SUCH A MARKED DEGREE THAT IT COULD BE SEEN READILY WITH THE NAKED EYE. ORDINARILY SENSITIVE GROUP A CELLS SHOWED THE SAME DEGREE OF AGGLUTINATION WHEN PLACED WITH THIS TEST SERUM IN LESS THAN FIVE SECONDS. A DIRECT MATCH BETWEEN THE DONOR'S AND THE PATIENT'S BLOODS SHOWED NO CROSS AGGLUTINATION AT THE END OF EIGHT HOURS.

ON THE BASIS OF THESE FINDINGS, ONE CAN ONLY CONCLUDE THAT THE CAUSE FOR THIS HEMOLYTIC TRANSFUSION REACTION WAS NOT AN ATYPICAL HEMOLYSIN IN THE SERUM OF THE BLOOD OF THE RECIPIENT. THE CAUSE WAS THE FAILURE OF A TEST SERUM WHICH HAD PROVED SATISFACTORY IN THE GROUPING OF THE USUAL BLOODS PROPERLY TO GROUP THE BLOOD OF THE DONOR. THE AGGLUTININ IN THE SERUM OF THE RECIPIENT ALSO FAILED TO AGGLUTINATE THE ANTICELLS IN THE BLOOD OF THE DONOR. THIS EXPLAINS THE ABSENCE OF AGGLUTINATION IN A DIRECT MATCH BETWEEN THE TWO BLOODS CONCERNED. THE AGGLUTINOGEN A PRESENT IN THE DONOR'S BLOOD CELLS WAS OF SUCH LOW TITER THAT IT COULD ONLY BE SHOWN WITH TEST SERUMS OF UNUSUALLY HIGH TITER.

SUMMARY AND CONCLUSIONS

ALTHOUGH THE EXPLANATION FOR THE CAUSE OF THE HEMOLYTIC TRANSFUSION REACTION IN McCANDLESS' CASE IS NOT THE EXPLANATION FOR THE REACTIONS IN ALL OF THE 42 CASES ANALYZED ABOVE, IT IS SIGNIFICANT THAT THE TITER OF THE TEST SERUM USED WAS NOT REPORTED IN 40 OF THE 42 CASE REPORTS. THE FREQUENCY OF THE OCCURRENCE OF BLOOD GROUP O IN BOTH THE PATIENT AND THE DONOR IN THESE CASE REPORTS IS ALSO SIGNIFICANT, BECAUSE IT IS IN GROUP O BLOODS ONLY THAT NO AGGLUTINATION OCCURS WHEN ANTI-A AND ANTI-B TEST SERUMS ARE PLACED WITH THE CELLS OF THESE BLOODS.

THE BLOOD GROUP OF McCANDLESS' DONOR PROVED TO BE OF

SUB-GROUP A₂ AS MIGHT BE EXPECTED SINCE THE AGGLUTINOGENS OF THIS SUB-GROUP ARE KNOWN TO BE WEAK. THE SIGNIFICANCE OF SUB-GROUPS A₁ AND A₂ IN TRANSFUSION REACTIONS IS CONSIDERED IN SUCCEEDING PAGES (CF. P. 30).

CERTAINLY THE EVIDENCE PRESENTED INDICATES THAT TEST SERUMS FREQUENTLY ACCEPTED AS ADEQUATE IN MANY HOSPITALS FOR GROUPING THE USUAL BLOOD LACK THE NECESSARY POTENCY FOR GROUPING THE UNUSUAL BLOOD IN WHICH THE AGGLUTINOGEN IS OF EXTREMELY LOW TITER. SUCH ERRORS WILL BE DETECTED BY COMPATIBILITY TESTS ONLY IF THE ANTI-SERUMS ARE BY CHANCE OF HIGH POTENCY.

ATYPICAL AGGLUTININS WHICH DO NOT CONFORM TO THE BEHAVIOUR OF AGGLUTININS a AND b OCCUR RARELY. BEFORE ANY HEMOLYTIC TRANSFUSION REACTION IS ATTRIBUTED TO SUCH A QUALITATIVE FACTOR, THE BLOODS CONCERNED SHOULD BE SUBJECTED TO AN ADEQUATE STUDY FROM THE QUANTITATIVE STANDPOINT. WEAK AGGLUTINOGENS WILL BE DETECTED BY TESTING WITH SERUMS OF HIGH AGGLUTININ POTENCY.

THE ROLE OF SUB-GROUPS A_1 AND A_2 IN TRANSFUSION REACTIONS

IN 1910 VON DUNGERN AND HIRSCHFIELD⁵⁵ SHOWED THAT, WHEN A GROUP B SERUM WAS ABSORBED WITH GROUP A CELLS, THE GROUP B SERUM LOST ITS POWER TO AGGLUTINATE SOME GROUP A CELLS, BUT RETAINED ITS POWER TO AGGLUTINATE OTHERS. ON THE BASIS OF THESE OBSERVATIONS, THEY SUGGESTED A SUBDIVISION OF GROUP A INTO GROUP A_1 AND A_2 AND OF GROUP AB INTO GROUPS A_1B AND A_2B . THESE OBSERVATIONS WERE LATER CONFIRMED AND SUBSTANTIATED BY MANY OTHER WORKERS. IN THE RECENT LITERATURE CERTAIN AUTHORS^{56,57} HAVE CONTENDED THAT THE SUB-GROUPS OF A MAY BE RESPONSIBLE FOR TRANSFUSION REACTIONS FOR THE FOLLOWING TWO REASONS: (1) BECAUSE THEY MAY BE INCOMPATIBLE WITH EACH OTHER; (2) BECAUSE THE SUB-GROUPS A_2 AND A_2B ARE CHARACTERISTICALLY WEAK IN AGGLUTINOGEN A AND MAY NOT BE DETECTED EXCEPT WITH TEST SERUMS OF UNUSUALLY HIGH ANTI-A TITER. THERE IS NO DIFFERENCE IN OPINION AMONG OBSERVERS ABOUT THE LATTER FACTOR PLAYING A PART IN TRANSFUSION ACCIDENTS. WITHOUT TEST SERUM OF UNUSUALLY HIGH TITER, BLOOD OF GROUP A_2 IS FREQUENTLY ERRONEOUSLY GROUPED AS O BECAUSE OF THE FAILURE OF THE A CELLS TO AGGLUTINATE, AND GROUP A_2B IS FREQUENTLY ERRONEOUSLY GROUPED AS B FOR THE SAME REASON. OBVIOUSLY SUCH ERRORS IN GROUPING MAY NOT BE REVEALED BY COMPATIBILITY TESTS, FOR THE SAME REASON THAT THE BLOODS WERE ERRONEOUSLY GROUPED. THAT IS, THE ANTI-A AGGLUTININ IN THE GROUP O OR GROUP B BLOOD WITH WHICH THE DIRECT MATCH WAS MADE

WOULD NOT BE SUFFICIENTLY POTENT TO CAUSE AGGLUTINATION AND THE DIRECT MATCH WOULD BE READ AS COMPATIBLE. REPORTS OF MISTAKES OF THIS KIND ARE FREQUENT IN THE LITERATURE. THE CASE ERRONEOUSLY REPORTED BY MCCANDLESS AS DUE TO AN ATYPICAL HEMOLYSIN IS AN EXAMPLE FROM THE CINCINNATI GENERAL HOSPITAL (CF. P. 25).

THERE IS MUCH DOUBT, HOWEVER, CONCERNING THE OPINION THAT INCOMPATIBILITY BETWEEN GROUPS A_1 AND A_2 AND GROUPS A_1B AND A_2B MAY BE RESPONSIBLE FOR TRANSFUSION REACTIONS. SOME WRITERS^{58,59} SAY THAT THE DIFFERENCE BETWEEN A_1 AND A_2 IS ONLY QUANTITATIVE AND NOT QUALITATIVE AND THAT THE A_2 FACTOR IS MERELY WEAKER THAN A_1 . THEY SUPPORT THEIR ARGUMENT WITH THE FACT THAT ALL ANTI-A AGGLUTININ MAY BE WASHED FROM A GIVEN SERUM IF SUFFICIENT A_2 CELLS ARE ADDED, ALTHOUGH IT MAY TAKE A MUCH GREATER QUANTITY OF A_2 CELLS TO ABSORB THE SERUM.

THOSE AUTHORS WHO CONTEND THAT THERE IS A QUALITATIVE DIFFERENCE BETWEEN A_1 AND A_2 OFFER THE FOLLOWING EVIDENCE TO SUPPORT THEIR CONTENTIONS. DEGOWIN⁶⁰ LISTS THREE FATAL TRANSFUSION REACTIONS IN PATIENTS OF GROUP A GIVEN TRANSFUSIONS WITH BLOOD OF THE SAME GROUP. ANOTHER OF DEGOWIN'S PATIENTS RECEIVED FIVE BLOOD TRANSFUSIONS; THE PATIENT WAS A GROUP A; ALL FIVE DONORS WERE GROUP A; REACTION FOLLOWED THE FIRST THREE TRANSFUSIONS AND NONE FOLLOWED THE NEXT TWO. THIS IS NOT NECESSARILY EVIDENCE OF INCOMPATIBILITY BETWEEN SUB-GROUPS OF A. THE REACTIONS SUCH AS HE DESCRIBES, CHILLS AND FEVER, ARE FREQUENTLY OBSERVED BETWEEN MEMBERS OF OTHER GROUPS AND EVEN

WITH THE INTRAVENOUS INJECTION OF GLUCOSE OR SALINE SOLUTION.

BLINOW⁵⁷ REPORTS A HIGHER INCIDENCE OF TRANSFUSION REACTIONS BETWEEN MEMBERS OF BLOOD GROUP A THAN BETWEEN MEMBERS OF OTHER GROUPS. HE ALSO ANALYZED THE SUB-GROUPS AND NOTED INSTANCES WHERE PATIENTS OF GROUP A₁ RECEIVED GROUP A₁ BLOOD WITHOUT REACTION, BUT HAD REACTIONS REGULARLY WHEN BLOOD OF SUB-GROUP A₂ WAS TRANSFUSED. BLINOW TOO NOTED REACTIONS OF MILD AND MODERATE SEVERITY CHARACTERIZED BY CHILLS AND FEVER WHEN THE SUB-GROUPS OF THE DONOR AND THE RECIPIENT WERE IDENTICAL.

SEVERAL WRITERS⁶² SUPPORT THEIR CONTENTION OF THE QUALITATIVE DIFFERENCE BETWEEN THE SUB-GROUPS OF A BY THE FACT THAT THEY HAVE BEEN ABLE OCCASIONALLY TO DEMONSTRATE AGGLUTININ a₁ IN SUB-GROUP A₂ AND AGGLUTININ a₂ IN SUB-GROUP A₁. AGGLUTININ a₁ AGGLUTINATES THE CELLS OF SUB-GROUP A₁ AND A₁B. AGGLUTININ a₂ IS VERY RARE ACCORDING TO THESE AUTHORS AND WILL AGGLUTINATE THE CELLS OF A₂ AND A₂B AND, IN ADDITION, WILL AGGLUTINATE THE CELLS OF O. THESE WORKERS ONLY IN RARE INSTANCES HAVE BEEN ABLE TO DEMONSTRATE THIS PHENOMENON AT ROOM TEMPERATURE AND ONLY IN EVEN RARER INSTANCES HAVE THEY BEEN ABLE TO DEMONSTRATE IT AT BODY TEMPERATURE. THERE ARE VARIOUS THEORIES FOR THE EXPLANATION OF THESE PHENOMENA, NOTABLY BY THOMPSEN, LANDSTEINER, LEDERER, AND WIENER⁶¹, AND THE STUDY OF THESE FACTORS IS UNDERGOING CONSIDERABLE INVESTIGATION AT THE PRESENT TIME.

EVIDENCE TO SUPPORT THE CONTENTION THAT TRANSFUSION

REACTIONS RESULT FROM INCOMPATIBILITY BETWEEN THE SUB-GROUPS OF A APPEARS TO BE INADEQUATE. THE MILD AND MODERATELY SEVERE REACTIONS CHARACTERIZED ONLY BY CHILLS AND FEVER, AT THE CINCINNATI GENERAL HOSPITAL, OCCUR JUST AS OFTEN BETWEEN MEMBERS OF OTHER GROUPS AS BETWEEN MEMBERS OF GROUP A. TO CONCLUDE THAT REACTIONS OF THIS NATURE ARE DUE TO INCOMPATIBILITIES BETWEEN SUB-GROUPS A_1 AND A_2 IS AGAIN HARDLY JUSTIFIED, SINCE THEY DO OCCUR FOLLOWING THE INTRAVENOUS ADMINISTRATION OF SALINE AND GLUCOSE SOLUTIONS. THEY MAY BE ATTRIBUTABLE TO VARIOUS FACTORS, SUCH AS CONTAMINANTS FROM GLASSWARE, RUBBER TUBING AND CITRATE, PYROGENIC SUBSTANCES, AND INCIPIENT COAGULATIVE CHANGES IN BLOOD. THE DEMONSTRATION OF INCOMPATIBLE AGGLUTININS BETWEEN GROUP A_1 AND GROUP A_2 BLOODS IS ONLY EVIDENCE ON A GLASS SLIDE AND, AS THESE AGGLUTININS SHOW DEFINITE RELATIONSHIP TO COLD AGGLUTININS, THEY MIGHT WELL HAVE NO SIGNIFICANCE IN TRANSFUSION REACTIONS.

IT CAN BE STATED THAT, DESPITE ARGUMENTS FOR INCOMPATIBILITY BETWEEN GROUP A_1 AND GROUP A_2 BLOODS AND THEIR RESPONSIBILITY FOR TRANSFUSION REACTION, THERE IS NOT A SINGLE REPORT IN THE LITERATURE WHERE SLIDE EVIDENCE OF INCOMPATIBILITY BETWEEN MEMBERS OF SUB-GROUP A_1 AND SUB-GROUP A_2 BLOODS HAS BEEN DEMONSTRATED EITHER BEFORE OR AFTER A SEVERE OR FATAL HEMOLYTIC REACTION HAS OCCURRED AS THE RESULT OF THE TRANSFUSION. DEGOWIN AND OTHERS HAVE RECORDED CASES OF SLIDE EVIDENCE OF INCOMPATIBILITY FOLLOWING SEVERE AND FATAL REACTIONS BETWEEN MEMBERS OF GROUP A, BUT THERE IS NO REPORT OF THE SUB-

GROUPS INVOLVED. HEMOLYTIC TRANSFUSION REACTIONS BETWEEN MEMBERS OF OTHER GROUPS WHICH ARE IDENTICAL, GROUPS OTHER THAN A, DO OCCUR, AND DE GOWIN'S CASES MIGHT JUST AS EASILY BE DUE TO ATYPICAL AGGLUTININS AS DUE TO INCOMPATIBILITIES BETWEEN SUB-GROUPS A_1 AND A_2 . IT WOULD SEEM REASONABLE TO STATE THAT THE CAUSE OF REACTIONS OCCURRING BETWEEN MEMBERS OF GROUP A COULD NOT BE ATTRIBUTED TO INCOMPATIBILITIES BETWEEN SUB-GROUPS IF THE PERCENTAGE OF REACTIONS OCCURRING BETWEEN MEMBERS OF GROUP A WAS ABOUT THE SAME AS THE PERCENTAGE OF REACTIONS OCCURRING BETWEEN MEMBERS OF OTHER GROUPS, WHEN COMPARED IN A LARGE SERIES OF CASES STUDIED ON THE STATISTICAL BASIS OF THE FREQUENCY OF REACTIONS. IN THE LAST 3077 CONSECUTIVE BLOOD TRANSFUSIONS AT THE CINCINNATI GENERAL HOSPITAL THERE HAS BEEN NO SIGNIFICANT INCREASE IN THE INCIDENCE OF REACTIONS BETWEEN MEMBERS OF GROUP A AS COMPARED TO MEMBERS OF OTHER BLOOD GROUPS (CF. P. 106).

PART II

A SIMPLE TECHNIQUE FOR DETERMINATION OF BLOOD GROUPS
AND COMPATIBILITY FROM SMALL AMOUNTS OF DE-
FIBRINATED WHOLE BLOOD

BLOOD GROUPING AND COMPATIBILITY

A SIMPLE TECHNIC FOR DETERMINATION FROM SMALL AMOUNTS OF DEFIBRINATED WHOLE BLOOD⁹

IN MUNICIPAL HOSPITALS HEAVILY BURDENED WITH TRAUMATIC SURGERY, THE METHOD EMPLOYED FOR GROUPING AND MATCHING BLOOD PRIOR TO TRANSFUSION MUST BE CHOSEN FOR SPEED AS WELL AS FOR ACCURACY. WHILE MEETING MODERN REQUIREMENTS FOR SAFETY, THE TECHNIC WILL OF NECESSITY BE DESIGNED PRIMARILY FOR EFFICIENCY. AT THE CINCINNATI GENERAL HOSPITAL, WHERE MORE THAN 2500 TRANSFUSIONS ARE GIVEN EACH YEAR, THERE HAS BEEN A GRADUAL EVOLUTION TOWARD A MORE EFFICIENT ROUTINE FOR THE SELECTION OF DONORS FROM GROUPS OF UNKNOWN VOLUNTEERS. THE PROCEDURE THAT WE NOW CONSIDER IDEALLY SUITED TO OUR NEEDS IS A COMBINATION OF THE VINCENT⁶³ OPEN MACROSCOPIC METHOD FOR GROUPING AND THE COCA⁶⁴ COMPATIBILITY TEST FOR DIRECT MATCHING. EACH METHOD HAS BEEN SLIGHTLY MODIFIED, SO THAT BOTH DETERMINATIONS MAY BE MADE WITH A SINGLE SMALL SAMPLE OF DEFIBRINATED WHOLE BLOOD. THE VINCENT AND THE COCA METHODS WERE REPORTED ALMOST SIMULTANEOUSLY IN 1918. WE KNOW THEY WERE USED IN COMBINATION FOR MANY YEARS BY COCA AND GROVE AT THE NEW YORK HOSPITAL PRIOR TO 1932, AND PERHAPS OTHERS HAVE EMPLOYED BOTH METHODS; BUT THE ADVANTAGES OF THEIR USE IN COMBINATION HAVE NEVER BEEN EMPHASIZED, AND THE COCA COMPATIBILITY TEST IS KNOWN TO VERY FEW.

PRIOR TO 1918 THE BEST METHODS FOR GROUPING AND DIRECT

MATCHING WERE THOSE ADVOCATED BY MINOT.⁶⁵ HE POINTED OUT THE NEED FOR SIMPLE RAPID METHODS, DID AWAY WITH THE WASHING OF CELL SUSPENSIONS, AND ENCOURAGED ELIMINATION OF THE OLD HEMOLYSIS TESTS ESTABLISHED BY MOSS⁶⁶ AND EPSTEIN AND OTTENBERG⁶⁷ AND LATER MODIFIED BY WEIL⁶⁸ AND BY ROUS AND TURNER.⁶⁹ FOR BLOOD GROUPING HE ADVISED THE USE OF STOCK TEST SERUMS AND A SIMPLE CITRATED BLOOD SUSPENSION (ONE DROP OF BLOOD IN 1 CC. OF A 1.5 PERCENT SODIUM CITRATE SOLUTION IN SALINE SOLUTION) MIXED IN COVER SLIP PREPARATIONS. FOR DIRECT MATCHING HE ADVOCATED WEIL'S⁶⁸ 1:9 AND 9:1 MIXTURES OF CITRATED WHOLE BLOOD SET UP IN TUBES BUT READ MICROSCOPICALLY IN HANGING DROP COVER SLIP PREPARATIONS. THE CONTINGENCIES OF WAR LED TO THE DEVELOPMENT OF A RAPID MACROSCOPIC AGGLUTINATION TEST FOR BLOOD GROUPS BY VINCENT, WHO FOUND THAT, BY CITRATING STOCK TEST SERUMS, BLOOD COULD BE ADDED DIRECTLY FROM FINGER PUNCTURE TO DROPS OF SERUM ON A SLIDE.

