on	Mercer	Mineral	Mingo	Monongal	Nicholas	Ohio	Pocahonta	Preston	Putnam	Raleigh	Randolph	Roane	Summers	Taylor	Tucker	Tyler	Upshur	Wayne	Webster	Wetzel	Wirt	Wyoming	COAL SEAM	TOTAL A.
				81,786		30,000						19,200				166,477				230,701	6,400		Washington	1,058,461
				98,695		40,000														76,800			Waynesburg	500,430
																105,600				44,800			Uniontown	182,400
		214		115,303		45,000														96,000			Sweickley	595,008
		973		7,213													20,032						Redstone	152,295
380		1,971		123,801		50,000		1,059	44,800			29,632		9,024			9,088	5,120		152,320			Pittsburgh	1,385,565
640									640						45								Little Pittsburgh	1,389
		8,224																					Little Clarksburg	8,224
		19,904						19,200									26,912	3,200					Elk Lick	148,424
		17,088						26,620															Harlem	137,948
		17,504																					Upper Bakerstown	69,152
		28,672						54,240			1,840	6,400			16,656								Bakerstown	574,689
												3,200											Brush Creek	18,200
		21,600																					Mahoning	44,933
		32,896		34,199				148,660			2,736			22,675	34,368		40,768	11,520	7,085				Upper Freeport	746,785
					7,680	25,000		64,000				12,800											Lower Freeport	244,232
		2,432		22,579	46,464			207,870			5,088			87,962			107,616		28,141				Upper Kittanning	906,008
					60,096														45,984				Middle Kittanning	203,992
		14,080	15,398	32,640	77,984			234,515			18,688	26,400		91,725			158,624	112,000	48,800			186	Lower Kittanning	1,706,802
					33,920			286,960			19,200						37,728						Clarion	459,184
											31,680						120,640		77,056				Upper Mercer	338,112
			23,456		99,904					4,480	6,592	19,200					18,176	19,200	93,024			1,312	Stockton	863,588
			61,702		110,816														55,360			3,200	Coalburg	558,469
			109,728		131,776			17,280		11,840	10,208						17,152		112,000			5,760	Winifrede	868,448
			104,531																				Chilton A	238,931
			139,379		141,504														120,096			10,880	Chilton	748,787
										19,840													Hernshaw	227,840
			108,480																				Dinges	299,840
			118,848																			20,720	Williamson	360,560
			133,363							33,280									77,216			17,334	Cedar Grove	863,996
			91,392																			21,184	Lower Cedar Grove	311,488
			97,568		55,360					39,680									17,728			25,088	Alma	787,750
					131,112						78,432						38,752						Peerless	366,696
			228,192		119,456					43,200		4,800						89,600	150,496			36,448	No. 2 Gas	1,474,163
										10,240												44,051	Powellton	172,972
																						48,026	Matewan	52,506
			40,960		160,640					56,320	91,142						35,520		182,336			58,784	Eagle	870,457
			42,560																			6,080	Bens Creek	71,744
					45,472					24,960												71,872	Little Eagle	240,153
			42,880																			9,280	Cedar	71,552
			55,520							73,800									25,120			72,960	Lower War Eagle	275,784
			60,160																			88,128	Glenalum Tunnel	219,923
					49,088		8,390			7,680	105,856								201,824			63,296	Gilbert	483,078
																						48,640	Douglas	119,257
							36,435				186,304						32,864		99,976			28,800	Iaeger	415,099
											170,752						22,400						Castle	276,448
																						6,400	Sewell B	33,920
					258,144		52,467			97,280	249,664				49,472		27,360		132,288			85,760	Sewell	1,409,132
											19,520								116,960			11,520	Welch	226,080
										121,600												109,440	Beckley	358,400
					73,280					76,800	26,272								17,760			73,600	Fire Creek	597,760
																						35,200	Pocahontas 9	40,320
	9,600									16,000													Pocahontas 8	25,600
																						13,440	Pocahontas 7	20,480
	6,400									39,680			320									48,000	Pocahontas 6	208,870
																							Pocahontas 5	14,080
																						16,000	Pocahontas 4	99,200
	38,400									104,320			3,200									110,080	Pocahontas 3	446,195
	33,280									39,680													Pocahontas 2	72,960
																								24,274,759

TABLE 2—Acreage of West Virginia coal seams by counties*

COAL SEAM	Barbour	Boone	Braxton	Brooke	Cabell	Calhoun	Clay	Doddridge	Fayette	Gilmer
Washington						6,400		151,616		15,360
Waynesburg										
Uniontown								32,000		
Sewickley										
Redstone	16,416									
Pittsburgh	22,261		52,941	21,667	8,860	29,632	6,809	58,496		69,120
Little Pittsburgh										
Little Clarksburg										
Elk Lick	10,304									
Harlem										
Upper Bakerstown										
Bakerstown	32,064		30,502	5,000						219,136
Brush Creek										
Mahoning				8,333						
Upper Freeport	93,408		107,872				24,992			
Lower Freeport			13,494	8,333						
Upper Kittanning	118,144		89,824	8,333			116,672			
Middle Kittanning			14,208				67,232		1,472	
Lower Kittanning	154,912	37,152	121,376	8,334			125,792		7,110	
Clarion	44,640						36,736			
Upper Mercer	108,736									
Stockton		57,632	62,400				126,560		12,292	
Coalburg		54,598					126,784		17,881	
Winifrede		163,968					70,784		26,304	
Chilton A										
Chilton		148,544							34,464	
Hernshaw		208,000								
Dingess										
Williamson		12,800								
Cedar Grove		238,592	32,928				47,936		52,429	
Lower Cedar Grove										
Alma		253,056							57,862	
Peerless										
No. 2 Gas		230,016				14,400	36,576		63,347	
Powellton		19,200							70,681	
Matewan										
Eagle		19,200	23,040				37,792		78,765	
Bens Creek										
Little Eagle									80,441	
Cedar										
Lower War Eagle										
Glenalum Tunnel									12,115	
Gilbert									10,912	
Douglas									9,785	
Iaeger										
Castle										
Sewell B										
Sewell	3,232		30,400						175,449	
Welch										
Beckley										
Fire Creek									79,648	
Pocahontas 9										
Pocahontas 8										
Pocahontas 7										
Pocahontas 6									19,110	
Pocahontas 5										
Pocahontas 4										
Pocahontas 3									15,155	
Pocahontas 2										

COAL SEAM	Grant	Greenbrier	Hancock	Harrison	Kanawha	Lewis	Lincoln	Logan	McDowell	Marion	Marshall	Mason	Mercer
Washington				51,072		11,520				86,163	201,766		
Waynesburg										115,335	169,600		
Uniontown													
Sewickley										136,891	201,600		
Redstone				8,128		99,533							
Pittsburgh	32		670	159,488	29,472	106,137				149,325	200,960	42,880	
Little Pittsburgh	64											640	
Little Clarksburg													
Elk Lick	14,184					54,720							
Harlem	17,440			76,800									
Upper Bakerstown	51,648												
Bakerstown						180,179							
Brush Creek			15,000										
Mahoning			15,000										
Upper Freeport	68,992					30,208	74,880			11,526			
Lower Freeport			39,330								73,595		
Upper Kittanning				32,000		21,907				10,967			
Middle Kittanning			15,000										
Lower Kittanning			15,000		194,560	27,667	124,800	16,563		42,496			
Clarion													
Upper Mercer													
Stockton					217,600		57,600	44,160					
Coalburg					55,040			73,088					
Winifrede					37,760			124,160					
Chilton A								134,400					
Chilton								153,920					
Hernshaw													
Dingess								191,360					
Williamson								208,000	192				
Cedar Grove					3,200			227,398	320				
Lower Cedar Grove					78,080			120,320	512				
Alma								240,640	768				
Peerless					118,400								
No. 2 Gas					131,840		64,000	260,256	1,536				
Powellton					25,600				3,200				
Matewan									4,480				
Eagle					28,800			49,920	7,238				
Bens Creek								12,160	10,944				
Little Eagle									17,408				
Cedar									19,392				
Lower War Eagle								19,200	29,184				
Glenalum Tunnel								19,200	40,320				
Gilbert									36,032				
Douglas									60,832				
Iaeger									30,720				
Castle									83,296				
Sewell B									27,520				
Sewell		153,600							94,016				
Welch									78,080				
Beckley									127,360				
Fire Creek		100,000							150,400				
Pocahontas 9									5,120				
Pocahontas 8													9,600
Pocahontas 7									7,040				
Pocahontas 6		80,000							15,360				6,400
Pocahontas 5									14,080				
Pocahontas 4									83,200				38,400
Pocahontas 3		40,000							135,040				33,280
Pocahontas 2													

*Data are tabulated for 59 seams of coal.

SERIES 36, NO. 13 WEST VIRGINIA UNIVERSITY BULLETIN FEBRUARY 15, 1936

THE WEST VIRGINIA ACADEMY OF SCIENCE

Proceedings of The Elkins Meeting (1935)

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ISSUED TWICE IN OCTOBER, NOVEMBER, DECEMBER, JANUARY, FEBRUARY AND MARCH, AND ONCE IN JULY, AUGUST, SEPTEMBER, APRIL AND JUNE

CONTENTS

PAPERS PRESENTED TO THE MATHEMATICS AND PHYSICS SECTION

PAPERS PRESENTED TO THE SOCIAL SCIENCES SECTION (GROUP I)

PAPERS PRESENTED TO THE SOCIAL SCIENCES SECTION (GROUP II)

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Speicher, B. I., Dept. of Botany, W. V. U., Morgantown.
Stathers, Allan, Teacher Mathematics, Sistersville High School.
Stayman, Joseph W., President, Potomac State School, Keyser.
Stevenson, C. A., Prof. of Education, Davis and Elkins College, Elkins.
*Stewart, Joseph K., Instructor in Mathematics, W. V. U., Morgantown.
Stout, Wilbur, State Geologist, Columbus, Ohio.
*Strader, L. D., Teacher of Biology, High School, Bolivar.
†Straley, H. W., III, Stralehurst, Princeton.
†Strausbaugh, Perry D., Prof. of Botany, W. V. U., Morgantown.
*Strickland, Cecil, Teacher, High School, Clendenin.
*Strosnider, Ruth, Teacher of Chemistry, High School, Blacksville.
*Sutton, J. B., Dept. of Chemistry, W. V. U., Morgantown.
Talbot, S. Benton, Prof. of Biology, Davis and Elkins College, Elkins.
†Taylor, Leland H., Assoc. Prof. of Zoology, W. V. U., Morgantown.
Tissue, Rhema Smith, Montgomery.
†Todd, Leslie J., Prof. of Chemistry, Marshall College, Huntington.
Toothman, H.F., Dean, West Liberty State College, West Liberty.
Trent, W. W., State Supt. of Schools, Charleston.
Tucker, R. C., State Geological Survey, Box 265, Morgantown.
†Turner, Bird M., Prof. of Mathematics, W. V. U., Morgantown.
Ulbrich, Albert, Medical Student, 1065 E. Broad St., Westfield, N. J.
†Utterback, W. I., Prof. of Zoology, Marshall College, Huntington.
Van Tromp, H. O., Physician, French Creek.
Vehse, Charles H., Asst. Prof. of Mathematics, W. V. U., Morgantown.
*Vest, G. Ellis, Teacher of Biology, High School, Sutton.
Vest, M. L., Prof. of Mathematics, Davis and Elkins College, Elkins.
Wagner, John R., Prof. of Chemistry, Glenville State College, Glenville.
Ward, John Baylis, Coal Prospector, Beverly.
Weakley, Chas. E., Jr., Chemist, Agricultural Experiment Station, W. V. U., Morgantown.
†Weimer, B. R., Prof. of Biology, Bethany College, Bethany.
Wells, Hawley, Instructor in Biology, Concord State College, Athens.
White, Frank S., Prof. of Psychology, Fairmont State College, Fairmont.
*White, Raymond C., Graduate Student, W. V. U., Morgantown.
White, Ryland, Fairmont State College, Fairmont.
Wiles, I. A., Medical School, W. V. U., Morgantown.
*Wilmoth, Stark A., Teacher of Biology, High School, Elkins.
*Wimer, Ralph P., Teacher of Science, High School, Parsons.
†Winter, John E., Prof. of Psychology, W. V. U., Morgantown.
Wolfe, Russell, Physician, Elkins.
Wooddell, W. S., Teacher of Science, High School, Mullens.
Woods, Roy C., Prof. of Education, Marshall College, Huntington.
*Yost, A. W., Teacher, High School, Farmington.
Zucchero, Peter J., Teacher of Biology, High School, Morgantown.

MINUTES OF THE TWELFTH ANNUAL MEETING

The twelfth annual meeting of the West Virginia Academy of Science was called to order by the president, C. E. Albert, on May 3, 1935, at Davis and Elkins College at Elkins, West Virginia.

President James E. Allen of Davis and Elkins College extended greetings to the society. President Albert responded in behalf of the Academy.

The secretary read a letter from Governor Kump expressing regret at his inability to attend. He then read a letter from the American Association for the Advancement of Science stating that the allowances to affiliated academies had been discontinued, at least for the present. He reported also that the petition for an engineering section as recommended at the Montgomery meeting had not been received and that the matter therefore had been dropped.

The following report of the Executive Committee was read:

"The Executive Committee of the West Virginia Academy of Science makes the following recommendations: (1) that the Senior Academy accept President Cramblett's invitation to hold the next annual meeting at Bethany College on May 1 and 2, 1936, and that the Junior Academy hold its meeting in Charleston next spring at a date to be set by the Junior Academy Committee; (2) that a Junior Academy Committee be instituted as a standing committee, this committee to consist of three members one of whom shall be the secretary of the Senior Academy; (3) that the Academy consider the formation of a medical section provided ten members petition for such a section; and (4) that the Academy appropriate $100 for the use of the Biological Survey Committee to be used as that committee sees fit." The report was accepted.

No report was heard from the Legislative Committee.

Chairman Wallace Smith reported for the Activities Committee:

The chairman of this committee appeared before the Science Section of the State Education Association on an invitation from Prof. H. F. Rogers and presented the idea of the Junior Academy. This was greeted with much enthusiasm on the part of the high-school science teachers. From this group some committees were appointed: The Constitution Committee—Raymond Bell, Montgomery; Miss B. E. Collins, Charleston; Miss Daisy Chapman, South Charleston. The News Letter or Publicity Committee—Miss B. E. Collins, Charleston; Miss Mildred Hadden, Charleston; with many other club sponsors as advisors.

"These people organized the methods of procedure, drew up a constitution, edited four numbers of the News Letter, and prepared a program. The committee feels that this program was a success. Mr. William Lee, Oak Hill High School, presided.

"Mr. Jack Cornell, Clendennin High School, was elected president for the coming year. Mr. Carl Boyles, Northview Junior High School, Clarksburg, was chosen vice president, and Miss Mary Oliver, Montgomery High School, was elected secretary.

"We believe that another year of hard work on the part of those interested in this work with the encouragement of the seniors will make a very strong organization of the Junior Academy. About 50 boys and girls attended the first meeting and fifteen clubs registered.

"The committee submits with this report a copy of the Junior Academy program and copies of the news letters containing the constitution, membership rules, and other data.

"The committee recommends that all members of the Senior Academy respond promptly when they are called on by the Junior Academy for ideas and suggestions. We desire the full cooperation of any seniors who may be called on to appear on the program next year."

WALLACE SMITH, Chairman.

This report was accepted.

A report of the Membership Committee was given by Chairman J. E. Judson, who reported that good progress had been made and a number of new members obtained.

The secretary read the names of eleven proposed new members who had been approved by the Executive Committee. These were elected, as indicated by names starred in the complete membership list on page 5.

The report of the representative to the Pittsburgh meeting of the American Association for the Advancement of Science was given by H. A. Davis:

THE ACADEMY CONFERENCE REPORT

The 1934 meeting of the Academy Conference was called to order on December 27, at Pittsburgh, Pa. The first topic covered the Junior Academy movement. Of the 24 existing academies, nine have junior academies organized and under their sponsorship. These nine academies are Illinois (with about 200 junior academies), Indiana, Ohio, Iowa, Kansas, Alabama, Kentucky, Pennsylvania, and the New Orleans City Academy.

Delegate Alexander of Ohio, Otis Caldwell, and others advocated nationalization of junior academies with the publication of a national journal of source material to be used at regular or irregular intervals. This idea was strongly opposed by several delegates who favored local inexpensive mimeographed leaflets as more likely to hold the interest of the junior members.

Delegate Thomas of Illinois reported that the Illinois Junior Academies lost $250 on a publication depending on subscriptions. The State Academy had to pay the deficit. They now use a "Science Leaflet."

Illinois sponsors a radio program which is found successful. The programs are talks given by scientists in their own fields to high-school students. They would like to associate with other states in this venture.

Any further movement toward nationalization of junior academies must come up through the state academies. Such nationalization has been authorized by the A. A. A. S., but it will not take the initiative. A committee of four, including Dr. Caldwell, is to be appointed to work through the state academies and cooperate with the A. A. A. S.

Dr. Cattell spoke of the possibility of organizing "local branches" of the A. A. A. S. An experimental branch of this kind has been organized at Lancaster, Pa. This local branch has a membership of 60, including 12 of the 20 resident members of the A. A. A. S. Membership dues of a dollar or so might be charged. Membership is not limited to scientists, but is advocated for all who are interested in scientific matters. Scientific "movies" and short-wave radio talks to be amplified in the local auditorium are suggested as cheap means to provide programs, or to supplement oral programs by local or imported speakers.

Many delegates advocated that the state academies take the initiative and cooperate with the A. A. A. S. in organizing such local branches.

A mimeographed report entitled "Credit Value of Laboratory Teaching" was presented without discussion. A copy is appended to this report.

A discussion of academy financing was led by Secretary Bilsing of Texas. A total of $1482.50 was distributed by the A. A. A. S. to the various academies last year. This ranged from $15 to North Dakota to $156 to Illinois. It was intimated that this support may be withdrawn in the near future.

McGill of Tennessee said that they realized about $300 annually from advertisements of school and laboratory supplies, etc., in their journal. They also have sustaining memberships of $10 which are paid annually or occasionally by interested persons, whether scientists or not.

Miller of Virginia reported that a number of institutions of higher learning in Virginia paid substantial sustaining membership fees of various amounts.

Dr. Cattell stated that the A. A. A. S. has a fund of $100,000, the income of which is to be used for research. He stated that grants from this fund can be obtained by applying through the academies to the Permanent Secretary of the A. A. A. S. He stated further that preference would be given persons connected with the smaller institutions of the country where funds for research are less likely to be available from other sources.

The report was accepted.

The report of the Fred E. Brooks Wild-Flower Memorial Garden Committee was given by P. D. Strausbaugh:

Your committee recommends the location of the Fred E. Brooks Wild-Flower Memorial Garden in Watoga State Park, Pocahontas County, West Virginia; it being understood that all plans for the development of such a garden will first have the approval of the National Park Service, and that the West Virginia Academy of Science will assume all responsibility for the general upkeep and maintenance of same.

"In order that there may be a uniform policy through the years for the development of this memorial garden, your committee recommends that, in so far as possible, the vegetation of the area selected be preserved in its natural state; also that only native species be used for such plantings as may be made from time to time. This recommendation has the unqualified and unanimous approval of numerous friends and relatives of the late Fred E. Brooks, and it is in full accord with the thought and practice of the unexcelled student and lover of wild life, in whose honor this garden is to be established."

The report was accepted.

President Albert then appointed the following committees:

Membership Committee: E. C. H. Davies (chairman), B. R. Weimer, Carl Campbell.

Resolutions Committee: Nelle Ammons (chairman), C. C. Regier, A. C. Blackwell.

Nominations Committee: H. A. Davis (chairman), Frank White, E. Meade McNeill.

Legislative Committee: C. W. Maxwell (chairman), W. W. Trent, Phil Conley.

Activities Committee: W. W. Hodge (chairman), R. P. Hron, R. B. Purdum.

Auditing Committee: F. D. Galbraith (chairman), S. B. Talbott, T. L. Harris.

F. E. Brooks Wild Flower Garden Memorial Committee: P. D. Strausbaugh (chairman), J. B. McLaughlin, W. S. Downs, E. Meade McNeill, Carl Campbell, H. V. Meakin.

State Biological Survey Committee: A. M. Reese (chairman), Frank Gilbert, J. E. Judson, S. B. Talbott, H. D. Bond, B. R. Weimer, C. M. Roberts, E. R. Grose, E. Meade McNeill, L. M. Peairs, R. C. Patterson, G. H. Bretnall, C. L. Shilliday, A. P. Hamblan, H. W. Shawhan, A. B. Brooks.

Committee for the Preservation of Bird and Mammal Life: A. B. Brooks (chairman), P. C. Bibbee, A. J. Dadisman, N. B. Green, S. B. Talbott.

Junior Academy Committee: Wallace Smith (chairman), H. F. Rogers, M. L. Vest.

Vice-President Dodds now introduced President Albert, who delivered the President's Address, "Our Heritage in Science." He was followed by Vice-President Dodds, whose address was entitled, "Science in Relation to Democracy."

A film, the work of members of the chemistry department of the West Virginia University, entitled "Old Chemical Industries of West Virginia," was shown.

Mr. Strausbaugh introduced H. V. Meakin, who spoke briefly concerning the possibilities of the proposed Brooks Memorial Garden in Watoga State Park.

On Friday afternoon the various Sections held their meetings. At the same time a tea was held for the wives of members. In the evening the principal address of the meeting was delivered by Dr. W. W. Cort of the School of Hygiene and Public Health of Johns Hopkins University, the subject being, "Parasitic Diseases in Egypt in Relation to Village Life and Agricultural Practices."

Following this a reception for members and wives was held at Hallihurst Hall.

The second general meeting was held Saturday morning, May 4. The names of 24 additional persons were proposed for membership and accepted by the Academy.

The president now called for committee reports.

The Committee for Preservation of Bird and Mammal Life reported that no progress had been made during the year but that plans were under way for the coming year.

Chairman A. M. Reese then presented the report of the State Biological Survey Committee:

THE BIOLOGICAL SURVEY REPORT

"At the annual meeting of the Academy of Science held at New River State College in May 1934 it was voted to initiate a biological survey of the state, and an executive committee, consisting of a biologist from each college of the state, the park naturalist of Oglebay Park, and the head of the State Conservation Commission, was appointed to have charge.

The first meeting of the executive committee was held in Clarksburg on Nov. 10, 1934. Committees at this meeting were appointed to formulate a constitution and to draw up a sample card for recording animals and plants as collected. A committee also was appointed to consider the advisability of asking the State Legislature for an appropriation for the expenses of the survey.

"It was moved and carried that the Survey compile, as soon as possible, a catalog of the biological literature of the state. West Virginia University was selected as the repository for the collection.

"The second meeting of the executive committee was held at the Carnegie Museum, Pittsburgh, on Dec. 28, 1934, during the national science meetings. It was decided that the legislative program, proposed at the Clarksburg meeting, be postponed for two years.

"The Constitution and By-Laws, formulated by the committee of which L. M. Peairs was chairman, were read and adopted with a few changes. Copies of this constitution may be had from the chairman or from the secretary of the Survey. R. C. Patterson, of Potomac State, who acted as secretary for the Clarksburg meeting, was elected secretary of the executive committee, and Earl L. Core of the State University was elected custodian of the collection of the Survey.

"During the year several circular letters were sent to the members of the executive committee; and a list of collectors and identifiers of the different groups of plants and animals was sent to each member. Copies of this list may be had from the chairman.

"Several valuable lists of animals and plants collected by members have been received by the chairman, as well as a small number of animals and a much larger number of plants, the latter going direct to the custodian, Dr. Core.

"Five thousand cards for cataloging collections are ready for distribution by the chairman and secretary. The cards were supplied by the State University and were printed through the cooperation of the New River State College.

"With the spasmodic aid of F. E. R. A. students, the chairman and Dr. Core have been compiling a bibliography of biological papers pertaining to West Virginia. The following sources have been consulted: reports of the U. S. Department of Agriculture and of the Bureau of Fisheries; the proceedings of the W. Va. Academy of Science; W. Va. Wild Life Magazine; W. Va. Review; bulletins of the W. Va. Agricultural Experiment Station; reports of the Smithsonian Institution; Biological Abstracts; the Bulletin of the Torrey Botanical Club; Torreya; Rhodora; W. Va. Geological Survey; Mycology; American Journal of Botany; American Fern Journal; Bryologist; Journal of the New York Botanical Garden; and Ecology.