IN THE HANDS OF EXPERIENCED TECHNICIANS EMPLOYING STANDARDIZED HIGH TITERED TEST SERUMS, THE VINCENT METHOD IS NOW GENERALLY CONSIDERED THE SAFEST AS WELL AS THE SIMPLEST PROCEDURE FOR DETERMINING BLOOD GROUPS. IF THE SELECTION OF DONORS COULD BE RIGIDLY RESTRICTED TO A CHOICE OF INDIVIDUALS FROM THE SAME BLOOD GROUP AS THE PATIENT, NO FURTHER TEST OF COMPATIBILITY WOULD BE REQUIRED EXCEPT AS A CHECK FOR POSSIBLE ERRORS IN GROUPING AND THE EXCEPTIONAL OCCURRENCE OF ATYPICAL AGGLUTINATION. IN EMERGENCIES, HOWEVER, JUST AS ONE MUST SOMETIMES EMPLOY A DONOR WITHOUT KNOWLEDGE OF HIS WASSERMANN REAC-

TION, RELYING ON AN EXAMINATION FOR PRIMARY AND SECONDARY LESIONS,⁷⁰ SO MUST ONE ALSO AT TIMES MAKE USE OF A "UNIVERSAL" DONOR OR, MORE RARELY, IN THE CASE OF A "UNIVERSAL" RECIPIENT, A DONOR FROM GROUP A OR B. UNDER THESE CIRCUMSTANCES A COMPATIBILITY TEST IS IMPERATIVE, FOR IT IS WELL KNOWN THAT GROUP O⁷¹ DONORS FREQUENTLY POSSESS AGGLUTININS OF A TITER DANGEROUS FOR A OR B RECIPIENTS,⁷² EVEN IN THE PROPORTIONS OF A SMALL TRANSFUSION. FURTHERMORE, COMPATIBILITY MUST BE DETERMINED QUANTITATIVELY AS WELL AS QUALITATIVELY BY SOME METHOD THAT WILL REPRODUCE AS FAITHFULLY AS POSSIBLE IN VITRO THE CONDITIONS (WHOLE BLOOD) AND PROPORTIONS OF THE PORPOSED TRANSFUSION IN VIVO. THEREFORE IT IS QUITE ESSENTIAL IN HOSPITALS OF THIS TYPE THAT THE METHOD EMPLOYED FOR DIRECT MATCHING BE DESIGNED NOT ONLY FOR CHECKING GROUPING ERRORS AND ATYPICAL AGGLUTINATION BUT ALSO FOR ACTUAL SLIDE TITRATION OF THE DONOR'S AGGLUTININS AGAINST A PROPER PROPORTION OF THE PATIENT'S BLOOD. COCA'S METHOD, SIMPLIFYING THE OLDER METHODS OF WEIL, AND OF ROUS AND TURNER, AND MODIFIED BY LEVINE AND MABEE⁷³ AND LANDSTEINER,⁷⁴ ADMIRABLY FULFILLS THESE REQUIREMENTS.

TECHNIC

APPROXIMATELY TEN DROPS OF BLOOD ARE OBTAINED BY FINGER PUNCTURE AND DEFIBRINATED IN A WASSERMANN TUBE BY WHIPPING WITH A WOODEN APPLICATOR FOR FIVE MINUTES. THIS QUANTITY IS SUFFICIENT FOR GROUPING AND SEVERAL COMPATIBILITY TESTS.

SEPARATION OF CELLS AND SERUM IS NOT DESIRABLE.

GROUPING.-- LARGE DROPS OF HIGH TITERED TEST SERUMS ANTI-B AND ANTI-A ARE PLACED ON THE LEFT AND RIGHT ENDS RESPECTIVELY OF A GLASS SLIDE. DEFIBRINATED BLOOD IS ADDED TO EACH DROP OF SERUM AND THOROUGHLY MIXED WITH THE AID OF A PLATINUM LOOP. THE SLIDE IS TILTED BACK AND FORTH OVER A WHITE BACKGROUND IN BRIGHT LIGHT AND OBSERVED MACROSCOPICALLY FOR CLUMPING. AGGLUTINATION IS STRIKING (FIG. 2) AND, IF SERUM OF GRADE I (COCA⁷⁵) IS USED, WILL BE COMPLETE IN LESS THAN ONE MINUTE. WHEN NO AGGLUTINATION IS SEEN AFTER ONE MINUTE ON EITHER SIDE, THE SLIDE IS PLACED UNDER A PETRI DISH WITH WET BLOTTING PAPER AND OBSERVED AGAIN FIFTEEN MINUTES LATER AS A PRECAUTION AGAINST WEAK AGGLUTINOGENS.

MATCHING.-- A 1:1 OR 50 PERCENT SUSPENSION OF THE RECIPIENT'S DEFIBRINATED BLOOD IS PREPARED IN THE STEM OF A WHITE BLOOD CELL COUNTING PIPET BY DRAWING BLOOD UP TO THE 0.5 MARK AND THEN FILLING TO THE 1.0 MARK WITH PHYSIOLOGIC SOLUTION OF SODIUM CHLORIDE. THE BLOOD IS DILUTED 1:1 WITH SALINE SOLUTION BECAUSE AGGLUTINATION CANNOT BE DIFFERENTIATED MICROSCOPICALLY IN ANY GREATER CONCENTRATION AND BECAUSE DILUTION INHIBITS UNDESIRABLE ROULEAU FORMATION. THE DILUTED BLOOD IS DEPOSITED ON THE LEFT END OF A GLASS SLIDE AND MIXED BY MEANS OF A JET OF AIR BLOWN FROM THE PIPET. AN IDENTICALLY PREPARED SUSPENSION OF DONOR'S DEFIBRINATED BLOOD IS PLACED ON THE RIGHT END OF THE SAME SLIDE, AND ONE FIFTH OF THIS DROP (TWO DIVISIONS OF THE PIPET) IS TRANSFERRED TO THE DROP OF

DILUTED RECIPIENT'S BLOOD. THIS 1:5 RATIO IS BASED ON THE ASSUMPTION THAT 500 CC. IS TO BE TRANSFUSED TO A PATIENT WHOSE BLOOD VOLUME IS DEPLETED 50 PERCENT, OR APPROXIMATELY TO 2,500 CC. IT PROVIDES A WIDE MARGIN OF SAFETY IN TRANSFUSIONS FROM A "UNIVERSAL" DONOR, AS DANGEROUSLY POTENT AGGLUTININS WILL NOT BE COMPLETELY ABSORBED IN THIS CONCENTRATION WITHOUT MANI-

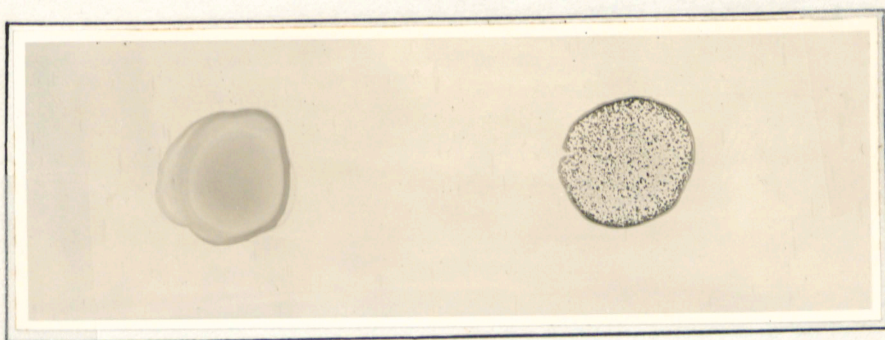


FIG. 2. -- GROUP A AGGLUTINATION FIFTEEN SECONDS AFTER BLOOD WAS MIXED WITH SERUMS.

FEST AGGLUTINATION.⁷³ THE 1:5 MIXTURE OF DONOR'S AND RECIPIENT'S BLOOD IS THEN STIRRED WITH A PLATINUM LOOP OR GLASS ROD, AND THE SLIDE IS PLACED UNDER AN INVERTED PETRI DISH WITH A PIECE OF WET BLOTTING PAPER. AFTER FIFTEEN MINUTES THE MIXTURE IS AGAIN AGITATED AND OBSERVED MICROSCOPICALLY UNDER LOW POWER FOR AGGLUTINATION.

CARE MUST BE TAKEN NOT TO CONFUSE ROULEAU FORMATION WITH AGGLUTINATION. THE FORMER CAN ALWAYS BE BROKEN UP BY STIRRING, WHILE THE LATTER WILL BE INTENSIFIED. AGGLUTINATION WILL BE STRIKING IF A GROUPING ERROR HAS BEEN MADE (FIG. 3), BUT A LITTLE PRACTICE IS REQUIRED TO ESTIMATE THE DEGREE OF

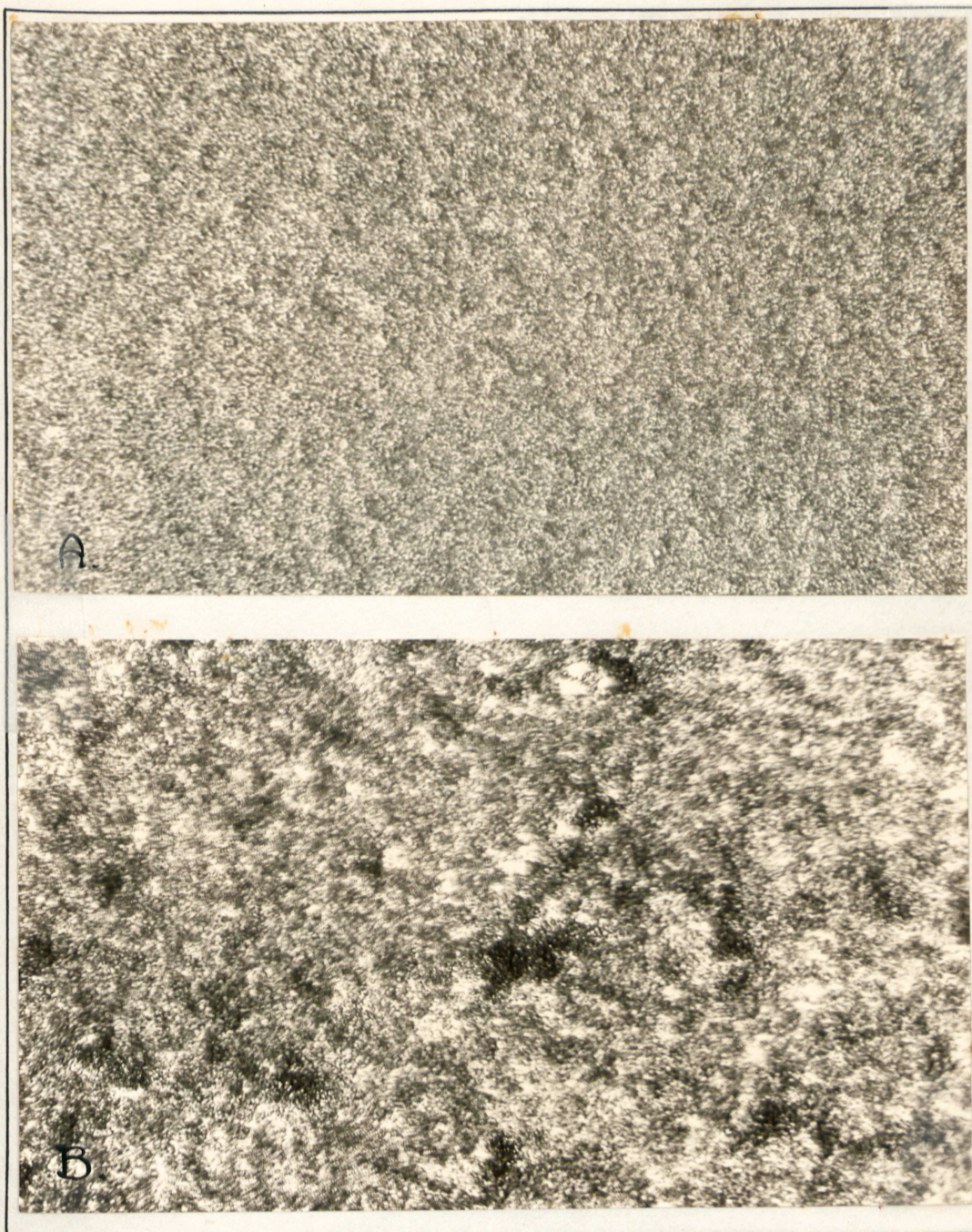


FIG. 3. -- LOW POWER PHOTOMICROGRAPHS OF COMPATIBILITY TESTS SHOWING (A) COMPATIBILITY AND (B) INCOMPATIBILITY (2:10 MIXTURES OF 50 PERCENT WHOLE BLOOD SUSPENSIONS AT THE END OF FIFTEEN MINUTES).

AGGLUTINATION OF THE RECIPIENT'S CELLS BY A "UNIVERSAL" DONOR'S AGGLUTININS, IN THE PRESENCE OF NON-AGGLUTINABLE CELLS FORMING ROULEAUX. UNLESS THE AGGLUTINATION IS SO DEFINITE AND CONSPICUOUS THAT THERE IS NO QUESTION OF CONFUSION WITH ROULEAU FORMATION, THE BLOOD MAY BE PRONOUNCED COMPATIBLE.

DATA

THE IMPORTANCE OF EMPLOYING RELIABLE STANDARDIZED HIGH TITERED TEST SERUMS CANNOT BE OVEREMPHASIZED. OPEN MACROSCOPIC GROUPING METHODS REQUIRE AN ABUNDANT SUPPLY OF SUCH SERUMS. BEFORE UNDERTAKING EXPERIMENTS WITH THE VINCENT METHOD, WE PREPARED LARGE QUANTITIES OF ANTI-B AND ANTI-A SERUM FROM THE BLOOD OF TWO VOLUNTEERS POSSESSING UNUSUALLY HIGH AGGLUTINATION POWER AS DETERMINED BY SLIDE TITRATION OF AGGLUTININS.⁷⁵ THESE SERUMS EXCELLED THE REQUIREMENTS OF COCA'S GRADE I FOR COMMERCIAL TEST SERUMS⁷⁵(TABLE XX) WITHOUT ANY ARTIFICIAL CONCENTRATION SUCH AS THE ALTERNATE FREEZING AND THAWING PROPOSED BY TERRY.⁷⁶

FOR MANY YEARS WE HAD USED HOME-MADE OR COMMERCIAL SERUMS OF INDIFFERENT QUALITY, RELYING ON CROSS-MATCHING FOR SAFETY, AND EMPLOYED A MODIFICATION OF MINOT'S METHOD FOR GROUPING. BLOOD WAS OBTAINED BY VENIPUNCTURE AND THREE DROPS WERE MIXED WITH A TEST TUBE FULL OF SALINE SOLUTION TO MAKE AN UNCITRATED CELL SUSPENSION. THE REMAINDER WAS ALLOWED TO CLOT AND WAS THEN CENTRIFUGATED TO SEPARATE THE SERUM. AGGLUTINATION

TABLE XX

COMPARISON OF AGGLUTININ TITER OF SERUMS USED AT CINCINNATI GENERAL HOSPITAL WITH GRADE I (COCA) SERUM			
SERUM	SERUM DILUTION	CELL DILUTION	MACROSCOPIC AGGLUTINATION TIME
GRADE I (COCA).. SERUM AT CINCINNATI GENERAL HOSPITAL	1-4 ANTI-A 1-10 ANTI-B 1-10	1-4 1-4 1-4	11 SECONDS 5 SECONDS 5 SECONDS

WAS DETERMINED MICROSCOPICALLY IN PETROLATUM-RIMMED COVER SLIP PREPARATIONS OF CELL SUSPENSION MIXED WITH TEST SERUM AND ALLOWED TO STAND FOR FROM TWENTY TO THIRTY MINUTES. FOR DIRECT MATCHING WE HAD ALWAYS USED MOSS'S METHOD⁷⁷ SIMPLIFIED BY ELIMINATION OF CITRATING AND WASHING OF THE CELLS. RECIPROCAL HANGING DROP PREPARATIONS OF EQUAL PARTS OF SERUM AND SALINE CELL SUSPENSION WERE OBSERVED MICROSCOPICALLY AFTER MECHANICAL SHAKING FOR FROM THIRTY TO SIXTY MINUTES.

IN ORDER TO PROVE THE GREATER EFFICIENCY AND RELIABILITY CLAIMED FOR THE COMBINED VINCENT AND COCA PROCEDURES, ALL GROUPINGS AND MATCHINGS FOR TRANSFUSIONS GIVEN IN THE SURGICAL SERVICE DURING A PERIOD OF TWO MONTHS WERE DETERMINED BOTH BY THE OLDER METHODS AND BY OUR NEW VINCENT-COCA TECHNIC. THESE EXAMINATIONS WERE MADE IN PARALLEL SERIES ON MORE THAN 200 CONSECUTIVE SPECIMENS OF BLOOD. IN EACH INSTANCE THE NEW TECHNIC WAS TRIED FIRST AND THEN CHECKED BY THE OLDER METHODS. NOT ONLY WAS EACH PAIR OF READINGS IN AGREEMENT BUT IN EVERY INSTANCE THE CRITERIA OF AGGLUTINATION WERE MORE PROMPTLY AND

CLEARLY DEFINED WITH THE VINCENT-COCA PROCEDURE. THE GROUP COULD BE DETERMINED BY THE OPEN MACROSCOPIC METHOD IN A TOTAL ELAPSED TIME OF FROM TWO OR THREE MINUTES, AND THE INTERVAL OF FIFTEEN MINUTES PRESCRIBED FOR OBSERVATION OF THE COMPATIBILITY TEST PROVED MORE THAN AMPLE, AS IN NO CASE DID AGGLUTINATION APPEAR AFTER FIVE MINUTES THAT HAD NOT ALREADY OCCURRED. "UNIVERSAL" DONORS WITH AGGLUTININ TITER POTENTIALLY DANGEROUS FOR A OR B RECIPIENTS COULD BE DETECTED BY AGGLUTINATION IN THE 1:5 MIXTURE OF DONOR'S AND RECIPIENT'S BLOOD, AND MANY TIMES WE WERE ABLE TO EMPLOY EMERGENCY "UNIVERSAL" DONORS WITH PERFECT SAFETY. OCCASIONALLY "UNIVERSAL" DONORS WERE USED TWO OR THREE TIMES FOR ONE PATIENT WITHOUT ILL EFFECT. BY VIRTUE OF THE SAME QUANTITATIVE FEATURE, LOW TITERED A DONORS AND OCCASIONALLY B DONORS WERE SAFELY SELECTED FOR "UNIVERSAL" RECIPIENTS.⁷² ON COMPLETION OF THESE STUDIES WE ABANDONED THE OLD MODIFIED MOSS AND MINOT METHODS AND ADOPTED THE COMBINED VINCENT-COCA TECHNIC AS A ROUTINE. OVER A PERIOD OF FOUR YEARS BLOOD HAS BEEN GROUPED AND MATCHED BY THIS METHOD FOR MORE THAN 8000 CONSECUTIVE TRANSFUSIONS WITH BUT THREE REACTIONS DUE TO INCOMPATIBILITY. EACH OF THESE WAS TRACEABLE TO A LABORATORY ERROR MADE BY THE INDIVIDUAL PERFORMING THE TEST.

SUMMARY AND CONCLUSIONS

THIS TECHNIC COMBINES THE PRINCIPLES OF THE VINCENT OPEN MACROSCOPIC METHOD FOR BLOOD GROUPING AND THE COCA COM-

PATIBILITY TEST FOR DIRECT MATCHING.

THE ADVANTAGES OF THESE METHODS IN GENERAL, AND THE COMBINED TECHNIC IN PARTICULAR, MAY BE SUMMARIZED AS FOLLOWS:

1. BOTH GROUPING AND COMPATIBILITY MAY BE DETERMINED WITH APPROXIMATELY TEN DROPS OF DEFIBRINATED WHOLE BLOOD OBTAINED BY FINGER PUNCTURE.

2. VENIPUNCTURE AND SEPARATION OF CELLS AND SERUM ARE UNNECESSARY. THIS IS PARTICULARLY ADVANTAGEOUS WHEN DONORS MUST BE SELECTED IN EMERGENCIES FROM LARGE GROUPS OF UNKNOWN VOLUNTEERS, AS IT SAVES THE TIME REQUIRED FOR PREPARATION OF NEEDLES AND SYRINGES, SUSPENSIONS AND SERUM.

3. THE VEINS OF PATIENTS REQUIRING REPEATED INTRA-VEINUS THERAPY MAY BE CONSERVED.

4. PROVIDED STANDARDIZED, HIGH TITERED TEST SERUMS ARE EMPLOYED, THE BLOOD GROUP IS USUALLY OBVIOUS IN LESS THAN ONE MINUTE.

5. COMPATIBILITY MAY BE DETERMINED WITH A WIDE MARGIN OF SAFETY IN FIFTEEN MINUTES, AND THE CONDITIONS AND PROPORTIONS OF THE PROPOSED TRANSFUSION MAY BE DUPLICATED BEFOREHAND IN VITRO, BOTH QUALITATIVELY AND QUANTITATIVELY.

6. THE TIME AND MATERIAL CONSUMED IN MAKING COVER SLIP PREPARATIONS ARE SAVED.

7. "UNIVERSAL" DONORS WITH AGGLUTININ TITER DANGEROUS FOR A OR B RECIPIENTS CAN BE DETECTED BY THE 1:5 MIXTURE OF DONOR'S AND RECIPIENT'S BLOOD.

8. LOW TITERED A DONORS MAY BE SELECTED FOR "UNI-

VERSAL RECIPIENTS.

9. THE TOTAL ELAPSED TIME FROM THE ARRIVAL OF UNKNOWN DONORS TO THE FINAL READING OF THE COMPATIBILITY TEST HAS BEEN REDUCED TO THIRTY MINUTES, AND OFTEN THE BLOOD MAY BE DRAWN IN TWENTY MINUTES PENDING THE FINAL READING.