"A grant of $100 has been requested of the executive committee of the Academy to pay the field expenses of a collector during the coming summer. If this grant be made a trained collector will accompany the W. Va. Biological Expedition for six weeks and then continue alone as long as funds will permit."

A. M. REESE, Chairman.

The report was accepted.

F. D. Galbraith presented the report of the Auditing Committee:

"We the undersigned, have examined the accounts of Frank Cutright, Treasurer, and find them in satisfactory condition."

F. D. GALBRAITH,
S. B. TALBOTT,
T. L. HARRIS.

The report was accepted.

Miss Nelle Ammons presented the following report of the Resolutions Committee.

Resolved: That the West Virginia Academy of Science in its twelfth annual meeting extend its thanks to President and Mrs. Allen for their cordial reception and entertainment; to the local committee and organizations for the efficient handling of details which contributed to our comfort; to the women of the Methodist and Presbyterian churches, and to the orchestra for their entertainment; to the school authorities for providing rooms for meetings of the Junior Academy; to the people who opened their homes to the junior members; to A. A. Wood, supervisor of the Monongahela National Forest, and to his assistants for their service in connection with the local trips; and finally to the officials of the Academy, especially to the president and secretary, for their services."

NELLE AMMONS,
C. C. REGIER,
A. C. BLACKWELL.

The report was accepted.

E. Meade McNeill made the following report of the Nominations Committee:

For president .... G. S. Dodds
For vice-president .... Frank Cutright
For secretary .... M. L. Vest
For treasurer .... C. G. Brouzas
For member of Publications Committee .... T. L. Harris

H. A. DAVIS, Chairman,
E. MEADE McNEILL,
FRANK S. WHITE.

The slate was accepted by unanimous election.

The section chairmen now reported as follows:

Biology: 30 present. Chairman for 1936, B. R. Weimer. Frank Gilbert, chairman.

Chemistry: 39 present. Chairman for 1936, R. B. Dustman. R. B. Purdum, chairman.

Geology and Mining: 25 present. Chairman for 1936, Paul Price. H. M. Fridley, chairman.

Mathematics and Physics: 20 present. Chairman for 1936, Joseph K. Stewart. H. A. Davis, chairman.

Social Science, Group 1: 22 present. Chairman for 1936, C. C. Regier. C. G. Brouzas, chairman.

Social Science, Group 2: 28 present. Chairman for 1936, Frank White. C. A. Stevenson, chairman.

The reports were accepted.

President Albert introduced the new officers, who spoke briefly. The meeting then adjourned.

PROGRAM OF THE ELKINS MEETING

General Program

President's address: Our Heritage in Science.

G. S. Dodds: Science in Relation to Democracy.

J. A. Gibson, Jr., H. Hill, and F. E. Clark: Old Chemical Industries of West Virginia, a film.

Meetings by Sections

Biology

(Botany, Zoology, Physiology, Medicine, Agriculture)

C. E. Irvine, Beverly: Multiple Oocytes in a Dog's Ovaries (Lantern).

Nelle Ammons, Morgantown: Preliminary List of West Virginia Liverworts.

Charles Gould, Huntington: Polyporaceae of Southern West Virginia.

P. D. Strausbaugh and Earl L. Core, Morgantown: Additions to the Millspaugh Check-List of West Virginia Spermatophytes, No. 2.

L. Dow Strader, Harper's Ferry: A Preliminary Survey of the Herpetology of the Eastern Panhandle.

N. Bayard Green, Elkins: Further Notes on the Food Habits of Cryptobranchus alleganienis.

Frank A. Gilbert, Huntington: Additions to the Cryptogamic Flora of West Virginia, No. 2.

Chemistry

(Chemistry, Chemical Engineering, Pharmacy)

W. W. Hodge and L. K. Herndon, Morgantown: The Nature and Extent of West Virginia Coal Seams and of Their Drainage.

F. D. Galbraith, Keyser: A Modern Periodic Arrangement of the Elements.

Earl C. H. Davies, Morgantown: Silicic-Acid Gel Structure as Shown During Syneresis.

R. B. Purdum, Carl Moore, Kenneth Bullivant, and Keith Heltzel, Elkins: The Solubility of Benzidine Sulphate in Water-Alcohol Mixtures.

A. C. Blackwell, Barboursville: Heavy Hydrogen and Some of Its Compounds.

Virgil Greene Lilly, Morgantown: The Pulvic Acids Produced by the Nitric Acid Oxidation of Coal.

R. B. Purdum and Leola Wills, Elkins: An Improved Method for the Volumetric Estimation of Soluble Sulphates.

Geology and Mining

(Geology, Archaeology, Geophysics, Coal and Oil Engineering, Road Commission, Building Material)

Robert E. Bayles, Morgantown: Opal Stalactites in Sandstone.

R. E. Sherill, Pittsburgh: Devonian Foldings in the Allegheny Plateau.

R. C. Tucker, Morgantown: Isopach Maps of Berea-Onondaga (Corniferous) Interval for State, Huntington, Charleston, and Adjoining Portions of Pennsylvania and Ohio.

H. W. Straley, Chapel Hill, N. C.: Terminology of the Tectonic Forms Assumed by Igneous Rocks.

S. G. Wilkinson, Morgantown: Terrace Sands of the Monongahela Valley.

Paul H. Price, Morgantown: Geology of Road Slips.

Lewis B. Law, Morgantown: The Iron Oxide Minerals.

Mathematics and Physics

(Mathematics, Astronomy, Physics, Mechanical Engineering, Electrical Engineering)

R. C. Colwell, Morgantown: The Sand Figures on Chladni Plates. (Lantern.)

R. P. Hron, Huntington: Electric Tube-Lights.

M. J. Kelly, Elkins: Units of Time.

C. H. Vehse, Morgantown: Stresses in a Rotating Sphere.

J. K. Stewart, Morgantown: An Extension of the Birational Quadratic Transformation.

H. A. Davis, Morgantown: The Birational Transformation Associated with the Twisted Cubic.

Social Sciences—Group I

(Philosophy, Philology, Economics, History, Sociology)

K. D. Hutchinson, Morgantown: The Right to Gold.

J. W. Matheny, Montgomery: Transportation in the Kanawha Valley.

A. J. Dadisman, Morgantown: A Changing County Government..

F. R. Gay, Bethany: The Influence of Sophocles' *Philoctetes* on Modern Literature and Criticism.

C. C. Regier, Montgomery: What Every American Citizen Should Know.

M. S. Cushman, Athens: The Influence of Democracy Upon English Historiography.

T. L. Harris, Morgantown: Investigators and Interpreters.

C. G. Brouzas, Morgantown: The Pre-Hellenic Inhabitants of Greece and Italy.

Social Sciences—Group II

(Education, Psychology)

E. V. Bowers, Huntington: What is Intelligence?

N. Bayard Green, Elkins: A Study of Biology Teaching in the First-Class High Schools of West Virginia.

Harry H. Greene, Rivesville: Nationality and High School Achievement.

Roy C. Woods, Huntington: A Study of the College Student's Ability to Evaluate.

Frank White, Fairmont: The Relationship of Intelligence to Scholarship.

A. A. Schoolcraft, Buckhannon: The Relation of Intelligence Quotients to College Grades.

A. E. McGuire, Athens: A Reorganization of the Junior College Curriculum for Present Day Needs.

Lucille Strickland, Morgantown: Results of an Experimental Study at West Virginia University. (tentative).

Dinner Program, Friday, May 3

Address by Dr. W. W. Cort, the School of Hygiene and Public Health of the Johns Hopkins University: "Parasitic Diseases in Egypt in Relation to Village Life and Agricultural Practices."

Papers Read at the Elkins Meeting

OUR HERITAGE IN SCIENCE*

(An Abstract)

C. E. ALBERT

Davis and Elkins College

WE ARE GATHERED here today as a group interested primarily in the great world of science. We are not unmindful however of our responsibility to those men and women of the past who have contributed to our welfare and happiness, and today we pause awhile at the beginning of our sessions to pay them due respect and homage.

As those interested in science we do not talk alone for we acknowledge with sincerity our fellow worker in other fields and with him travel the highway of life knowing that he too is contributing his share to human life and progress.

There have been great men and women of literature and music and religion as well as those of science and to neglect them does not become the fair and unselfish spirit of true men of scientific thought. We are indebted to those benefactors who have given bountifully of their means, time, and thought to place for our convenience and use great institutions of learning, hospitals, and research, and have made it possible for the humblest person to enjoy their privileges and benefits. Men have given us government, industry, and commerce, and a new army of men and women now are teaching us something of other peoples of the world and something of their difficulties so that we are learning to appreciate them as well as they learn to appreciate us. The whole world is tied together by mutual bonds, and to those men and women who are giving us a world understanding we pay our respects today.

I shall not assume that the scientific heritage is all-sufficient for life. Like material wealth it is the sure foundation upon which our social and moral welfare may rest. We could be a happy people with the oil lamp and the simple means of transportation and communication if we had good books. This brings me to our heritage in literature. I suppose literature, including the Bible, has healed more distress of the spirit of men than any other factor. Good literature carries us out and beyond the sordid environment of dull days and even in pleasant and congenial surroundings it takes us on excursions to other lands to live awhile with the minds of the great. Here I can mention the names of a few of those to whom we are indebted for new worlds, new visions, and oft times new comprehensions of life. A few are Shakespeare, Tennyson, Browning, Wordsworth, Keats, Whittier, Longfellow, Woodrow Wilson, and Abraham Lincoln. History is the story of mankind retold. From the experience of the past we build our present and future and these stories are guiding posts on the way. From the experiences of the past as soil, life grows upward.

Music is an almost indispensable art in complete living. Who is there with any sense of pleasing sound that does not enjoy good music. I cannot enter here very far into this realm, for music has its roots in the very history of a people. You who have listened to the song of the Volga boatman with the slow rhythm of the song and the steady beats of the theme can almost visualize the swaying bodies of the men as they pull on the ropes and you can al-

*The address of the president of the Academy.

most hear the rasping of the hobnailed shoes in time with the beat of the music. There is pathos in the song and it tells us the story of oppression of these men. The Watch on the Rhine brings before us battallions of soldiers marching to the frontiers in defense of the fatherland and translates the spirit of love of country in vibrations of harmonious sound rather than in words of patriotism. Our own Star Spangled Banner stirs us to a renewed appreciation of our own beloved America. The weird, pathetic music of the people of the islands of the sea tells us of their sufferings and distresses. Unhappy people tell their story in music; light-hearted people tell us theirs. I must mention here another group: those who have perfected methods of transmission and reproduction and of standardizing instrumentation and those of invention. We must also pay due respect to those faithful ones who have kept alive the love of music or rather the love to play or sing during this recent period of machine-made music. And also to those faithful teachers whose patience has kept alive the appreciation of good music and who unselfishly give of their talent with little reward to those who grow into greatness in the music realm.

Religion has done more to soothe the sorrows of the human heart than any other principle. Religion is the effort by man to attain the goodness of God. The Greek, Hindu, and Mohammedan, and the Hebrew faiths all attempted to reach God and taught that goodness so that they all have added to man's welfare. They taught belief in a divine power and obedience and reverence, splendid attributes for any people. Many of us feel that Jesus of Galilee led His people farther than any other leader in religion in that He made a plan of salvation of the human race a simple one. To leaders of religious thought and to Jesus of Galilee we pay our respects today for His conscientious leadership and His devotion to a principle which the world has learned is good.

We are indebted to the men of science for our modern conveniences and luxuries. Some of these could have become wealthy had they chosen to keep their discoveries to themselves. "I could never work for money but I would always work for science," said Pasteur on one occasion. The joy of discovery and the satisfaction of having contributed some new knowledge are all the rewards the scientific investigator expects. "My sole object," said Sir Humphrey Davy, "was to serve the cause of humanity, and if I have succeeded I am amply rewarded in the gratifying reflection of having done so." He refused a fortune for his discovery of the safety lamp.

Science is not cold and mechanical, nor does it lose the compassionate heart of a full life. It attempts to subdue nature by inquiry and uses infinite patience and labor in order to reach this end. Nor does it seek personal or commercial gain. Scientific work is rarely carried on with a spirit of profit. It does not thrive in a commercial atmosphere. It produces a habit of mind that is not always acquired in other fields. Scientific method is becoming as important as the purely material products of science and invention. Our modern inventions had their foundations in the purely scientific work of investigators. Practical application alone is not the measure of science, for science is also a gospel of truth.

From men of science we inherit the virtues of courage, persistence, duty, accuracy, humility, and hope. Future generations will cherish them as today we pay them honor.

SCIENCE IN RELATION TO DEMOCRACY

G. S. DODDS

School of Medicine, West Virginia University

IT IS THE PROVINCE of science to discover the laws of nature and to utilize them for the good of mankind. It is the province of democracy to learn the will of the people and to give practical expression of this will in governmental activities. It may be of profit to inquire briefly to what extent these two fields are supplementary, and in what respects they may be working to contrary purposes; also to what extent the two may be harmonized and how this may be brought about. In the time available only brief suggestions can be given.

Under the heading of science I include not only the physico-chemical and biological sciences in all their ramifications but also the sciences of human relations. The fundamental concept of science is, I suppose, a belief in the existence of law; the belief that there exists a definite body of truth based upon the fundamental actualities of nature, entirely apart from any system of belief based upon public opinion. On the basis of such a premise it might appear that science and democracy have little in common.

As science has sought for knowledge concerning the laws of nature, progress has been retarded at each step by the prevailing ignorance and superstition. In spite of such retardation, remarkable progress has been made in the mastery of nature for the satisfaction of mankind. When science seeks to extend its field into the realm of human relations, the difficulties increase, partly because in this realm primal human emotions play a large part, and partly because the laws of human relations are not readily subject to laboratory analysis. It is, however, the firm conviction of the speaker that there is no dividing line between natural laws on the one hand and the laws governing human conduct and relations on the other. I firmly believe that the final security of the human race depends upon the recognition of the unity of natural law and moral law and upon the intelligent pursuit of the course indicated by this attitude of mind.

Democracy has arisen as a protest against certain abuses of power on the part of autocracy, as, for example, the founding of our own nation. Moreover, we all recognize that great progress has been made in the betterment of humanity by the rise of "government of the people, by the people, and for the people," even though it still falls far short of its ideal. We of this land of popular institutions look with serious misgivings upon conspicuous examples of great nations that recently have returned to high-handed autocracy. Our people believe that government by the people, even at its worst, is likely to be better for the people than autocracy, and many of our citizens believe that the voice of the people is indeed the voice of God.

While we recognize fully that an autocracy is no better than the small group of men who hold the power, we are less ready to recognize that democracy is subject to a similar limitation in that it cannot rise above the level set by the intelligence and integrity of its citizens. Moreover a democracy suffers the disadvantage that in it responsibility and power are widely distributed, and hence are highly intangible and at the same time are subject to the risks of mob psychology.

As we look back through the centuries we see that nation after nation has become great through conquest; by constant extension of borders and markets, by annexing new sources of raw materials, by dispossessing or exploiting weaker peoples. Thus one civilization after another has arisen and has passed away. Through these centuries man has been seeking security and thus far has failed to attain it. Cannot science in a larger measure than ever before be invoked to aid in the making of plans by which man can live in security and contentment without the constant necessity for expanding markets and territorial growth?

Must the race of armaments go on indefinitely and must the results of past wars and the fear of wars to come continue to sap the strength of the so-called civilized nations? And within nations, must class strife continue to make enemies of men whose best interests would be served by cooperation? Are we to believe that the law of natural selection, operating through the survival of the fittest, endlessly must drive mankind to utilize his greatest strength and ingenuity, either to seize what other men have produced or to provide defense against such aggression? Would it not be more in accord with the scientific ideal if man were to direct his intelligence and power toward devising means for producing an abundance of the necessities of life and for the peaceful utilization of this abundance?

At the present time it appears that mankind actually has made great progress toward the mastery of the laws which will enable him to induce nature to produce in abundance. But it is even more apparent that man has failed in an understanding of the laws which would give to every individual the assurance of an adequate share of this abundance. Several large-scale experiments today are being tried in planned production and distribution as well as in the regulation of human relations, as, for example, in Italy, Soviet Russia, and our own country. Only the future can tell to what extent each of these plans is in accord with nature's laws.

Our own land has been successful above others in the production of abundance (too successful, in the opinion of certain men of prominence), but we are all well aware of the fact that we have failed in the distribution of our products. It is also evident to men of scientific viewpoint that we are exploiting our natural resources and largely are ignoring the laws of nature by which resources may be conserved and renewed. Will we not allow science to teach us that to enjoy we must also produce—that no nation safely can support a large non-productive class, whether that class draw its support by public beneficence or by banditry, burglary, dishonest business, speculation, or plain gambling.

If solutions to the problems just enumerated are to come through democracy rather than through some form of autocracy, there must be brought about a high level of human intelligence and of ethical standards. I insist on the scientific basis of ethics. Man must learn, first of all, the scientific truth that the voice of the people is the voice of God only in so far as their voice is in accord with the laws of God's Universe, in which they live. Man must learn that if he complies with the laws of nature, nature will become his friend and helper, but that if he ignores or violates these laws, nature may destroy him.

In a democracy the laws for the regulation of human affairs are made and administered by representatives chosen by the people. These representatives often hold office for but a short time and too often are chosen without much regard for fitness for the office. It will be a long step toward scientific efficiency in government when citizens shall demand that their representatives and public servants shall be men who are well trained for their duties, and that their tenure of office shall be secure as long as they efficiently and honestly meet the problems that come to them.

There are, indeed, those who will contend that in a democracy the will of the people should be the highest court of appeal—that what the people want they should have. If they want corrupt government and dishonest business, that desire of the people makes these things right. Will these people also go so far as to say that if the people want typhoid epidemics and a high infant mortality, this wish makes such conditions desirable? The voters of our country recently have spoken with swift and decisive emphasis on a certain much-debated question. We await with great interest the verdict of science as to the wisdom of the decision.

So much for the masses. But what has science to say about the individual who is unwilling to conform to established law? I believe it says that the man who wishes to live dishonestly or unsocially is the man who, knowingly or unknowingly, plans to secure personal gain by violation of law. To violate law is unscientific. Cannot science make it plain that in a human society there is no more place for unrestrained individualism than there is for faulty design or defective material in a costly and complicated mechanism?

We who have devoted our lives to the field of science believe that we work in a field that brings us very close to important basic truths. I wonder if, on the other hand, we appreciate sufficiently our responsibility to the great mass of mankind which does not share our intimate approach to Nature's secrets? Though the benefits of scientific discovery have rapidly and extensively been made available to the public in the form of commercialized inventions for our comfort and well being, may it not at the same time be true that workers in scientific lines have neglected to make available to the masses those scientific truths and viewpoints which will correct many inadequacies in fundamental knowledge and manner of thought? And we must remember that the masses of mankind are not craving scientific truth. The responsibility rests upon us, as men of science, to demonstrate to them that conformity to law is their surest path to security and happiness, and so create in them the desire for truth. Moreover I believe that in this purpose, science and religion must see eye to eye, and must, as never before, unite in common purpose.

As I understand the purpose of the West Virginia Academy of Science, it is to bind together those men and women of the State who believe in the ideals of science, in order that these ideals may become built the more speedily and effectively into the fabric not only of our industrial life but also of our social system and governmental organization. In this purpose let us carry on.

The Biology Section

SOME POLYPORACEAE OF SOUTHERN WEST VIRGINIA*

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Since the publication of the Millspaugh check-list in 1913 our knowledge of the Polyporaceae of West Virginia has been increased by two papers. In one (2), among other fungi new to the state, four polypores were recorded, and in the other (3) 36 species were listed from Monongalia county.

The present paper is the result of a survey of the Polyporaceae made by the writer in Cabell, Wayne, Mason, and Logan counties. Since the first three are in the Allegheny foothill region and the latter is in the mountain district, they give a good cross-section of southern West Virginia terrian. The study was taken up in conjunction with the State Biological Survey, with the intention of adding to the number of species known from West Virginia while at the same time making a representative study of the types found in the southern part of the state. Forty-eight species have been found in the four counties and 14 of these are reported for the first time from West Virginia. The writer has been able to collect only during the winter and spring months; collections during the summer probably would augment the present list considerably.

There have been several nomenclatural changes in the family within the last few years. Many of the present writers break down the genus Irpex, leaving in it only members which have teeth from the beginning, and placing it under the Hydnaceae. They transfer the other species to various genera in the Polyporaceae. Overholts (8) has removed *Irpex tulipiferus* (Schwe.) Fr. to the genus Polyporus and *Irpex farinaceus* Fr. to the genus Daedalea, the latter according to a recent letter received from him. Shope (9) notes the comparatively new genus Ganoderma as probably the best-defined of any of the recently-formed genera.

All the following species have been collected by the writer except as noted. Specimens are in his herbarium and, as far as possible, duplicates will be placed in the Marshall College and West Virginia University herbaria. He is very much indebted to Dr. L. O. Overholts for his aid in identifications and to Dr. F. A. Gilbert for his encouragement and aid throughout the work.

POLYPORUS

Polyporus adustus (Willd.) Fr. A very common member of the Polyporaceae of this region. It has been found in all four counties on dead deciduous trees.

Polyporus abietinus (Dicks.) Fr. Collected in both Cabell and Logan counties on coniferous and deciduous wood. It is frequent.

Polyporus arcularius (Batsch) Fr. This was found commonly during the spring months in both Cabell and Logan counties. It grows usually on buried deciduous wood but has been found on damp, exposed deadwood.

Polyporus biformis (Kl.) Berk. Collected once (March 30, 1935) in Cabell county on dead deciduous wood.

*Contribution No. 6 from the Botany Department of Marshall College.

Polyporus brumalis (Pers.) Fr. This species has been collected in both Cabell and Wayne counties on dead branches of deciduous trees and apparently is frequent.

Polyporus cinnabarinus (Jacq.) Fr. Another very common type, having been found in all counties visited, usually on oak logs or branches. The other red species, *P. sanguineus* (L.) Fr., can be distinguished by its thinner pileus and substipitate appearance.

***Polyporus conchifer* (Schw.) Fr. January 6, 1935, Cabell Co. near Huntington on a dead elm branch. Although listed os common in both Ohio (7) and Penn. (8) this is the first specimen to be reported from W. Va. It is rather uncommon here. No. 3.

Polyporus dichrous Fr. Specimens have been found in Cabell, Wayne, and Logan counties on dead deciduous, usually standing trees. It seems to be rather localized but is very plentiful in spots.

***Polyporus fumosus* (Pers.) Fr. Jan. 12, 1935. Mason Co. near Apple Grove on a dead deciduous tree. It probably is common although but one collection has been made by the writer. New to the state. No. 57.

Polyporus gilvus (Schw.) Fr. A very common species found in all four counties, usually on dead or living oaks. It is variable in form.

Polyporus hirsutus (Wulf.) Fr. Another common species, usually found on deciduous logs. It has been found in all four counties and the collections include both thin and thick forms.

Polyporus lucidus (Curt.) Fr. Has been found in both Wayne and Cabell counties, usually on the base of living oaks. It is rather frequent.

Polyporus pargamenus Fr. A very common type on dead wood of deciduous trees. It has been found in all counties visited but in Logan Co. has a darker brown surface.

Polyporus picipes Fr. Collections of this species have been made in both Mason and Logan counties on dead, usually rotted deciduous wood. It is occasional.

Polyporus pubescens (Schum.) Fr. This species is common in both Ohio (7) and Penn. (8) but so far the writer has made but one collection in W. Va. This was on April 22, 1935, near Neibert in Logan Co. on fallen oak. No. 142.

Polyporus resinosus (Schrad.) Fr. was not collected in any county other than Logan but in the latter was common, usually growing on old deciduous logs.