PART III

ESTABLISHMENT AND OPERATION OF A BLOOD TRANSFUSION SERVICE

EARLY INVESTIGATION

THE PRESENT STATUS OF BANK BLOOD

ORGANIZATION OF THE SERVICE

ADMINISTRATION

HEADQUARTERS, EQUIPMENT, AND PERSONNEL

METHOD OF OPERATION

1. THE BLOOD BANK

2. THE VOLUNTEER DONOR BUREAU

THREE THOUSAND TRANSFUSIONS OF REFRIGERATED BLOOD

ESTABLISHMENT AND OPERATION OF A BLOOD TRANSFUSION SERVICE

THE SELECTION AND ARTIFICIAL PREPARATION OF HIGH TITERED TEST SERUMS, THE STUDY OF THE CAUSE AND PREVENTION OF HEMOLYTIC TRANSFUSION REACTIONS, THE CONSIDERATION OF THE ROLE OF SUB-GROUPS AND INTRA-GROUP AGGLUTININS IN TRANSFUSION ACCIDENTS, AND THE ADOPTION OF A SIMPLE ACCURATE TECHNIQUE FOR THE DETERMINATION OF BLOOD GROUPING AND COMPATIBILITY HAVE BEEN DESCRIBED. ALL ARE PARALLEL ACTIONS DIRECTED TOWARD A SINGLE PURPOSE, THE TRANSFUSION OF BLOOD WITH THE GREATEST SIMPLICITY AND THE LEAST POSSIBLE DELAY IN LABORATORY PROCEDURE, WHILE OBSERVING THE BEST KNOWN STANDARDS OF SAFETY.

ANOTHER MAJOR OBSTACLE TO THE DISPATCH OF BLOOD TRANSFUSION SERVICE IN LARGE MUNICIPAL HOSPITALS IS THE INACCESSABILITY OF BLOOD DONORS. THERE ARE DELAYS, INEFFICIENCY, AND TRAGIC RESULTS ATTENDANT TO LOCATING FRIENDS AND RELATIVES AND THE LABORATORY SEARCH FOR COMPATIBLE AND SUITABLE BLOODS FOR PATIENTS WHOSE BLOODS ARE OF THE RARE GROUPS. OCCASIONALLY THERE IS AN EMERGENCY WHICH DOES NOT PERMIT EVEN THE TIME USED TO SELECT A DONOR FOR A PATIENT WHOSE BLOOD IS OF THE COMMON GROUP. THESE ARE MATTERS OF ORDINARY KNOWLEDGE TO ANY RESIDENT PHYSICIAN. ANY INNOVATION IN BLOOD TRANSFUSION SERVICE WHICH ABOLISHES THESE DELAYS RESULTS IN A DECREASED MORBIDITY AND THE SAVING OF LIVES. IT BECOMES ANOTHER PARALLEL FORCE DESIGNED TO ACCOMPLISH THE SAME PURPOSE AS THE TECHNICAL IMPROVEMENTS AND CONSIDERATIONS MENTIONED ABOVE.

SUCH AN INNOVATION IS THE ESTABLISHMENT OF THE AMERICAN RED CROSS BLOOD TRANSFUSION SERVICE AT THE CINCINNATI GENERAL HOSPITAL. THIS SERVICE CONSISTS OF A BLOOD BANK AND A VOLUNTEER DONOR BUREAU. HEREIN WILL BE PRESENTED THE DETAILS OF THE ORGANIZATION AND METHOD OF OPERATION OF THIS SERVICE. A STATISTICAL ANALYSIS OF THE FIRST 3077 TRANSFUSIONS OF REFRIGERATED BLOOD IS APPENDED.

EARLY INVESTIGATION

ALTHOUGH A FEW EXPERIMENTAL WORKS ARE RECORDED EARLIER IN THIS CENTURY, THE WIDESPREAD CLINICAL USE OF PRESERVED BLOOD IS STRICTLY A DEVELOPMENT BELONGING TO THE PAST DECADE. ROUS AND TURNER⁷⁸ OF THE ROCKEFELLER INSTITUTE PRESERVED BLOOD BY ADDING AN ANTI-COAGULANT MEDIUM CONSISTING OF TWO PARTS OF ISOTONIC SODIUM CITRATE SOLUTION AND FIVE PARTS OF ISOTONIC DEXTROSE SOLUTION TO THREE PARTS OF WHOLE BLOOD. THEY WERE CHIEFLY INTERESTED IN RED BLOOD CELLS AND NOTED THAT IN THIS MIXTURE THE CELLS REMAINED INTACT FOR FOUR WEEKS. THEIR ONLY ATTEMPTS AT TRANSFUSION WERE EXPERIMENTAL AND WERE LIMITED TO THE TRANSFUSION INTO ANIMALS OF RED BLOOD CELLS SUSPENDED IN PHYSIOLOGIC SALT SOLUTION, THE PLASMA HAVING BEEN DISCARDED. THE FIRST RECORDED TRANSFUSION OF PRESERVED WHOLE BLOOD WAS THAT OF WEIL⁶⁸. BLOOD FROM THREE TO FIVE DAYS OLD, IN WHICH 1 CC. OF 10 PERCENT SODIUM CITRATE SOLUTION HAD BEEN ADDED TO EACH 10 CC. OF BLOOD, WAS TRANSFUSED. DURING THE WORLD WAR ROBERTSON⁷⁹ EMPLOYED THE ROUS-TURNER TECHNIQUE IN TWENTY CASES.

THE RED CELLS OF BLOOD WHICH HAD BEEN STORED FOR AS LONG AS TWENTY-FOUR DAYS WERE GIVEN INTRAVENOUSLY AFTER SUSPENSION IN ISOTONIC SALT SOLUTION. THE PLASMA WAS DISCARDED BECAUSE OF FEAR OF TOO HIGH A CONCENTRATION OF SODIUM CITRATE IN THE WHOLE BLOOD MIXTURE. INTEREST LAGGED IN THIS INVESTIGATION FOR A NUMBER OF YEARS AFTER THE WORLD WAR, BUT THEN RECEIVED CONSIDERABLE ENCOURAGEMENT WHEN YUDIN⁸⁰ OF MOSCOW REPORTED THE RESULTS IN 1000 TRANSFUSIONS OF REFRIGERATED CADAVER BLOOD. ADDED IMPETUS ALSO EMANATED FROM RUSSIA AS A RESULT OF REPORTS OF THE TRANSFUSION OF PRESERVED BLOOD OBTAINED FROM THE PLACENTAL END OF THE SEVERED UMBILICAL CORD. THE TRANSFUSION OF PLACENTAL BLOOD WAS FIRST REPORTED FROM THIS CONTINENT BY GOODALL.⁸¹

AT THE CINCINNATI GENERAL HOSPITAL USE OF THE CADAVER AS A SOURCE OF BLOOD WAS INVESTIGATED ONLY FROM THE STANDPOINTS OF OBTAINING THE BLOOD IN STERILE CULTURE, AND OF DETERMINING HOW MUCH BLOOD COULD BE OBTAINED. BEFORE DRAWING BLOOD FROM THE CADAVER, THE FOLLOWING REQUIREMENTS HAD TO BE MET:

1. IT WAS NECESSARY TO OBTAIN AN AUTOPSY PERMIT AND DRAW THE BLOOD WITHIN SIX HOURS AFTER DEATH SINCE THE DANGER OF PENETRATION OF INTESTINAL BACTERIA INTO THE BLOOD STREAM AFTER SIX HOURS IS GREAT.

2. IT WAS NECESSARY TO PREDETERMINE THAT NO INFECTIOUS DISEASE WAS PRESENT AT THE TIME OF DEATH.

3. FREEDOM FROM SYPHILIS AS DETERMINED BY PREVIOUS NEGATIVE WASSERMANN OR KAHN TESTS WAS NECESSARY.

ONCE THESE REQUIREMENTS WERE MET IT WAS FOUND THAT ONLY ONE CADAVER EACH THREE OR FOUR WEEKS WAS AVAILABLE FOR THE EXTRACTION OF BLOOD. THE AVERAGE AMOUNT OBTAINED FROM EACH OF THREE CADAVERS BY CANNULATING THE INTERNAL JUGULAR VEIN WITH THE HEAD IN A DEPENDENT POSITION WAS 1200 CC. EFFORTS TOWARDS OBTAINING BLOOD FROM THIS SOURCE WERE ABANDONED BECAUSE THE AMOUNT OBTAINABLE WAS TOO SMALL TO BE OF VALUE TO A TRANSFUSION SERVICE WHICH REQUIRED APPROXIMATELY 4000 CC. OF BLOOD PER DAY AND, ALSO, BECAUSE IT WAS BELIEVED THAT PATIENTS WOULD NOT BE WILLING TO ACCEPT THE TRANSFUSION OF CADAVER BLOOD. FOLLOWING THE TECHNIQUE OUTLINED BY GOODALL AND IN COOPERATION WITH THE OBSTETRICAL DEPARTMENT, FETAL CORD BLOOD AS A SOURCE OF SUPPLY WAS INVESTIGATED. QUANTITIES OBTAINED IN STERILE CULTURE AMOUNTED TO ABOUT 115 CC. FOR EACH CORD. THE NUMBER OF CORDS AVAILABLE UPON WHICH NEGATIVE WASSERMANN'S COULD BE OBTAINED AVERAGED 6 EACH DAY. THUS SIX OPERATIONS AND SIX SETS OF STERILE EQUIPMENT WERE REQUIRED IN ORDER TO OBTAIN LESS THAN 700 CC. OF BLOOD. THE POOLING OF THESE BLOODS IN ORDER TO OBTAIN AMOUNTS FOR PRACTICAL USE AND THE NUMBER OF GROUPING TESTS REQUIRED IN THE LABORATORY BEFORE THEY COULD BE POOLED WERE ADDED DIFFICULTIES. THE EXPERIENCE IN THIS CLINIC IS THAT AN EQUAL AMOUNT OF BLOOD CAN BE OBTAINED WITH MUCH LESS DIFFICULTY FROM FRIENDS AND RELATIVES AND FROM OTHER VOLUNTEER DONORS. FOR THIS REASON, PLACENTAL BLOOD OBTAINED FROM FETAL CORDS IS REGARDED HERE AS AN IM-

THE PRESENT STATUS OF BANK BLOOD

BLOOD IS A LIVING FLUID AND THE LIMITATIONS OF ITS USE WHEN PRESERVED HAVE BECOME A PROBLEM OF MAJOR INTEREST. IN THE SHORT SPACE OF TWO YEARS MUCH WORK HAS BEEN DONE IN VARIOUS CLINICS IN ORDER TO ANSWER THE NATURAL QUESTIONS WHICH ARISE PERTAINING TO THESE LIMITATIONS. THE QUESTION OF HOW LONG BLOOD CAN BE STORED BEFORE USE CAN BE ANSWERED ONLY BY FURTHER STUDY OF THE CHANGES WHICH OCCUR IN THE MANY DIFFERENT COMPONENTS DESIRABLE IN TRANSFUSIONS. WHEN THE STABILITY OF EACH OF THESE COMPONENTS HAS BEEN DETERMINED AND IS KNOWN IN TERMS OF DAYS, THE ANSWER TO THE QUESTION OF HOW LONG BLOOD MAY BE KEPT BEFORE TRANSFUSION WILL THEN BE KNOWN. THE LENGTH OF TIME WILL UNDOUBTEDLY VARY A GREAT DEAL, DEPENDING UPON WHAT COMPONENT OF THE BLOOD IS DESIRED IN A PARTICULAR TRANSFUSION. THE ONLY TWO METHODS OF APPROACH FOR THIS STUDY ARE (1) A DETERMINATION OF THE CHANGES WHICH OCCUR IN PRESERVED BLOOD AND (2) AN EVALUATION OF THE RESULTS OF THE TRANSFUSION OF SUCH BLOOD.

IN REGARD TO THE CHANGES WHICH OCCUR IN PRESERVED BLOOD, THE FOLLOWING CONTRIBUTIONS ARE OF INTEREST. USING KJELDAHL NITROGEN DETERMINATIONS ON PROPERLY REFRIGERATED BLOOD AS INDICES OF PROTEOLYSIS, KREMERMAN⁸³ CONCLUDED THAT BLOOD STORED FOR TWENTY-ONE DAYS WAS NOT TOXIC TO THE RECIPIENT AS FAR AS THE DEGREE OF PROTEOLYSIS IS CONCERNED. SCUDDER⁸⁴ OBSERVED A SHIFT OF POTASSIUM IONS FROM CELLS TO

PLASMA AND FEELS THAT CARE SHOULD BE TAKEN IN USING IT IN CERTAIN TYPES OF CASES. IT SEEMS DOUBTFUL, HOWEVER, THAT THE AMOUNT OF FREE POTASSIUM IS SUFFICIENT TO CAUSE TOXIC SYMPTOMS.

THE MARKED HEMOLYSIS OF RED CELLS WHICH OCCURS AT THE END OF TEN DAYS HAS BEEN A SUBJECT OF MUCH DISCUSSION, SINCE ERYTHROCYTES ARE THE IMPORTANT ELEMENTS IN THE TREATMENT OF HEMORRHAGE AND ANEMIA. FOLLOWING THE LEAD OFFERED BY THE EARLY WORK OF ROUS AND TURNER; DEGOWIN⁸⁵ HAS SHOWN THAT THE ADDITION OF THIRTEEN PARTS OF 5.4 PERCENT OF GLUCOSE SOLUTION AND TWO PARTS OF 3.2 PERCENT OF SODIUM CITRATE SOLUTION TO EACH TEN PARTS OF BLOOD PREVENTS RAPID HEMOLYSIS AND DELAYS POTASSIUM ION DIFFUSION INTO THE SERUM. IT IS OBVIOUS, HOWEVER, THAT THIS MIXTURE SHOULD NOT BE ADDED ROUTINELY TO ALL BANK BLOOD, SINCE THE DILUTION WOULD REDUCE THE BLOOD EFFICIENCY OF THE FLUID TRANSFUSED TO 40 PERCENT PER UNIT VOLUME. THE RESULT OF DEGOWIN'S WORK MAY FIND PRACTICAL APPLICATION IN THOSE CASES WHERE THE VOLUME OF FLUID TRANSFUSED CAN BE RAISED TO THE POINT DESIRED WITHOUT CONTRA-INDICATION. CERTAINLY IN THE TREATMENT OF SHOCK, WHERE THE PLASMA IS THE DESIRED ELEMENT AND THE ERYTHROCYTES ARE GENERALLY CONSIDERED TO BE INCONSEQUENTIAL, ANY DILUTION OF BANK BLOOD IS UNDERSIRABLE BECAUSE OF THE DIMINUTION IN THE HYDROSCOPIC ACTION OF THE PLASMA WHICH RESULTS.

RHOADS AND PANZER⁸⁶ BELIEVE BANK BLOOD TO BE AN UNSATISFACTORY SOURCE OF PLASMA PROTHROMBIN FOR THE TREATMENT OF THE HEMORRHAGIC DIATHESIS ASSOCIATED WITH JAUNDICE. THEY

BASE THEIR OPINIONS ON DETERMINATION OF THE PROTHROMBIN TIME OF BANK BLOOD PLASMA BY THE METHOD OF QUICK.⁸⁷ LORD AND PASTORE⁸⁸ MADE THE SAME STUDY ON BANK BLOOD, USING THE METHOD OF WARNER, BRINKHOUSE, AND SMITH⁸⁹ FOR THE DETERMINATION OF PROTHROMBIN TIME, AS WELL AS THE METHOD OF QUICK. THEY CORROBORATED THE WORK OF RHOADS AND PANZER WHEN USING THE METHOD OF QUICK, BUT SHOWED THAT THE PROTHROMBIN LEVEL DROPPED ONLY TO 84 PERCENT IN EIGHT DAYS, AS COMPARED TO 23 PERCENT BY THE QUICK TEST WHEN USING THE METHOD OF WARNER, BRINKHOUSE, AND SMITH. AT THE END OF TWELVE DAYS THE PROTHROMBIN TIME WAS 27 PERCENT BY THE METHOD OF QUICK AND 75 PERCENT BY THE METHOD OF WARNER, BRINKHOUSE, AND SMITH. THESE FINDINGS WERE ON PROPERLY REFRIGERATED BLOOD (2° TO 4° C.). DETERMINATIONS MADE BY LORD AND PASTORE ON THE PROTHROMBIN TIME OF PLASMA KEPT AT ORDINARY ICE BOX TEMPERATURE SHOWED THE PROTHROMBIN TIME TO BE ONLY 48 PERCENT IN TWELVE DAYS, USING THE METHOD OF WARNER, BRINKHOUSE, AND SMITH. THE DISCREPANCY IN THE RESULTS OBTAINED WHEN USING THE METHOD OF WARNER, BRINKHOUSE, AND SMITH AS COMPARED TO THE METHOD OF QUICK IS PARTIALLY EXPLAINED BY LORD AND PASTORE BY THE FACT THAT THE QUICK TEST CONTROLS ONLY THE CALCIUM AND THROMBOPLASTIN (SINCE QUICK CORRECTLY CONSIDERED IT UNIMPORTANT TO CONTROL THE FIBRINOGEN CONTENT WHICH IS NORMAL IN THE BLOOD OF THE JAUNDICED PATIENT) AND THAT THE WARNER, BRINKHOUSE, AND SMITH TEST CONTROLS THE FIBRINOGEN AS WELL. SINCE THE DIFFERENCE IN THE LEVEL IN THE PROTHROMBIN TIME OF BANK BLOOD WHEN

DETERMINED BY THE TWO METHODS IS CREATED BY THE ADDITION OF FIBRINOGEN AND SINCE THE FIBRINOGEN CONTENT OF BANK BLOOD PLASMA HAS BEEN SHOWN TO BE NORMAL QUANTITATIVELY BY BANCROFT,⁹⁰ A POSSIBLE EXPLANATION FOR THE DIFFERENCE IN RESULTS MAY LIE IN THE FACT THAT THERE ARE QUALITATIVE CHANGES IN THE FIBRINOGEN OF BANK BLOOD PLASMA. HOWEVER THIS MAY BE, LORD AND PASTORE CONCLUDE THAT BANK BLOOD IS AN ADEQUATE SOURCE OF PLASMA PROTHROMBIN FOR ABOUT NINE DAYS AS DETERMINED BY THE ACCURATE METHOD OF WARNER, BRINKHOUSE, AND SMITH. THEY ALSO CONCLUDE THAT CAREFULLY CONTROLLED REFRIGERATION IS AN IMPORTANT FACTOR IN THE PRESERVATION OF PROTHROMBIN. THEIR CONCLUSIONS ARE QUITE REASONABLE AND, SINCE THE FIBRINOGEN CONTENT OF THE PLASMA IN JAUNDICED PATIENTS IS QUITE NORMAL, THE PROTHROMBIN WHICH IS TRANSFUSED SHOULD BE AFFECTED BY THE FIBRINOGEN OF THE PATIENT IN SUCH A MANNER AS TO DECREASE THE CLOTTING TIME, JUST AS OCCURS WHEN THE FIBRINOGEN IS ADDED IN A TEST TUBE IN THE METHOD OF WARNER, BRINKHOUSE, AND SMITH. A CAREFULLY CONTROLLED STUDY OF THE EFFECTS OF BANK BLOOD OF VARIOUS AGES UPON THE PROTHROMBIN TIME OF PATIENTS WITH JAUNDICE HAS NEVER BEEN MADE AND WOULD BE OF EXTREME VALUE AT THE PRESENT TIME IN ORDER TO DETERMINE THIS PARTICULAR LIMITATION OF BANK BLOOD.

ANOTHER QUESTION OF INTEREST IN THE LIMITATIONS OF BANK BLOOD IS THAT OF STERILITY. REPORTS SHOWING THE RESULTS OF CULTURES ON SPECIMENS TAKEN FROM BANK BLOOD ARE TOO NUMEROUS TO MENTION. IT IS GENERALLY AGREED THAT, PROVIDING CAREFUL

TECHNIQUE IS EXERCISED IN THE DRAWING OF THE BLOOD IN A CLOSED SYSTEM, IT IS NOT DESIRABLE TO CULTURE ROUTINELY BANK BLOOD BEFORE IT IS TRANSFUSED. THE MERE TAKING OF THE CULTURE SUBJECTS THE SPECIMEN TO INCREASED OPPORTUNITY FOR CONTAMINATION. NOVAK⁹¹ BELIEVES THAT PYROGENS PRODUCED BY BACTERIA GROWING IN BANK BLOOD MAY BE A CAUSE OF TRANSFUSION REACTIONS AND STATES THAT THE FREQUENCY OF TRANSFUSION REACTIONS WITH BANK BLOOD "RANGES UP TO 50 PERCENT DEPENDING ON THE INDEX USED FOR DEFINING A TRANSFUSION REACTION." HE DOES NOT SAY WHERE THESE STATISTICS WERE OBTAINED. ASSUMING THAT THE LACK OF STERILITY IS A MAJOR CAUSE OF TRANSFUSION REACTIONS, NOVAK ADVOCATES THE ADDITION OF SULFANILAMIDE, 20 MGS. TO 100 CC. OF BLOOD, AS A BACTERIOSTATIC AGENT. THE METHOD OF HIS STUDY WAS TO INNOCULATE 10 CC. OF FRESH BLOOD WITH 24-HOUR CULTURES OF STAPHYLOCOCCUS ALBUS, PSEUDOMONAS AERUGINOSA, AND HEMOLYTIC SPORE-FORMING RODS. THE SPECIMENS WERE THEN PLATED ON AGAR AND THE COLONIES WERE COUNTED AFTER REFRIGERATION FOR 48 HOURS AT 4° - 6° C. COMPLETE BACTERIOSTASIS AND, IN SOME CASES, STERILIZATION, WAS AFFECTED BY A 20 MG. PERCENT CONCENTRATION OF SULFANILAMIDE. IT IS DOUBTFUL THAT PYROGENS PRODUCED BY BACTERIA GROWING IN BANK BLOOD DRAWN WITH PROPER STERILE TECHNIQUE ARE A CAUSE OF TRANSFUSION REACTIONS, SINCE THE INCIDENCE OF REACTIONS IN SOME REPORTED SERIES OF BANK BLOOD TRANSFUSIONS IS NO GREATER THAN THE INCIDENCE OF REACTIONS IN REPORTED SERIES OF TRANSFUSIONS OF FRESH BLOOD (CF. P. 99).