***Polyporus sanguineus* (L.) Fr. Although this species is listed as rare in Ohio (7) it has been found frequently in Cabell Co. and observed in Logan Co. The substratum usually is a dead deciduous branch. One collection is given for reference since it is new to the state. March 30, 1935. Cabell Co. near Huntington on dead deciduous wood. No. 96.

Polyporus sulphureus (Bull.) Fr. This type was found frequently in both Cabell and Logan counties, usually on living hardwood trees.

Polyporus tulipiferus (Schw.) Overh. This is one of the most common of the nearly-resupinate or resupinate polypores found in the southern part of the state . It was transferred from the genus Irpex by Overholts. The substratum usually is dead deciduous wood.

Polyporus versicolor (L.) Fr. The most common member of the Polyporaceae found. In Logan Co. on the stumps of pine trees it was much more imbricate with a smaller, browner, and fewer-zoned pileus.. It grows on both deciduous and coniferous trees.

FAVOLUS

Favolus alveolaris (DC.) Quél. was found in both Cabell and Logan counties. It is common in spring on dead deciduous branches.

TRAMETES

***Trametes malicola* B. & C. One collection has been made on a dead beech branch of this new species. It was found in Cabell Co. near Huntington on April 14, 1935. No. 114.

Trametes mollis (Sommerf.) Fr. is a rather rare species, having been collected once. It was found on April 22, 1935, near Neibert in Logan Co. on a dead deciduous tree. No. 144 a & d.

Trametes sepium Berk. This species has been found in both Mason and Cabell counties on deciduous logs. It is occasional.

DAEDALEA

Daedale ambigua Berk. Although the writer has made but one collection of this species (Wayne Co. near Dickson, Feb. 24, 1935) it has been found often enough by other collectors to justify being called frequent. The collection was made on deciduous wood.

Daedalea confragosa (Bolt.) Fr. Feb. 25, 1935. Wayne Co. near Dickson at the base of a live willow. It is listed as common in Ohio (7) and likely will be found so here. The writer has but one collection of the species. No. 43.

***Daedalea farinaceus* (Fr.) Overh. Jan. 6, 1935. Cabell Co. near Huntington on cork elm No. 24 and April 22, 1935. Logan Co. near Neibert on a dead deciduous tree. No. 144 b & c. This rare species is new to the state. The specimens are of the effused-reflexed type. Overholts has transferred this species from the genus Irpex.

Daedalea unicolor (Bull.) Fr. Collections of this Daedalea have been made in both Cabell and Logan counties on dead standing white oak. It is frequent.

LENZITES

Lenzites betulina (L.) Fr. has been found frequently in all four counties on dead deciduous trees on logs and damp boards.

Lenzites saepiaria (Wulf.) Fr. Another species which has been collected from both Cabell and Logan counties. It was found occasionally on fallen or dead standing pine.

***Lenzites vialis* Peck. This Lenzites, although new to the state, has been found frequently in both Cabell and Logan counties on damp boards or deciduous logs. One collection is listed since it is new to the state. March 30, 1935. In Cabell Co. near Huntington on fallen white oak. No. 103.

FOMES

Fomes applanatus (Pers.) Gill. Very common in all counties on both living and dead deciduous trees, especially oak. It is one of the most destructive polypores in this region.

Fomes connatus (Weinm.) Gill. Although F. connatus is supposed to be a common species, only one collection has been made by the writer. This was in Cabell Co. on an exposed root of a living red maple. No. 104.

Fomes fraxinophilus (Peck) Sacc. Collections have been made of this species in both Cabell and Mason counties on dead deciduous trees. It is occasional.

Fomes lobatus (Schw.) Cooke. Was found in Cabell Co. only, growing on deciduous logs or dead deciduous branches. It probably is frequent.

Fomes ohiensis (Berk) Murr. Although not frequent, this species has been found in Cabell, Mason, and Logan counties. It usually is found on dead deciduous trees, but one collection was made on living locust.

Fomes rimosus (Berk.) Cooke. This and*F. applanatus* are the two most common Fomes found in the southern part of the state. *F. rimosus* is very common on living and dead locust trees.

IRPEX

***Irpex cinnamomeus* Fr. A very common polypore, having been found in all four counties very often and growing, usually, entirely resupinate, on deadwood. Since it is new to the state, one collection is listed for reference. March 30, 1935, in Cabell Co. near Huntington on fallen birch. No. 101.

Irpex crassus B. & C. Feb. 2, 1935. Cabell Co. near Huntington. The only collection of this species was made from a deciduous log. It probably is uncommon. No. 37.

PORIA

***Poria ambigua* Bres. One collection was made of this Poria. It was found on April 19, 1935, in Logan Co. on Blair Mt. The substratum was an oak stump. It is new to the state. No. 129.

Poria corticola Fr. Feb. 24, 1935. Cabell Co. near Nine Mile Creek on willow. It was collected by Nolan Fowler and apparently is uncommon. No. 63.

Poria ferruginosa (Schw.) Pers. Although but one collection of this Poria has been made, it is likely a common species. It was found in Logan Co. on fallen oak. No. 134.

***Poria medulla-panis* (Jacq.) Pers. Although listed (9) as widespread in the U. S. this is the first time *P. medulla-panis* has been reported in W. Va. It is the most common Poria found in southern W. Va. One collection is listed for reference. April 19, 1935, in Logan Co. near Blair Mt. an black oak log. No. 132, Overholts writes that "perhaps this (No. 132) was the bright-colored form of the species, often referred to as *P. pulchella* Schw."

***Poria nigrescens* Bres. This is another Poria new to the state and was collected April 22, 1935, in Logan Co. near Neibert on a deciduous log. No. 137.

***Poria punctata* Fr. This species has been collected twice in Cabell Co. (Feb. 2, 1935. Roby Hollow, No. 65 and March 30, 1935. 16th St. Rd. No. 98 both near Huntington) and once in Logan Co. (April 22, 1935. Blair Mt. No. 136) on deciuous logs or stumps, and has been observed at other times. Although new to the tsate is probably is frequent, at least in the southern part.

***Poria subacida* (Peck) Sacc. Found in Logan Co. near Neibert on April 22, 1935, on a coniferous log. New to the state. No. 138.

***Poria undata* (Pers.) Bres. Jan. 12, 1935. Mason Co., near Apple Grove. This was collected on a rotten log, probably deciduous. New to the state. No. 70.

***Poria versiporia* Pers. This has been found only in Cabell Co., once by Nolan Fowler (Feb. 24, 1935, Nine Mile Creek, No. 64) and once by the writer (Feb. 2, 1935, near Huntington, No. 77). The former was on grapevine while the latter was on dead deciduous wood. It is also new to the state.

**Reported as new to the state.

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ADDITIONS TO THE MILLSPAUGH CHECK-LIST OF WEST VIRGINIA SPERMATOPHYTES

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SINCE PUBLICATION of our list of additions[1] to the Millspaugh check-list,[2] continued explorations in the field and critical studies of herbarium material have brought to light a considerable number of species hitherto unreported in these lists. It is believed that, pending the completion of a revision of the Millspaugh list, now under way, publication of these additions might be welcomed by workers in the field. Acknowledgments are due W. C. Muenscher for his critical studies of *Potamogeton;* to G. L. Stebbins for his studies of *Antennaria*, resulting in the description of a new species, *A. virginica,* from the shale barrens of Hampshire county; to F. W. Pennell for his studies of the *Scrophulariaceae;* to R. E. Woodson, Jr., for checking our sheets of *Tradescantia;* to K. M. Wiegand for his examination of our material in *Amelanchier;* and to C. A. Weatherby for miscellaneous determinations. A few apparent errors in the Millspaugh list and in our first list are corrected here.

Typha angustifolia L. Sistersville, Tyler, *E. E Berkley.*

Sparganium diversifolium Graebn. Elk Garden, Mineral, *W. V. U. Bot Exped.*

Potamogeton amplifolius Tuckerm. Minnehaha Springs, Pocahontas, *E. E. Berkley.*

P. crispus L. White Sulphur Springs, Greenbrier, *W V. U. Bot. Exped.*

P. diversifolius Raf. (P. hybridus B. Michx. Wardensville, Hardy, *W. V. U. Bot. Exped.*

P. foliosus Raf. Hillsboro, Pocahontas, *J. G. Needham.*

P. gramineus L. var. *graminifolius* Fries. Wardensville, *W. V. U. Bot. Exped.*

P. pusillus L. (P. *panormitanus* Bio.) Minnehaha Springs, *W. V. U. Bot. Exped.*

Zannichellia palustris L. White Sulphur Springs, *Earl L. Core,* 4296.

Sagittaria lancifolia L. Cacapon River, Hardy, *W. V. U. Bot. Exped.* 3800 ft. *E. E. Berkley.*

Alopecurus agrostis L. Morgantown, Monongalia, *John L. Sheldon.*

Andropogon scoparius Michx. This heading in Millspaugh (l. c., p. 203) should be exchanged with *Andropogon virginicus* L. (p. 205) which is far more abundant in West Virginia.

Anthoxanthum puelii Lecoq. & Lamotte. Morgantown, *John L. Sheldon.*

Aristida dichotoma Michx. var. *Curtissii* Gray. Wild Meadow Run, Mineral, *E. E. Berkley.*

Bouteloua curtipendula (Michx.) Torr. Wardensville, *Earl L. Core,* 4373.

Bromus altissimus Pursh. Bretz, Preston, *Eva May Fling.*

B. arvensis L. Morgantown, *J. C. Cox.*

Cynodon dactylon (L.) Pers. Morgantown, *John L. Sheldon.*

Elymus brachystachys Scribn. & Ball. Littleton, Wetzel, *Haught,* 947.

Sporobolus asper (Michx.) Kunth. Nuttallburg, Fayette, *L. W. Nuttall.*

Stipa avenacea L. Wardensville, *W. V. U. Bot. Exped.*

Carex blanda Dewey. Roland Park, Cabell, *F. A. Gilbert,* 260.

Carex grisea Wahlenb. Burlington, Mineral, *Harry Cordray.*

Eleocharis compressa Sull. Nuttallburg, *L. W. Nuttall.*

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E. engelmanni Britt. Minnehaha Springs, *Earl L. Core,* 3468.

Xyris flexuosa Muhl. Flat Top Mt., Raleigh, *Earl L. Core,* 3110.

Tradescanthera canaliculata Raf. Cotton Hill, Fayette, *W. V. U. Bot. Exped.*

Heteranthera dubia (Jacq.) Mac M. Caldwell, Greenbrier, *W. V. U. Bot Exped.*

Smilacina stellata (L.) Desf. Hinton, Summers, *Weldon Boone.*

Stenanthium gramineum (Ker.) Kunth. Cowen, Webster, *Mr. and Mrs. Harold Roush.*

Tofieldia glutinosa (Michx.) Pers. Cheat Bridge, Randolph, *P. D. Strausbaugh.*

Spiranthes beckii Lindl. Hanging Rock, Hampshire, *Adolph Koenig.*

Betula papyrifera Marsh. North Fork Mt., Pendleton, alt. 4200 ft., *Fred and Maurice Brooks.*

Quercus prinus L. (Q. Michauxii Nutt.) Sunset Beach, Monongalia, *L. M. Peairs.*

Celtis georgiana Small. Shale barrens near Burlington, Mineral, *P. D. Strausbaugh.*

Urtica chamaedryoides Pursh. Sabraton, Monongalia, *John L. Sheldon.*

Polygonum muhlenbergii (Meisn.) Wats. Shawnee Lake, Mercer, *W. V. U. Bot. Exped.*

Chenopodium bonus-henricus L. Uffington, Monongalia, *R. C. Spangler.*

Ceratophyllum demersum L. Wardensville, Hardy, *W. V. U. Bot. Exped.*

Aconitum vaccarum Rydb. This plant, the type locality of which is Spruce Knob, Pendleton, does not seem to be specifically distinct from *A reclinatum Gray.*

Anemone parviflora Michx., reported in our previous list from Ice Mt., Hampshire, was based on a misidentification. This plant to our knowledge does not occur in West Virginia.

Clematis albicoma Wherry is apparently the correct name for the shale barren species which Millspaugh refers to *C. ovata* Pursh.

Alliaria officinalis Andrz. Burlington, Mineral, *P. D. Strausbaugh.*

Arabis serotina Steele, Brandywine Creek, Pendleton,*Earl L. Core,* 3671.

Berteroa incana (L.) D. C. Ronceverte, Greenbrier, *P. D. Strausbaugh.*

Dentaria maxima L. Deckers Creek, Monongalia, *S. J. Wright.*

Thlaspi arvense L. Canaan Valley, Tucker, *Earl L. Core,* 2883.

Heuchera alba Rydb. North Fork Mt., Pendleton, *W. V. U. Bot. Exped.*

Agrimonia microcarpa Wallr. Elk Garden, Mineral, *W. V. U. Bot. Exped.*

Amelanchier bartramiana (Tausch.) Roem. is the correct name for the plant which has been known as *A. oligocarpa* (Michx.) Roem.

A. laevis Wieg. Osceola, Randolph, *Earl L. Core,* 3579.

A. sanguinea (Pursh.) D. C. North Fork Mt., *Earl L. Core,* 5441.

Geum strictum Ait. Mountain glade, Abram's Creek, Grant, *Earl L. Core,* 4657.

Amphicarpa pitcheri T. & G. Huttonsville, Randolph, *C. F. Millspaugh,* 730.

Crotalaria sagittalis L. Harper's Ferry, Jefferson, *Earl L. Core,* 3830.

Euphorbia heterophylla L., reported by error in our previous list, is not known in West Virginia.

E. humistrata Engelm. Morgantown, *John L. Sheldon.*

Callitriche palustris L. Osceolo Randolph, *W. V. U. Exped.*

Helianthemum canadense (L.) Michx. Hanging Rock, *Earl L. Core,* 4406.

Oenothera speciosa Nutt. Oglebay Park, Ohio, *Earl L. Core,* 4100.

Vaccinium melanocarpum Mohr. Huntington, Cabell, *F. A. Gilbert,* 259.

Gentiana clausa Raf. Long Bottom, Raleigh, *W. I. Utterback.*

Acerates floridana (Lam.) Hitchc. Ripley, Jackson, *W. V. U. Bot. Exped.*
Vincetoxicum carolinense (Jacq.) Britton. Burlington, *P. D. Strausbaugh.*
Convolvulus arvensis L. Morgantown, *Earl L. Core.*
C. fraterniflorus Mackenzie and Bush. Ripley, *W. V. U. Bot. Exped.*
C. stans Michx. has been shown by Wherry to be the correct name for the shale barren plant which formerly had been referred to *C. spithamaeus* L.
Phlox buckleyi Pursh. White Sulphur Springs, *E. T. Wherry.*
Hedeoma hispida Pursh. Ronceverte, *P. D. Strausbaugh.*
Sideritis romana L. Stinson, Calhoun, *Ray Harris.*
Thymus serpyllum L. Seneca Creek, Pendleton, *Maurice Brooks.*
Chelone montana (Raf.) Pennell and Wherry. Cass, Pocahontas, *Fred W. Gray.*
Gratiola neglecta Torr. Nuttallburg, *L. W. Nuttall.*
Linaria elatine (L.) Mill. Mouth of Seneca, Pendleton, *Earl L. Core*, 3179.
Lindernia anagallidea (Michx.) Pennell. Reyman Memorial Farm, Hardy, *W. V. U. Bot. Exped.*
Pedicularis lanceolata Michx. Dunmore, Pocahontas, Fred W. Gray... ....
Pentstemon brevisepalus Pennell. Uneeda, Boone, *W. V. U. Bot. Exped.*
Verbascum Phlomoides L. Wardensville, *W. V. U. Bot. Exped.*
Veronica polita Fr. Huntington, Cabell,*F. A. Gilbert*, 205.
Veronica glandifera Pennell. Wardensville, *W. V. U. Bot. Exped.*
V. scutellata L. Patterson Creek, Mineral,*W. V. U. Bot. Exped.*
Ruellia strepens L. Martinsburg, Berkeley, *Weldon Boone.*
Galium verum L. French Creek, Upshur,*John L. Sheldon.*
Antennaria neodioica Greene Cass, Pocahontas, *W. V. U. Bot. Exped.*
A. virginica Stebbins. Hanging Rock, Hampshire, *W. M. Frye.*
A. virginica var. *argillicola* Stebbins. Hanging Rock, Hampshire, *G. L. Stebbins*, 43.
A. grandis (Fernald) House. Hanging Rock, *W. M. Frye*, 45.
A. neglecta Greene. Hanging Rock, *W. M. Frye.*
A. occidentalis Greene. Hildacrest, Cabell, *F. A. Gilbert*, 251b.
A. parlinii Fernald. Huntington,*F. A. Gilbert*, 252.
A. petaloidea Fernald. Morgantown, *Edith Stevens.*
Carduns crispus L. Charles Town, Jefferson, *W. M. Sharp.*
Lepachys columnaris, T. & G. Woodland Farm, Monongalia, *A. D. Hopkins.*
Solidago erecta Pursh. Pisgah Pike, Monongalia, *Ward M. Sharp.*
S. flexicaulis L. Traction Park, Monongalia, *R. C. Spangler.*
S. hispida Muhl. Reymann Farms, *W. V. U. Bot. Exped.*
Prenanthes trifoliolata (Cass) Fernald. South Branch Mt., Hardy, *W. M. Sharp.*
Tussilago farfara L. Greer, Monongalia, *Mrs. Clara Sheldon.*

HERPETOLOGY OF THE EASTERN PANHANDLE OF WEST VIRGINIA

(A Preliminary Survey)

L. DOW STRADER

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ALTHOUGH ENTITLED "THE EASTERN PANHANDLE," this survey has been confined for the most part to the three eastern counties—Morgan, Berkeley, Jefferson, and a part of Hampshire. The specimens collected in the western limits have been confined to the more settled areas east of 97° W. Longtitude, or a line running through Romney, where the first ridge of the Allegheny Mountains forms a natural barrier between the Central Appalachian Plateau and the Potomac and Shenandoah Rivers, there being one opening in this barrier at Cumberland, Maryland. Southward there is no natural boundary, and all the fauna found north to the Potomac in all probability are found throughout the Valley of the Shenandoah, with the northern species becoming more rare and the more southern species appearing. In fact, this is the case with several of the Lacertilia which have come to my notice. (The notes of Dr. Ditmar's for this section also bear out this premise). The boundary to the north is the natural boundary between West Virginia and Maryland, the Potomac River, which drains a considerable area of the western part of the state not covered by this survey but which does account for the preponderance of certain aquatic forms so plentiful to the east of 76°—30' W. Longitude along all the tributaries of the Potomac.

The Blue Ridge Mountains to the east also form a natural boundary and prevent the occurrence of many species found farther east along the Coastal Plain from Louden County, Virginia, to the Chesapeake Bay. The top of this ridge is 900 feet above sea level and this drops to 275 feet below Harper's Ferry. Here a wide range of mountain dwelling and semi-arid fauna is found close together: witness *Rana sylvatica* and *Sceloporus undulatus*. Along the top of the Blue Ridge is a large area of Sphagnum bogs where*Hyla* and *Rana sylvatica* may be found. Lower down in the valley no wood frogs have been located.

Practically all the eastern part of Jefferson county is made of limestone and dolomitic outcropping, overlaid with red clay, from the Opequon Creek to the Shenandoah River, and there are very few streams in this area compared to the rest of the panhandle. There are, however, several very cold springs and short creeks flowing into the Shenandoah River, the Potomac River and Opequon Creek. In most of these, larvae and adults of the Amphibia have been observed or collected. In the central part of the county the only water is in artificial ponds made by scraping depressions in the ground and catching surface water. Here many Amphibia eggs, larvae, and adults also have been found in company with three species of *Testudinata* (turtles) and two species of *Serpentes* (snakes). There are also several abandoned quarries 60 feet or more in depth which provide breeding places for Amphibia and Testudinates. From the Opequon Creek westward to the foothills of the Shenandoah Mountains the terrain changes to poor shale soil covered for the most part with pine thickets, and is usually dry. Through this section and southward to Clarke county, Virginia, two species of *Lacertilia* (lizards) and several common terrestrial *Serpentes* (snakes) are most plentiful. There is a gradual increase in altitude from this point westward with an increase in the number of streams and a change from shale to sandstone and limestone outcroppings. The wooded areas also are mostly hardwood, with pine on the poorer shale hillsides, until the western limit of this survey is reached.

Most of the streams flow through rocky beds in Berkeley and Morgan counties and are cold for the most part—Back Creek, Cacapon River, Little Cacapon River, and the South Branch of the Potomac being the notable exceptions—the lower Back Creek being a slow-moving, muddy stream where many aquatic reptiles have been collected.

The following incomplete list with the notes on their collection and observation will attempt to show the distribution of the Amphibia and reptiles which occur in the Eastern Panhandle, with their relation to the geographical outline just given.

AMPHIBIA

Order: *Caudata* (Urodela

1. *Proteidae*: *Necturus Maculosus* (Rafinesque). South Branch below Romney. July 1932. Caught while fishing. One male—251 mm.

Several have been reported from the Potomac and Back Creek by fishermen near Martinsburg. These reports cannot be authenticated with certainty, as no specimens have been seen by the author.

2. *Ambystomidae*: Egg masses of two species found in three cold quarries near Bakerton, Jefferson county, March 1932-33-34. These have been collected and hatched, but larvae died when about fifteen millimeters in length, after about six weeks in an aquarium. Change in temperature was probably the cause.

Ambystoma Maculatum (Shaw). One adult male—164 mm. In small spring near Harper's Ferry, March 1934.

A. Tigrinum (Green). One adult (sex undetermined) seen near an egg moss on Shenandoah River near Bloomery on March 18, 1933—at night.

Both above very rarely seen although egg mosses have been collected in every cold spring and quarry which has been visited for three years.

A. Jeffersonianum: One adult female found at Mill Creek near Inwood, Berkeley County, March 20, 1932. About 100 mm. One adult female (gravid) in surface pond near Harper's Ferry, March 1935, at night. 154 mm.

3. *Salamandridae*: *Triturus viridescens* (Raf). Aquatic form common in roadside surface ponds, and backwater pools along streams throughout the panhandle. Red Phase—three specimens found under logs near a pond on Old Furnace Creek, Jefferson County, June 1934.

4. *Plethodontidae*: *Desmognathus fusca* (Baird). Larvae in cold spring near Berkeley Springs, May 1933. One adult female in moist earth along Opequon Creek near Middleway, May 1933. 75 mm.

Plethodon cinereus (Green). Common under stones and logs along northern hillsides throughout area. About half of these observed have been light-color phase and relatively smaller than the dark phase.

Pseudotriton ruber: One adult male under stones on Blue Ridge Mountains, September 1934. 132 mm.

Plethodon glutinosus (Green). One adult (sex undetermined) found in so-called Spruce Pine Hollow, Berkeley County, September 1933. About 130 mm.

5. Eurycea: *Eurycea bislineata* (Green). Quite common in wooded areas throughout panhandle.

Order 2: Salientia (Anura).

1. *Bufonidae*: *Bufo americanus* (Holbrook). Quite common except in dry pine hill sections. Both sexes found wherever there is sufficient water for egg laying from March to July.

B. fowleri (Garman-Hinckley). Fairly common in damp places in company with above species.

2. *Hydilae*: *Hyla crucifer* (Wied). Common in ponds and backwater in early spring throughout area.

H. versicolor (Le Conte). One adult male in algae-filled small creek near Inwood, Berkeley County, September 1933. 20 mm. Several observed June 1934 in marsh below Island Park, Harper's Ferry, but none captured.

4. *Pseudacris*: *Pseudacris feriarum* (Baird)? This or a closely-related species collected in backwater ponds along Shenandoah River, spring 1932, from March to May (sex undetermined) but probably all males.

5. *Ranidae*: *Rana catesbeiana* (Shaw). Common in quarries along the Back Creek, Opequon Creek, and Potomac and Shenandoah Rivers. Egg masses frequently found in quarries near Potomac River at Bakerton.

R. Clamitans (Latrielle). Common in permanent surface ponds and pools throughout area.

R. palustris (Le Conte). Several pairs have been collected from the short, cold, rocky streams emptying into the Shenandoah from the Blue Ridge opposite Harper's Ferry. Several single specimens have been taken from other streams throughout the panhandle. Fairly common.