DREW AND SCUDDER⁹² CAREFULLY DETERMINED THE FATE OF

THROMBOCYTES IN BANK BLOOD AND FOUND THAT THEY RAPIDLY FALL TO LESS THAN 100,000 FOR EACH CUBIC MM. IN 24 HOURS AND TO 40,000 AT THE END OF THREE DAYS. KOLMER ALSO DEMONSTRATED THE INSTABILITY OF PLATELETS (CF. P. 59). BECAUSE OF THIS, BANK BLOOD SHOULD NOT BE USED AS A SOURCE OF THROMBOCYTES.

NUMEROUS WORKERS^{85,92,93} HAVE DEMONSTRATED THE DEGREE OF SPONTANEOUS HEMOLYSIS IN PROPERLY REFRIGERATED BANK BLOOD. THE RESULTS OF THESE STUDIES INDICATE THAT PRESERVED BLOOD IS A GOOD SOURCE OF ERYTHROCYTES UP TO FIVE DAYS OF AGE AND SHOULD NOT BE USED FOR THIS PURPOSE AFTER EIGHT DAYS.

THE AGE LIMITATION THAT SHOULD BE PLACED ON PRESERVED BLOOD WHICH IS USED IN THE TREATMENT OF INFECTIONS, SEPTIC STATES, AND SEPTICEMIAS IS NOT YET CLEAR AND MUST NECESSARILY DEPEND UPON THE COMPONENT OR COMPONENTS OF BLOOD DESIRED IN A PARTICULAR CASE. THE SUPPORTIVE VALUE OF THE ELEMENTS CONTAINED IN PLASMA FOR NUTRITION AND OF THE RED CELLS IN COMBATING THE ANEMIA OF THESE CONDITIONS IS WELL KNOWN. SINCE THE VALUE OF IMMUNE SUBSTANCES, BOTH SPECIFIC (ANTIBODIES) AND NON-SPECIFIC BACTERICIDAL (LEUKINS AND PLAKINS), EVEN IN FRESH BLOOD IN 200 CC. TO 500 CC. AMOUNTS IS DEBATABLE, DETERIORATION OF THESE SUBSTANCES IN PRESERVED BLOOD AS SHOWN BY KOLMER⁹³ MAY OR MAY NOT BE A LIMITATION TO ITS USE. THE RESULTS OF HIS STUDIES ON CITRATED BLOOD PRESERVED AT 4° TO 6° ARE AS FOLLOWS:

1. COMPLEMENT IS WELL PRESERVED UP TO 14 DAYS.
2. BACTERICIDAL ACTIVITY FOR STAPHYLOCOCCUS AUREUS,

BETA HEMOLYTIC STREPTOCOCCUS AND BACILLUS COLI IS DECREASED AFTER SEVEN DAYS PRESERVATION.

3. PHAGOCYTIC ACTIVITY OF NEUTROPHILS ON THE SAME THREE ORGANISMS IS DEFINITELY REDUCED WITHIN 72 HOURS, BECOMING MARKEDLY SO ABOUT THE FIFTH DAY, DUE TO DEGENERATIVE CHANGES IN THE LEUKOCYTES.

4. LEUKOCYTES DISPLAY DEGENERATIVE CHANGES WITHIN 24 HOURS.

5. THE PLATELETS EXHIBIT DISTINCT CLUMPING IMMEDIATELY, WITH EVIDENCE OF DETERIORATION IN 24 HOURS. THEY ARE SCARCE AT THE END OF 48 HOURS.

ALTHOUGH IT IS NOT ESTABLISHED, KOLMER BELIEVES, AS DO MANY OTHERS, THAT IMMUNE SUBSTANCES IN TRANSFUSED BLOOD ARE EFFICACIOUS IN THE TREATMENT OF SEPTIC CONDITIONS AND CONCLUDES THAT FRESH BLOOD IS PREFERABLE AND THAT PRESERVED BLOOD MORE THAN 2 TO 3 DAYS OLD SHOULD NOT BE USED FOR THESE PURPOSES.

THE SECOND METHOD OF APPROACH TO THE STUDY OF THE VALUE OF PRESERVED BLOOD, NAMELY, THE STUDY OF RESULTS OF TRANSFUSION OF SUCH BLOOD, IS ONE WHICH DESERVES CAREFUL ATTENTION AND ONE WHICH WILL INCREASE IN VALUE AS CAREFULLY COMPILED STATISTICS ACCUMULATE. IT IS FROM THIS STANDPOINT THAT THE STATISTICAL ANALYSIS OF 3077 TRANSFUSIONS OF REFRIGERATED BLOOD AT THE CINCINNATI GENERAL HOSPITAL BECOMES OF INTEREST. THE RESULTS OF THIS STUDY ARE COMMENTED UPON AS IT IS PRESENTED (CF. P. 93).

SCHAEFFER AND WIENER⁹⁴ TRACED THE FATE OF THE ERYTHROCYTES OF BANK BLOOD WHEN TRANSFUSED AND FOUND THAT THE RESULT WHEN FIVE TO EIGHT-DAY OLD BLOOD WAS USED WAS ABOUT THE SAME AS WHEN FRESH BLOOD WAS TRANSFUSED. THE PERIOD OF SURVIVAL OF THE ERYTHROCYTES WAS FROM THREE TO FOUR MONTHS. HOWEVER, FOUR SPECIMENS OF TEN TO TWENTY-DAY OLD BLOOD WERE TRANSFUSED AND THE ERYTHROCYTES GIVEN COULD NOT BE DEMONSTRATED IN THE CIRCULATION OF THE RECIPIENT AFTER FROM ONE TO THREE WEEKS.

IN THE OPERATION OF THE BLOOD BANK AT THE CINCINNATI GENERAL HOSPITAL IT HAS BEEN ORDINARY PRACTICE TO DISPENSE UNITS OF BLOOD WITH REGARD TO THE KNOWN LIMITATIONS OF PRESERVED BLOOD FOR THE PARTICULAR CASES, THE AGE OF THE BLOOD ISSUED DEPENDING UPON THE DIAGNOSIS SUBMITTED FOR THE PATIENT. ALTHOUGH IT IS CONSTANTLY SUBJECT TO CHANGE AS MORE IS LEARNED CONCERNING THESE LIMITATIONS THE FOLLOWING GUIDE TO THE MEMBERS OF THE HOUSE STAFF IS POSTED AT THE TIME OF THIS WRITING. EXPERIENCE OF 16 MONTHS' DURATION, DURING WHICH TIME MORE THAN 3500 TRANSFUSIONS OF PRESERVED BLOOD HAVE BEEN GIVEN, HAS SHOWN THAT THESE TIME LIMITATIONS HAVE NOT INTERFERED WITH THE PRACTICAL OPERATION OF THE BLOOD BANK SERVICE.

CONDITION OF THE PATIENT*AGE IN DAYS

1. SHOCK NOT ASSOCIATED WITH TOXEMIA (HEMORRHAGIC, TRAUMATIC, SURGICAL, THERMAL)	21
2. ANEMIA NOT ASSOCIATED WITH SEPSIS ...	8
3. HYPOPROTEINEMIA	21
4. INFECTION, SEPTIC STATE, SEPTICEMIA .	3
5. HEMORRHAGIC DIATHESIS IN OBSTRUCTIVE JAUNDICE	8
6. THROMBOCYTOPENIC PURPURA	1/2 (12 HRS.)

ORGANIZATION OF THE SERVICE

THE AMERICAN RED CROSS BLOOD TRANSFUSION SERVICE, CONSISTING OF A BLOOD BANK AND A VOLUNTEER DONOR BUREAU WITH HEADQUARTERS AT THE CINCINNATI GENERAL HOSPITAL, IS THE FIRST OF ITS KIND. IT IS WITHOUT PRECEDENT THAT A LOCAL CHAPTER OF THE AMERICAN RED CROSS HAS COLLABORATED WITH A MUNICIPAL HOSPITAL IN ORDER TO PRODUCE SUCH AN ORGANIZATION. THE CINCINNATI AND HAMILTON COUNTY CHAPTER OF THE AMERICAN RED CROSS FIRST BECAME INTERESTED IN A SERVICE TO BE OFFERED ALL HOSPITALS AND PHYSICIANS IN HAMILTON COUNTY EARLY IN 1938. IN MAY, 1938 THE OFFICIALS OF THE RED CROSS, IN ORDER TO ASCERTAIN WHETHER OR NOT SUCH A SERVICE WAS BADLY NEEDED, MET WITH A GROUP CONSISTING OF PHYSICIANS, SUPERINTENDENTS OF CINCINNATI HOSPITALS, MEMBERS OF THE HAMILTON COUNTY BOARD OF HEALTH, AND REPRESENTATIVES OF INDUSTRIAL HOSPITALS. A PRO-

*THE AGE LIMITATIONS EXPRESSED ABOVE ARE MAXIMUM ONES AND IN ACTUAL PRACTICE ALMOST ALL UNITS OF BLOOD ARE ISSUED SEVERAL DAYS BEFORE THESE TIME LIMITS EXPIRE.

POSED PLAN OF OPERATION WAS PRESENTED AT THIS TIME AND WAS GIVEN UNQUALIFIED APPROVAL BY ALL MEMBERS OF THIS GROUP. ON THE BASIS OF THIS ASSURANCE, THE RED CROSS WAS WILLING TO PROCEED WITH THE FINANCIAL SUPPORT OF THE PLAN AS OUTLINED. THE AMERICAN RED CROSS BLOOD TRANSFUSION SERVICE, WITH HEAD-QUARTERS AT THE CINCINNATI GENERAL HOSPITAL, WAS THEN ORGANIZED AND HAS NOW BEEN IN FULL OPERATION FOR MORE THAN A YEAR. THE ADMINISTRATION, THE HEADQUARTERS, THE PHYSICAL EQUIPMENT, THE DUTIES OF THE PERSONNEL, AND THE METHOD OF OPERATION OF THE SERVICE IN RELATION TO HOSPITALS AND PHYSICIANS OF HAMILTON COUNTY ARE DESCRIBED BELOW.

ADMINISTRATION OF THE SERVICE

THE SERVICE IS KNOWN AS THE AMERICAN RED CROSS BLOOD TRANSFUSION SERVICE. THE MEDICAL DIRECTION AND ADMINISTRATION ARE RESPONSIBILITIES OF A SERVICE COMMITTEE APPOINTED BY THE CINCINNATI AND HAMILTON COUNTY CHAPTER OF THE AMERICAN RED CROSS, SUBJECT TO THE APPROVAL OF THE DIRECTING MEDICAL STAFF OF THE CINCINNATI GENERAL HOSPITAL. THE INTERESTS OF HOSPITALS OTHER THAN THE CINCINNATI GENERAL ARE REPRESENTED BY TWO MEMBERSHIPS ON THIS COMMITTEE. THERE ARE A DIRECTOR AND AN ASSISTANT DIRECTOR OF THE SERVICE FROM THE DEPARTMENT OF SURGERY AT THE CINCINNATI GENERAL HOSPITAL AND THE UNIVERSITY OF CINCINNATI, WHO ARE ALSO MEMBERS OF THE SERVICE COMMITTEE. THIS COMMITTEE MEETS PERIODICALLY TO DETERMINE THE POLICIES OF THE SERVICE. THE DIRECTOR OR THE ASSISTANT DIRECTOR IS CONSTANTLY

AVAILABLE FOR NORMAL OPERATION.

HEADQUARTERS AND EQUIPMENT

THE CINCINNATI GENERAL HOSPITAL PROVIDES SPACE WHICH MEASURES 48 X 15 FEET FOR THE LOCATION OF THE OFFICE, TWO BOOTHS FOR THE DRAWING OF BLOOD, AND A LABORATORY AND BLOOD STORAGE ROOM. THE HOSPITAL ALSO FURNISHES WATER, JANITOR AND LAUNDRY SERVICE, STEAM STERILIZATION AND ELECTRICITY FOR LIGHTS, REFRIGERATION AND VENTILATION. MECHANICAL, CARPENTRY, AND REPAIR SERVICE ARE ALSO PARTIALLY MAINTAINED BY THE HOSPITAL. ITEMS OF OPERATING EQUIPMENT SUCH AS GAUZE SPONGES, COTTON, TOWELS, SHEETS, WRAPPERS, RUBBER GLOVES, STERILIZING SOLUTIONS, HYDROGEN PEROXIDE, IODINE, PROCAINE, SODIUM CITRATE, COLLODION, APPLICATOR STICKS, CRESOL, ETHER, ACETONE, AND DISTILLED WATER ARE SUPPLIED AT HOSPITAL EXPENSE.

THE RED CROSS ASSUMED THE COST OF THE PHYSICAL CHANGES IN THE SPACE, INCLUDING PARTITIONS, DECORATING, ELECTRICAL WIRING, LIGHT FIXTURES, AND PLUMBING. THEY ALSO PROVIDED ALL FIXED EQUIPMENT FOR THE OFFICE, BOOTHS, AND LABORATORY, AND SUPPLY ALL OPERATING EQUIPMENT NOT MENTIONED ABOVE. THE OFFICE (FIG. 4) EQUIPMENT INCLUDES DESKS, CHAIRS, FILING AND STORAGE CABINETS, ONE TYPEWRITER, OFFICE SUPPLIES AND ALL PRINTED FORMS. EACH BOOTH (FIG. 5) IS EQUIPPED WITH A DONOR BED, TWO UTILITY TABLES, AND AUXILIARY LIGHTS. THE LABORATORY (FIG. 6) EQUIPMENT PURCHASED AND SUPPLIED BY THE RED CROSS INCLUDES ONE REFRIGERATOR (FIG. 7), THE LABORATORY



FIG. 4



FIG. 5

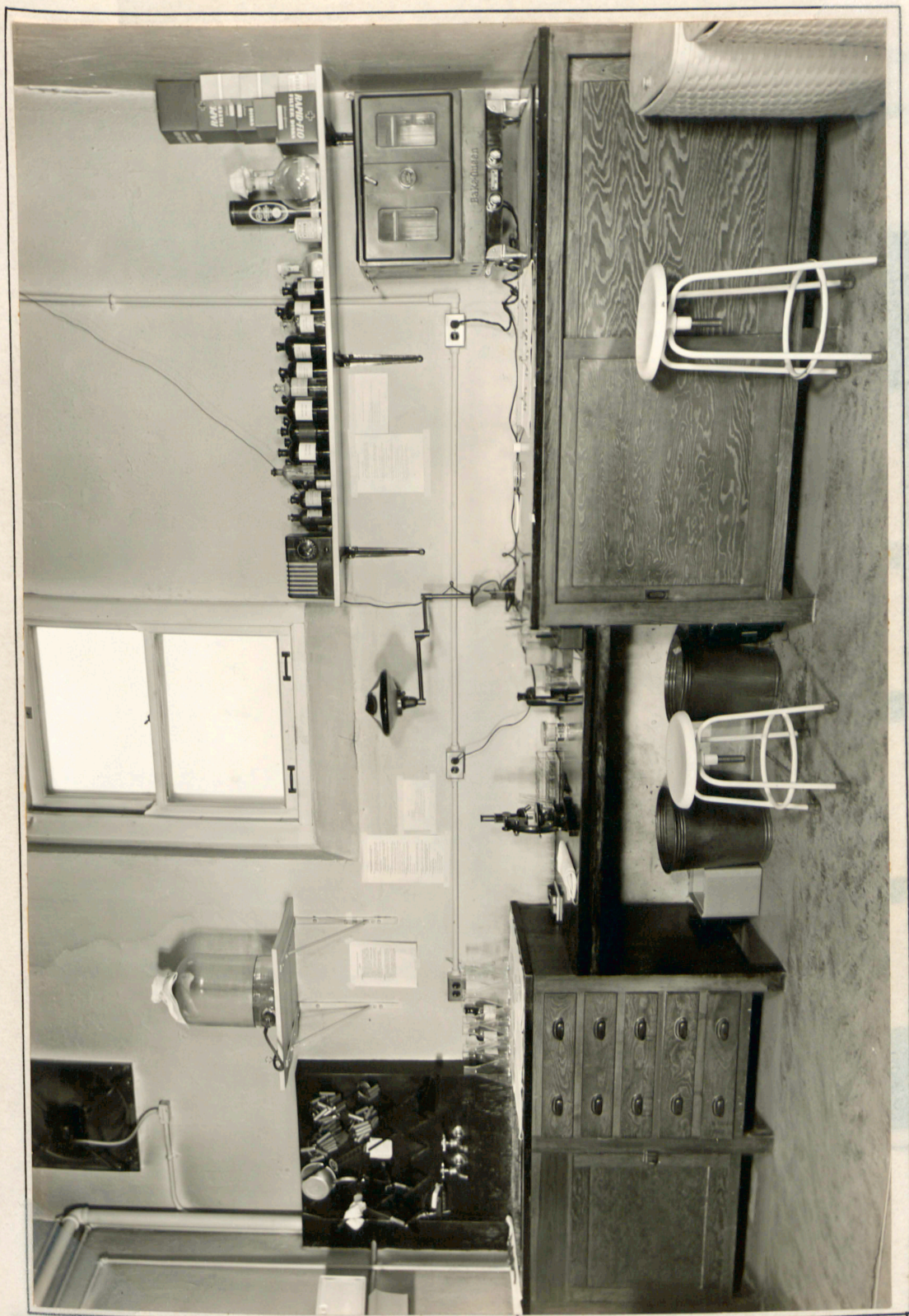


FIG. 6

THE DONOR SETS (FIG. 8) WITH THE EXCEPTION OF THE MUSLIN

DESK AND SINK, STORAGE CABINETS FOR LINEN AND STERILE SUPPLIES, ONE MICROSCOPE, ONE DRYING OVEN, HUMAN BLOOD GROUPING SERUMS, GLASS SLIDES, PETRI DISHES, GLASS PIPETTES AND



FIG. 7

PLATINUM WIRE. THE RED CROSS ALSO FURNISHES THE ITEMS USED IN THE DONOR SETS (FIG. 8) WITH THE EXCEPTION OF THE MUSLIN



FIG. 8 DONOR SET

WRAPPERS, GAUZE AND POWDER PAPER. THESE ITEMS ARE AS FOLLOWS:
ONE 28 X 28 INCH WRAPPER, ONE ALUMINUM CONTAINER, ONE 24 X
24 INCH WRAPPER, ONE 14 X 14 INCH WRAPPER, TWO TEST TUBES
STOPPERED WITH COTTON, ONE HYPODERMIC SYRINGE, TWO GAUZE FLASK
COVERS WITH POWDER PAPER FOLDED INSIDE, ONE GAUZE PAD WITH
THIRTEEN, FIFTEEN, AND TWENTY-FIVE GAUGE NEEDLES WITH STYLETS
INSERTED, ONE 750 CC. GRADUATED ERLLENMEYER FLASK, ONE TWO-
HOLED RUBBER STOPPER WITH GLASS BENDS AND RUBBER TUBING
ATTACHED, AND ONE METAL ADAPTOR.

PERSONNEL

THE SALARIED PERSONNEL OF THE SERVICE CONSISTS OF
THREE LABORATORY TECHNICIANS AND A SECRETARY. THEIR SALARIES
ARE PAID BY THE RED CROSS. THE TECHNICIANS OPERATE IN THREE
EIGHT-HOUR SHIFTS, COVERING THE ENTIRE TWENTY-FOUR HOURS OF
EACH DAY. EACH IS RELIEVED FOR ONE DAY EACH WEEK BY A SENIOR
MEDICAL STUDENT PROVIDED BY THE NATIONAL YOUTH ADMINISTRATION.

METHOD OF OPERATION

EARLY IN THE CONCEPTION OF THIS SERVICE IT WAS CON-
SIDERED HIGHLY DESIRABLE TO INCORPORATE INTO THE SERVICE HEAD-
QUARTERS ALL THE ACTIVITIES POSSIBLE PERTAINING TO THE TRANS-
FUSION OF BLOOD. REACTIONS WHICH RESULT FROM THE TRANSFUSION
OF BLOOD ARE KNOWN TO BE CAUSED BY A MULTIPLICITY OF FACTORS
WHICH MAY BE DUE EITHER TO IMPROPER TECHNIQUE USED IN THE

2

DRAWING OF BLOOD OR TO CARELESS HANDLING AND CLEANSING OF THE EQUIPMENT WHICH CONTACTS THE BLOOD, AS WELL AS TO ERRORS MADE IN THE LABORATORY TESTING OF BLOOD PRIOR TO TRANSFUSION. ALL THESE ACTIVITIES ARE CARRIED OUT AT CENTRAL HEADQUARTERS IN ORDER TO AVOID DEVIATIONS FROM ACCEPTABLE STANDARDS OF TECHNIQUE WHICH WOULD BE UNCONTROLLABLE IF FACILITIES WERE SCATTERED AND RESPONSIBILITY DIVIDED. ALSO, UNDER A SYSTEM OF CENTRALIZED CONTROL SPECIAL PROBLEMS RELATIVE TO THE KNOWN LIMITATIONS OF BANK BLOOD CAN BEST BE MET AND IMPROVEMENTS IN TECHNIQUE PERTAINING TO ANY OF THE ABOVE PROCEDURES CAN BE READILY ADOPTED AND ENFORCED. TOO MUCH EMPHASIS CANNOT BE PLACED UPON THESE CONSIDERATIONS. A PROPERLY REGULATED BLOOD BANK SHOULD RESULT IN A DECREASED INCIDENCE OF TRANSFUSION REACTIONS, AND IT MUST CONSIST OF MORE THAN A REFRIGERATOR IN WHICH TO STORE BLOOD.

THE BLOOD TRANSFUSION SERVICE CONSISTS OF TWO ALMOST INDEPENDENT DIVISIONS, A BLOOD BANK AND A VOLUNTEER DONOR BUREAU, OPERATING UNDER THE SAME DIRECTION FROM THE SERVICE HEADQUARTERS. THE OPERATION OF THESE DIVISIONS WILL BE DESCRIBED SEPARATELY.

I. THE BLOOD BANK

THE HOUSE PHYSICIAN DESIRING BLOOD FOR TRANSFUSION PRESENTS A SMALL SAMPLE OF DEFIBRINATED WHOLE BLOOD FROM THE PATIENT TO THE OFFICE ALONG WITH A REQUEST FORM (FIG. 9) BEARING THE DATE, NAME OF THE DOCTOR, SERVICE, WARD, PATIENT'S

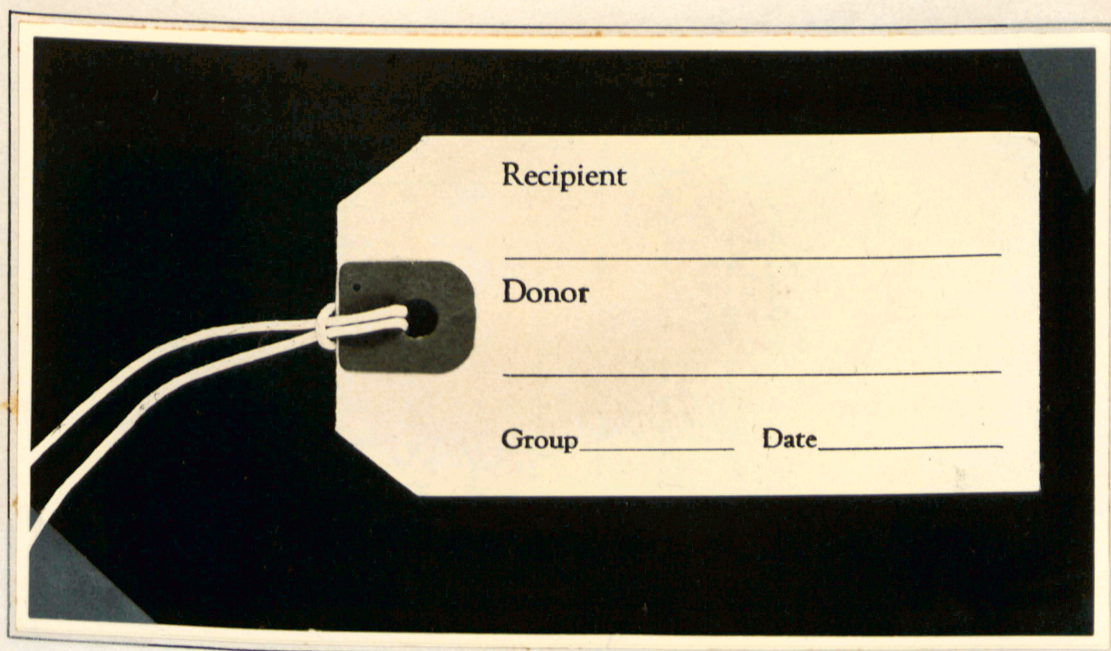
NAME, CASE NUMBER, RACE, AND DIAGNOSIS, AND THE TIME THE BLOOD IS DESIRED. IF FOR SOME REASON RELATIVELY FRESH BLOOD IS INDICATED, THE MAXIMUM AGE POSSIBLE IS RECORDED ON THE REQUEST FORM. THE TECHNICIAN, AFTER DETERMINING THE GROUP OF THE BLOOD SAMPLE, MAKES A DIRECT MATCH WITH A SAMPLE

CINCINNATI GENERAL HOSPITAL		
RED CROSS		
BLOOD TRANSFUSION SERVICE		
DATE		_____
DR. _____	SERVICE _____	WARD _____
RECIPIENT _____	GROUP _____	NO. _____
DIAGNOSIS _____	RACE _____	
DONOR _____	GROUP _____	
TIME BLOOD DESIRED _____		
DIRECT MATCH _____		
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FIG. 9

CARRIED ON THE SIDE OF A UNIT (500 CC.) OF BLOOD OF THE SAME GROUP FROM THE REFRIGERATOR. IF BLOOD OF IDENTICAL GROUP IS NOT AVAILABLE, GROUP O BANK BLOOD IS MATCHED AGAINST SAMPLES OF GROUP A OR B, AND GROUP A OR B BANK BLOOD IS MATCHED AGAINST SAMPLES OF GROUP AB. THE ENTIRE LABORATORY PROCEDURE REQUIRES TWENTY MINUTES AND IN CASES OF EXTREME EMERGENCY THE

BLOOD IS ISSUED IN FIVE MINUTES, PENDING THE RESULT OF THE DIRECT MATCH. THIS RESULT IS THEN RELAYED BY TELEPHONE, THUS ALLOWING THE PHYSICIAN TO UTILIZE THE FIFTEEN MINUTES REQUIRED FOR THE DIRECT MATCH IN DISPENSING WITH ALL PREPARATIONS PRELIMINARY TO THE ACTUAL TRANSFUSION. TO THE FORM (FIG. 10) WHICH IS CARRIED ON THE BOTTLE OF REFRIGERATED BLOOD ISSUED IS ADDED THE NAME OF THE PATIENT AND THIS IS FILED ALPHABETICALLY, ACCORDING TO HIS NAME. THIS FILE



Recipient _____

Donor _____

Group _____ Date _____

FIG. 10

THEN BECOMES OF VALUE IN DETERMINING THE NUMBER OF TRANSFUSIONS GIVEN TO ANY PATIENT AND THE IDENTITY OF THE DONORS.

FOR EACH WITHDRAWAL OF 500 CC. OF BLOOD THE SECRETARY ENTERS THE DATA CONTAINED ON THE REQUEST FORM, THE AGE OF THE BLOOD ISSUED AND ONE DEBIT UNIT IN THE MONTHLY RECORD

OF TRANSACTIONS (FIG. 11). EACH HOSPITAL SERVICE, SUCH AS MEDICINE, GENERAL SURGERY, GYNECOLOGY OR OBSTETRICS, IS HELD RESPONSIBLE FOR A BALANCE OF ITS OWN DEBIT AND CREDIT COLUMNS ON THIS RECORD. ON THE DAY FOLLOWING THE TRANSFUSION THE SECRETARY MAKES A FOLLOW-UP CALL TO THE RESPON-

[illegible]

FIG. 11

SIBLE PHYSICIAN AND RECORDS THE PRESENCE OR ABSENCE OF A TRANSFUSION REACTION. THE TOTAL OF THE INFORMATION COMPILED ON THE MONTHLY RECORD THEN BECOMES OF VALUE IN THE COMPILATION OF STATISTICS FOR FUTURE STUDY.

THE REPLACEMENT OF A UNIT OF BLOOD WHICH HAS BEEN
WITHDRAWN BECOMES THE OBLIGATION OF THE HOSPITAL SERVICE TO

WHICH IT WAS ISSUED. IN THIS WAY AN OBLIGATION IS NOT CANCELLED WHEN A PHYSICIAN WHO MAKES A WITHDRAWAL IS TRANSFERRED TO ANOTHER SERVICE OR TERMINATES HIS RESIDENCY. ACTUAL OPERATION FOR MORE THAN A YEAR HAS PROVED TWO IMPORTANT FACTS. FIRST, THAT FRIENDS AND RELATIVES OF PATIENTS AND CONVALESCENT PATIENTS IN WHOM THERE IS NO MEDICAL CONTRAINDICATION AFFORD A MORE THAN ADEQUATE SOURCE OF BLOOD REPLACEMENT. SECOND, THAT THE BANK WILL ABSORB WITHOUT EMBARRASSMENT REASONABLE DELAY, SUCH AS TWO TO THREE DAYS, IN REPLACING A UNIT.

THE PHYSICIAN PRESENTING HIMSELF WITH A DONOR FOR REPLACEMENT IS EXPECTED TO QUALIFY THE DONOR WITH A CURSORY MEDICAL HISTORY AND PHYSICAL EXAMINATION. AN ACCESSIBLE ARM VEIN IS REQUIRED, BECAUSE CUTTING DOWN ON A VEIN IS NOT PERMITTED. IF THESE CONDITIONS ARE SATISFIED, THE ARM OF THE DONOR IS THEN DRAPED AND PREPARED FOR VENIPUNCTURE BY THE TECHNICIAN WHILE THE PHYSICIAN SCRUBS. PRELIMINARY GROUPING IS NOT MADE UNLESS THERE IS AN OVER-STOCK OR SHORTAGE OF ONE OF THE BLOOD GROUPS. THE TECHNICIAN THEN ASSISTS THE PHYSICIAN (FIG. 5) OUTSIDE THE STERILE FIELD IN SUCH MATTERS AS PROVIDING PROCAINE, SODIUM CITRATE FOR THE FLASK, OPERATION OF THE TOURNIQUET, SUCTION TO THE COLLECTING SYSTEM, AND IN THE COLLECTION OF TEST TUBE SAMPLES OF BLOOD FOR FUTURE KAHN, GROUPING AND MATCHING TESTS.

THE PHYSICIAN THEN ASSEMBLES THE DONOR SET, INJECTS 2% PROCAINE INTO THE SKIN OVER THE VEIN, AND WITH THE AID OF

THE TECHNICIAN ADDS 50 CC. OF 2.5% SODIUM CITRATE SOLUTION TO THE FLASK BY SUCTION THROUGH THE COLLECTING SYSTEM. 2.5% SODIUM CITRATE SOLUTION IS USED IN PREFERENCE TO A HIGHER CONCENTRATION IN SMALLER VOLUME IN ORDER TO OBTAIN BETTER DISTRIBUTION OF THE SOLUTION THROUGHOUT THE BLOOD. VENIPUNCTURE IS THEN MADE. THE RESULTING PERCENT OF SODIUM CITRATE (0.22) IN THE TOTAL VOLUME (550 CC.) HAS PROVEN TO BE SUFFICIENT TO PREVENT ANY COAGULATION IF THE FLASK IS ALMOST CONSTANTLY AGITATED BY GENTLE ROTATION IN ALTERNATE DIRECTIONS.

AFTER 500 CC. OF BLOOD HAS BEEN OBTAINED THE RUBBER STOPPER AND CONTAINED GLASS BENDS ARE LIFTED FROM THE FLASK BEFORE THE VENIPUNCTURE NEEDLE IS WITHDRAWN AND SAMPLES FOR KAHN AND GROUPING AND MATCHING ARE COLLECTED IN THE TEST TUBES. THE STERILE COVER WHICH CONSISTS OF A POWDER PAPER AND TWO LAYERS OF CLOSE-MESH MUSLIN GAUZE, FILLED WITH A LAYER OF COTTON SHEET WADDING, IS THEN TIED FIRMLY OVER THE NECK AND SIDES OF THE FLASK WITH GAUZE BANDAGE.

AT THE END OF THE OPERATION ENTRY IS MADE IN THE CREDIT COLUMN OF THE MONTHLY RECORD OF TRANSACTIONS (FIG. 11) FOR THE PROPER HOSPITAL SERVICE. THE NAME OF THE DONOR IS ENTERED ON THE TAG FORM (FIG. 10) WHICH IS ATTACHED TO THE FLASK'S NECK AND ON THE FORM ENTITLED "DONOR OF BANKED BLOOD" (FIG. 12). THE LATTER FORM IS FILED ALPHABETICALLY ACCORDING TO THE NAME OF THE DONOR AND MAY BE USED IN CONJUNCTION WITH THE TAG FORM IN RECALLING HIM FOR A FUTURE TRANSFUSION IN A PROTRACTED CASE. THE TEST TUBE SAMPLE FOR

FUTURE GROUPING AND MATCHING TESTS IS LABELLED AND PLACED IN THE METAL CONTAINER ATTACHED TO THE SIDE OF THE FLASK. THE SAMPLE FOR THE KAHN TEST IS LABELLED AND PLACED WITH OTHERS FOR DETERMINATION ON THE FOLLOWING MORNING.

DONOR OF BANKED BLOOD.		
NAME		
ADDRESS		
TEL.		
REMARKS:		
GROUP	RACE	DATE

FIG. 12

THE UNIT OF BLOOD IS THEN PLACED ON THE UNCLASSIFIED SHELF OF THE REFRIGERATOR (FIG. 7) AND IS REMOVED TO THE CLASSIFIED SHELF FOR THE CORRESPONDING BLOOD GROUP AFTER THE BLOOD GROUP HAS BEEN DETERMINED AND A NEGATIVE KAHN TEST HAS BEEN PERFORMED. IN THE EVENT THAT THE TEST IS POSITIVE, A WASSERMANN CORROBORATORY TEST IS MADE. IF BOTH TESTS ARE POSITIVE, THE CREDIT IS WITHDRAWN BY DRAWING A RED INK LINE THROUGH THE ENTRY ON THE MONTHLY RECORD. THE PHYSICIAN IS THEN NOTIFIED OF THE CANCELLATION, AND THE FOLLOWING FORM LETTER IS SENT TO THE DONOR.

"WE ARE SORRY TO INFORM YOU THAT A TEST MADE UPON THE BLOOD WHICH YOU RECENTLY DONATED AT THE CINCINNATI GENERAL HOSPITAL SHOWS THAT YOU HAVE AN AILMENT WHICH SHOULD BE CORRECTED.

WE ADVISE YOU TO CONSULT YOUR PHYSICIAN IMMEDIATELY IN ORDER THAT HE MAY BEGIN TREATMENT. HE IS PRIVILEGED TO ASCERTAIN THE NATURE OF THE ILLNESS TO WHICH WE REFER AND MAY DO SO BY CALLING UNIVERSITY 1523 BETWEEN THE HOURS OF 9:00 A.M. AND 5:00 P.M. ON WEEK DAYS, OR FROM 9:00 A.M. TO 12:00 NOON ON SATURDAY.

SINCERELY,

DIRECTOR OF BLOOD TRANSFUSION SERVICE"

ONCE EACH MONTH THE NAMES AND ADDRESSES OF ALL PERSONS TO WHOM THIS LETTER HAS BEEN SENT ARE SUBMITTED TO THE SOCIAL HYGIENE COUNCIL OF THE PUBLIC HEALTH FEDERATION FOR FOLLOW-UP PROCEEDINGS. DURING THE PAST YEAR OVER 300 PERSONS HAVING SYPHILIS WITH NO PREVIOUS KNOWLEDGE OF THE DISEASE HAVE BEEN APPREHENDED AND DIRECTED TO CLINICS OR PHYSICIANS FOR TREATMENT. THE VALUE OF THIS PROGRAM AS A COLLATERAL ADVANTAGE TO THE COMMUNITY IN THE OPERATION OF THE BLOOD BANK IS OBVIOUS. IN ADDITION TO THE PERFORMANCE OF LABORATORY TESTS AND ASSISTANCE TO THE PHYSICIAN IN DRAWING BLOOD, THE TECHNICIANS ARE REQUIRED TO MAINTAIN PROPER EQUIPMENT AND TIDINESS IN THE DONOR BOOTHS, TO MAKE ENTRIES ON PRINTED FORMS IN THE ABSENCE OF THE SECRETARY, AND TO MECHANICALLY CLEANSE, ASSEMBLE,

AND WRAP DONOR SETS PREPARATORY TO STEAM STERILIZATION. RIGID ADHERENCE TO THE FOLLOWING PROCEDURE FOR PREPARATION OF ITEMS CONTAINED IN THE DONOR SETS IS MAINTAINED:

1. FLASK

- (A) SCRUB WITH BRUSH AND TAP WATER. USE HYDROGEN PEROXIDE (TWO OUNCES) IF NECESSARY. (NO OTHER CHEMICALS OR SOAP ARE TO BE USED) BRUSHES USED ARE NEVER TO CONTACT SOAP OR BE USED FOR ANY OTHER PURPOSE.
- (B) IRRIGATE WITH TAP WATER OVER INVERTED HYDRANT FOR THREE MINUTES BY THE CLOCK.
- (C) INSPECT CLOSELY FOR VISIBLE CONTAMINANTS. REPEAT (B) IF CONTAMINANTS ARE PRESENT. AVOID HANDLING MOUTH OF FLASK FROM THIS STEP ON.
- (D) RINSE INSIDE OF FLASK THOROUGHLY WITH 270 CC. OF DISTILLED WATER AND INVERT FLASK IN DRYING OVEN.

2. RUBBER TUBING

- (A) ALL NEW RUBBER TUBING INTRODUCED INTO A SET MUST BE BOILED FOR 15 MINUTES IN 5 PERCENT SODIUM HYDROXIDE SOLUTION.
- (B) ATTACH TUBES TO MECHANICAL IRRIGATOR FOR FIVE MINUTES. REPEAT IF VISIBLE CONTAMINANTS ARE PRESENT.
- (C) BOIL FOR 15 MINUTES IN 0.1 PERCENT SODIUM HYDROXIDE SOLUTION.
- (D) IRRIGATE WITH TAP WATER FOR TWO MINUTES.
- (E) BOIL FOR FIVE MINUTES IN DISTILLED WATER.
- (F) SHAKE WELL AND PLACE ON TOP SHELF IN OVEN TO DRY.

3. RUBBER STOPPERS

- (A) ALL NEW STOPPERS INTRODUCED INTO SETS MUST BE BOILED FOR FIFTEEN MINUTES IN 5 PERCENT SODIUM HYDROXIDE SOLUTION.
- (B) RINSE THOROUGHLY IN TAP WATER.
- (C) SAME AS 2 (C).
- (D) SAME AS 2 (D).

- (E) BOIL FOR FIVE MINUTES IN DISTILLED WATER, CONNECT TO RIGHT-ANGLED GLASS TUBES AND PLACE IN OVEN TO DRY.

4. GLASS TUBING

- (A) ATTACH TO MECHANICAL IRRIGATOR FOR FIVE MINUTES IMMEDIATELY AFTER USE.
- (B) HOLD UP TO LIGHT AND INSPECT CAREFULLY FOR VISIBLE CONTAMINANTS. REPEAT STEP (A) AND IRRIGATE WITH HYDROGEN PEROXIDE IF CONTAMINANTS ARE PRESENT.
- (C) BOIL IN DISTILLED WATER FOR FIVE MINUTES, AND LAY ON CLEAN TOWEL TO DRY.

5. NEEDLES AND METAL ADAPTORS

- (A) SCRUB WITH HYDROGEN PEROXIDE.
- (B) IRRIGATE WITH TAP WATER.
- (C) REPEAT (B) IF CONTAMINANTS ARE PRESENT.
- (D) IRRIGATE WITH DISTILLED WATER.
- (E) IRRIGATE WITH TWO CC. OF ETHER.

THE LAUNDERING, STEAM STERILIZATION, AND KAHN AND WASSERMANN TESTS ARE THE ONLY OPERATIONS PERFORMED OUTSIDE THE CENTRAL QUARTERS.