R. Pipiens (Schreber). Quite common in quarries and surface ponds in March and early April.

R. sylvatica (Le Conte). Only in sphagnaceous swamp on top of Blue Ridge Mountain near where road crosses. One adult male—42 mm.

SERPENTES

Order 1: *Colubridae*

Diadophis punctatus (L). One adult male and several young captured in Jefferson county near Harper's Ferry. September 1933.

Heterodon contortix (L). One adult male and two females collected along Potomac River near Bakerton. Several small young specimens have been collected from same area. Male collected in February in snow 1935. Others, June 1934.

Liopeltis vernalis (Fitzinger). Two adults (sex undetermined) in brushy place along Shenandoah River near Bloomery. June 1934.

Coluber constrictor (L). One adult female, 1800 mm., found on shale bank along Opequon Creek, Berkeley County, August 1933. Several young have been collected throughout panhandle and mistaken for *Elaphe*.

Elaphe obseleta? (Say). Black phase quite common.

Elaphe obseleta confinis (Baird & Girard). Gray spotted phase collected at several places in the Pine Hill section of Berkeley county, 1932-33-34. Confused with Coluber. Several specimens not definitely classified to date.

Lampropeltis triangulum triangulum (Lacepede). Many of both sexes collected throughout area. Several color variations noticeable in Shenandoah Valley and Pine Hill section.

Natrix septemvittata (Say). Quite common in ponds and slow moving creeks throughout area. Several specimens have been taken from Back Creek, Berkeley county. Young snakes quite plentiful in muddy pools along both large rivers.

Natrix sipedon sipedon (L). Common in all streams visited. *Taxipilota*, a probable sub-species, found plentifully along Potomac on mud flats. Identity not certain.

Thamnophis sauritus (L). Two specimens have been collected near a barn in Berkeley county pine hills. Identity not certain.

Thamnophis sirtalus (L). Several specimens have been collected, no two showing same coloration. Jefferson and Morgan counties.

Order 2: *Crotalidae*

Agkistrodon-mokasen (Beauvois). One female containing ten young and several males collected on Blue Ridge Mountains near Harper's Ferry, June 1934. Common in rocky places.

Crotalus horridus (L). Several specimens have been brought to the writer from Schaffenaker Mountain and the Blue Ridge, Hampshire and Jefferson counties, 1932-33-34.

LACERTILIA

Order 1: *Iguanidae*

Sceloporus undulatus (Latrielle). One male with blotch under chin, enclosing more or less blue. Two large patches on the abdomen. Five females with no color on abdomen. Located in pine hills along Shenandoah River, Opequon Creek, and Camp Frame, Berkeley county. Common and plentiful in cut-over pine-covered hillsides throughout panhandle. Shale soil.

Adults: Total length—135 mm.; length of tail—55-60 mm.; width of body—22-25 mm.; width of head—15-20 mm.

Several young: 6065 mm.

Order 2: *Scincidae*

Eumeces quinquelineatus (Linn). Two color phases. Southern boundary in Shenandoah Valley along Opequon Creek near Clarke county line on limestone islands and dry hillsides with *Sceloporus undulatus.*

Note: (not positively identified).

TESTUDINATA

Order 1: *Chelydridae*

Chelydra serpintina (Linn). Several average specimens taken in the sandy pools along the Potomac and Shenandoah Rivers near Harper's Ferry. The total length of one specimen was about 2000 mm. and it weighed about 23 pounds. Taken by Franklin Sperry on July 10, 1934, from Shenandoah River.

Several young turtles 35 to 50 mm. in length are now being kept alive in aquarium at Harper's Ferry. One female taken from Back Creek in Berkeley county, October 1932, near Hedgesville.

Order 2: *Cinosternidae*

Cinostenon odoratus (Latr). A specimen was brought in, found in February under a log in a pond near Harper's Ferry. This specimen lived for a year in a small aquarium. Apparently very young, measuring only a little over 25 mm. in length. Many specimens caught each year by fishermen along both of the larger rivers bordering the panhandle. Common.

C. pennsylvanicum (Gmelin). Adult male taken in Old Furnace Creek, June 1932. Two females, small but mature, brought from small creek near Shepherdstown.

Order 3: *Testudinidae*

Chrysemys picta (Schneider)? Common in surface ponds and backwater pools throughout. Several adults of both sexes have been collected.

Clemmys guttata (Schneider)? Found in company with the above in eastern part of range especially. Common.

Order 4: *Terrapene*

Terrapene carolina: Common throughout.

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FURTHER NOTES ON THE FOOD HABITS OF THE WATER DOG, *CRYPTOBRANCHUS ALLEGANIENSIS* DAUDIN

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THE WATER DOG is well known to all West Virginia sportsmen. Despised because of its food habits, disliked because of its appearance, it is sought by all interested in the welfare of the food fishes of this state. Recent investigations have brought to light much information with regard to the food habits of the water dog. As food habits of animals frequently vary with the locality in which they live, the author decided to investigate the food of these salamanders found in upper Cheat River, a well-known trout stream. This paper will attempt to give an account of the stomach contents of these salamanders.

34 water dogs were caught on June 21, 1934, between the hours of 8 and 12 o'clock at night from the headwaters of Shavers Fork of Cheat River. By means of an acetylene light their large bodies could be seen swimming through the water in their search for food. They were speared with a pitchfork. Despite the fact that many of them were badly wounded, 25 of them were alive the following day. The majority of them were males but no effort was made to correlate the stomach contents with sex. The ovaries of two of the females were swollen with large yellow eggs. No food was reguritated. Their stomachs were not full, an indication that they were just beginning their search for food that evening.

An examination of the 34 stomachs revealed the fact that 20, or 59% of them had been eating crayfish. These crustaceans were in all states of digestion. None was of a natural color, however, a further indication that the animals had not eaten for a considerable time. Numerous chela and other remains were encountered. In two specimens the chela had punctured the stomach wall and were protruding into the body cavity.

Thirty-five percent of the stomachs contained fish. Many of the fish could not be identified. No remains of trout were present as far as could be determined; 21% of the stomachs contained insect larvae, tadpoles, and worms.

Extraneous matter such as leaves, mud, pebbles, and sticks was found in 53% of the stomachs. This was probably gotten in the process of catching food.

One stomach was empty, with no evidence of food in either the upper or lower portion.

In the other stomachs the food in the upper portion showed very little digestive action while that of the lower region showed extensive digestion.

The stomach is a long slender organ capable of enormous distension.

A summary of the contents of these stomachs shows crayfish found in 59%; fish, 35%; insects, tadpoles, 21%; extraneous matter 53%

ADDITIONS TO THE CRYPTOGAMIC FLORA OF WEST VIRGINIA (No. 2)*

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IN THE RECENT WORK on North American Myxomycetes by Macbride and Martin appeared references to two species occurring in West Virginia which were not on the Millspaugh check-list or on subsequent additions to this list. Correspondence brought out the information that the species occurred on the bark of living trees and were brought to light by cultures of this bark in moist chambers. Because of their extremely small size and inconspicuous nature they heretofore have been overlooked, although Dr. Martin states that he regards both of them as common and widespread. They are as follows:

Echinostelium minutum DeBary (Family Stemonitaceae). Mt. Storm, Grant Co.
Hymenobolina parasitica Zukal (Family Liceaceae). Mt. Storm, Grant Co.

The following species of fungi also are new to West Virginia, so far as is known. The specimens are in the writer's herbarium at Marshall College, and duplicates have been sent, along with other specimens from the southern part of the state, to the University herbarium at Morgantown.

(BASIDIOMYCETES—Agaricales)

Clitocybe monadelpha Morg. Base of decayed stump, Huntington, Cabell Co., Oct. 11, 1934. 509.

Lactarius trivialis Fr. var. *viridilactis* Kauff. Edge of woods, Salt Rock, Cabell Co., Oct. 16, 1934. 510.

Lepiota cristatatellus Pk. On moss and leaves, Huntington, Cabell Co., Oct. 9, 1934. 503.

Marasmius cohærens Fr. (Bres.) On decaying leaves, Huntington, Cabell Co., Oct. 9, 1934. 503.

Tricholama personatum Fr. On ground under trees, Roland Park, Cabell Co., Oct. 11, 1934. 508.

ASCOMYCETES—Pezizales

Elvella elastica Bull. On ground near edge of woods, Huntington, Cabell Cc., July 16, 1934. 520.

ASCOMYCETES—Sphæriales

Chætomium globosum Kunze. On mouse-dung culture, Huntington, Nov. 4, 1934. This species has been found a number of times in laboratory cultures of various media. 515.

Endothia parasitica (Murr.) A. & A. On *Castanea dentata*, Huntington, Cabell Co., Oct. 10, 1933. The ubiquitous chestnut blight probably has been collected dozens of times in West Virginia but since it has not been reported in Millspaugh's check-list, is recorded here. 485.

The following species have been collected in the state at least once before but are reported here in order to help show their distribution and prevalence:

ASCOMYCETES—Erysiphales

Phyllactinia corylea (Pers.) Karst. On leaves of *Castanea dentata* sprouts, Huntington, Cabell Co., Oct. 4, 1931. 489.

Microsphæra alni (Wallr.) Salm. On leaves of *Syringa vulgaris*, Huntington, Cabell Co., Oct. 4, 1931. 488.

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*Contribution No. 7 from the Botany Department of Marshall College.

Erysiphe cichoracearum (DC) Burr. On leaves of cultivated zinnia, Roland Park, Cabell Co., Oct. 10, 1933. 487.

ASCOMYCETES—Pezizales

Plectania coccinea (Scop.) Fuckel (*Sarcosypha coccinea*. On decaying branch in leaf mould, Cabell Co., April 14, 1935. 484.

Morchella esculenta (L.) Pers. On manured lawn, Huntington, Cabell Co., April 10, 1928. 483.

ASCOMYCETES—Sphaeriales

Xylaria polymorpha (Pers.) Grev. At base of stump, Kenova, Wayne Co., Oct. 3, 1933. 486.

Daldinia concentrica (Bolt.) C. & DeN. On fallen branches, Huntington, Cabell Co., Oct. 3, 1931. 482.

BASIDIOMYCETES—Uredinales

Puccinia smilacis Schw. On*Smilax glauca*, Roland Park, Cabell Co., Nov. 15, 1931. 514.

Puccinia podophylli Schw. On Podophyllum peltatum, Huntington, Cabell Co., April 20, 1934. 516.

Puccinia mariæ-wilsoni G. W. Clint. On*Claytonia virginca*, Russell Creek, Cabell Co., April 20, 1934. 517.

Puccinia heucheræ (Schw. Diet. On *Saxifraga virginensis*, Pleasant Valley, Cabell Co., April 19, 1934. 518.

Puccinia malvacearum Bert. On *Althaea rosea*, Huntington, Cabell Co., May 29, 1934. 490.

BASIDIOMYCETES—Agaricaceæ

Clitocybe illudens Schw. Cabell Co., Oct. 9, 1934. 505.
Lepotia naucina Fr. Cabell Co., Oct. 8, 1934. 506.
Mycena leajana Berk. Wayne Co., Sept. 27, 1934. 501.
Pleurotus ostreatus Fr. Cabell Co., Oct. 9, 1934. 507.
Lepiota americana Pk. Cabell Co., Oct. 1, 1931. 499.
Panus stypticus Fr. Cabell Co., Oct. 1, 1931. 497.
Panus rudis Fr. Cabell Co., Oct. 1, 1931. 496.
Armillaria mellea Fr. Wayne Co., Sept. 28, 1931. 495.
Pholiota adiposa Fr. Cabell Co., Oct. 9, 1931. 493.
Psalliota (*Agaricus*) *hæmorrhodaria* Fr. Cabell Co., Oct. 20, 1931. 498.

BASIDIOMYCETES—Polyporaceæ

Fistulina hepatica Fr. Cabell Co., Oct. 9, 1931. 491.

BASIDIOMYCETES—Boletaceæ

Boletus brevipes Pk. Cabell Co., Oct. 14, 1934. 519.

BASIDIOMYCETES—Hydnaceæ

Hericium (*Hydnum*) *Erinaceus* (Bull) Pers. Cabell Co., Jan. 3, 1932. 511.

BASIDIOMYCETES—Thelephoraceæ

Stereum lobatum (Kunze) Fr. Cabell Co., Nov. 24, 1931. 513.

BASIDIOMYCETES—Gasteromycetales

Cyathus striatus Willd. Nicholas Co., Oct. 18, 1931. 492.
Lycoperdon gemmatum Batsch. Wayne Co., Oct. 15, 1931. 512.

The Chemistry Section

WEST VIRGINIA COAL SEAMS AND THEIR DRAINAGE

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GEOLOGY OF WEST VIRGINIA COAL MEASURES

THERE ARE 117 coal beds in West Virginia, of which 60 are reported to be minable. They are found in the Dunkard, Monongahela, Conemaugh, Allegheny, and Pottsville Series. The latter series has been subdivided into the Kanawha, New River, and Pocahontas groups. Tabulations presented later will give the beds in their proper order, arranged according to series and group. Table 1 gives typical analyses of West Virginia Coals, and Table 2 indicates the large portion of the 55 counties of the state containing these coal measures. Their wide distribution as well as their large number has resulted in the past in more or less confusion regarding the names and correlation of the seams. The excellent work of the West Virginia Geological Survey* has cleared up many of the misunderstandings, although it probably is proper to suppose that some of the production figures taken from the records of the State Department of Mines* reflect this earlier confusion.

For comparison Table 1 gives the analyses of the more important coal seams. The figures were obtained from a reprint of the Department of Mines (47) which had been summarized from the reports of the State Geological Survey. Averages taken from Technical Paper 405 of the U. S. Bureau of Mines (30) have been inserted for some seams. The averages for percentages of moisture, volatile matter, fixed carbon, ash, sulfur, and B. T. U. are given. Table 2 gives the acreage of the different coal seams by counties. The writers have used the acreage figures rather than tonnages in order to utilize them in later calculations.

COAL PRODUCTION IN WEST VIRGINIA

The annual reports of the West Virginia Department of Mines (27) give their estimates of the acreage mined in the state for each year. However, we could not find in any report or other source the data on the acreage removed from each seam. Consequently a laborious task was necessary. From each annual report on file in the State Department of Archives and History the complete table on "Production According to Geological Series and Coal Beds" was copied for each year from 1904 through 1931. These tables give the tonnages mined in each county in each seam. All these figures were compiled into a single table. Several obvious errors in the original tables were corrected. Many production figures were given for seams in counties for which the Geological Survey did not report the acreage present. In such cases the name and location of the mine were obtained from another section of the report and then the probable seam used. For the period 1897-1903, in which the production by

*The authors express their thanks to the West Virginia Department of Mines and the West Virginia Geological Survey for their cooperation extended in making available much of the statistical data in this paper. Mr. R. C. Tucker of the Survey kindly checked all the data in Table 2 (28).

counties was given, but not by seams, it was possible to allocate the amounts, since at that time but few seams were mined in each county. The production data by counties for 1888-1897 were obtained from a paper by J. V. Sullivan (50). Figures for 1863-1887 given in Table 1 were used also. In the various reports some figures were given in short tons and others in long tons. All data were converted to tons of 2000 pounds.

After the total tonnage produced in each seam in each county was obtained, the acreage was calculated using the average thickness given in the Geological Survey county reports as checked against the Department of Mines' figures and using the figure of 80 pounds per cubic foot of coal as determined by the U. S. Bureau of Mines for Pittsburgh coal.

Some confusion as to the correct name for some of the seams resulted in incorrect production figures. Some of the Welch coal in McDowell County has been reported in the Sewell seam, and the Fire Creek and Sewell have been

TABLE I—*Analysis of West Virginia Coals*
Percentage composition

SEAM	MOIS.	V. M.	F. C.	ASH	S	B. T. U. Lb
Washington	1.04	34.75	45.76	18.83	2.8	11,885
Waynesburg	0.43	34.40	47.67	17.50	3.7	12,008
Uniontown	1.7	38.6	47.9	11.9	4.6	12:647
Sweickley	1.15	38.45	51.97	8.43	3.48	14,187
Redstone	0.67	36.89	55.41	7.03	2.43	13,831
Pittsburgh	0.67	37.03	55.68	6.62	1.65	14,079
Little Pittsburgh	3.57	38.76	50.22	7.45	3.32	12,660
Elk Lick	1.10	37.40	46.46	15.04	2.49	13,360
Harlem	4.0	37.2	47.4	11.3	2.8	11,895
Bakerstown	0.78	41.25	52.36	5.61	3.15	13,698
Brush Creek	4.5	30.6	59.5	5.4	1.5	13,380
Mahoning	3.46	31.80	59.12	5.62	2.56	13,556
Upper Freeport	0.79	29.45	61.91	7.85	1.51	14,178
Lower Freeport	1.15	24.01	59.41	15.43	3.52	13,819
Upper Kittanning	0.86	29.78	58.53	10.83	2.37	13,580
Middle Kittanning	0.68	19.37	71.20	8.75	1.76	13,418
Lower Kittanning	0.95	28.05	62.16	8.84	1.33	13,967
Clarion	1.2	30.6	59.2	9.0	1.9	13,370
Upper Mercer	1.4	32.8	56.9	8.9	1.5	
Stockton	1.51	33.41	50.01	6.07	0.86	13,501
Coalburg	1.11	33.90	57.37	7.78	0.8	13,591
Winifrede	1.09	36.59	58.42	3.90	0.65	13,732
Chilton A	1.5	40.2	46.9	11.4	0.7	
Chilton	1.91	36.21	56.04	5.84	0.75	14,258
Hernshaw	0.67	38.94	52.79	7.60	3.13	13,700
Dingess	1.50	40.81	50.43	7.26	1.43	13,241
Williamson	1.62	38.53	53.13	6.72	1.82	14,000
Cedar Grove	0.86	36.31	57.85	4.98	0.61	14,561
Lower Cedar Grove	0.3	32.1	64.9	2.7	0.7	
Alma	1.29	39.53	53.80	5.36	1.32	14,120
No. 2 Gas	1.15	29.49	63.00	6.36	1.51	14,203
Powellton	1.10	32.26	60.70	5.87	0.97	14,339
Eagle	0.81	31.01	63.09	5.09	0.86	14,709
Little Eagle	0.25	29.45	60.85	9.45	0.57	13,700
Cedar	1.40	28.92	61.70	7.98	1.14	13,965
Lower War Eagle	0.34	35.21	60.85	3.60	0.79	14,860
Glenalum Tunnel	0.65	27.24	67.00	5.11	0.55	14,400
Gilbert	0.87	26.21	65.04	7.88	0.77	14,565
Douglas	0.82	26.52	70.20	2.46	0.66	15,240
Iaeger	0.87	25.61	68.88	4.64	0.66	14,880
Sewell B	0.7	31.3	66.1	1.9	0.7	
Sewell	0.78	19.79	75.91	3.52	0.88	15,072
Welch	0.74	17.72	74.07	7.47	0.74	14,547
Beckley	0.81	14.83	79.22	5.14	0.73	14,831
Fire Creek	0.84	16.66	77.06	5.44	0.65	14,748
Pocahontas 9	0.7	19.0	76.7	3.6	0.7	
Pocahontas 8	0.7	19.4	77.3	2.6	0.8	
Pocahontas 7	0.8	20.8	64.1	14.3	0.7	
Pocahontas 6	0.70	19.66	76.54	3.10	0.58	15,190
Pocahontas 5	2.3	20.7	71.8	6.7	0.7	14,540
Pocahontas 4	0.97	15.67	78.45	4.91	0.66	15,123
Pocahontas 3	1.21	15.66	78.01	5.12	0.69	15,027
Pocahontas 2	0.78	18.09	76.53	4.60	0.93	14,950

TABLE 3—*Production of coal in West Virginia*, 1863-1931

Series and Seam	County	Tonnage	Thickness	Acreage	
MONONGAHELA SERIES					
Swickley Seam					
	Marion	9,638,430	54 inches	1,225	
	Marshall	46,078	60	5	
	Monongalia	38,370,070	54	4,890	
	Mineral	97,045	60	12	
	Ohio	890	72	1	
	Wetzel	11,200	60	2	6,135
Redstone Seam					
	Barbour	8,766,940	36	1,680	
	Harrison	2,176,953	60	250	
	Lewis	503,599	48	72	
	Monongalia	1,232,155	48	177	
	Upshur	4,385,989	60	505	2,684
Pittsburgh Seam					
	Barbour	20,075,734	84	1,640	
	Braxton	5,714,308	42	940	
	Brooke	31,539,353	54	4,020	
	Gilmer	2,166,034	72	207	
	Grant	5,006	132	1	
	Hancock	564,852	48	81	
	Harrison	154,061,512	72	14,725	
	Lewis	352,418	72	34	
	Marion	179,463,868	96	12,940	
	Marshall	35,876,321	66	3,742	
	Mason	5,903,488	54	703	
	Mineral	17,097,011	144	817	
	Monongalia	50,482,096	96	3,622	
	Ohio	24,514,527	60	2,815	
	Preston	499,202	120	33	
	Putnam	15,454,327	66	1,615	
	Taylor	26,629,171	84	2,282	
	Upshur	278,219	48	40	50,257
CONEMAUGH SERIES					
Little Pittsburgh Seam					
	Tucker	55,084	35	11	11
Elk Lick Seam					
	Mineral	19,561	28	5	5
Bakerstown Seam					
	Barbour	108,643	24	31	
	Brooke	3,573	48	1	
	Grant	803,326	36	153	
	Mineral	3,297,328	36	628	
	Preston	900,414	24	26	
	Tucker	21,036,347	60	2,420	3,259
Mahoning Seam					
	Grant	538,276	48	77	
	Mineral	1,029,334	48	148	225
ALLEGHENY SERIES					
Upper Freeport Seam					
	Barbour	7,287,657	36	1,390	
	Grant	2,625,811	48	376	
	Lincoln	9,689	24	3	
	Marion	17,722	36	3	
	Mineral	4,001,140	48	573	
	Monongalia	3,235,645	36	617	
	Preston	39,425,618	36	7,520	
	Taylor	577,131	36	121	
	Tucker	12,655,558	60	1,450	
	Upshur	4,029,379	36	770	
	Webster	3,136	24	1	12,824
Lower Freeport Seam					
	Brooke	1,220,337	60	140	
	Hancock	46,822	60	5	
	Preston	75,354	24	21	166
Upper Kittanning Seam					
	Barbour	5,819,233	36	1,110	
	Braxton	270,362	36	52	
	Clay	1,394,604	36	266	
	Marion	30,240	36	6	
	Mineral	1,173,913	24	337	
	Monongalia	5,182	36	1	
	Nicholas	28,138	36	5	
	Preston	319,413	18	12	1,789

TABLE 3—*Production of coal in West Virginia*, 1863-1931—(Continued)