IT IS THE DUTY OF THE TECHNICIAN TO REPORT ANY VIOLATION OF STERILE TECHNIQUE MADE IN THE DRAWING OF BLOOD TO THE DIRECTOR OR ASSISTANT DIRECTOR OF THE SERVICE. THE BLOOD UNIT CONCERNED IS DISCARDED AND THE CREDIT IS WITHDRAWN IF A STERILE CULTURE IS NOT OBTAINED.

EACH DAY AN INVENTORY (FIG. 13) OF THE UNITS OF BLOOD OF EACH GROUP IN THE BANK IS RECORDED AND FILED. THIS INFORMATION IS OF VALUE IN DETERMINING AND ANTICIPATING AN OVERSTOCK OR A SHORTAGE OF ANY PARTICULAR BLOOD GROUP IN THE

BANK. IF AN IMBALANCE OCCURS, SELECTIVE INSTEAD OF RANDOM DRAWING OF BLOOD IS EXERCISED UNTIL IT IS CORRECTED. THIS IS DONE BY DETERMINING THE GROUP OF EACH PROSPECTIVE DONOR BEFORE DRAWING BLOOD, REJECTING THOSE OF THE GROUP IN WHICH THERE IS AN OVERSTOCK, AND SELECTING THOSE OF THE GROUP IN WHICH THERE IS A SHORTAGE. FORTUNATELY THE VOLUME OF TRANS-

American Red Cross CINCINNATI AND HAMILTON COUNTY CHAPTER BLOOD TRANSFUSION SERVICE			
INVENTORY		Date _____	
WHITE		COLORED	
(International) Group	Amount (500 cc. units)	(International) Group	Amount (500 cc. units)
AB		AB	
A		A	
B		B	
O		O	

FIG. 13

FUSIONS GIVEN BY THE SERVICE, AN AVERAGE OF EIGHT EACH DAY, IS LARGE ENOUGH TO PERMIT EFFICIENT OPERATION MOST OF THE TIME WITHOUT RESORTING TO SELECTIVE DRAWING. IT IS OUR OPINION THAT A BLOOD BANK WOULD NOT BE PRACTICABLE FOR A HOSPITAL AVERAGING LESS THAN FIVE TRANSFUSIONS EACH DAY. TO MAINTAIN AN INVENTORY OF 50 UNITS OF BLOOD, WHICH IS THE LEAST POSSIBLE IN ORDER TO SECURE A SUPPLY OF THE RARER BLOOD GROUPS,

THE AVERAGE AGE OF BLOOD ISSUED ON A SERVICE REQUIRING FIVE TRANSFUSIONS A DAY WOULD BE TEN DAYS. THE FLUCTUATIONS IN THE INVENTORY RESULTING FROM ORDINARY DELAYS IN REPLACEMENT ON A SERVICE DOING LESS IN VOLUME OF TRANSACTIONS WOULD RESULT IN PERIODS OF SHORTAGE OF THE RARER GROUPS AND OVERSTOCKING OF THE COMMONER GROUPS, OR VICE VERSA. AN OVERSTOCK WOULD REQUIRE THE WASTE OF MANY BLOODS DUE TO AGE.

BECAUSE IT IS NECESSARY TO OPEN THE FLASKS IN ORDER TO OBTAIN SPECIMENS, WHICH INCREASES THE OPPORTUNITIES FOR CONTAMINATION, NO EFFORT IS MADE TO TEST UNITS OF BANK BLOOD FOR STERILITY.

THE BLOOD IN THE BANK IS MAINTAINED CONSTANTLY AT A TEMPERATURE OF FROM 2° TO 4° C. FLUCTUATIONS IN THE TEMPERATURE OF THE AIR INSIDE THE REFRIGERATOR CAUSED BY THE NECESSARY OPENING AND CLOSING OF THE DOORS IS NEVER MORE THAN TWO DEGREES C. AS SHOWN ON RECORDING THERMOMETER CHARTS (FIG. 14A). RECORDINGS OF THE TEMPERATURE OF THE BLOOD ITSELF SHOW NO VARIATION UNDER THE SAME CONDITIONS (FIG. 14B).

THE SEPARATION OF WHITE AND COLORED BLOOD IN THE BANK HAS BEEN A CONSTANT PRACTICE FOR REASONS OTHER THAN SCIENTIFIC ONES. AS IS TRUE IN OTHER PHASES OF THE PRACTICE OF MEDICINE, SOCIETY IS NOT YET WILLING TO ACCEPT WHAT MEDICINE ALREADY KNOWS. AS FAR AS IS KNOWN, NO IMMEDIATE OR ULTIMATE UNDESIRABLE EFFECTS ACCOMPANY THE TRANSFUSION OF BLOOD FROM A PERSON WITH SKIN OF ONE COLOR TO A PERSON WITH SKIN OF ANOTHER.

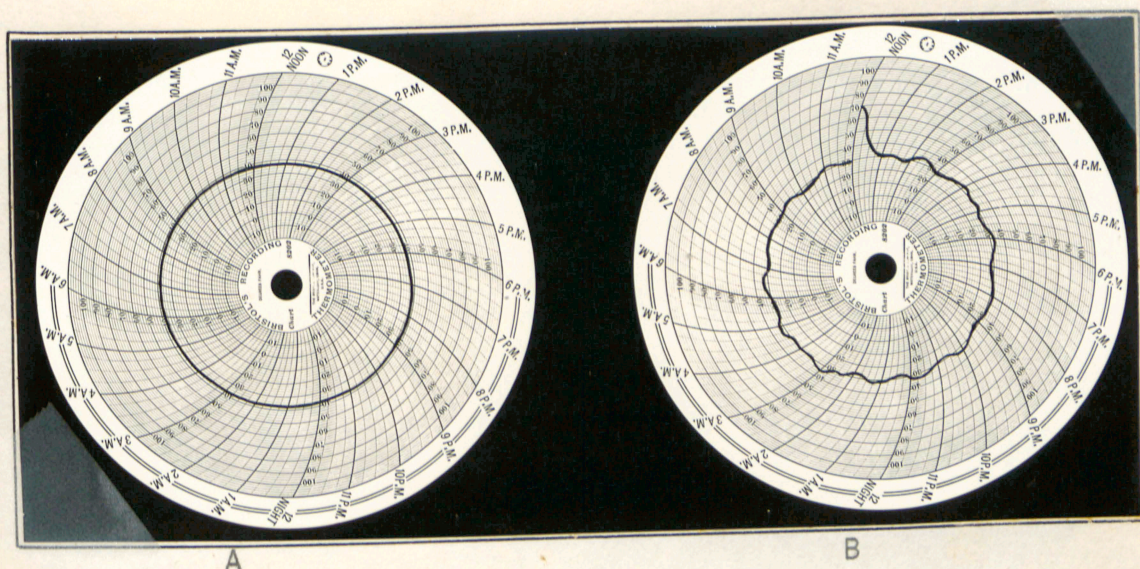


FIG. 14

2. THE VOLUNTEER DONOR BUREAU

THE VOLUNTEER DONOR BUREAU OPERATES FOR THE BENEFIT OF ALL HOSPITALS IN HAMILTON COUNTY OTHER THAN THE CINCINNATI GENERAL HOSPITAL. EARLY IN THE ORGANIZATION OF THE BLOOD TRANSFUSION SERVICE IT BECAME OBVIOUS THAT MAJOR DIFFICULTIES WOULD BE ENCOUNTERED IF AN ATTEMPT WERE MADE TO EXTEND THE OPERATIONS OF THE BLOOD BANK TO OTHER HOSPITALS. A UNIT OF BANK BLOOD, IF SENT TO A HOSPITAL AT SOME DISTANCE AWAY, MUST NECESSARILY BE REPLACED. THIS MIGHT BE DONE BY ONE OF TWO METHODS. EITHER THE REPLACEMENT UNIT COULD BE DRAWN AT THE HOSPITAL TO WHICH THE UNIT WAS SENT AND RETURNED BY MESSENGER TO THE BANK, OR THE VOLUNTEER DONOR FOR REPLACEMENT COULD BE SENT TO THE HEADQUARTERS FOR THE BLOOD TO BE DRAWN THERE. THE FIRST METHOD OF REPLACEMENT IS HIGHLY UNDESIRABLE, SINCE IT

IS IMPOSSIBLE TO CONTROL THE TECHNIQUE UNDER WHICH BLOOD IS DRAWN UNLESS IT IS DONE AT CENTRAL HEADQUARTERS. THE OBJECTION TO THE SECOND METHOD OF REPLACEMENT IS THAT THE SERVICE DOES NOT MAINTAIN A RESIDENT PHYSICIAN TO DRAW BLOOD. THE ONLY METHOD OF DOING THIS WOULD BE TO EXPLOIT THE RESIDENT HOUSE STAFF AT THE CINCINNATI GENERAL HOSPITAL. ANOTHER OBJECTION TO THE EXTENSION OF THE BLOOD BANK SERVICE TO OTHER HOSPITALS IS THAT THE SERVICE IS NOT ANXIOUS TO USURP THE FUNCTIONS PROPERLY BELONGING TO A HOSPITAL, RELATIVE EITHER TO THE NORMALLY OPERATING HOSPITAL PROCEDURE PRIOR TO TRANSFUSION OR TO THE ACTUAL TRANSFUSION OF BLOOD. INSTEAD, IT IS ITS DESIRE TO SUPPLEMENT THESE FUNCTIONS WITH A SERVICE WHICH WILL MAKE COMPATIBLE AND SUITABLE BLOOD QUICKLY AVAILABLE WHENEVER NEEDED.

IT IS THE EXPERIENCE OF ANY HOSPITAL THAT IN THE MAJORITY OF INSTANCES WHERE BLOOD TRANSFUSION IS DESIRED THE PROPER DONOR MAY BE FOUND AMONG FRIENDS AND RELATIVES OF THE PATIENT WITHOUT UNDUE DELAY. THE VOLUNTEER DONOR BUREAU WAS ORGANIZED AS A SECOND DIVISION OF THE RED CROSS BLOOD TRANSFUSION SERVICE TO SERVE ALL HOSPITALS IN HAMILTON COUNTY IN INSTANCES WHERE FRIENDS OR RELATIVES OF THE PATIENT CANNOT BE LOCATED OR ARE NOT OF THE COMPATIBLE BLOOD GROUP OR WHEN AN EMERGENCY EXISTS WHICH DOES NOT PERMIT OF WAITING FOR LABORATORY SEARCH.

FOR THIS PURPOSE THE SERVICE MAINTAINS A LIST OF CERTIFIED BLOOD DONORS WHICH IS AVAILABLE BY TELEPHONE CALL

DAY OR NIGHT. THE MEMBERSHIP OF THIS LIST WAS ORIGINALLY ACQUIRED THROUGH NEWSPAPER PUBLICITY. ITS MEMBERS ARE GIVEN A THOROUGH PHYSICAL EXAMINATION (FIGS. 15A, 15B). IN ADDITION, THEY ARE QUALIFIED EACH SIX MONTHS FROM THE STANDPOINTS OF AGE, GOOD GENERAL HEALTH, NEGATIVE KAHN TEST, ABSENCE OF PRIMARY OR SECONDARY LESIONS OF SYPHILIS, ACCESSIBLE ARM VEINS AND NORMAL BLOOD HEMOGLOBIN CONTENT. PERIODIC EXAMINATIONS ARE PERFORMED BY VOLUNTEER PHYSICIANS FROM THE RESIDENT STAFF OF THE CINCINNATI GENERAL HOSPITAL. EACH DONOR HAS EXPRESSED HIS WILLINGNESS TO RESPOND AT ONCE TO A SERVICE CALL WHETHER IT BE FOR AN INDIGENT PATIENT OR FOR ONE WHO IS ABLE TO PAY FOR THE BLOOD.

EACH MEMBER OF THE LIST, WHEN PROPERLY QUALIFIED, IS ISSUED A BLOOD DONOR'S IDENTIFICATION BOOK (FIG. 16), WHICH IS HIS CERTIFICATE OF REGISTRATION WITH THE SERVICE. THIS BOOK CONTAINS THE SIGNATURE OF THE DONOR, THE DATE OF REGISTRATION AND HIS REGISTRATION NUMBER. IN ADDITION IT CONTAINS A DESCRIPTION OF THE DONOR, HIS BLOOD CLASSIFICATION, A RECORD OF THE TRANSFUSIONS GIVEN THROUGH THE SERVICE, AND A RECORD OF HIS PERIODIC PHYSICAL AND LABORATORY EXAMINATIONS. THE SERVICE MAINTAINS A CARD INDEX IN WHICH EACH DONOR IS CLASSIFIED ACCORDING TO BLOOD GROUP AND DISTRICT IN WHICH HE LIVES. THE CARD CONTAINS ON THE FRONT (FIG. 17) INFORMATION NECESSARY FOR QUICK COMMUNICATION WITH THE DONOR. ON THE BACK (FIG. 18) OF THE CARD IS A DUPLICATE RECORD OF THE RESULTS OF THE PERIODIC LABORATORY AND PHYSICAL EXAMINATIONS

AND OF THE TRANSFUSIONS GIVEN THROUGH THE SERVICE.

Physical Examination Record	
Volunteer Blood Donor	
Cincinnati & Hamilton County Chapter	
American Red Cross	
Name _____	No. _____
Age _____	Sex _____
Color _____	Weight _____
Height _____	
Address _____	Occupation _____
Temperature _____	Pulse _____
Blood Pressure- Systolic _____	Diastolic _____
General appearance _____	Condition of Veins _____
(State whether healthy, robust, sickly, thin, anemic, etc.)	
Skin _____	Mucus Membrane _____
(is skin clear - if not, describe condition)	
History of previous illness, Allergy (hay fever, autumnal, vernal, non seasonal, asthma, others) Epilepsy, alcoholism, drug addiction, hyperthyroidism, cancer, diabetes, nephritis, anemia, heart disease, others. Acute infectious diseases.	

(underscore - state when illness occurred - is recovery complete)	
Eyes, ears, nose, throat, teeth, thyroid _____	(is there evidence of disease - if so, describe)

Heart & Vascular System _____	
Lungs _____	

(x-ray if indicated)	
Abdomen _____	
Spine - Extremities _____	
Genitals _____	
Mental & Nervous Diseases (Fainting or nervous reactions) _____	
Reflexes _____	
Is there evidence of any disease _____	
Do you recommend applicant as a safe donor _____	
DATED _____	Physician _____

FIG. 15A

WITH THE PERMISSION OF THE ACADEMY OF MEDICINE
OF CINCINNATI EACH OF ITS MEMBERS AND RESIDENT PHYSICIANS

OF ALL HOSPITALS IN CINCINNATI WERE ACQUAINTED WITH THE OPER-

<u>Infectious Diseases</u>				
	Check	No. Attacks	Date Last Attack	Remarks
1. Anterior Poliomyelitis				
2. Chicken-pox				
3. Chancroid				
4. Diphtheria				
5. Dysentery				
Type				
6. Erysipelas				
7. German Measles				
8. Gonorrhea				
9. Herpes Zoster				
10. Malaria				
11. Meningitis				
Type				
12. Mumps				
13. Measles				
14. Paratyphoid Fever				
Type				
15. Pneumonia				
Type				
16. Scarlet Fever				
17. Septic Sore Throat				
18. Small Pox				
19. Staphylococcus Infections				
Kind				
20. Streptococcus Infections				
Kind				
21. Syphilis				
22. Tuberculosis				
of what				
Other				

FIG. 15B

ATION OF THE SERVICE BY MEANS OF A DESCRIPTIVE PAMPHLET. BY
TELEPHONE ANY TIME DAY OR NIGHT THE PHYSICIAN MAY SECURE WITHIN

**BLOOD DONOR'S
IDENTIFICATION BOOK**

**BLOOD TRANSFUSION SERVICE
THE AMERICAN RED CROSS**
Cincinnati and Hamilton County Chapter



FIG. 16

**CINCINNATI & HAMILTON COUNTY CHAPTER
AMERICAN RED CROSS**

IV Moss }
I Jansky } GROUP O Inter-
national

No.

Date Full Name

Age Home Address
(Street Number) (Post Office)

Sex Business Address

Race Home Telephone Business Phone

Occ. Neighbor or employer or friend who can convey message

Name Address Phone

Name Address Phone

Name Address Phone

Times available: Day Evenings Nights

Saturdays Sundays

FIG. 17

IV Moss }
I Jansky } GROUP O Inter-
national

EXAMINATIONS

Date	Haemoglobin %	Luetic Test	Skin & MM	Genitalia	General	Examiner

TRANSFUSIONS

Date	Where Done	By Whom	Amount Taken	Remarks

FIG. 18

AN HOUR A VOLUNTEER DONOR OF ANY BLOOD GROUP. THE SECRETARY OR TECHNICIAN, UPON RECEIVING THE CALL, ENTERS THE INFORMATION REQUIRED BY ITEMS 1 THROUGH 7 ON THE FORM ENTITLED "MEMORANDUM OF SERVICE DETAILS" (FIG. 19). THE CARD INDEX FILE OF CERTIFIED DONORS IS THEN CONSULTED AND A DONOR IS SELECTED WITH CONSIDERATION FOR THE FOLLOWING POINTS. INsofar AS POSSIBLE THE DONORS ARE USED IN ROTATION, IN ORDER THAT NO ONE BE ASKED TO SERVE OFTENER THAN ONCE EACH SIX WEEKS AND NOT TO EXCEED FOUR TIMES EACH YEAR AND ALSO THAT EACH DONOR IS USED OFTEN ENOUGH THAT HE RETAINS HIS INTEREST IN THE SERVICE. IF THE BLOOD IS NEEDED FOR EMERGENCY USE, A DONOR IS CALLED WHO LIVES CLOSE TO THE HOSPITAL. IF THE TRANSFUSION CAN BE SCHEDULED TO MEET THE CONVENIENCE OF THE DONOR, HE IS SELECTED FROM AN OUTLYING DISTRICT. SINCE ALL DONOR SERVICES ARE CLASSIFIED AS TO A "FULL PAY," "PART PAY," OR INDIGENT PATIENT, AN ATTEMPT IS MADE ALSO TO DISTRIBUTE THE "PAY TRANSFUSIONS" THROUGHOUT THE LIST. ONCE THE DONOR IS SELECTED, HE IS NOTIFIED AND HIS NAME AND TIME OF NOTIFICATION ARE ENTERED UNDER ITEM 8 (FIG. 19). A FOLLOW-UP CALL TO THE PHYSICIAN FROM WHOM THE REQUEST WAS RECEIVED IS MADE BY THE SECRETARY ON THE NEXT DAY AND THE RESULT IS ENTERED UNDER ITEM 9. AT THIS TIME THE TRANSFUSION IS CREDITED TO THE DONOR ON THE BACK OF HIS CARD IN THE INDEX FILE.

EXPERIENCE SHOWS THAT TO MAINTAIN A SATISFACTORY LIST OF DONORS IT IS NECESSARY TO GIVE THEM EVERY CONSIDER-

AMERICAN RED CROSS
CINCINNATI AND HAMILTON COUNTY CHAPTER
BLOOD TRANSFUSION SERVICE

Whole Number
4922
Transaction Number

MEMORANDUM OF SERVICE DETAILS

1. Date _____
2. Name of patient for whom blood is requested _____
3. Name of Physician making request _____ His Telephone _____
4. Name of Hospital _____ Telephone _____
- Case Number _____
- Hospital Room _____ Hospital Ward _____ Hospital Service Department _____
5. Type of Donor or Blood requested: (encircle)
International— A AB B O
Jacks— II IV III I
Jacks—
6. Regular Procedure to be followed:
() Donor requested of encircled type
() Donor requested of _____ type
Number of donors requested? _____
- If not possible in required time:
() Emergency use of banked blood
Units to be needed? _____

Request Details

7. Time, notification received _____ () Phone— () Telegraph— () Messenger—
By: _____
Time, Donor or Blood wanted _____ () Radio Station (Call letters _____)

Disposition

8. Regular Procedure to be followed:
() Name of Donor notified _____ Phone No. _____ Time _____
() Name of Donor notified _____ Phone No. _____ Time _____
(Use back of sheet for recording additional notifications)
9. Check-up on Donors
Donor Service reported by _____ Phone No. _____ Time _____
Donor Service reported by _____ Phone No. _____ Time _____
(Use back of sheet for recording additional information)

CLASSIFICATION OF SERVICE TRANSACTION

Regular Donor Service Procedure

10. () Full Pay Patient — Rate \$50.00 per 500 C.C.—for Donor blood.
11. () Part Pay Patient — Rate \$ _____ per 500 C.C. for Donor blood.
12. () Indigent Patient — Donor blood, voluntarily given, without charge.

EMERGENCY BANKED BLOOD PROCEDURE

13. () Full Pay Patient — Rate \$50.00 per 500 C.C. for banked blood.
14. () Part Pay Patient — Rate \$ _____ per 500 C.C. for banked blood.
15. () Indigent Patient — Banked blood, voluntarily given, without charge.

SEE OTHER SIDE OF THIS SHEET FOR OTHER DETAILS

CERTIFICATIONS OF RECORDERS

I hereby certify that the above constitutes a true record of the details up to Item _____ inclusive.
Signed: _____ Technician. Approved: _____ Secretary.