Series and Seam	County	Tonnage	Thickness	Acreage	
Middle Kittanning Seam					
	Hancock	978	36	1	
	Nicholas	9,919	36	2	
	Webster	14,244	48	2	5
Lower Kittanning No. 5 Block-Seam					
	Barbour	3,258,046	60	374	
	Boone	7,998,855	60	918	
	Braxton	24,836	36	5	
	Clay	10,383,046	36	1,980	
	Fayette	5,149,057	60	590	
	Hancock	95,359	36	18	
	Kanawha	30,973,750	44	4,480	
	Lincoln	2,716,102	48	388	
	Logan	555,788	48	80	
	Mingo	31,033	48	4	
	Nicholas	297,724	48	43	
	Preston	1,394,724	24	1,761	
	Randolph	18,413,796	72	400	
	Taylor	228,520	48	33	
	Upshur	461,343	60	53	
	Wayne	932,247	48	154	
	Webster	106,412	60	12	11,653
POTTSVILLE SERIES					
KANAWHA GROUP					
Stockton Seam					
	Boone	334,620	60	38	
	Kanawha	7,857,118	45	1,205	
	Lincoln	795,271	48	114	
	Raleigh	575,332	36	110	
	Webster	5,858	36	1	1,468
Coalburg Seam					
	Boone	3,596,703	60	412	
	Clay	3,092,853	36	590	
	Fayette	436,931	42	71	
	Kanawha	49,934,699	60	5,725	
	Lincoln	176,067	24	51	
	Logan	387,823	48	56	
	Mingo	6,853,610	60	787	
	Nicholas	1,180,229	36	229	
	Wayne	1,411,486	24	405	8,326
Winifrede Seam					
	Boone	7,969,224	60	914	
	Fayette	398,789	24	114	
	Kanawha	27,589,098	54	2,510	
	Logan	9,978,387	24	2,850	
	Mingo	20,642,587	24	5,920	
	Raleigh	17,919,776	84	1,469	13,777
Chilton Seam					
	Logan	42,707,129	48	6,280	6,280
Hernshaw Seam					
	Boone	1,449,604	36	276	
	Raleigh	94,217	24	27	303
Cedar Grove Seam					
	Boone	1,612,530	36	308	
	Kanawha	4,876,716	36	930	
	Logan	153,625,326	48	22,100	
	Mingo	36,605,811	48	5,240	
	Webster	16,544	24	5	28,583
Alma Seam					
	Boone	4,978,754	36	951	
	Logan	8,600,627	24	2,462	
	Mingo	22,948,258	24	6,570	
	Raleigh	10,361	48	2	
	Webster	22,981	18	7	9,992
No. 2 Gas Seam					
	Boone	8,039,420	42	1,312	
	Clay	15,560	24	4	
	Fayette	84,335,367	84	6,910	
	Kanawha	55,357,621	54	7,040	
	Logan	24,853,039	36	4,750	
	McDowell	3,270,521	48	468	
	Mingo	4,902,588	36	938	
	Nicholas	433,336	30	100	
	Raleigh	61,008	48	9	
	Wayne	133,757	50	18	
	Webster	102,234	24	29	21,578
Powelton Seam					
	Fayette	15,861,429	36	3,230	
	Kanawha	1,698,434	30	389	3,619

TABLE 3—*Production of coal in West Virginia*, 1863-1931—(Continued)

Series and Seam	County	Tonnage	Thickness	Acreage	
Eagle Seam					
	Boone	4,031,077	42	660	
	Fayette	30,693,055	48	4,400	
	Kanawha	8,226,975	48	1,180	
	Logan	38,553,977	24	11,040	
	McDowell	3,707,899	48	532	
	Mingo	3,958,829	24	1,132	
	Nicholas	454,390	36	87	
	Raleigh	5,206,202	54	663	
	Webster	61,986	30	14	19,708
Glenalum Tunnel Seam					
	Mingo	5,949,774	60	681	681
Douglas Seam					
	McDowell	1,124,830	24		
NEW RIVER GROUP				322	322
Sewall Seam					
	McDowell	163,302,172	36	3,120	
	Fayette	14,229,920	36	2,720	
	Greenbrier	28,767,773	36	5,300	
	Nicholas	1,658,131	36	317	
	Raleigh	39,385,680	48	5 ,640	
	Randolph	1,375,029	30	268	
	Webster	1,316,416		189	
	Wyoming	2,989,348		686	18,240
Welch Seam			30		
	McDowell	13,960,605			
Beckley Seam				5,720	
	McDowell	29,909,107	36	7,1450	
	Raleigh	128,518,816	60	2,410	22,880
	Wyoming	8,405,557	24		
Fire Creek Seam					
	Fayette	36,105,352	36	6,900	
	Greenbrier	399,398	36	77	
	McDowell	1,730,398	24	496	
	Raleigh	4,574,834	36	868	
	Wyoming	7,977	36	2	8,343
POCAHONTAS GROUP					
Pocahontas No. 6 Seam					
	Fayette	389,922	48	56	
	McDowell	3,901,202	24	1,118	
	Mercer	1,444,205	36	276	
	Raleigh	6,797,243	24	1,945	
	Wyoming	1,363,940	24	392	3,787
Pocahontas No. 5 Seam					
	McDowell	2,178,554	36	416	416
Pocahontas No. 4 Seam					
	McDowell	90,028,438	54	11,480	11,480
Pocahontas No. 3 Seam					
	Fayette	726,058	36	139	
	Greenbrier	19,254	48	3	
	McDowell	331,657,266	60	38,000	
	Mercer	111,132,779	54	14,180	
	Raleigh	9,843,008	48	1,410	
	Wyoming	16,289,700	42	2,662	57,394
TOTAL ESTIMATED ACREAGE MINED					329,490

confused, judging solely from the way the annual productions vary. Other places might be noted, but it is felt that Tabe 3 as presented is sufficiently accurate for the purposes of this work, particularly as the seams concerned do not differ greatly in the type of mine drainage produced. The total acreage estimated by this method is 329,490, while the figure reported by the Department of Mines is 336,076.

FORMATION OF ACID MINE WATER

The "sulfur water" is supposed to be formed by the oxidation of the pyrites and marcasites exposed to the action of water and air by the removal of the coal. These insoluble sulfides are oxidized to the soluble sulfate and free sulfuric acid. The reactions are assumed to be

$$2\ FeS_2 + 7\ O_2 + 2H_2O = 2\ FeSO_4 + 2\ H_2SO_4$$

$$4\ FeSO_4 + 2\ H_2SO_4 + O_2 = 2\ Fe_2\ (SO_4)_3 + 2H_2O$$

The oxidation takes place slowly on the strictly chemical basis, thus giving support to the work of Carpenter and Davidson (21), who showed that unsterilized coal samples produced sulfates more rapidly than sterilized ones. This is taken to be evidence of the action of sulfate-producing organisms.

The sulfur-bearing material in the mine is found mainly in the gob material left in the mine by the worker who has thus cleaned the coal and in the material forming the top and bottom strata, which are now exposed to the action of air and water. These strata are said to be higher in the sulfur-bearing materials than the coal itself. In some mines a heavy mass of material is deposited upon the surfaces, as the water leaches out the sulfur compounds, and further action at the surface deposits it there. The water coming from some mines is clear, but upon standing the ferrous salts are oxidized, and ferric material is precipitated in a heavy reddish brown floc.

Not only do the characteristics of the water vary with the different seams of coal, but striking differences are found sometimes in mines in the same seam or even in the same mine. In general the old or worked-out portions of the mine or the old abandoned mines produce the most acid. This is true especially when the pillars have been drawn and surface water enters to increase the chemical action going on in the mine.

STREAM SURVEYS IN WEST VIRGINIA

A great deal of information regarding the pollution of the streams within the state of West Virginia was collected by the junior author for the State Water Commission*. Detailed surveys were made of the Cheat, West Fork, Elk, Coal, and Guyandotte Rivers. Through the cooperation of the Fairmont Water Board* the Tygart River also was surveyed. This work also made possible observations on the Monogahela, Kanawha, Little Kanawha, New, Gauley, Greenbrier, Bluestone and the Tug—Big Sandy River basins. Industrial pollution surveys were made on the Potomac River basin and on the Ohio River. In addition two months of the summer of 1932 were spent in a detailed study of the Ohio River from Weirton to Lang.

Since acid mine drainage is one of the major problems of this state, this work was emphasized. On the detailed pollution surveys and whenever possible elsewhere a data sheet was compiled on the mine and a sample of the water tested. In this manner it is thought that the data collected upon the key watersheds of the state may be expanded to include the entire state. The work was interrupted before complete information by the detailed studies could be obtained upon all of the state's watersheds.

In the more detailed pollution surveys each mine on the watershed was visited and information obtained from a responsible person. This was sometimes difficult in the case of a long-abandoned mine. From the information a data sheet was filled in with the name and address of the mine; the person interviewed; whether the mine was a shaft or drift operation; the vein of coal mined; its thickness; the cover; the acreage exhausted; the acreage unexhausted; the daily tonnage. Concerning the mine water, the following factors were

*The authors thank the State Water Commission, especially Director E. S. Tisdale, also the Fairmont Water Board, for their kind cooperation and permission to use the data collected during these stream surveys.

studied: Number and size of pumps, duration of pumping, number of outlets, and the quantity of drainage; the streams into which the drainage was discharged; and any other pertinent information. The operator was asked also if it were possible to seal the abandoned entries, if it were feasible to have all outlets discharge into one stream, and if the water fluctuated with the rainfall.

The mines were numbered and located on the drainage map made from the U. S. Geological Survey quadrangle maps. Samples were taken from the outlets and from the streams above and below the point of entrance of the drainage. The pH measurements were made in the field using a colorimetric kit.

The report of the Cheat River Survey was published by the State Water Commission in 1929 (1) and the report on the West Fork River was published in the Proceedings of the Sixth Annual West Virginia Water Conference (2) (1930). The other material has not been published. Some of the data will be included in this paper; the balance is on file in the West Virginia University Library.*

QUANTITY OF MINE DRAINAGE

The quantity of drainage from coal mines varies, with many factors to be considered. The operators in general reported that the quantity varied with season and rainfall. A. B. Crichton (24) arrived at an average of about 1000 gallons per acre per day, with the smaller mines showing the greater amounts per acre. L. V. Carpenter (29) in studying mines in northern West Virginia arrived at about the same figure. Howard N. Eavensons (26) figures prepared for the Indian Creek case give the much higher findings of about 2,000 gallons per acre per day for a 500-acre mine. A large mine of 1650 acres in southern West Virginia had an average over 2,000 with a maximum of over 10,000 gallons per acre per day. During the drought of 1930 the writers (2) found that the drainage on the West Fork River Basin was about half that normally expected. Even in 1931 the Coal and Guyandotte basins during the summer had low flows in the drainage. Experience and observation over most of the state has led the writers to the conclusion that the figure of 1,000 gallons per acre per day is a very conservative figure for the annual average in years of normal rainfall, especially since most mines in this state are of relatively small acreage and contain much surface water. The critical times occur in the drier portions of the year when the streams are lower and the mine water makes up a greater proportion of the flow than in wetter winter weather.

QUALITY OF MINE WATERS

When the chemical analysis of a mine water is considered, doubt arises as to the proper procedure or method to be used. The convenience of the pH test led to its early adoption in the work of this state. As a means of detecting and and classifying sources of pollution it is very satisfactory. Mr. R. D. Leitch (3 to 13) chemical engineer with the U. S. Bureau of Mines at Pittsburgh, used the method for total mineral acid as given in the Standard Methods of Water (44) with phenolphthalein indicator in the hot solution. Water works in general used the methyl orange indicator, which would not indicate possible

*Cf. thesis by L. K. Herndon, "Acid drainage from West Virginia coal mines" (June 1934).

acid from ferrous salts. The Aspinwall plant of the Pittsburgh water works developed the use of methyl red indicator in their control tests since the methyl red neutrality would give a pH at which the slow sand filters would work satisfactorily, while the lower pH of the methyl orange neutrality would not. Subsequently the Pennsylvania Sanitary Water Board (17) adopted the use of methyl red in their mine drainage surveys. For stream studies the committee on standard methods for the Ohio River Survey adopted the methyl orange and pH tests. The choice of indicator depends upon the use to be made of the information. In the present summary of the mine drainage, figures are given in total mineral acidity as parts per million of $CaCO_3$, as determined by the phenolphthalein indicator in the hot solution, because the total effect of the drainage could best be measured in that way. Furthermore the records for this study using this indicator are more complete. To calculate the acid as 100% H_2SO_4, the gravimetric factor converting the $CaCO_3$ to H_2SO_4 was used.

It is felt that the new approach to the estimation of the quantity of acid released to the streams will be more nearly accurate and better adapted to state-wide estimates.

Since not all the coal seams in the state have been mined in commercial quantities, no estimates can be made of the amount of acid likely to come from those seams, for until the coal has been removed, no drainage from the measure is produced. For this reason no attempt will be made to forecast the acid that will be produced far in the future. However, from the figures of the estimated production of today and the undeveloped acreages, an idea of what the future holds may be obtained.

In the following figures estimates are made of the average acidity in units of counties. In some instances individual mines will run much higher, but it is thought that over the area given the average is weighted carefully from analyses. When the acidity is given in parentheses, it is an area where insufficient data have been collected to form more nearly accurate conclusions. In all cases the pH test and the analyses have been used to give the best approximation.

Tests have shown the drainage from the No. 2 Gas (Campbell Creek), Eagle, Douglas, Beckley, Fire Creek, and all the Pocahontas coal to be alkaline. The writers have no information regarding the drainage from the Powellton, Glenalum Tunnel, or Welch seams.

At the rate of 2,875,827 pounds of 100% H_2SO_4 per day measured as total mineral acidity, the streams of West Virginia receive over 524,973 tons per year.

As a rough check on the amount of acid going into each of the watersheds of the state, the following calculations are given. The Monongahela basin includes the West Fork, Tygart, and Cheat, as well as the main stream. The Kanawha basin includes the Coal, Elk, Gauley, New, and Greenbrier Rivers. The Ohio River in this instance includes the smaller tributaries and the Little Kanawha.

It should be commented upon that the 168,349,000 gallons of water per day is only about half of the estimated drainage, the remainder being alkaline; in fact some of the seams in southern West Virginia are used as sources of public water supplies (51).

TABLE 4—*Mine drainage by seams, watersheds, and counties*

COUNTY	ORIGINAL ACREAGE	MINED ACREAGE	ACIDITY p. p. m.	ACID LBS DAY	WATERSHED
		SEWICKLEY COAL			
Marion	136,891	1225	3000	30,000	Monongahela
Marshall	201,600	5	(1500)	6	Ohio
Mineral	214	12	(1500)	14	Potomac
Monongalia	115,303	4890	5000	204,000	Monongahela
Ohio	45,000	1	(1500)	12	Ohio
Wetzel	96,000	2	(1500)	24	Ohio
Total	595,008	6135		234,056	
		REDSTONE COAL			
Barbour	16,416	1680	1200	16,400	Monongahela
Harrison	8,128	250	1200	2,440	Monongahela
Lewis	99,533	72	1200	704	Monongahela
Mineral	913	—	(1200)	——	Potomac
Monongalia	7,213	177	(1200)	1,730	Monongahela
Upshur	20,032	505	(1200)	4,930	Monongahela
Total	152,295	2684		26,204	
		PITTSBURGH COAL			
Barbour	22,261	1,640	3500	47,000	Monongahela
Braxton	52,941	940	(500)	3,840	Kanawha
Brooke	21,667	4,020	2000	65,000	Ohio
Cabell	8,860				Ohio
Calhoun	29,632				Ohio
Clay	6,809				Kanawha
Doddridge	58,496				Ohio
Gilmer	69,120	207	(500)	845	Ohio
Grant	32	1	2000	16	Potomac
Hancock	670	81	2000	1,320	Ohio
Harrison	159,488	14,725	3500	421,000	Monongahela
Kanawha	29,472				Kanawha
Lewis	106,137	34	3500	970	Monongahela
Marion	149,325	12,940	3500	370,000	Monongahela
Marshall	200,960	3,742	2000	61,200	Ohio
Mason	42,880	703	(500)	2,870	Ohio
Mineral	1,971	817	(2000)	13,300	Potomac
Monongalia	123,801	3,622	8000	236,500	Monongahela
Ohio	50,000	2,815	2000	46,000	Ohio
Preston	1,059	33	3500	945	Monongahela
Putnam	44,800	1,615	(500)	6,600	Kanawha
Roane	29,632				Kanawha
Taylor	9,024	2,282	2000	37,300	Monongahela
Upshur	9,088	40	(2000)	650	Monongahela
Wayne	5,120				Kanawha
Wetzel	153,200				Ohio
Total	1,385,565	50,228		1,304,956	
		BAKERSTOWN COAL			
Barbour	32,064	31	250	63	Monongahela
Braxton	30,502				Kanawha
Brooke	5,000	1	(250)	2	Ohio
Gilmer	219,136				Ohio
Lewis	180,179				Monongahela
Mineral	28,672	628	(250)	1,280	Potomac
Preston	54,240	26	(250)	53	Monongahela
Randolph	1,840				Monongahela
Roane	6,400				Kanawha
Tucker	16,656	2,420	(250)	4,830	Monongahela
Total	574,689	3,106		6,228	
		UPPER FREEPORT COAL			
Barbour	93,408	1,390	600	6,810	Monongahela
Braxton	107,872				Kanawha
Clay	24,992				Kanawha
Grant	68,992	376	(600)	1,830	Potomac
Lewis	30,208				Monongahela
Lincoln	74,880	3			Kanawha
Marion	11,526	3			Monongahela
Mineral	32,896	573	(600)	2,810	Potomac
Monongalia	34,189	617	(3800)	19,200	Monongahela
Preston	148,660	7,520	(5000)	307,000	Monongahela
Randolph	2,736				Monongahela
Taylor	22,675	121	(600)	594	Monongahela
Tucker	34,368	1,450	(2800)	33,200	Monongahela
Upshur	40,768	770	(600)	3,770	Monongahela
Wayne	11,520				Kanawha
Webster	7,085	1			Kanawha
Total	746,785	12,824		368,414	

TABLE 4—*Mine drainage by seams, watersheds, and counties*—(Continued)

COUNTY	ORIGINAL ACREAGE	MINED ACREAGE	ACIDITY p. p. m.	ACID LBS DAY	WATERSHED
		UPPER KITTANNING COAL			
Barbour	118,144	1,110	(1500)	13,600	Monongahela
Braxton	89,824	52	(500)	213	Kanawha
Brooke	8,333				Ohio
Clay	116,672	266	(500)	1,085	Kanawha
Harrison	32,000				Monongahela
Lewis	21,907				Monongahela
Marion	10,976	6		24	Monongahela
Mineral	2,432	337	(500)	1,375	Potomac
Monongalia	22,579	1		4	Monongahela
Nicholas	7,680	5		20	Kanawha
Ohio	25,000				Ohio
Preston	207,870	12		49	Monongahela
Randolph	5,088				Monongahela
Taylor	87,962				Monongahela
Upshur	107,616				Monongahela
Webster	28,141				Kanawha
Total	906,008	1,789		16,370	
		LOWER KITTANNING (NO. 5 BLOCK)			
Barbour	154,912	374	(300)	918	Monongahela
Boone	37,152	918	200	1500	Kanawha
Braxton	121,376	5			Kanawha
Brooke	8,334				Ohio
Clay	125,792	1,980	200	3,240	Kanawha
Fayette	7,110	590	(200)	965	Kanawha
Hancock	15,000	18			Ohio
Kanawha	194,560	4,840	500	19,750	Kanawha
Lewis	27,667				Monongahela
Lincoln	124,800	388	200	634	Kanawha
Logan	16,563	80	(200)	131	Guyandotte
Marion	42,496	4			Monongahela
Mineral	14,080				Potomac
Mingo	15,398				Guyandotte
Monongalia	32,640				Monongahela
Nicholas	77,984	43			Kanawha
Preston	234,515	400	(300)	980	Monongahela
Randolph	18,688	1,761	(500)	7,200	Monongahela
Roane	26,400				Kanawha
Taylor	91,725	33			Monongahela
Upshur	158,624	53			Monongahela
Wayne	112,000	154	200	251	Kanawha
Webster	48,800	12			Kanawha
Wyoming	186				Guyandotte
Total	1,706,802	11,653		35,569	
		STOCKTON-LEWISTON COAL			
Boone	57,632	38	250	68	Kanawha
Braxton	62,400				Kanawha
Clay	126,560				Kanawha
Fayette	12,292				Kanawha
Kanawha	194,560	1,205	250	2,460	Kanawha
Lewis	27,667				Monongahela
Lincoln	124,800	114	250	233	Kanawha
Logan	16,563				Guyandotte
Mingo	23,456				Guyandotte
Nicholas	99,904				Kanawha
Raleigh	4,480	110	(250)	225	Kanawha
Randolph	6,592				Monongalia
Roane	19,200				Kanawha
Upshur	18,176				Monongahela
Wayne	19,220				Kanawha
Webster	93,024	1		2	Kanawha
Wyoming	1,312				Guyandotte
Total	863,588	1,468		2,988	
		COALBURG COAL			
Boone	54,598	412	350	11,750	Kanawha
Clay	126,784	590	(200)	865	Kanawha
Fayette	17,881	71	350	225	Kanawha
Kanawha	55,040	5,725	400	18,700	Kanawha
Logan	73,088	56	(350)	160	Guyandotte
Mingo	61,702	787	(400)	2,575	Guyandotte
Nicholas	110,816	229	(200)	374	Kanawha
Webster	55,360				Kanawha
Wyoming	3,200			34,649	Guyandotte
Total	558,469	7,870			

TABLE 4—*Mine drainage by seams, watersheds, and counties*—(Continued)

COUNTY	ORIGINAL ACREAGE	MINED ACREAGE	ACIDITY p. p. m.	ACID LBS DAY	WATERSHED
		WINIFREDE COAL			
Boone	163,968	914	100	745	Kanawha
Clay	70,784				Kanawha
Fayette	26,304	114	100	93	Kanawha
Kanawha	37,760	2,510	100	2,050	Kanawha
Logan	124,160	2,850	100	2,330	Guyandotte
Mingo	109,728	5,920	100	4,830	Guyandotte
Nicholas	131,776				Kanawha
Preston	17,280				Monongahela
Raleigh	11,840	1,469	100	1,200	Kanawha
Randolph	10,208				Monongahela
Upshur	17,152				Monongahela
Webster	112,000				Kanawha
Wyoming	5,760				Guyandotte
Total	868,448	13,777		11,248	
		CHILTON COAL			
Boone	148,544				Kanawha
Fayette	34,464				Kanawha
Logan	153,920	6,280 (Alkaline drainage)			Guyandotte
Mingo	139,379				Guyandotte
Nicholas	141,504				Kanawha
Webster	120,096				Kanawha
Wyoming	10,880				Guyandotte
Total	748,787				
		HERNSHAW COAL			
Total	227,840	(Alkaline drainage)			
		CEDAR GROVE (THACKER-ISLAND CREEK) (Upper and Lower seams)			
Boone	238,592	308	500	1,260	Kanawha
Braxton	32,928				Kanawha
Clay	47,936				Kanawha
Fayette	52,429				Kanawha
Kanawha	81,240	930	500	3,800	Kanawha
Logan	347,718	22,100	3,500	631,000	Guyandotte
McDowell	832				Guyandotte
Mingo	224,755	5,240	1,500	18,350	Guyandotte and Tug
Raleigh	33,280				Kanawha
Webster	77,216	5			Kanawha
Wyoming	38,518				Guyandotte
Total	1,175,484	28,583		654,410	
		ALMA COAL			
Boone	253,056	951	3,500	27,100	Kanawha
Fayette	57,862				Kanawha
Logan	240,640	2,462	3,500	70,400	Guyandotte
McDowell	768				Guyandotte
Mingo	97,568	6,570	(2000)	10,720	Guyandotte and Tug
Nicholas	55,360				Kanawha
Raleigh	39,680	2			Kanawha
Webster	17,728	7			Kanawha
Wyoming	25,088				Guyandotte
Total	787,750	9,992		108,220	
		SEWELL COAL			
Barbour	3,232				Kanawha
Braxton	30,400				Kanawha
Fayette	175,449	3,120	500	12,720	Kanawha
Greenbrier	153,600	2,720	500	11,100	Kanawha
McDowell	94,016	5,300	(500)	21,600	Tug
Nicholas	258,144	317	(500)	1,295	Kanawha
Pocahontas	52,467				Kanawha
Raleigh	97,280	5,640	500	23,000	Kanawha
Randolph	249,664	268			Monongahela
Tucker	49,472				Monongahela
Upshur	27,360				Monongahela
Webster	132,288	189			Kanawha
Wyoming	85,760	686	(500)	2,800	Tug
Total	1,409,132	18,240		72,515	

TABLE 5—*Summary of drainage and acid by seams*

SEAM	DRAINAGE (Gal.—day)	ACID (Lbs.—day)
Sewickley	6,135,000	234,056
Redstone	2,684,000	26,204
Pittsburgh	50,228,000	1,304,956
Bakerstown	3,106,000	6,228
Upper Freeport	12,824,000	368,414
Upper Kittanning	1,789,000	16,370
Lower Kittanning	11,653,000	35,569
Stockton	1,468,000	2,988
Coalburg	7,870,000	34,649
Winifrede	13,777,000	11,248
Cedar Grove	28,583,000	654,410
Alma	9,992,000	108,220
Sewell	18,240,000	72,515
TOTAL	168,349,000	2,875,827

TABLE 6—*Summery of drainage and acid by watersheds*

WATERSHED	DRAINAGE (Gal.—day)	ACID (Lbs.—day)
Monongahela	61,898,000	1,755,064
Ohio	11,592,000	177,879
Kanawha	48,289,000	157,363
Guyandotte	31,775,000	711,426
Tug-Big Sandy	11,511,000	53,470
Potomac	3,284,000	20,625

TABLE 7—*Estimated future mine drainage by seams*

SEAM	ACREAGE	DRAINAGE (Gal.—day)	ACID (Lbs.—day)
Sewickley	378	378,000	15,800
Redstone	50	50,000	48
Pittsburgh	2,200	2,200,000	62,000
Elk Lick	2	2,000	
Bakerstown	21	21,000	43
Upper Freeport	163	163,000	6,640
Lower Freeport	1	1,000	
Upper Kittanning	19	19,000	77
Middle Kittanning	25	25,000	
Lower Kittanning	545	545,000	2,220
Stockton	21	21,000	43
Coalburg	118	118,000	396
Winifrede	478	478,000	390
Chilton	480	480,000	
Hernshaw	107	107,000	
Cedar Grove	2,510	2,510,000	71,800
Alma	293	293,000	8,370
No. 2 Gas	250	250,000	
Powellton	422	422,000	
Eagle	840	840,000	
Glenalum Tunnel	19	19,000	
Douglas	94	94,000	
Sewell	2,040	2,040,000	8,300
Welch	86	86,000	
Beckley	1,240	1,240,000	
Fire Creek	273	273,000	
Pocahontas 6	96	96,000	
Pocahontas 5	83	83,000	
Pocahontas 4	732	732,000	
Pocahontas 3	1,670	1,670,000	
TOTAL	15,235	15,235,000	176,127

The extrapolation of the values given for each seam to include the unmined acreages in an effort to forecast the effect of continued mining upon the drainage would be subject to error. In the case of seams in the same area which have been mined at their respective levels, the allocation of the quantity of drainage to each seam would be a matter for measurement. A much better way is to assume that the operation of the mines in the different seams will continue at about the same amount for the next few years and calculate the drainage and acid from present figures. The 1931 production figures in tons (27) have been calculated to acreage, and an estimate of the sulphuric acid to be expected has been computed.

Thus it may be seen that as our coal reserves are depleted, the acid burden of the streams increases in proportion. Nor does the strength of the acid or the flow decrease with the passing of years in the case of abandoned mines. One mine in the Cedar Grove seam that had been idle and draining for about 30 years was even more acid than active mines in the same area.

EFFECTS OF THE ACID DRAINAGE

The acid drainage from the mines has a marked effect upon the condition of the streams, as has been shown in the surveys in West Virginia. The natural alkalinity of the surface waters and the effect of dilution has minimized the conditions in some places where the concentration of drainage was not too great. However, critical conditions occur in the Cheat, West Fork, Tygarts, Coal and Guyandotte basins and as the concentration of acid increases these situations will grow worse. For example the West Fork River during the summer months has a pH of about 3.0 from below Clarksburg to its mouth at Fairmont. The work of Carpenter and Davidson (22) upon the relation of dilution to pH indicates the vast dilution required to bring the pH to even moderate levels. For example a mine water having a pH of 3.0 (acidity 3,600 p.p.m.) diluted 500 times still has a pH of 5.6, which is still very acid.

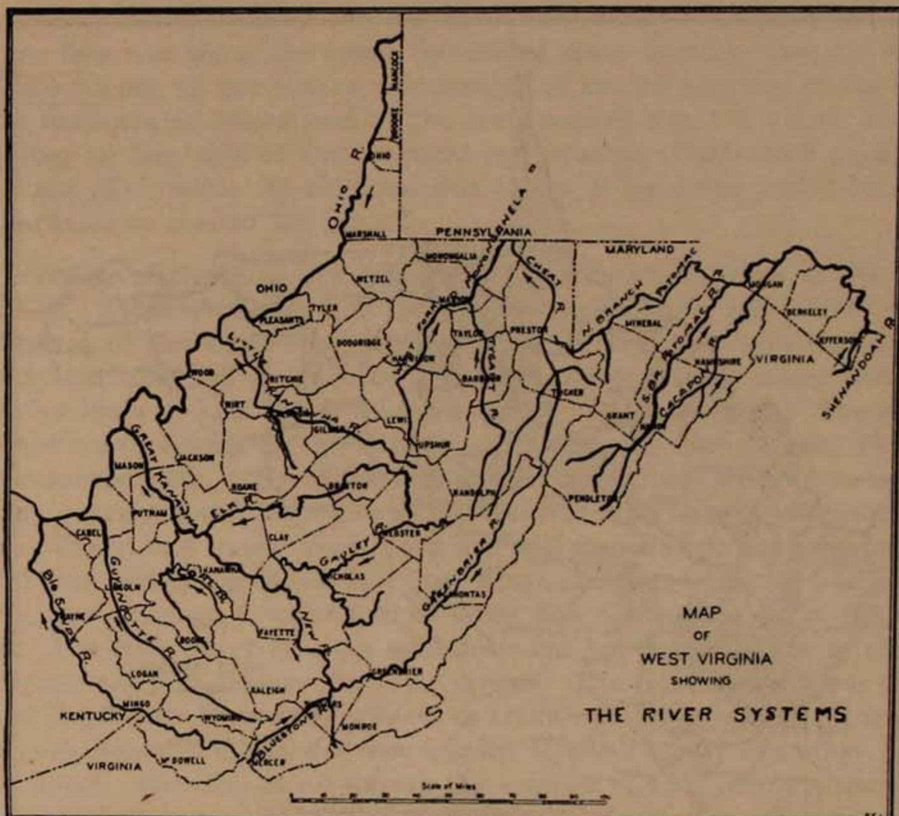
Inspection of the records of the U. S. Geological Survey (32) upon the flow of the Monongahela River indicated a mean discharge of about two cubic feet per second for the average year. Since the Monongahela basin (above the mouth of Dunkard Creek and including the area in West Virginia only) has an area of 4385 square miles, we have a mean discharge of approximately 5,670,000,000 gallons per day. The estimate of 61,898,000 gallons of acid-mine drainage discharging into the Monongahela River thus shows a dilution of a little over 900 times (918). The estimated amout of 100% H_2SO_4 in this drainage was 1,755,000 pounds. Assuming that the alkalinity of the water to offset this is measured in the alkalinity test, we find that the average alkalinity in p.p.m. for a normal year is about 13 at Weston, 23 at Clarksburg, 16 at Elkins, and 19 at Fairmont. The water for the entire watershed probably would be near 15 p.p.m. (methyl-orange indicator and expressed in terms of $CaCO_3$). Thus the alkalinity of the stream would have a daily output equivalent to 708,750 pounds of $CaCO_3$, which would react with 694,150 pounds of acid leaving 1,060,914 pounds of acid not neutralized. Undoubtedly there is further alkaline material for this acid to act upon and thus reduce the acidity. Unfortunately sufficient data could not be gathered by the limited means at our disposal to make more accurate field determinations upon the streams to determine quantitatively these reactions. Also there is the consideration of the acidity and alkalinity determinations in which different indicators were used. However, as a rough check the writers estimate that the acidity by the methyl-orange indicator would give 633,000 pounds of acid per day in the Monongahela basin. Even with this figure it is evident that critical conditions prevail in the Monongahela River throughout an ever-increasing number of days each year.

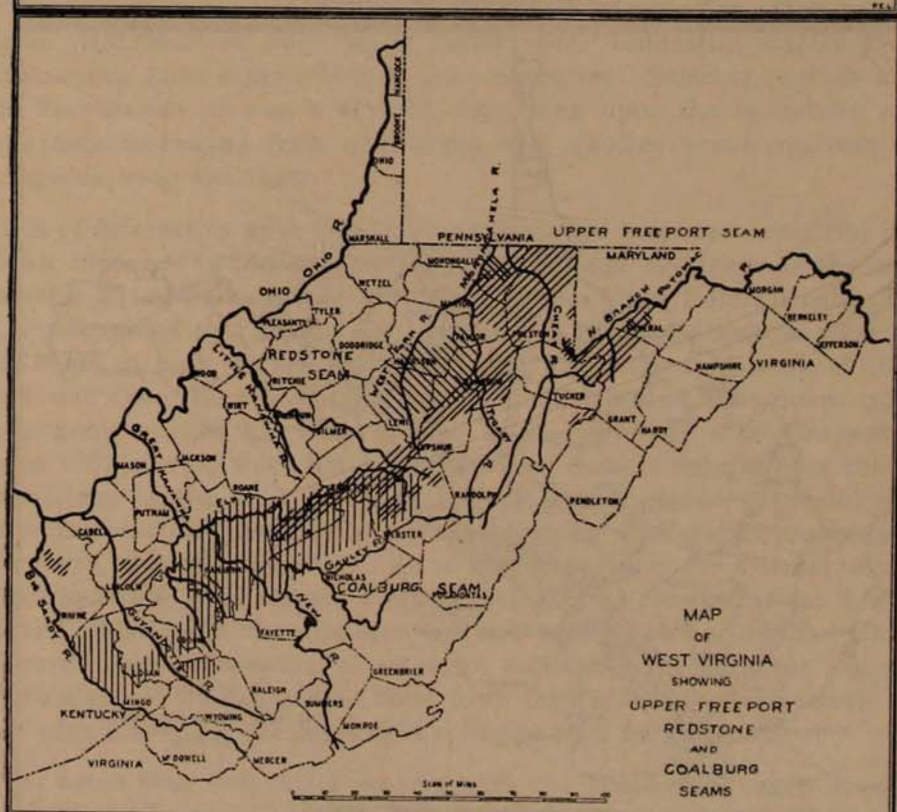
The other drainage basins in this state do not present as critical conditions as indicated here. Certain limited areas on Coal River and the Guyandotte River give trouble as will others when the mined area increases. The following maps indicate the principal river systems of the state and some of the coal seams whose drainage flows into the different rivers.

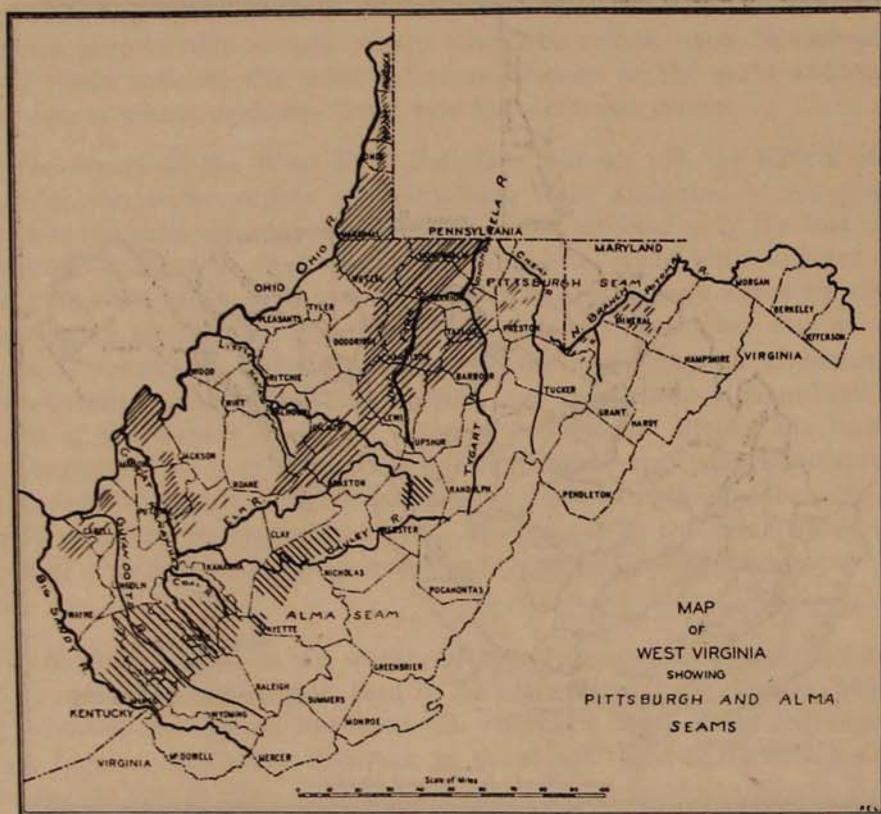
In the report on the West Fork Pollution Survey (2) the effects of mine drainage on the water supply of Clarksburg were discussed at some length. In this case the polluted waters of Browns Creek affected only the last pool of their storage system, so that comparison could be made with upriver conditions and also the effect of increased quantities of drainage noted by the conditions existing during the drought, when the flow in the river was at a minimum. Acid conditions in the river prevent the rapid growth of plankton of the taste-forming groups and also provide iron for use as a coagulant in the treatment of the water. As to the other or detrimental effects, the treatment is more expensive as a result of the additional material used in neutralizing the acid, and further, the increased mineral content and hardness are detrimental in domestic and industrial uses. Manganese in the mine water is also a source of trouble and requires great care and additional treatment to remove it.

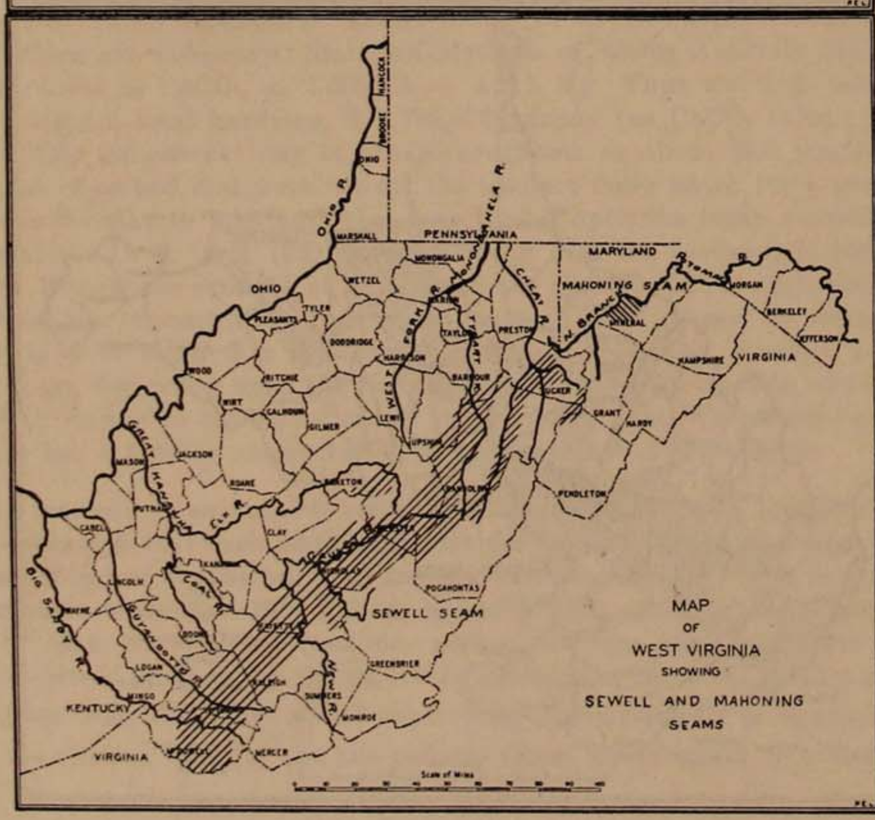
The hardness added to the waters of the Monongahela River may be estimated by calculating the 100% acid to its neutralized form $CaSO_4$. This compound produces permanent hardness. In northern West Virginia magnesium salts are found in the water analyses as about one third of the alkaline earths, and calcium as two thirds. (In these calculations the hardness due to R_2O_3 will be ignored). Since hardness is further measured on the basis of $CaCO_3$, more computations are necessary. Standard Methods of Water Analysis (44) gives total hardness as $CaCO_3$, as 2.495 Ca + 4.115 Mg. Thus we find the mine water adding a total hardness of 1,790,000 pounds (as $CaCO_3$ calcd.) to the 5,670,000,000 gallons per day of the Monongahela or about 38.0 p.p.m. This would not be so bad if it were not for the summer flows which for a period of three months may be one tenth this flow (based upon the mean monthly flow figures of the U. S. G. S. (32) with the result that the hardness is increased tenfold. During the drought of 1930, when the streams fell to such extremely low flows, the concentration was much greater. With respect to water supplies it is to be noted that local conditions differ from the average for the whole basin, depending upon the favorable or unfavorable location of the supplies with respect to concentrations of the drainage. The West Fork basin for example has a greater concentration of acid than the Tygart River.

An increase in hardness is reflected in the increased soap consumption, it being estimated that each additional part per million of hardness adds or requires 0.13 pound of soap per 1000 gallons water softened. If each person uses as estimated amount of 1900 gallons annually (33) which is completely softened by soap, the increased cost per person per year at 15 cents per pound for soap would be $1.41 for the estimated increase in hardness of 38 p.p.m. It is realized that this figure would apply only to communities in Pennsylvania, since the diluting effect of the less-polluted Cheat River would be evident only there.


MAP
OF
WEST VIRGINIA
SHOWING
THE RIVER SYSTEMS
PENNSYLVANIA
MARYLAND
OHIO
KENTUCKY
VIRGINIA


UPPER FREEPORT SEAM
REDSTONE SEAM
COALBURG SEAM
MAP
OF
WEST VIRGINIA
SHOWING
UPPER FREEPORT
REDSTONE
AND
COALBURG
SEAMS
PENNSYLVANIA
MARYLAND
OHIO
KENTUCKY
VIRGINIA


MAP
OF
WEST VIRGINIA
SHOWING
PITTSBURGH AND ALMA
SEAMS
PITTSBURGH SEAM
ALMA SEAM
PENNSYLVANIA
MARYLAND
OHIO
VIRGINIA
KENTUCKY
Scale of Miles


MAP
OF
WEST VIRGINIA
SHOWING
SEWELL AND MAHONING
SEAMS
MAHONING SEAM
SEWELL SEAM
PENNSYLVANIA
MARYLAND
OHIO
VIRGINIA
KENTUCKY
Scale of Miles

To check the figure for hardness, the writers made an analysis of the Monongahela River water at the Morgantown intake on September 4, 1929, when the flow was below the mean (estimated mean monthly flow for September 1929 = 0.2 sec. ft. per square mile instead of the 2.0 assumed at the mean), and the hardness as determined by the soap method was 183 p.p.m. However, calculating on the basis of the chemical constituents ($CaO = 53.5$ p.p.m., $MgO = 22.6$, and $SO_3 = 450$), the hardness due to the H-ion being added brings the total hardness to around 560 p.p.m.

The effect of the mine drainage upon the recreational uses of the stream is marked. Already portions of the Monongahela Basin are unfit for the maintenance of fish life. Four parts per million acid has been stated as the concentration that will destroy the fish. It is evident that many tributaries contain amounts of acid many times in excess of this quantity. The detailed watershed surveys made by the writers indicated many such places. The Potomas, Greenbrier, Elk, Little Kanawha, and Gauley Rivers will not be menaced for many years or until the drainage has reached high figures. Portions of the Tygarts, Cheat, and upper West Fork are still unpolluted, and other sections are acid only during low flows. Big Coal River and part of Little Coal are still alkaline, but drainage from the Alma seam was responsible for a fish-killing in 1932. The New River receives acid drainage but probably not in sufficient quantity seriously to damage the main stream. The Guyandotte River and the Tug and Big Sandy Rivers are subject to trouble in the areas near Logan and Williamson, where the Island Creek (Cedar Grove-Thacker are other names) seam is mined. The Ohio River during the summer of 1932, while a survey was being conducted, was alkaline, but water-works records for other years indicate acid conditions at least below Sistersville. Industrial wastes from the steel industries have some effect in this connection. Summer periods are subject to fluctuations or waves of acid, depending upon the industries or upon the alternate discharge from acid areas and alkaline areas upriver; this in turn depends upon the rains.

It is of interest to note that the acid drainage has been beneficial in keeping down nuisance conditions coming from sewage pollution of the streams. In the Ohio River Survey (42) conducted by the U. S. Public Health Service, W. C. Purdy noted that in the acid waters the types of plankton were limited even in zones of high sewage concentrations. The important work of these organisms and their relationship to the bacterial life and subsequent oxidation of the organic matter has been studied extensively, but until Carpenter and Roetman (25) started work not much had been done in determining the inhibitory reactions of the acid drainage. Purdy and Butterfield (34-40) explain that the bacteria are responsible for the oxidizing and this is associated with their growth and multiplication. In a given media under normal conditions they will multiply until certain limiting numbers or concentrations are reached, beyond which point the numbers will not vary much and beyond which the initial rapid rate of oxidation slows down noticeably. If plankton are present to absorb some of the bactria as their food, thus allowing new growth of bacteria to take place, the oxidation will continue at a faster pace.

It is noted that even brief contact with the acid-mine water lowers the numbers of the bacteria present in sewage, thus lowering the limiting numbers which will be found in the unfavorable environment, and in the acid streams the plankton are fewer. The reduced biological action is responsible for the apparent reduction in the B.O.D. found by Carpenter and Roetman (25). The recommended procedure of the Great Lakes and Ohio River Boards of Engineers (46) for the B.O.D. test to obtain the index of the condition of the stream at the time of sampling is to neutralize the water and seed it with a measured amount of sewage containing both bacteria and organisms of the plankton. Laboratory tests with this procedure indicated that somewhat higher and hence nearer the true B.O.D. could be obtained. However it was observed that the Ohio River during the summer of 1932 was alkaline in the range supposed to support active bacterial and plankton growth that did not give representative B.O.D. figures. This might be due to earlier acid conditions that had killed most of the plankton. Unusual conditions were present for the best growth of certain types of plankton in the long sunny days of that summer. Low flows afforded excellent opportunities for sedimentation, although no sediment was found at the sampling stations.

The alkalinity present in the sewage will neutralize the mine water to some extent, giving a heavy flow of iron to aid sedimentation. It is a moot question whether or not the subsequent scouring by floods produces critical conditions further down the river when the neutralization takes place. Comparison of the water works records and discharge records of the streams did not show the peaks that would be expected. The best explanation to be offered at this time is that chemical combinations take place so that a minimum of oxidation is necessary, and this function of oxidation is performed by bacteria and plankton that will thrive in the acid environment. Just what the reaction between H_2SO_4, $FeSO_4$, $Fe_2(SO_4)_3$ and related compounds, and the organic material in the sewage might be, the writers are not prepared to say.

DISPOSAL OF ACID DAINAGE

The usual procedure has been to drain all the acid waters of a mine to the nearest stream, as indeed the law in West Virginia permits the operator to do. The only provision is that, having polluted one stream, he cannot then change the drainage into another stream. Not much attention has been paid to the latter provision. As has been demonstrated, the drainage has serious effects upon the use of the streams for other purposes.

Naturally the first thought in the treatment of the drainage is to neutralize the acid. If we say that the natural alkalinity of the Monongahela River will take care of part of the acid according to the previous estimate, leaving about 1,000,000 pounds per day of 100% H_2SO_4 to be neutralized, we realize that enormous expenditures of money will be required. Lime at $8.50 per ton in bulk would require about $2700 a day or almost $1,000,000 a year as the cost of the chemical alone (20), (29). The problem has only started there however, for treatment plants would have to be built requiring constant attention and supervision. The cost of hauling the lime to the mine opening would add greatly to the undertaking. If each mine owner were required to treat the water from his mine it would place prohibitive amounts upon the high-acid areas. That property would revert to the state as have many of the abandoned and worked out properties. It would be safe to estimate that the annual cost to the state-wide industry would be about three cents per ton of coal mined. On top of this is the difficulty of handling the sludge, amounting to 20 to 40% of the volume of the material treated. Also the water in the streams would have a high permanent hardness, rendering softening treatment necessary. In case of the highly-mineralized water the softened water would still give trouble in boilers through foaming.