MEMORANDUM OF FINANCIAL DETAILS
COVERING SERVICE RECORDED ON OTHER SIDE

Item 17
FULL PAY PATIENT

Name _____ Address _____ Phone _____
Through _____ Physician, and _____ Hospital _____
For Donor Service or equal at \$50.00 per 500 C. C. _____ \$ _____

Item 17-17-A

Payment received for the recorded amount _____ \$ _____
on _____ (Date) by _____
Payment forwarded to Cincinnati and Hamilton County Chapter, 2343 Auburn Ave., on _____ (Date)
with instructions to distribute the sum as follows: (At the rate of 80% to Donors, 20% to Chapter.)

Item 17-B - 17-C

To _____ (Donor) Address, \$ _____ Amount
To _____ (Donor) Address, \$ _____
To _____ (Donor) Address, \$ _____
To _____ (Donor) Address, \$ _____
(Mailed to Chapter Headquarters by _____)

Item 18
PART PAY PATIENT

Name _____ Address _____ Phone _____
Through _____ Physician, and _____ Hospital _____
For Donor Service or equal at \$ _____ per 500 C. C. _____ \$ _____

Item 18-18-A

Payment received for the recorded amount _____ \$ _____
on _____ (Date) by _____
Payment forwarded to Cincinnati and Hamilton County Chapter, 2343 Auburn Ave., on _____ (Date)
with instructions to distribute the sum as follows: (At the rate of 80% to Donors, 20% to Chapter.)

Item 18-B - 18-C

To _____ (Donor) Address, \$ _____ Amount
To _____ (Donor) Address, \$ _____
To _____ (Donor) Address, \$ _____
To _____ (Donor) Address, \$ _____
(Mailed to Chapter Headquarters by _____)

OTHER MEMORANDA

CERTIFICATE OF COMPLETION OF ALL DETAILS

I hereby certify that all service and financial details have been satisfactorily completed and that the record can be closed.

Date of Closing _____

Secretary of the Blood Transfusion Service.

ATION TO WHICH THEY ARE ENTITLED. FOR THIS REASON THE HOSPITAL STAFFS HAVE BEEN CHARGED THAT THE DONOR SHOULD BE COURTEOUSLY RECEIVED WHEN HE ARRIVES AT THE HOSPITAL, THAT THE BLOOD SHOULD BE DRAWN AS PROMPTLY AS POSSIBLE, AND THAT HE SHOULD BE DISMISSED WITH AN EXPRESSION OF APPRECIATION BY THE ATTENDING PHYSICIAN OR NURSE. THEY HAVE ALSO BEEN ASKED NOT TO CALL FOR A DONOR UNLESS IT IS REASONABLY CERTAIN THAT HE IS TO BE USED. AFTER EACH TRANSFUSION THE DONOR RECEIVES A LETTER OF APPRECIATION FROM SERVICE HEADQUARTERS.

WHEN A CALL IS RECEIVED FOR A DONOR THE PERSON MAKING THE CALL IS ASKED IF THE PATIENT IS INDIGENT, "FULL PAY," OR "PART PAY." IF THE PATIENT IS INDIGENT, NO BILL IS SENT. IF HE IS CLASSIFIED AS "FULL PAY," THE BLOOD TRANSFUSION SERVICE SENDS A BILL AT THE RATE OF \$50 PER 500 CC. OF BLOOD. A "PART PAY" PATIENT IS ONE WHO IS ABLE TO PAY SOMETHING FOR THE BLOOD GIVEN, BUT WHO CANNOT AFFORD TO PAY THE FULL RATE OF \$50 PER 500 CC. IN THIS CASE THE AMOUNT OF THE PAYMENT IS TO BE DETERMINED BY THE PATIENT OR HIS RELATIVES. ALL STATEMENTS ARE SENT TO THE ACCOUNTING DEPARTMENT OF THE HOSPITAL FOR SUBMISSION TO THE PATIENT. IT IS UNDERSTOOD THAT THE HOSPITAL IS NOT RESPONSIBLE FOR THE COLLECTION OF THE MONEY, ITS ONLY FUNCTION BEING THE SUBMISSION OF THE BILL. THE HOSPITAL, HOWEVER, IS RESPONSIBLE FOR THE PAYMENT OF TRANSPORTATION OF A DONOR TO AN INDIGENT PATIENT. PAYMENT FOR ALL BLOOD GIVEN IS MADE BY THE PATIENT TO SERVICE HEADQUARTERS AND THE SUM IS DISTRIBUTED AT THE RATE OF 80 PERCENT

TO THE DONOR AND 20 PERCENT TO THE SERVICE. ENTRY OF FINANCIAL DETAILS IS THEN MADE THROUGH ITEMS 17 TO 18-C (FIG. 19).

THE INDIVIDUAL "MEMORANDUM OF SERVICE DETAILS" FORM IS KEPT ON EACH TRANSACTION, WHETHER IT BE OF BANK BLOOD OR VOLUNTEER DONOR SERVICE. ALL ITEMS FROM DETAIL NUMBER 1 TO 18 ARE THEN ENTERED ON A SINGLE LINE OF A LARGE LEDGER SHEET (FIG. 20) FOR THE PURPOSE OF OBTAINING A COMPOSITE RECORD OF TRANSACTIONS FROM WHICH MONTHLY AND ANNUAL TOTALS MAY BE COMPILED.

SEVERAL REASONS WHY THE BLOOD BANK SERVICE COULD NOT BE EXTENDED TO HOSPITALS OTHER THAN THE CINCINNATI GENERAL WERE STATED ABOVE. THESE OBJECTIONS WOULD ARISE ONLY IF THE SENDING OF UNITS OF BANKED BLOOD IN RESPONSE TO REQUESTS FOR BLOOD TRANSFUSION SERVICE WERE INDISCRIMINATE. IF, HOWEVER, IN ANY INSTANCE OF EMERGENCY THE CIRCUMSTANCES ARE SUCH THAT THE VOLUNTEER DONOR LIST SERVICE IS NOT ENTIRELY ADEQUATE, BANK BLOOD IS SENT BY TAXICAB. SUCH CONDITIONS ARE ENCOUNTERED ONLY VERY OCCASIONALLY, AND THE RESPONSIBILITY FOR THE REPLACEMENT OF THESE UNITS IN THE BANK IS ONE THAT IS READILY AND WILLINGLY MET BY THE MEMBERS OF THE RESIDENT STAFF OF THE CINCINNATI GENERAL HOSPITAL.

THREE THOUSAND TRANSFUSIONS OF BANK BLOOD

A STATISTICAL ANALYSIS

AN IMPORTANT METHOD OF APPROACH TO THE STUDY OF THE VALUE OF PRESERVED BLOOD IS AN ANALYSIS OF THE RESULTS OF TRANSFUSION OF SUCH BLOOD. JUST AS SOME QUESTIONS WHICH ARISE AS TO THE LIMITATIONS OF BANK BLOOD ARE ANSWERED BY INQUIRY INTO THE CHANGES WHICH OCCUR IN VARIOUS COMPONENTS OF BLOOD WHEN PRESERVED, OTHER EQUALLY IMPORTANT QUESTIONS, SUCH AS THE EFFECT OF AGE OF BLOOD UPON THE INCIDENCE AND TYPE OF TRANSFUSION REACTIONS, CAN ONLY BE ANSWERED BY ACCURATE RECORDING OF THE RESULTS OBTAINED FROM A LONG SERIES OF TRANSFUSIONS OF BANK BLOOD. IT IS FROM THIS STANDPOINT PRIMARILY THAT A STATISTICAL ANALYSIS OF 3077 CONSECUTIVE TRANSFUSIONS OF BANK BLOOD AT THE CINCINNATI GENERAL HOSPITAL BECOMES OF INTEREST. NUMEROUS COLLATERAL POINTS OF INTEREST WHICH PERTAIN TO THE PRACTICAL OPERATION OF THE SERVICE ARE ALSO REVEALED BY THIS STUDY. THESE ARE OF VALUE TO ANYONE PLANNING A SIMILAR ORGANIZATION AND ARE COMMENTED UPON AS THEY ARE PRESENTED.

A DETAILED DESCRIPTION OF THE ADMINISTRATION, HEAD-QUARTERS AND EQUIPMENT, AND METHOD OF OPERATION OF THE BLOOD TRANSFUSION SERVICE PRESENTED IN PRECEDING PAGES FORETELLS THE METHOD BY WHICH DATA WERE ACCUMULATED. THE STATISTICS PRESENTED ARE OBTAINED FROM ACCURATE RECORDS COMPILED AT THE TIME OF TRANSACTION, FROM FOLLOW-UP CALLS AND FROM CAREFUL

LABORATORY AND CASE ANALYSES WHEN INDICATED.

DATA

TABLE XXI

DONORS TO BLOOD BANK (JAN. 1, 1939 TO FEB. 23, 1940)						
GROUP	WHITE (64.2%)		COLORED (35.8%)		BOTH RACES	
	NO.	PERCENT	NO.	PERCENT	NO.	PERCENT
AB	52	2.3	47	3.8	99	2.9
A	925	41.3	368	29.5	1293	37.1
B	184	8.2	262	21.0	446	12.8
O	1079	46.2	570	45.7	1649	47.2
TOTAL	2240	100.	1247	100.	3487	100.

COMMENT

OF 3487 DONORS WHO GAVE BLOOD TO THE BANK IN THE PERIOD FROM JANUARY 1, 1939 TO FEBRUARY 23, 1940, 64.2 PERCENT WERE WHITE AND 35.8 PERCENT WERE COLORED. THE PERCENTAGE OF OCCURRENCE OF EACH OF THE FOUR BLOOD GROUPS AMONG THE DONORS IS GIVEN. A HIGHER INCIDENCE OF GROUPS AB AND B AND LOWER INCIDENCE OF GROUP A WERE PRESENT IN THE COLORED DONORS. THIS CONCURS WITH NUMEROUS ANTHROPOLOGICAL OBSERVATIONS.⁶¹

TABLE XXII

INCIDENCE OF SYPHILIS AMONG DONORS					
	NO. OF DONORS		POSITIVE KAHN TESTS		
			NO.	PERCENT	
WHITE		2240	58	2.6	
COLORED		1247	203	16.2	
TOTAL		3487	261	7.5	

COMMENT

ALL PROSPECTIVE DONORS GIVING A HISTORY OF SYPHILIS WERE REJECTED. DESPITE THIS PRACTICE, 7.5 PERCENT OF THE BLOOD DRAWN COULD NOT BE USED FOR TRANSFUSION BECAUSE OF POSITIVE KAHN TESTS. IN THE WHITE DONOR SERIES THE INCIDENCE OF POSITIVE TESTS FOR SYPHILIS WAS 2.6 PERCENT AS COMPARED TO 16.2 PERCENT IN THE GROUP OF COLORED DONORS.

THE LOSS DUE TO SYPHILIS COULD BE ELIMINATED BY MAKING TESTS BEFORE DRAWING BLOOD FOR TRANSFUSION. HOWEVER, IF THESE TESTS WERE MADE THROUGH REGULARLY SCHEDULED MORNING LABORATORY PROCEDURE, PROSPECTIVE DONORS WOULD HAVE TO RETURN ON THE FOLLOWING DAY. EXPERIENCE BEFORE THE ADVENT OF THE BLOOD BANK SHOWS THAT MANY FAIL TO RETURN. IF RAPID TESTS WERE MADE PRELIMINARY TO EACH DRAWING, ADDITIONAL EXPENSE FOR TECHNICAL ASSISTANCE WOULD BE NECESSARY.

TABLE XXIII

NUMBER OF DONORS USED AND TRANSFUSIONS GIVEN		
	NO.	PERCENT
DONORS	3487	100.0
TRANSFUSIONS	3077	88.2
UNITS DISCARDED	410	11.8
DUE TO		
TO		
SYPHILIS	261	7.53
AGE	95	2.72
CLOTTING	51	1.46
BREAKAGE	3	0.09
	410	11.8

COMMENT

OF THE 3487 UNITS OF BLOOD DRAWN, 3077 OR 88.2 PERCENT WERE GIVEN IN TRANSFUSION. FOUR HUNDRED TEN UNITS AND HALF-UNITS WERE DISCARDED; ALL BUT 149 OF THESE WERE DUE TO POSITIVE TESTS FOR SYPHILIS. NINETY-FIVE UNITS AND HALF-UNITS WERE LOST BECAUSE THE TIME LIMIT OF TWENTY-ONE DAYS HAD EXPIRED BEFORE THEY COULD BE USED. MOST OF THIS LOSS OCCURRED DURING THE EARLY OPERATION OF THE BANK AND WAS THE RESULT OF ACCUMULATION OF HALF-UNITS NOT DESIRED AND OF THE RARER GROUPS AB AND B WHEN ENCOUNTERED IN FAMILIES OF DONORS. ANTICIPATION OF OVER-STOCKING OF THIS KIND IMPROVED AS OPERATION OF THE BANK PROGRESSED AND THIS LOSS WAS REDUCED IN THE LATER MONTHS OF OPERATION BY CAREFUL SELECTIVE DRAWING (CF. P. 80). THE WASTE OF THE REMAINING FIFTY-FOUR UNITS RESULTED FROM CLOTTING BECAUSE OF INSUFFICIENT AGITATION OR DIFFICULTY WITH VEINS DURING THE DRAWING AND FROM BREAKAGE. THERE WAS NO LOSS DUE TO BACTERIAL CONTAMINATION. MUCH OF THE BLOOD DISCARDED BECAME USEFUL IN VARIOUS EXPERIMENTAL LABORATORIES.⁹⁵

TABLE XXIV

TRANSFUSIONS GIVEN ACCORDING TO HOSPITAL SERVICE		
<u>SERVICE</u>	<u>No.</u>	<u>PERCENT</u>
SURGERY	1265	41.11
MEDICINE	589	19.14
GYNCOLOGY	435	14.13
PEDIATRICS	227	7.37
UROLOGY	150	4.87
OBSTETRICS	131	4.25
CONTAGIOUS DISEASES	94	3.05
DERMATOLOGY	88	2.79
OTOLARYNGOLOGY	62	2.01
ORTHOPEDICS	24	.78
OPHTHALMOLOGY	7	.22
PSYCHIATRY	7	.22
TOTAL	3077	100.

COMMENT

THE AMOUNT OF BLOOD GIVEN ON EACH HOSPITAL SERVICE IN RELATION TO THE TOTAL IS ABOUT WHAT WOULD BE EXPECTED IN A GENERAL HOSPITAL. KNOWLEDGE OF THE EXACT RELATIONSHIP BECOMES OF VALUE IN ACTUAL OPERATION IN PRORATING BANK DEBITS OVER THE VARIOUS SERVICES (CF. P. 73). ACTUALLY THE NUMBER OF TRANSFUSIONS GIVEN ON THE PEDIATRIC SERVICE IS MUCH HIGHER THAN STATED. THE FIGURE EXPRESSED REPRESENTS THE NUMBER OF UNITS OR HALF-UNITS ISSUED FROM THE BANK AND DOES NOT TAKE INTO ACCOUNT THE FRACTIONAL TRANSFUSION OF SOME UNITS, WHICH PRACTICE IS MOST COMMON THE THE PEDIATRIC SERVICE.*

*IN THIS REPORT THE NUMBER OF TRANSFUSIONS CORRESPONDS TO THE NUMBER OF UNITS AND HALF-UNITS OF BLOOD ISSUED FROM THE BLOOD BANK. ACTUALLY THE NUMBER OF TRANSFUSIONS WAS LARGER BECAUSE SOME OF THESE WERE DIVIDED AND GIVEN AS MULTIPLE TRANSFUSIONS.

TABLE XXV

TRANSFUSIONS FROM BLOOD BANK (JAN. 1, 1939 TO FEB. 23, 1940)						
GROUP	WHITE (68.9%)		COLORED (31.1%)		BOTH RACES	
	No.	PERCENT	No.	PERCENT	No.	PERCENT
AB	41	2.0	23	2.4	64	2.1
A	915	43.1	274	28.7	1189	38.6
B	162	7.6	177	18.5	339	11.0
O	1003	47.3	482	50.4	1485	48.3
TOTAL	2121	100.	956	100.	3077	100.

COMMENT

THREE THOUSAND SEVENTY-SEVEN UNITS AND HALF-UNITS OF BLOOD WERE ISSUED FROM THE BANK AND GIVEN IN TRANSFUSION. THE DISTRIBUTION OF THESE UNITS AND HALF-UNITS ACCORDING TO RACE AND TO THE FOUR BLOOD GROUPS IS RECORDED HERE.

TABLE XXVI

TRANSFUSIONS OF UNLIKE GROUPS			
	GROUPS	No.	PERCENT
	O--B	31	26.7
	O--A	50	43.1
	O--AB	1	.9
	A--AB	18	15.5
	B--AB	16	13.8
	TOTAL	116	100.
TOTAL TRANSFUSIONS OF UNLIKE GROUPS		116	3.8
TOTAL TRANSFUSIONS OF LIKE GROUPS		2961	96.2
TOTAL TRANSFUSIONS IN SERIES		3077	100.

COMMENT

OF THE 3077 TRANSFUSIONS GIVEN, 2961 OR 96.2 PERCENT REPRESENTED TRANSFUSIONS OF LIKE GROUPS. IN ONLY 3.8 PERCENT OF THE CASES WAS THE BANK UNABLE TO SUPPLY THE GROUP REQUESTED.

THE UNIVERSAL DONOR AND UNIVERSAL RECIPIENT PRINCIPLE WAS APPLIED IN EACH OF THE 116 CASES WHERE IT WAS NECESSARY ONLY AFTER A PRELIMINARY DIRECT MATCH, USING THE COCA COMPATIBILITY TEST (CF. P. 39). IN THE ABSENCE OF GROUP AB BLOOD, GROUP A OR GROUP B BLOOD WAS ALWAYS SELECTED IN PREFERENCE TO GROUP O BECAUSE ONLY ONE INCOMPATIBLE AGGLUTININ-AGGLUTINOGEN COMPLEX IS DEALT WITH IN THE DILUTION PRINCIPLE.

TABLE XXVII

INCIDENCE OF TRANSFUSION REACTIONS		
	No.	PERCENT
TRANSFUSIONS	3077	100.0
REACTIONS		
HEMOLYTIC	2*	0.06
FEBRILE	125	4.06
URTICARIAL	56	1.82
TOTAL	182	5.94

*ONE QUESTIONABLE.

TABLE XXVIII

TYPES OF TRANSFUSION REACTIONS		
	No.	PERCENT
HEMOLYTIC	2*	1.1
FEBRILE WITH CHILL	95	
FEBRILE	30	68.3
MILD URTICARIAL	53	
SEVERE URTICARIAL	3	30.6
TOTAL	183	100.0

*ONE QUESTIONABLE.

COMMENT

ANY REPORT ON THE INCIDENCE OF UNFAVORABLE TRANSFUSION REACTIONS MUST NECESSARILY BE AFFECTED BY THE AUTHOR'S DEFINITION OF A TRANSFUSION REACTION. SUBJECTIVE COMPLAINTS NOT ACCOMPANIED BY ANY RELATED OBJECTIVE, CLINICAL OR LABORATORY FINDINGS DURING OR FOLLOWING THE TRANSFUSION HAVE BEEN DISREGARDED IN THIS PRESENTATION. ALL REACTIONS OCCURRING IN THIS SERIES ARE CLASSIFIED AS HEMOLYTIC, FEBRILE, OR URTICARIAL. UNTOWARD REACTIONS RESULTED IN 5.94 PERCENT OF THE 3077 TRANSFUSIONS GIVEN. OF THE TWO HEMOLYTIC TRANSFUSION REACTIONS REPORTED, ONE WAS THE RESULT OF A LABORATORY ERROR IN WHICH GROUP A BLOOD WAS GIVEN TO AN INDIVIDUAL WHOSE BLOOD WAS GROUP O AND THE OTHER, WHICH IS NOT WELL ESTABLISHED, RESULTED FROM THE TRANSFUSION OF GROUP A BLOOD TO AN INDIVIDUAL WHOSE BLOOD WAS GROUP A. THE FOLLOWING IS A PRESENTATION OF THE CLINICAL AND LABORATORY FACTS IN EACH INSTANCE.