It is evident that a direct continuous treatment of this nature would not be economical or satisfactory. Many systems have been suggested whereby by-products could be recovered to help pay the expense. So far as is known none of these are in operation at present, thus answering the question of their success. One of the writers visited a treatment plant installed on a branch of Elk Creek about 20 miles from Clarksburg. It had been built by the Game and Fish Commission under the direction of J. L. Travers, patentee of the treatment process. The acid drainage flowed over a bed of porous marl ($CaCO_3$) theoretically at a rate sufficient for neutralization yet fast enough to prevent the deposition of the neutralized material on the marl to inhibit further action. Sedimentation was provided for removal of the suspended material. The plant was placed in operation when built but never recharged with marl. At the time of the visit it was not accomplishing any improvement of the mine waters. Undoubtedly some neutralization would take place when the plant was properly charged, but as to the success of the marl and the rate of flow, we are unable to say. However, it was noted that additional marl was placed in the exit throughs from the sedimentation basins.

For a while there was some thought that rock-dusting in mines might affect the quality of the drainage. The only rock-dusted mines located were in seams that produced alkaline water and were relatively dry, it being unnecessary to dust in wet mines.

There has always been talk of 'sealing' mines to prevent the flow of water from them. The only mine that could be sealed in this sense would be by stopping the pumping system in a shaft mine. In the drift mine the water collects and will find some outlet as the hydraulic head mounts. Sealing mines to prevent the excess of air or flooding holds promise in that the oxygen of the air seems essential to the process of acid formation. If the mine has all the oxygen removed by flooding, the oxidation would stop much more quickly than when the air is left in the mine and only additional air by circulation prevented entrance.

Analysis	No. 1	No. 2	No. 3
Residue on evaporation	1,026	414	3,160
Residue on ignition	727	357	2,955
Loss on ignition	299	57	205
SiO_2	97	68	87
Fe_2O_3, Al_2O_3	291	216	1,436
CaO	105	77	9
MgO	742	678	654
SO_3	549	255	1,985
Cl	.01	.005	.01
Hardness (Soap)	39	20	93
Mn	0.2	0.1	2
pH	7.9	7.9	5.3
Alkalinity—Methyl Orange	281	144	–183
Alkalinity Phenolphthalein	17	4.5	–193

One mine visited was in the Pittsburgh seam, which had been operated by means of a shaft, but had been abandoned several years and allowed to flood. The water had a pH of 7.9 (Analysis No. 1). Nearby was a mine so located that an air shaft penetrated to the flooded section and outlets were available where the overflow from the unflooded portion of the same mine could be sampled. (Analyses No's. 2 and 3). Data are in p.p.m., except pH.

Other mines in this same area had a pH of 2.7 to 3.0, so there was evidence that the exclusion of all or part of the air had some effect, although it must be admitted that no samples were available for comparison before the mines were abandoned.

The Sanitary Water Board of Pennsylvania (14) (16) has been interested in bringing all the drainage to one point and that as far down the stream as possible, in order to clear as many of the smaller tributaries as possible. This is feasible only where the workings are of considerable size and adjacent mines more easily connected. With the relatively small mines in West Virginia (from the acreage standpoint) this does not promise much relief from acid-stream conditions.

The present program under way in this state does seem to be very worthy in that through the federal grants money was made available to use the unemployed labor in the mining communities in placing carriers at the various outlets of the abandoned or otherwise inactive mines that are unlikely to be worked for some time. These barriers place a water seal at each opening to prevent the entrance of air and yet allow free flow of the water from the opening. No head is built up by water pressure within the mine; hence there is little danger of sudden discharge of flooded mines, a hazard to life and property in the valleys or in adjacent working mines. Samples are being taken to determine the present condition of the drainage so that future comparisons may be made (52).

It is not expected that the acid character of the mine water will be changed at once, but if a marked reduction in acidity comes in two or three years the effort is worthy.

ADMINISTRATION OF A MINE-DRAINAGE CONTROL SYSTEM

As the present State Water Commission law reads, the mining industry is exempted specifically from the provisions of that act so that the law stands letting the operator have free and unhindered drainage of his mine. Nevertheless serious trouble may arise, as it did upon Coal River when a sudden discharge of acid water from a highly acid seam went into a low stream, killing fish for several miles. Later under agreement with the Commission future drainage was controlled so that no damage was done. One of the writers tested the drainage, found the dilution necessary, measured the flow in the stream, and so determined the quantity from the flooded area in the mine to be allowed to go to the stream. It is true that this was done after the fish-killing took place, but before it would have been difficult to convince the operator that he should be careful.

As to future control of the mine wastes it would seem best to require that as a mine is shut down, it should be barricaded in the manner described above in the federal projects to eliminate the trouble arising from the acid water projects to eliminate the trouble arising from the acid water from abandoned mines. Since the district mine inspectors are familiar with the conditions of the operating mines and are supposed to have maps of all the properties, they should supervise the closing of the mine. Removal of mining equipment would be considered equivalent to abandonment, although the title to the property would be retained in case of future operations. The above action would (1) have a beneficial effect upon the water; (2) prevent accidents by keeping people out of abandoned mines; and (3) prevent fires in the mines. The engineering provisions would thus be taken care of through the engineers in the Department of Mines who are the ones in closest contact with the industry. As to the mines, it is necessary to close them completely to the effects of air. A representative of the State Water Commission, guided either by; (a) previous field studies; (b) a knowledge of the drainage from the seam in question; (c) a study of this paper; or (d) actual tests in the field, should be able to give the necessary information, test a sample as the seal is placed, and then make such future tests as are necessary to demonstrate the effectiveness of the seal, leaks of air, and the effect upon the receiving watercourse. The effectiveness of the present Federal mine-sealing project should be followed in the same manner.

By making the mine operator responsible for the small expense of closing the mine properly before he is considered properly discharged from his obligation to the state, future drainage conditions will be met. It is to be hoped that the Federal workers under the CWA will have relieved definitely the present situation in regard to abandoned and inactive mines.

It is only through a state wide and systematic effort of this sort that we will be able to cope with the gigantic problem of maintaining our streams in proper condition. As conditions now exist it will take years to reduce the present load of acid to even moderate proportions and allow for drainage from active mines.

Future conditions in the drainage from active mines will demand the utmost cooperation from the operators. Many vexing situations could be handled in the manner described for solving the problem on Coal River.

CONCLUSION

The problem of acid mine water in West Virginia is of great importance. The watershed surveys made to date have given some insight into the character of the drainage to be expected and the problems that will arise. The key position of the industry demands that any program have a firm basis before it is undertaken. The estimates of the annual increase in acid to be expected from future operations indicate clearly that care and forethought be expended now before all our streams are affected as are the West Fork and other rivers.

The cheapness and desirability of the proposed program as a part of a general plan of conservation for this state, and the fact that the work already has been started on a temporary basis, should make it imperative to being a permanent program at the earliest possible time. Surely the beneficial effects of such planning over a period of time will show favorable results within a few years.

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A MODERN PERIODIC ARRANGEMENT OF THE ELEMENTS

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Experience in teaching undergraduate chemistry convinces me that students of high school and undergraduate college chemistry appreciate very little more of the ordinary periodic table than those most obvious features such as atomic symbol, atomic weight, and one valence for each element.

In designating this arrangement the primary purpose is to make as many of the fundamental properties of all the elements stand out so boldly visible as literally to strike them in the face, and their significance readily understood by even high-school students. To a limited extent of its use, experience amply and gratifyingly has sustained the fundamental purpose.

It might be a pertinent question to ask why this arrangement has not been made earlier in the decades of using the original arrangement of Mendeléef or even Moseley. Of course that is difficult to answer. I venture the suggestion that teachers are not prone to project themselves as it were back into that state of chemical knowledge of the elementary and under-graduate student. After an extensive study of all other arrangements of my knowledge, including W. D. Harkins spiral arrangement, the cross-word puzzle, with limited restrictions, occurred to me.

In this first edition every effort has been exerted to avoid errors and to obtain the most recently approved data, but new discoveries are being made, and old data are being corrected daily, so that as this goes to press, possibly many corrections and extensions could be made; therefore a revision to correct errors and to include more data to extend its usefulness is anticipated. Any suggestions as to correction of errors, and the addition of data to extend its usefulness, will be gratefully received.

BASIS AND SIGNIFICANCE OF ARRANGEMENT

The fundamental basis for the arrangement of the elements is that of Moseley's Atomic Numbers, but these are placed in order on either side of the zero column of the inert gases according to whether they lose or gain electrons, the distance from this column in the order of their ease of doing so.

Each element having more than one valence falls in a horizontal row and in the vertical columns corresponding with each known valence. To illustrate: the first element, Hydrogen, stands on either side and adjacent to Helium, and these two elements form the primary and secondary units of which all other elements are built. Also, Carbon is the second element to possess more than one valence and is an excellent example in that it occupies four valences on both the positive and negative sides of the zero column.

Note also, that no other element occupies as many places, which is accounted for by the structure of its atom, the consequence of which is that Carbon is able to combine in so many ways it forms about five times as many compounds as all the rest of the elements combined.

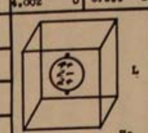
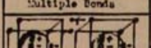
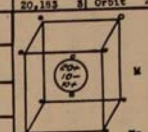
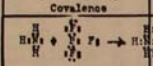
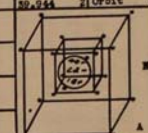
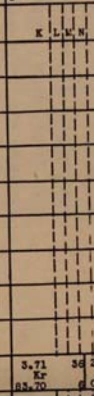
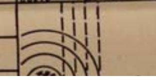
Each succeeding element is given the same consideration as for the Rare Earth elements indicated by the insert.

It is a notable feature that the so-called transition elements find places in their proper valence columns, and that the cause for that distinction disappears.

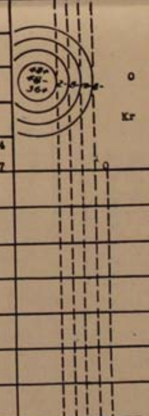
The elements of the seventh and incomplete period, or those having valence electrons in the seventh orbit, have the distinction of being radio-active—an important phenomenon in modern chemistry.

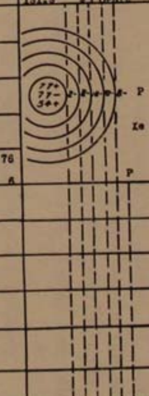
The two border columns on the right of the reader are headed by the formula for the atomic numbers and likewise the possible valences of the different periods indicated below. The Inert Gases have been raised one space so that they might appear at the end of the period to which they properly belong. The Langmuir-Lewis structure accompanies the first three, and only their respective orbits accompany the latter three.

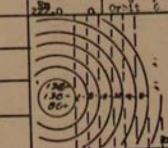
The two border columns on the left contain: first, an example of each of the different types of valence, namely (1) the heteropolar bonds of Lithium Fluoride, (2) the homopolar bonds of the atoms in the molecule of Nitrogen,

Types of Valences		A MODERN PERIODIC ARRANGEMENT OF THE ELEMENTS.								Copyrighted 1935, by F. D. Galbraith, Potomac State College, Keyser, W. Va.					Electrons in the Orbits
Electrovalence Heteropolar Bonds		ELEMENTS THAT HAVE GAINED ONE OR MORE ELECTRONS.					ELEMENTS THAT HAVE LOST ONE OR MORE ELECTRONS.								Atomic Numbers $2(1^2+2^2+2^2+3^2+3^2+4^2)$
		Negative Valences				0	Positive Valences								
		IV	III	II	I		I	II	III	IV	V	VI	VII	VIII	
					.0899 1 H_2 0 1.0078 2		.0899 1 H_2 0 1.0078 2								.177 2 He 0 4.002 0 2 K Orbit 1
Covalence Homopolar Bonds						.177 2 He 0 4.002 0	.534 3 Li 2.958 6.940 2	.185 4 Be 9.02 2	2.0 5 B 10.82						
		1.88 6 C 12.0 2	1.88 6 C 12.0 2	1.88 6 C 12.0 2	1.88 6 C 12.0 2		1.80 6 C 12.0 2	1.88 6 C 12.0 2	1.88 6 C 12.0 2	1.88 6 C 12.0 2					
			1.251 7 N_2 14.008 2				1.251 7 N_2 14.008 2	1.251 7 N_2 14.008 2	1.251 7 N_2 14.008 2	1.251 7 N_2 14.008 2	1.251 7 N_2 14.008 2				He
Elements occurring in the first short period				1.429 8 $O_{2,3}$ 16.0											
Nonpolar Valence Multiple Bonds					1.69 -1.90 9 F_2 19.0 0										.90 10 Ne 20.183 8 2+8 L Orbit 2
						.90 10 Ne 20.183 8	.971 11 Na 2.713 22.997 0	1.74 12 .55 Mg 24.32 2	2.70 13 Al 26.97 0						
		2.42 14 Si 28.06 3								2.42 14 Si 28.06 3					
Coordinate or Covalence			1.82 15 $P_{2,4}$ 31.02 0						1.82 15 $P_{2,4}$ 31.02 0		1.82 15 $P_{2,4}$ 31.02 0				
				1.128 16 $S_{2,-8}$ 32.06 3						1.120 16 $S_{2,-8}$ 32.06 3		1.128 16 $S_{2,-8}$ 32.06 3			A
					3.214 17 -1.35 Cl_2 35.457 3		3.214 17 -1.35 Cl_2 35.457 3		3.214 17 -1.35 Cl_2 35.457 3		3.214 17 -1.35 Cl_2 35.457 3		3.214 17 -1.35 Cl_2 35.457 3		1.782 18 A 39.944 2 2+8+8 M Orbit 3
Shells → K - Sc	3d or M 8	4th or N 1 - 3				1.782 18 A 39.944 2	.86 19 K 2.922 39.1 2	1.54 20 Ca 2.5 40.08 2	2.5 21 Sc 45.10 0						
Ti	10, 9, 8	2, 3, 4						4.5 22 Ti 47.90 2	4.5 22 Ti 47.90 2	4.5 22 Ti 47.90 2					
V	11, 10, 9, 8	2, 3, 4, 5							5.87 23 V 50.95 0		5.87 23 V 50.95 0		5.87 23 V 50.95 0		
Cr	12, 11, 8	2, 3, 6						7.1 24 Cr .5 52.01 4	7.1 24 Cr .5 52.01 4			7.1 24 Cr .5 52.01 4			
Mn	13, 12, 11, 9, 8	2, 3, 4, 6, 7						7.2 25 Mn 1.0 54.93 0	7.2 25 Mn 1.0 54.93 0	7.2 25 Mn 1.0 54.93 0		7.2 25 Mn 1.0 54.93 0	7.2 25 Mn 1.0 54.93 0		
Fe	14, 13	2, 3						7.85 26 Fe .045 55.84 2	7.85 26 Fe .045 55.84 2						
Co	15, 14	2, 3						8.9 27 Co .29 58.94 0	8.9 27 Co .29 58.94 0						
Ni	16, 15	2, 3						8.9 28 Ni .22 58.69 2	8.9 28 Ni .22 58.69 2						
Cu	18, 17	1, 2					8.93-5 29 -.345 Cu 63.57 2	8.93-5 29 -.345 Cu 63.57 2							
Zn - Kr	18	2 - 8						7.14 30 .758 Zn 65.38 5							
								5.91 31 Ga 69.72 2	5.91 31 Ga 69.72 2						
									5.36 32 Ge 72.60 8	5.36 32 Ge 72.60 8					
			5.73 33 -.3 As 74.93 0						5.73 33 -.3 As 74.93 0		5.73 33 -.3 As 74.93 0				
				4.47-80 34 Se 79.20 6						4.47-80 34 Se 79.20 6		4.47-80 34 Se 79.20 6			
					7.59 35 -1.066 Br_2 79.916 2		7.59 35 -1.066 Br_2 79.916 2		7.59 35 -1.066 Br_2 79.916 2		7.59 35 -1.066 Br_2 79.916 2		7.59 35 -1.066 Br_2 79.916 2		3.71 36 Kr 83.70 6 2+8+18+8 N Orbit 4
						3.71 36 Kr 83.70 6	1.5 2.9 37 Rb 85.44 2	2.6-.7 38 Sr 87.63 3	5.51 39 Yt 88.92 0	6.4 40 Zr 91.22 4					
Shells →	4th or N	5th or O							8.4 41 Cb or Nb 93.3 0		8.4 41 Cb or Nb 93.3 0				

					7.59 35 -1.066 Br_2 79.916 2		7.59 35 -1.066 Br_2 79.916 2		7.59 35 -1.066 Br_2 79.916 2		-1.066 Br_2 79.916 2		-1.066 Br_2 79.916 2		Kr 83.70 6 / Orbit 4
						3.71 36 Kr 83.70 6	1.5 2.9 37 Rb 85.44 2	2.6-.7 38 Sr 87.63 3	5.51 39 Yt 88.92 0	6.4 40 Zr 91.22 4					
Shells → Rb - Cb	4th or N 8	5th or O 1 - 5							8.4 41 Cb or Nb 93.3 0		8.4 41 Cb or Nb 93.3 0				
Mo	12, 11, 10, 8	2, 3, 4, 6						10.2 42 Mo 96.0 7	10.2 42 Mo 96.0 7	10.2 42 Mo 96.0 7		10.2 42 Mo 96.0 7			
Ma	---------	----------						Ma 43 97.8	Ma 43 97.8	Ma 43 97.8			Ma 43 97.8		
Ru	14, 13, 12, 8	2, 3, 4, 8						12.2 44 Ru 101.7 7	12.2 44 Ru 101.7 7	12.2 44 Ru 101.7 7				12.2 44 Ru 101.7 7	
Rh	15, 14, 13	2, 3, 4						12.5 45 Rh 102.91	12.5 45 Rh 102.91	12.5 45 Rh 102.91					
Pd	16, 14	2, 4						11.4 46 Pd -.82 106.7		11.4 46 Pd -.82 106.7					
Ag - Xe	18	1 - 8					10.5 47 -.8 Ag 107.88 2	8.65 48 .398 Cd 112.41 6							
							7.28 49 .35 In 114.8 0	7.28 49 .35 In 114.3 0	7.28 49 .35 In 114.3 0						
								5.75 50 1.36 Sn 118.7 11		5.75 50 1.36 Sn 118.7 11					
			6.68 51 -.1 Sb 121.76 2						6.68 51 -.1 Sb 121.76 2		6.68 51 -.1 Sb 121.76 2				
				6.24 52 Te 127.5 8						6.24 52 Te 127.5 8		6.24 52 Te 127.5 8			
					11.27 53 -.54 I_2 126.92 0		11.27 53 -.54 I_2 126.92 0		11.27 53 -.54 I_2 126.92 0		11.27 53 -.54 I_2 126.92 0		11.27 53 -.54 I_2 126.92 0		5.35 54 Xe 131.3 9 / 2+8+13+18+ 8 0 Orbit 5
			Rare Earth Insert II	III	IV	5.35 54 Xe 131.3 9	1.81 55 Cs 132.81 0	3.5 56 Ba 2.9 137.36 4	Rare Earth Continue in						
Shells → Cs - Ta	5th or O 8	6th or P 1,2-15x3-4-3		6.155 57 La 138.92					Insert	13.3 72 Hf 178.6	16.6 73 Ta 181.4 1				
W	10, 8	4, 6		6.90 58 Ce 140.13	6.90 58 Ce 140.13			19.3 74 W 184.0 4		19.3 74 W 184.0 4	19.3 74 W 184.0 4	19.3 74 W 184.0 4			
Re	---------	----------		6.80 59 Pr 140.92				20.53 75 Re 186.31 2	20.53 75 Re 186.31 2	20.53 75 Re 186.31 2	20.53 75 Re 186.31 2		20.53 75 Re 186.31 2		
Os	14, 13, 12 10, 8	2, 3, 4, 6, 8		8.40 60 Nd 144.27				22.48 76 Os 190.8 6	22.48 76 Os 190.8 6	22.48 76 Os 190.8 6		22.48 76 Os 190.8 6		22.48 76 Os 190.8 6	
Ir	14, 13	3, 4		Il 61 146.				22.42 77 Ir 193.1		22.42 77 Ir 193.1					
Pt	16, 14	2, 4		7.7-8 62 Sa 150.43				21.48 78 Pt 195.23		21.48 78 Pt 195.23					
Au	18	1	Eu 63 152.	Eu 63 152.			19.32 79 -1.5 Au 197.2		19.32 79 -1.5 Au 197.2						
Hg	19, 18	1, 2		1.31 64 Gd 157.3			13.595 80 -.199 Hg 200.61 9	13.595 80 -.199 Hg 200.61 9							
Tl	18	3		Tb 65 159.2			11.85 81 .336 Tl 204.39 2		11.85 81 .336 Tl 204.39 2						
Pb	20, 18	2, 4		Dy 66 162.46				11.35 82 .122 Pb 207.22 8		11.35 82 .122 Pb 207.22 8					
Bi - Rn	18	5 - 8		Ho 67 163.5					9.78 83 -.2 Bi 209.0 0		9.78 83 -.2 Bi 209.0 0	210. Po 84	Ab 85		9.73 86 Rn 222.0 0 / 2+8+18+32+ Orbit 6
				4.77 68 Er 167.64		9.73 86 Rn 222.0 0	Vi 87 223.	5.0 88 Ra 225.97	Ac 89 227.	11.2 90 Th 232.12					
Shells → 71 - Pa	6th or P 8	7th or Q 1 - 5		Tm 69 169.4						Ux_2-Pa 91 234.					
U	11, 8	4, 6		Yb 70 173.5						18.68 92 U 238.14		18.68 92 U 238.14			
				Lu 71 175.											







(3) the double covalent bonds of Oxygen (multiple bonds are found only in the Second or L period), and (4) the coordinate covalence of Ammonia Boro-Fluoride. The remaining part of these two columns shows the number of valence electrons in the outermost orbit and the variable number in the next to the outermost orbit, and in the valence electron orbit. These are placed opposite their respective elements.

The parallelograms contain physical constants as follows:

FAMILY GROUPS

A			B	
Density Symbol At. Wt.	At No. Potential No. Isotopes		Density Potential At. Wt.	At. No. Symbol No. Isotopes

Note that the two parallelograms represent the A and B families of the usual table; however, this arrangement gives the different families even greater distinction, eliminating the need of A and B sides.

A SUMMARY OF THE SALIENT POINTS

1. Symbol of the elements.
2. Atomic number.
3. Density.
4. Potential, Ionic (H equals zero.)
5. Number of Isotopes.
6. Atomic weights.
7. Atomicity, i. e., the number of atoms in the molecule.
8. Structure of the Inert Gas Atoms onto which the electrons of the next period are built.
9. Planetary electrons in the completed orbits, or atomic numbers of inert gases, $2\ (1^2+2^2+2^2+3^2+3^2+4^2+4^2)$
10. Family Groups of the elements.
11. The nucleus of the element at the end of each period.
12. Orbits—K, L, M, N, O, P, and Q.
13. Period—Each ending with an Inert Gas Element.
14. Radio-active Series occupy the Seventh or Q period.

VALENCES

14. Heteropolar Valence.
16. Homopolar Valence.
17. Covalence.
18. Coordinate Covalence.
19. Transition in building from one Orbit to the next.
20. Distinctive Positions of Carbon and others less distinctive.
21. Relation of Hydrogen to Helium and other Elements.
22. Gradation in the difference in properties.
23. Transition Elements (so-called).
24. Rare-Earth Elements.
25. Atomic Volume $= \dfrac{\text{Atomic Weight}}{\text{Density x Avogadro's Number}}$

SILICIC-ACID GEL STRUCTURE AS SHOWN DURING SYNERESIS

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SILICIC ACID GELS are made conveniently by stirring density 1.16 waterglass into an equal volume of 6N hydrochloric acid. Within half an hour the gel sets to a translucent block, showing striking similarities to glass, both in chemical composition and in physical properties. Hence the study of silicic-acid gel structure throws light not only on the nature of gels, but also on the balancing of contractile forces which account for directions and types of cracks developing in glass, brick walls, cement, coke, and other industrial products.

SETTING OF SILICIC-ACID GEL

Silicic-acid gel is essentially $SiO_2.xH_2O$. When the waterglass and acid first are mixed, by stirring the former into the latter, a clear, mobile colloidal solution is formed. But upon standing this solution sets to a stiff jelly, so that the vessel may be inverted without loss of material. The time for this solidification will vary with relative strengths of the two ingredients and with the temperature. With the density 1.16 waterglass and 6N hydrochloric acid, at room temperature, setting will be evident in 15 minutes, soon thereafter giving a firm jelly.