CASE NO. 1. PATIENT NO. 96780, A WHITE MALE AGED 55 YEARS WITH PYLORIC OBSTRUCTION DUE TO A DUODENAL ULCER, ON AUGUST 1, 1939 RECEIVED A PREOPERATIVE BLOOD TRANSFUSION. BLOOD OF GROUP A WAS GIVEN TO THE PATIENT, WHOSE BLOOD GROUP WAS LATER DETERMINED AS O. THE LABORATORY TECHNICIAN HAD, BY MISTAKE, PERFORMED THE GROUPING AND COMPATIBILITY TESTS USING A SPECIMEN OF GROUP A BLOOD WHICH HAD BECOME CONFUSED WITH THE SPECIMEN FROM THE PATIENT. APPROXIMATELY 75 CC. OF CITRATED BLOOD HAD BEEN GIVEN WHEN THE PATIENT SUDDENLY COMPLAINED OF PRECORDIAL PAIN AND A SENSATION OF TINGLING IN BOTH LOWER EX-

TREMITIES. THE TRANSFUSION WAS STOPPED AT THIS POINT. PALLOR AND DYSPNEA WERE NOTED; THE RADIAL PULSE COULD NOT BE FELT AND THE SYSTOLIC PRESSURE FELL TO ZERO. THERE WAS VOMITING AND DIARRHEA. TREATMENT FOR SHOCK WAS INSTITUTED AND THE BLOOD PRESSURE RAPIDLY ROSE TO 150/110. A SEVERE SHAKING CHILL OCCURRED TWENTY MINUTES LATER, FOLLOWED BY CYANOSIS. THE PATIENT WAS PLACED IN AN OXYGEN TENT AND HIS GENERAL CONDITION WAS QUITE GOOD FROM THAT TIME ON. FIVE HOURS POST-TRANSFUSION HE COMPLAINED OF CRAMPS IN THE GASTROCNEMIUS MUSCLES. TWELVE HOURS POST-TRANSFUSION HE VOIDED FOR THE FIRST TIME, 150 CC. OF DARK BROWN SMOKY URINE. EXAMINATION OF THE URINE REVEALED BENZIDINE +++, A FEW GRANULAR CASTS, ALBUMIN ++, SPECIFIC GRAVITY 1.015 AND A PH. OF 6. THE POSITIVE URINARY FINDINGS GRADUALLY DISAPPEARED OVER A PERIOD OF THREE DAYS. ON THE DAY FOLLOWING THE TRANSFUSION THE BLOOD UREA NITROGEN WAS 40 MGS. PERCENT. ONE DAY LATER THE BLOOD UREA NITROGEN WAS 26 MGS. PERCENT AND THE CARBON DIOXIDE COMBINING POWER WAS 49 VOLUMES PERCENT. ON THE THIRD DAY THE BLOOD UREA NITROGEN WAS 25 MGS. PERCENT AND THE CARBON DIOXIDE COMBINING POWER WAS 59 VOLUMES PERCENT. THE BLOOD CHEMISTRY WAS NORMAL ON THE FOURTH DAY. TWO DAYS LATER, ON AUGUST 7, A SUB-TOTAL GASTRIC RESECTION WAS PERFORMED AND THE POST-OPERATIVE COURSE WAS UNEVENTFUL.

CASE No. 2. PATIENT No. U-99838, A WHITE FEMALE AGED 34, WAS ADMITTED ON THE MEDICAL SERVICE JANUARY 5, 1940. A DIAGNOSIS OF CHRONIC MYELOGENOUS LEUKEMIA HAD BEEN ESTAB-

LISHED IN JULY, 1938. ON ADMISSION TO THE HOSPITAL THE PATIENT WAS COMPLAINING OF CHEST AND LEFT UPPER ABDOMINAL PAIN, SEVERE COUGHING AND GROSS HEMOPTYSIS. EXAMINATION REVEALED RALES OVER BOTH LUNG FIELDS AND A PLEURAL FRICTION RUB OVER THE LEFT LUNG BASE. THE SPLEEN WAS PALPABLE AND TENDER. A CLINICAL IMPRESSION OF PULMONARY AND SPLENIC INFARCTION WAS MADE. DURING THE NEXT TWO DAYS HER GENERAL COURSE WAS PROGRESSIVELY DOWNHILL, WITH A TEMPERATURE OF 104 TO 105 DEGREES, PULSE RATE FROM 140 TO 150, AND RESPIRATORY RATE FROM 30 TO 40 ACCOMPANIED BY CYANOSIS. THE RED BLOOD CELL COUNT FELL FROM 3,700,000 ON ADMISSION TO 2,510,000 ON THE FOURTH HOSPITAL DAY. THE PATIENT APPEARED MORIBUND ON THE FIFTH HOSPITAL DAY, WHEN A TRANSFUSION OF 300 CC. OF CITRATED BLOOD WAS GIVEN. THREE AND ONE-HALF HOURS LATER SHE COMPLAINED OF SEVERE GENERALIZED ABDOMINAL PAIN AND PROGRESSED ALMOST IMMEDIATELY INTO A STATE OF PROFOUND SHOCK. A SPECIMEN OF URINE VOIDED JUST BEFORE THE ONSET OF ABDOMINAL PAIN WAS RECORDED AS DARK RED IN COLOR AND WAS STRONGLY POSITIVE TO BENZIDINE. DEATH FOLLOWED FIFTEEN MINUTES AFTER THE OCCURRENCE OF ABDOMINAL PAIN.

PERMISSION FOR AUTOPSY WAS NOT OBTAINED AND, UNFORTUNATELY, THE TRANSFUSION SERVICE DID NOT LEARN OF THE DEATH UNTIL TWENTY-FOUR HOURS LATER, AT WHICH TIME THE BODY HAD BEEN EMBALMED. FOR THESE REASONS LABORATORY AND TISSUE STUDIES SUFFICIENT TO PROVE A DIAGNOSIS OF HEMOLYTIC TRANSFUSION REACTION WERE NOT POSSIBLE.

THE BLOOD GROUPS OF DONOR AND PATIENT PRIOR TO TRANSFUSION WERE DETERMINED AS A. THERE WAS NO EVIDENCE OF INCOMPATIBILITY ON THE DIRECT MATCH TEST. RE-EXAMINATION OF THE SPECIMENS OF BLOOD OBTAINED BEFORE TRANSFUSION REVEALED THAT THE BLOOD OF THE PATIENT BELONGED TO SUB-GROUP A₂ AND THAT OF THE DONOR TO SUB-GROUP A₁. THESE SPECIMENS WERE THEN SENT TO ALEXANDER WIENER, SEROLOGIST AND BACTERIOLOGIST IN THE OFFICE OF THE CHIEF MEDICAL EXAMINER OF NEW YORK CITY. RESULTS OF HIS EXAMINATION ALSO SHOWED THE BLOOD OF THE PATIENT TO BELONG TO SUB-GROUP A₂ AND THAT OF THE DONOR TO SUB-GROUP A₁. WIENER ALSO FOUND THE BLOOD OF THE PATIENT TO BE RH POSITIVE AND THAT OF THE DONOR TO BE RH NEGATIVE, AND STATED THAT THIS AGGLUTINOGEN THEREFORE COULD NOT HAVE PLAYED ANY ROLE IN THE REACTION (CF. P. 18). HE CONCURRED WITH THE OPINION THAT A HEMOLYTIC TRANSFUSION REACTION WAS NOT PROVEN AND STATED THAT, IF THIS WERE A TRANSFUSION REACTION, IT WOULD HAVE TO BE CONSIDERED AN UNEXPLAINED ONE NOT AVOIDABLE BY ANY OF THE TECHNIQUES AVAILABLE AT THE PRESENT TIME. THIS CASE IS REPORTED BECAUSE IT IS THE ONLY DEATH IN THE ENTIRE SERIES WHICH MIGHT BE ATTRIBUTED TO THE TRANSFUSION OF BLOOD.

BECAUSE OF THE KNOWN SUSCEPTIBILITY OF PATIENTS SUFFERING FROM LEUKEMIA TO SEVERE TRANSFUSION REACTIONS, SOME AUTHORITIES ON BLOOD TRANSFUSION CONSIDER LEUKEMIA A CONTRA-INDICATION TO BLOOD TRANSFUSION.⁶¹

IN REPORTING THIS SERIES OF TRANSFUSIONS THE FOLLOWING CASE IS ALSO OF INTEREST. THIS PATIENT, A WHITE MALE

AGED 32 YEARS, RECEIVED A TRANSFUSION ONE HOUR AFTER APPENDECTOMY FOR ACUTE APPENDICITIS WITH PERFORATION. THE PATIENT WAS OF GROUP A AND HAD RECEIVED 300 CC. OF GROUP B BLOOD ISSUED FROM THE BANK BY MISTAKE BEFORE THE TECHNICIAN HAD REALIZED THE ERROR. NO SIGNS OF IMMEDIATE OR DELAYED REACTION, SUBJECTIVE OR OBJECTIVE, DEVELOPED, DESPITE CLOSE WATCHING OF THE PATIENT. ALL POST-TRANSFUSION URINARY SPECIMENS WERE EXAMINED FOR A PERIOD OF SIX DAYS; THERE WAS NO EVIDENCE OF HEMOGLOBINURIA. THE PATIENT WAS DISCHARGED FROM THE HOSPITAL ON THE TWENTIETH POST-OPERATIVE DAY AND WAS SEEN ONE MONTH LATER IN FOLLOW-UP CLINIC. NO ILL EFFECTS RESULTED FROM THE TRANSFUSION OF INCOMPATIBLE BLOOD. RE-CHECK OF BOTH THE PRE-TRANSFUSION AND POST-TRANSFUSION SPECIMENS OF BLOOD SHOWED THAT OF THE PATIENT TO BE GROUP A AND THAT OF THE DONOR TO BE GROUP B. THE INCOMPATIBILITY ON DIRECT MATCH WAS QUITE EVIDENT IN BOTH SPECIMENS.

FEBRILE REACTIONS FOLLOWED 125 TRANSFUSIONS IN THIS SERIES, A PERCENTAGE OF 4.06. IN NINETY-FIVE CASES THE RISE IN TEMPERATURE WAS PRECEDED BY A CHILL. THERE WERE NO DEATHS IN WHICH THESE REACTIONS WERE CONSIDERED A CONTRIBUTORY CAUSE. IN FIFTY-THREE CASES URTICARIAL REACTIONS MARKED ONLY BY THE APPEARANCE OF WHEELS FOLLOWED CLOSE UPON TRANSFUSION. IN THREE CASES WIDESPREAD URTICARIA WAS PRECEDED BY PALLOR, SWEATING, A MARKED INCREASE IN PULSE RATE AND A FALL IN BLOOD PRESSURE. EACH OF THESE PATIENTS RESPONDED READILY TO SUPPORTIVE MEASURES INSTITUTED FOR ANAPHYLACTIC SHOCK.

THE INCIDENCE OF URTICARIAL REACTIONS MIGHT BE REDUCED IF BLOOD WERE DRAWN FROM DONORS IN A FASTING STATE. THE DIFFICULTY AND INCONVENIENCE IN OBTAINING SUCH DONORS MAKES THIS PLAN IMPRACTICABLE, PARTICULARLY IN VIEW OF THE MILDNESS AND INFREQUENCY OF URTICARIAL REACTIONS.

TABLE XXIX

FEBRILE REACTIONS IN RELATION TO GROUPS TRANSFUSED					
<u>GROUPS</u>	<u>NO. CASES</u>	<u>REACTIONS</u>	<u>FEBRILE</u>	<u>PERCENT</u>	
AB--AB	64	3	2	3.1	
*A--A	1171	78	56	4.7	
B--B	323	23	16	4.9	
O--O	1403	73	47	3.3	
O--AB	1	0	0	0	
B--AB	16	2	2	12.5	
O--A	49	1	1	2.0	
O--B	31	1	1	3.2	
A--AB	18	0	0	0	

*A--A SERIES CORRECTED FOR PATIENT NO. 78995
A--A TRANSFUSIONS 1171-60 = 1111
A--A FEBRILE REACTIONS 56-11 = 45
CORRECTED DETERMINATION $45/1111 = 4.0$ PERCENT

TABLE XXX

PATIENT No. 78995. BLOOD GROUP A. (CHRONIC LYMPHATIC LEUKEMIA)		
	<u>No.</u>	<u>PERCENT</u>
TRANSFUSIONS GIVEN	61	
TRANSFUSIONS OF GROUP A BLOOD	60	
TRANSFUSIONS OF GROUP O BLOOD	1	
FEBRILE REACTIONS	12*	19.7
URTICARIAL REACTIONS	6	9.8
TOTAL REACTIONS	18	29.5

*ONE REACTION WAS O--A.

COMMENT

THE CAUSES OF CHILLS AND FEVER WHICH FOLLOW THE INTRAVENOUS ADMINISTRATION OF SOLUTIONS, INCLUDING BLOOD, AND METHODS FOR REDUCING THE INCIDENCE OF THESE REACTIONS HAVE BEEN A SUBJECT OF MUCH INTEREST IN MANY HOSPITALS. THE ADOPTION OF RIGID ROUTINES IN THE PREPARATION OF SOLUTIONS AND CLEANSING OF GLASSWARE AND TUBING WITH WHICH THE SOLUTIONS COME IN CONTACT HAVE REDUCED THE INCIDENCE OF UNTOWARD REACTIONS. DESPITE CAREFUL ATTENTION TO THESE FACTORS, THE INCIDENCE OF CHILLS AND FEVER IN MOST REPORTED SERIES OF BLOOD TRANSFUSIONS VARIES FROM 5 PERCENT TO 20 PERCENT. IN ADDITION TO EXTRINSIC FACTORS IT IS PROBABLY TRUE THAT THE CONDITION OF THE PATIENT PLAYS A ROLE IN THE CAUSATION OF THESE REACTIONS. IT IS A MATTER OF COMMON OBSERVATION THAT PATIENTS IN SEVERE SEPTIC STATES AND WITH LEUKEMIA, FOR EXAMPLE, ARE MUCH MORE SUBJECT TO POST-TRANSFUSION CHILLS AND FEVER.

RECENTLY SOME WRITERS HAVE CONTENDED THAT THE SUBGROUPS OF A AND AB, NAMELY, A_1 AND A_2 AND A_1B AND A_2B , WHEN MIXED IN TRANSFUSIONS, MAY BE RESPONSIBLE FOR POST-TRANSFUSION CHILLS AND FEVER (CF. P. 30). FOR THIS REASON THE TRANSFUSIONS IN THIS SERIES WERE ANALYZED FROM THE STANDPOINT OF FEBRILE REACTIONS IN RELATION TO BLOOD GROUPS TRANSFUSED. THE INCIDENCE OF FEBRILE REACTIONS WAS 4.7 PERCENT BETWEEN MEMBERS OF GROUP A, 4.9 PERCENT BETWEEN MEMBERS OF GROUP B, AND 3.3

PERCENT BETWEEN MEMBERS OF GROUP O. WHILE THE PERCENTAGE OF REACTIONS OCCURRING AMONG MEMBERS OF GROUP A WAS NO HIGHER THAN AMONG MEMBERS OF GROUP B, BOTH OF THESE SERIES REVEALED A HIGHER PERCENTAGE THAN OCCURRED AMONG MEMBERS OF GROUP O. IT MAY BE THAT THE NUMBER OF TRANSFUSIONS GIVEN MEMBERS OF GROUP B IS NOT SUFFICIENTLY LARGE TO PERMIT ANY VALUE TO BE ATTACHED TO A PERCENTAGE ANALYSIS. CONSIDERING THIS, THE INCIDENCE OF REACTIONS AMONG 1171 TRANSFUSIONS OF GROUP A BLOOD TO GROUP A PATIENTS (4.7 PERCENT), AS COMPARED TO THOSE WHERE GROUP O WAS CONCERNED (3.3 PERCENT), IS CONSIDERABLY HIGHER. HOWEVER, IN THE GROUP A SERIES PATIENT NO. 78995 RECEIVED SIXTY-ONE TRANSFUSIONS FOR ANEMIA SECONDARY TO CHRONIC LYMPHATIC LEUKEMIA. FEBRILE REACTIONS FOLLOWED TWELVE OF THE SIXTY-ONE TRANSFUSIONS AND URTICARIAL REACTIONS FOLLOWED SIX, MAKING A TOTAL OF EIGHTEEN. THE TOTAL INCIDENCE OF REACTIONS WAS 29.5 PERCENT AND OF FEBRILE REACTIONS 19.7 PERCENT. ONE OF THE FEBRILE REACTIONS FOLLOWED A TRANSFUSION OF GROUP O BLOOD, LEAVING ELEVEN FEBRILE REACTIONS IN SIXTY TRANSFUSIONS OF GROUP A BLOOD. A TRUER ANALYSIS OF THE GROUP A REACTIONS RESULTS IF THE SERIES IS CORRECTED BY ELIMINATING THE TRANSFUSIONS AND REACTIONS OF THIS PATIENT, SINCE IN THE GROUP O SERIES NO PATIENT PARTICULARLY SUSCEPTIBLE TO REACTIONS RECEIVED A COMPARABLE NUMBER OF TRANSFUSIONS. THE CORRECTED REACTION RATE IN THE GROUP A SERIES IS 4.0 PERCENT WHICH IS VERY CLOSE TO THE RATE OF 3.3 PERCENT IN THE GROUP O SERIES, AND THE DIFFERENCE IS NOT SIG-

NIFICANT, BEING WELL WITHIN THE LIMITS OF STATISTICAL ERROR
WHEN THE NUMBER OF CASES REPORTED IS CONSIDERED.

TABLE XXXI

<u>AGE OF BLOOD IN DAYS</u>	<u>NUMBER OF TRANS- FUSIONS</u>	<u>RELATIONSHIP OF REACTIONS TO AGE OF BLOOD TRANSFUSED</u>			
		<u>FEBRILE</u>		<u>URTICARIAL</u>	
		<u>No.</u>	<u>%</u>	<u>No.</u>	<u>%</u>
1	468	21	4.5	19	4.1
2	540	25	4.6	9	1.1
3	386	13	3.4	5	1.3
4	286	10	3.5	2	0.7
5	248	13	5.2	5	2.0
6	230	10	4.3	4	1.7
7	182	6	3.3	2	1.1
8	140	5	3.6	3	2.1
9	110	2	1.8	1	0.9
10	93	4	4.3	1	1.1
11	99	4	4.4	3	3.0
12	64	2	3.1	0	0
13	55	2	3.6	1	1.8
14	56	2	3.6	1	1.8
15	29	1	3.5	0	0
16	20	2	10.0	0	0
17	16	2	12.5	0	0
18	7	1	14.3	0	0
19	5	0	0	0	0
20	2	0	0	0	0
21	1	0	0	0	0
TOTAL	3077	125		56	

COMMENT

WHETHER THE INCIDENCE OF REACTION INCREASES AS BANK
BLOOD AGES IS ANOTHER SUBJECT OF MUCH INTEREST. BECAUSE OF
THIS THE TRANSFUSIONS GIVEN IN THIS SERIES ARE ANALYZED FROM
THE STANDPOINT OF REACTIONS IN RELATION TO THE AGE OF THE

BLOOD GIVEN. THIS ANALYSIS WILL BECOME OF REAL VALUE AS MORE STATISTICS ARE ACCUMULATED. AT PRESENT FIGURES INDICATE THAT THE AGING OF BLOOD DOES NOT INCREASE THE RATE OF REACTIONS.

ANOTHER POINT OF INTEREST SHOWN IN THIS ANALYSIS IS THAT IN PRACTICAL OPERATION THE GREAT MAJORITY OF BANK BLOOD UNITS ARE GIVEN UNDER SEVEN DAYS OF AGE. THUS THE AGE LIMITATIONS OF BANK BLOOD, WHICH HAVE BEEN FAIRLY WELL ESTABLISHED (CF. P. 53), CAN BE MET WITHOUT DIFFICULTY.

SUMMARY AND CONCLUSIONS

AN ANALYSIS OF THE EXPERIENCE GAINED AND STATISTICS DERIVED FROM 3077 TRANSFUSIONS OF BANK BLOOD AT THE CINCINNATI GENERAL HOSPITAL HAS BEEN PRESENTED. THIS WAS MADE IN ORDER TO STUDY THE EFFECTS OF THE TRANSFUSION OF PRESERVED BLOOD AND ALSO TO PROVIDE INFORMATION HELPFUL IN THE ACTUAL OPERATION OF A BLOOD BANK.

THE RESULTS MAY BE SUMMARIZED AS FOLLOWS:

1. BLOOD OF THE SAME GROUP AS THAT OF THE PATIENT IS AVAILABLE WITHOUT DELAY IN NINETY-SIX PERCENT OF THE CASES.
2. THE INCIDENCE OF UNTOWARD TRANSFUSION REACTIONS COMPARES FAVORABLY TO THOSE IN REPORTED SERIES OF TRANSFUSIONS OF FRESH BLOOD.
3. AGING OF BLOOD DOES NOT INCREASE THE RATE OF FEBRILE REACTIONS.
4. THERE IS NO SIGNIFICANT INCREASE IN UNTOWARD

REACTIONS RESULTING FROM THE TRANSFUSION OF GROUP A BLOOD AS COMPARED TO TRANSFUSIONS OF BLOOD OF THE OTHER GROUPS.

5. THE CAUSES OF LOSS OF BANK BLOOD ARE, IN ORDER, POSITIVE TESTS FOR SYPHILIS, EXPIRATIONS OF THE TIME LIMIT, AND CLOTTING. METHODS FOR MINIMIZING THESE LOSSES ARE SUGGESTED.

6. IN THE 3077 TRANSFUSIONS OF BLOOD GIVEN ONLY ONE DEATH OCCURRED WHICH MIGHT BE ATTRIBUTED TO THE TRANSFUSION.

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