During this gelation the silica becomes highly swollen, and a portion of the water thus becomes fixed, so that the gel consists of hydrated silica interspersed with free water, which fills the irregular, capillary openings.

SYNERESIS

When any jelly stands, there is a tendency for it to contract and to squeeze out water, which may collect on the surface. The process by which water oozes from a jelly is called syneresis. It is due to the decrease of the hydration tendency of the particles forming the jelly. Syneresis causes pumpkin pie to get watery on the top, and fresh, dry, hard bread closed up air-tight to become soft because of water oozing from it. "Chalking" of paint is the result of the syneresis of the gel forming the paint film. In the case of coagulated blood, fibrin begins to separate during syneresis. In the body, clotting is prevented by motion. When the motion is disturbed, clots or thrombi are formed. Clotted blood is a jelly consisting of particles forming a network similar to that in gelatin, fruit jelly, starch, agar, soaps, and sicicic-acid gel.

The syneresis, which occurs in the silicic-acid gel, will soon result in drops of water collecting on the surface. The contraction of the gel is accompanied by the loss of bound water by the SiO_2, and if carried to completion would give anhydrous crystals of the silica. X-ray study has shown definitely that silica crystals are present in the jelly, and that they grow during aging.

POSSIBLE UNIDIRECTIONAL ORIENTATION OF GEL FIBERS

Silicic acid gels set more rapidly at high than at low temperatures. Therefore gelatin (the initial stage of crystallization) should begin at the outside or at the the inside, depending upon whether the gel mixture is cooler or hotter than the surrounding atmosphere. Under similar conditions many crystallizing masses such as monoclinic sulfur, ice, and ice cream will show macroscopic, parallel crystals which begin at the outside, cooler surfaces, and grow toward the center. In connection with musical gels and from other considerations, such as syneresis and capillary diffusion, it has been assumed sometimes that silicic-acid gels consist of definitely oriented fibers interspersed with the liquid phase. If such definitely oriented fibers resulted during syneresis it would be expected that they would tend to line up in the direction of maximum contraction, which would be that of the longest dimension of the gel block as attached between two supporting, solid walls.

Beside possible optical methods there are two mechanical methods available for finding whether or not the gel fibers are lined up parallel to each other, either during the original setting process or after syneresis has resulted in maximum contraction, especially in the direction of longest dimension of the gel block.

1. *Unidirectional crushing* of a solid with parallel fibers, will show the maximum strength when the force is applied in the direction of the fibers. It is for this reason that blocks of wood, used for paving, give maximum wear when they are laid with fibers in the vertical direction. Thus we found the crushing strength, for one inch cubes of yellow poplar wood, to be 8 times greater when the force was applied parallel to the fibers than when it was at right angles to them.

Using silicic-acid gel blocks of different dimensions, an accurate technique was developed for getting nearly perfect cubes of gel. Crushing strengths for these cubes were measured in the three possible directions*

When precautions were taken to eliminate the top crusts it was found that, within the experimental errors, the crushing forces were the same in the three possible directions. This homogeneity was found whether the gel had just solidified or had stood for several days. However, crushing force increased with time, rapidly at first and then more slowly for the older gels. Moreover, a gel block set at 40°C would, after 3 hours for example, require a greater crushing force than a similar block which had set at 25°C. But, at any temperature tried, the unidirectional crushing forces did not show parallel fibers running in a given direction, either during the earlier or later stages of syneresis.

2. *Cracks occurring spontaneously* during syneresis should follow the direction of any parallel fibers, if such were present in the silicic acid gel.

Observations on cracks developing spontaneously during syneresis were made mostly in circular and rectangular containers of different sizes and with a layer of mercury beneath the gel, in tubes, in flasks, on watch glasses, in crystallizing dishes, in photographic trays, and on microcopic slides.

With large gel blocks, at room temperature of about 30°C, cracks did not develop for more than five hours, whereas at 40°C they occurred in less than 2.5 hours.

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*The unique containers, the accurate cutting devices, and the crushing apparatus, especially developed for this investigation, were illustrated by lantern slides.

Splitting of silicic-acid gel in tubes is circular around the walls, a center split, or a rhythmic split. Minute quantitative studies have been made of such splitting, and reasons given for each of these types.[1]

Using watch glasses, a considerable number of experiments were carried out with gels made by mixing equal volumes of density 1.16 waterglass and various normalities of hydrochloric, sulfuric, and nitric acids. Some of these were kept in a special electric refrigerator at 18°C, others in a closed locker at about 27°C. Lantern slides, made from photographs and from photomicrographs, show some of the most interesting ones. The type of splitting varied not only with the kind of acid used for making the gel, but also with the strength of acid. However, in no case was there evidence to show the presence of planes of cleavage in the gels.

Using equal volumes of density 1.16 waterglass and 6N sulfuric acid in a shallow glass photographic tray, a gel was allowed to set at 18°C in the special refrigerator for 45 hours. Very little splitting had occurred. It was then placed at room temperature of about 27°C, carefully observed, and a series of photographs taken at about 15-minute intervals. Flash-like splits came from the ribbed surfaces of the tray. They occurred much as poorly annealed glass would split upon subjecting it to a sufficient temperature change.

A series of syneresis experiments carried out on microscope slides showed that a silicic-acid gel may be kept without cracking for a relatively long time, when the temperature is low and the atmosphere damp. At the proper stage of syneresis a sudden increase of about 10°C in temperature resulted in flash-like cracks.

SPLITTING OF SILICIC-ACID GEL COMPARED WITH THAT OF GLASS

Chemically, silicic-acid gel is similar to quartz glass. When cracks develop during syneresis, or upon the application of external force, the direction and characteristics of these will depend upon the amount of pull of the contracting gel on each side of the initial crack. During a gas explosion occurring in a glass tube we have obtained rhythmic splitting comparable to that in silicic-acid gel. A round-bottom flask nearly full of water, sealed and carefully heated showed remarkably symmetrical splits (lantern slide) when it suddenly burst. All these cracks originated at the center of the thin bottom and extended upward. The type of shatter hole produced in a plate glass by the impact of a bullet has its replica in those occurring during syneresis of some of the silicic-acid gels.

SUMMARY

When cubes of silicic-acid gel are crushed in each of the three possible directions, there is no evidence of parallel gel fibers.

During syneresis of this type of gel, the directions and characteristics of the cracks are comparable to those of glass, and give no evidence of parallel fibers or natural planes of cleavage. The important factor is the balancing of contractile forces on each side of the initial crack. .

[1]Earl C. H. Davies, J. Phys. Chem. 35: 3618-30 (Dec. 1931).

THE SOLUBILITY OF BENZIDINE SULPHATE IN WATER-ALCOHOL MIXTURES (An Abstract)

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THE SOLUBILITY of benzidine sulphate in various water-alcohol mixtures has been determined by methods similar to those employed in previous investigations in this laboratory. In this study the saturated solutions were concentrated in the presence of dilute HCl on a low-temperature water bath, the sulphate precipitated by addition of $BaCl_2$, and the solubility calculated.

The following data have been obtained, each value in the table representing the mean of at least four determinations.

%EtOH by volume.	Benzidine sulphate mg. per liter, 20°C
0.0	82.1
25.0	41.9
50.0	29.7
75.0	18.0 (extrapolated)
100.0	8.5 (extrapolated)

On the basis of the above data it is suggested that a water-alcohol mixture of approximately equal volumes of the two be employed for washing the precipitated benzidine sulphate in the benzidine method for the volumetric estimation of sulphates.

HEAVY HYDROGEN AND SOME OF ITS COMPOUNDS*

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THE SERIES of interesting researches leading to the discovery of deuterium and tritium are briefly reviewed; six methods of preparing deuterium are discussed, namely, electrolysis, fractional distillation of liquid hydrogen, fractional distillation of water, selective adsorption, diffusion, and exchange reactions; several properties of deuterium and some properties and physiological effects of deuterium oxide are mentioned; and some physical constants of other compounds of deuterium are listed.

The following tables give data concerning deuterium and certain of its compounds.

*The full text of this article appears in The Chi Beta Phi Record, vol. X, no. 1, October, 1935.

TABLE 1—*Abundance of Deuterium*

(Tap water is used as a standard, and it is believed that the standard contains one part of deuterium in 5000 parts. Δd represents difference in density when referred to tap water. A difference of one part per million corresponds to a variation in deuterium content of 1:100,000.)

Source of Water	Δd in parts per million
Surface Water	
From London	0
From South Wales	0
From Sumatra	0
Water from Sea and Lakes	
From sea	2.3
From Tibetan lake	1.5
From Dead Sea	3.0
Water from Animal Sources	
From human blood	1.5
From human milk	3.0
From human urine	0
From cow's milk	-1.0
From ox blood	3.0
Water from Vegetable Sources	
From willow-tree sap	2.8
From willow tree combined hydrogen	5.4
From fruits	0 - 5
From honey	4.0
Water from Mineral Sources	
From hydrated minerals	3 - 7.5
From kerosene from Oklahoma	7.0
From benzene from coal	8.0

TABLE 3—*Comparison of Atomic Weights*

Isotope	Atomic Weight
Hydrogen	1.007504
Deuterium	2.01309
Tritium	3.0151

TABLE 4—*Some Properties of Water and Deuterium Oxide*

Property	Of H_2O	Of D_2O
Specific gravity at 20° C	0.9982	1.1059
Temperature of maximum density	4.0° C	11.6° C
Molar volume at temperature of maximum density	18.015 c. c.	18.140 c. c.
Molar volume of ice	19.65 c. c.	19.32 c. c.
Dielectric constant	81.5—82	80.5—80.7
Equivalent conductances at 18° C		
K^+	64.2	54.5
Cl^-	65.2	55.3
H^+ from H_2O	315.2	
D^+ from D_2O		213.7
Surface tension at 20° C	72.75 dynes/cm.	67.8 dynes/cm.
Viscosity at 20° C	10.09	12.60
Refractive index n_D^{20}	1.33300	1.32828
Melting point	0.0°C	3.802°C
Boiling point	100.0°C	101.42°C
Heat of fusion per mol	1436.0 cal.	1510.0 cal.
Heat of vaporization per mol	9700.0 cal.	9960.0 cal.
Solubilities at 25° C in grams per gram of solvent		
NaCl	0.359	0.305
$BaCl_2$	0.357	0.289

TABLE 2—*Change of Vapor Pressure With Temperature*

Temperature (Absolute)	Vapor Pressure in mm. of mercury	
	Hydrogen	Deuterium
23.5 (boiling point of D_2)	1740	760
20.38 (boiling point of H_2)	760	257
18.58 (triple point of D_2)	429	121
13.92 (triple point of H_2)	54	5

TABLE 5—*Comparison of Constants of Compounds of Hydrogen and Deuterium*

Compound	M. P. (Absolute)	B. P. (Absolute)	Δ H Vaporization in calories	Δ H Sublimation in calories
NH_3	195.2	239.75	5797	
ND_3	199	242.3	5990	
HF		293.07	6023	
DF		291.81	5768	
HCl	158.9	188.1	4081	4557
DCl	158.2	191.6	4151	4292
HCN	261	299.2	6501	8722
DCN	259	298.5	6618	8585

TABLE 6—*Ionization Constants*

Compounds	Constant for Hydrogen Compound	Constant for Deuterium Compound
$H_2O—D_2O$	1.04×10^{-14}	$.33 \times 10^{-14}$
$CH_3COOH—CH_3COOD$	1.84×10^{-5}	$.45-.59 \times 10^{-5}$
$CH_2ClCOOH—CH_2ClCOOD$	$1.71-1.72 \times 10^{-5}$	$.63 \times 10^{-5}$
$NH_4OH—ND_4OD$	1.82×10^{-5}	$1.1-1.4 \times 10^{-5}$

More detailed information may be obtained from the following general references, which are used as authority for the data listed above:—

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FARKAS, A. 1935. Orthohydrogen, Parahydrogen, and Heavy Hydrogen, pp. 115-203, Cambridge University Press, London.

THE FULVIC ACIDS PRODUCED BY THE NITRIC-ACID OXIDATION OF COAL

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IN 1806 BERZELIUS (1, 2) described two acids which he obtained from the mineral spring of Porla; crenic acid (Quellsaeure) and apocrenic acid (Quellsatzsaeure), which now are considered to be oxidation products of the humic acids. Sven Odén (12) has given these acids the generic name of fulvic acids (L. fulvus=yellow) from their most striking characteristic, their yellow color. Odén states that fulvic acids are produced when peat and brown coal are oxidized by nitric acid. The fulvic acids are found also in bog-water

*The author wishes to acknowledge the aid and encouragement of the late Dr. C. E. Garland in carrying out this work.

and may be obtained from it by removing the colloidal material by filtering bog-water through a Chamberlain filter.

Hatchett (8) was perhaps the first to study the action of nitric acid on coal. He found that the nitric-acid solution when evaporated left a substance which possessed tanning properties. Frémy (5) treated woody brown coal with nitric acid and found it to be attacked vigorously. The coal by this treatment was transformed largely into a yellow resin which was soluble in alkalies and also in concentrated nitric acid. Donath (4) distinguished between brown and bituminous coals on the basis of their behavior towards 1:10 nitric acid. The brown coals are attacked vigorously and impart to the solution a color ranging from red to yellow; bituminous coals do not give this test, according to Donath. Fuchs (6) states that many of the North American bituminous coals give the Donath test. Thiessen and Johnson (13) found that fulvic acids were produced when peat was oxidized with chlorine dioxide.

Lilly and Garland (10) oxidized some 30 North American coals (mostly from West Virginia) with 1:1 nitric acid and found in all cases that a yellow- to red-colored solution resulted. These coals varied in rank from North Dakota lignite to Pennsylvania anthracite. In general the lower the rank of the coal, the more rapidly this color was produced; also, the intensity of the color depended somewhat on the rank of the coal. North Dakota lignite gave this color test immediately on nitric-acid oxidation. The next in order of activity were Pittsburgh number 8 (Marshall county,) and Coalburg (Mingo county. The Pocahontas coals (number 3, Mercer county, and number 4, McDowell county) showed only a slight yellow coloration after 36 hours of oxidation. Pennsylvania anthracite formed a yellow color after 100 hours of oxidation.

The nitric acid extract dried to a yellow to dark-red varnish, depending upon the coal from which it was prepared and the time of oxidation. These fulvic acids were only partially soluble in water, but completely soluble in nitric acid. The partial insolubility of these acids in water seemed to be due to the precipitation of the ferric salts. The fulvic acids were very resistant towards oxidation by nitric acid. Repeated evaporation with concentrated nitric acid was apparently without effect. Some of this material was recovered from a nitric-acid recovery-still after several days contact with boiling nitric acid. The residue from the recovery-still when diluted with water precipitated a yellow powder. Three samples of this yellow powder were ashed. The ash content varied from 17 to 23 percent. Iron was determined in one sample; it contained 8.3% iron.

Many investigations have been made on the oxidation of coal to simple aliphatic and aromatic acids, but little apparently has been done on the chemical nature of these "fulvic" compounds. The fulvic acids selected for further study were obtained by oxidizing Scotts Run Pittsburgh (Monongalia county) coal with 1:1 nitric acid at the temperature of the steambath. After oxidation for a stated time the nitric-acid solution of fulvic acids was filtered from the regenerated humic acids. The nitric acid was removed by evaporation in a large porcelain dish placed on a steam bath. The fulvic acids remaining had the appearance of a yellow varnish.

An aqueous solution of these fulvic acids was tested with the common metallic ions. Ferric, lead, silver, and mercurous ions caused precipitation of insoluble fulvates. These salts all had the same appearance: i. e., light yellow powders. The following ions did not cause precipitation of fulvates: zinc, magnesium, mercury (ic), manganese (ous), iron (ous), copper (ic), calcium, or barium. Treatment of the lead and silver fulvates with hydrogen sulfide liberated the fulvic acids.

It may be said that the composition of the lead and silver salts varied according to the method of preparation. Three factors were found to influence the composition of the fulvates: (a) the effect of fractional precipitation, (b) the length of time the coal was oxidized, and (c) the acidity of the solution from which the salt was precipitated. When an aqueous solution of fulvic acid was purged with insufficient silver nitrate to cause complete precipitation, the lead fulvate prepared from the filtrate by the addition of lead nitrate contained 47.65% lead. When lead fulvate was prepared directly from the solution the lead fulvate analyzed 50.75% lead.

It was found to be impossible to convert all of a sample of Scotts Run Pittsburgh coal into fulvic acids after 500 hours of oxidation. Indeed, the amount of fulvic acid fell off sharply after 48 hours of oxidation. The composition of the lead salts for various times of oxidation are given in Table 1.

TABLE 1

Time of Oxidation	Percentage of Lead
0-24 (hours)	59.48
24-48	58.84
48-72	54.69
72-96	41.17

The silver fulvate from the third oxidation contained 54.05% silver. The equivalent weights from these two salts are the same order.

In strongly acid solutions of fulvic acids, the addition of lead or silver nitrates did not cause precipitation.

In the lead and silver determinations considerable difficulty was experienced in destroying the organic material. Evaporation to fumes with sulfuric acid, with and without the addition of nitric acid, was insufficient to destroy the organic material. It was necessary to head the fulvates until they ignited. At this temperature they burned with vigor. Oxides of nitrogen were evolved during combustion.

One analysis is reported on an iron fulvate; it contained 10.1% iron. An ammonium salt of the fulvic acids was formed by adding an excess of ammonium hydroxide and evaporating off the excess ammonia and water. The ammonium fulvate was black in color. After drying at 105°C the nitrogen was determined by distilling a sample with sodium hydroxide in a Kjeldahl apparatus. Nitrogen 11.1%.

The only ultimate analysis found in the literature of the fulvic acids is that of Mulder (11), who gives data for crenic and apocrenic acids: crenic acid: C 51.81%, H 2.16%; apocrenic acid: C 49.0%, H 2.0%. The carbon-hydrogen ratio is about 2:1. A carbon-hydrogen determination was made on a sample of fulvic acids from Scotts Run Pittsburgh coal. Samples: 0.2030, 0.2060, 0.2087. Water 0.0747, 0.0699, 0.0738. Carbon dioxide 0.3722, 0.3760, 0.3803. Ash 0.0053, 0.0061, 0.0072. Carbon 51.36%, 51.32%, 51.39% (ash free). Hydrogen 4.23%, 3.92%, 4.10%. The carbon-hydrogen ratio is approximately 1:1. The carbon determination agrees well with Mulders analysis of crenic acid.

No indications were obtained as to the constitution of the fulvic acid. Bone, Horton, and Ward (3) found that the benzenoid acids obtained by oxidizing coals with alkaline permanganate had an average equivalent weight of 70. Fuchs and Stengel (7) obtained benzenoid acids by oxidizing brown coal with nitric acid. They did not report any nitro-benzenoid acids. Horn (9) in his literature survey does not report any nitro-aromatic acids formed from coal by nitric-acid oxidation. In general the higher benzenoid acids do not form nitro derivatives with dilute nitric acid.

The equivalent weights for the fulvic acids in this investigation varied from 88 to 110. The equivalent weights of the benzenoid acids from benzoic to mellitic are: 121, 83, 70, 63.5, 59.6, 57. A consideration of the equivalent weights obtained for the lead and silver fulvates exclude all the benzenoid acids except benzoic and the phthalic acids. One of the most striking characteristics of the lower benzenoid acids is that of sublimation. No indication of sublimation was observed with the fulvic acids. It is concluded that the fulvic acids have a much higher molecular weight than the benzenoid acids.

A number of German patents (14) have been issued for the preparation of tanning agents by treatment of organic substances, including coal, with nitric acid. The following experiments were carried out to determine the suitability of the fulvic acids as tanning agents: (1) an aqueous solution of fulvic acids was added to a solution of gelatin. A precipitate formed immediately. (2) Hide powder quickly decolorized an aqueous solution of fulvic acids. (3) The tanning action of the fulvic acids was tried on ox-hide. It was found possible to tan leather in this way. It was found necessary to control the high acidity of the solutions by means of a suitable buffer.

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AN IMPROVED METHOD FOR THE VOLUMETRIC ESTIMATION OF SOLUBLE SULPHATES

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WHEN BENZIDINE SULPHATE is precipitated from a solution of a sulphate with benzidine hydrochloride, the reaction takes place in a hydrochloric-acid medium because of the fact that the benzidine is triturated with a slight excess of the acid in making up the benzidine hydrochloride reagent. Before titrating the precipitated benzidine sulphate with standard alkali, the precipitate must be washed thoroughly to free it from the acid. Work on the solubility of benzidine sulphate in water-alcohol mixtures, recently completed in this laboratory by R. B. Purdum, Carl Moore, Kenneth Bullivant, and Keith Heltzel[1] indicates that as the percentage of alcohol increases, the solubility of the benzidine sulphate decreases. The work of W. B. Meldrum and I. G. Newlin[2] on the solubility of benzidine sulphate in hydrochloric-acid solutions shows that the solubility increases with an increase in the concentration of the acid. On this basis a 50% ethyl-alcohol solution was chosen to wash the precipitate in the standard procedure, since many inorganic salts are insoluble in pure alcohol. The purpose of this investigation has been to determine the effect of washing the benzidine sulphate with varying amounts of an alcohol mixture, and furthermore to determine the effect of carrying out the entire precipitation in an alcohol medium.

All materials used were the best available CP grade of chemicals. Benzidine hydrochloride was prepared by triturating 7.0 gms. of benzidine with 18 ml. of 6 N HCl and diluting to one liter. The Na_2SO_4 solution was standardized by the use of $BaCl_2$. The NaOH solution was standardized against potassium acid phthalate.

In the experimental method four series were run, two sets in each series. In the first three series the initial precipitation was carried out in 100 ml. of water, making the solution contain a quantity of sulphate equivalent to 0.1 gm. of H_2SO_4 per 50 ml. of solution. An equal volume (100 ml.) of benzidine hydrochloride reagent was added slowly and with constant stirring. The precipitate was allowed to stand for two hours or more and filtered through No. 42 Whatman filter paper with gentle suction. Series I, set 1, was washed with 50 ml. of distilled water, added in 10 ml. portions and sucked dry after each addition. Set 2 is identical with set 1 except that it was washed with 50 ml. of 50% al-

[1]Purdum, Moore, Bullivant, and Heltzel, see these Proceedings, page 67.

[2]W. B. Meldrum and I. G. Newlin, Journal Ind. Eng. Chem., Anal. Ed. I, 231 (1929).

cohol. Series II and III are the same as series I except that the washings were increased to 100 and 150 ml. respectively. Series IV gives a comparison when the initial precipitation is carried out in 25% alcohol instead of water. The precipitates were returned to their original beakers and titrated with standard NaOH with phenolphthalein indicator.

The figures in column 4 of Table I represent the mean, in each case, of five determinations. The average deviation of the mean for any set of data does not exceed 0.02 ml.

The data of Meldrum and Newlin (2) indicate the importance of having a minimum concentration of HCl in the precipitation medium, and from our data it appears advantageous to wash the precipitated benzidine sulphate with an alcohol solution as well as to carry out the initial precipitation in an alcohol medium.

TABLE I

Series	Precipitation medium	Wash solution in 10 ml. portions	Mean ml. of NaOH	Percentage difference
Set 1	H_2O	50 ml.-H_2O	41.11	
I				0.67
Set 2	H_2O	50 ml.-50% EtOH	41.39	
Set 1	H_2O	100 ml.-H_2O	40.28	
II				1.19
Set 2	H_2O	100 ml.-50% EtOH	40.77	
Set 1	H_2O	150 ml.-H_2O	39.75	
III				1.68
Set 2	H_2O	150 ml.-50% EtOH	40.40	
Set 1	H_2O	50 ml.-50% EtOH	38.78	
IV				0.23
Set 2	25% EtOH	50 ml.-50% EtOH	38.88	

THE TERMINOLOGY OF THE TECTONIC FORMS ASSUMED BY IGNEOUS ROCKS

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SOME THREE YEARS AGO the writer discovered that the terms *throw* and *heave* did not have the same significance to him as to students in advanced general geology. He has continued to find differences in usage and has broadened the scope of his inquiry into the use of terms. This paper is the third and last (38-39) of a series dealing with the nomenclature of structural geology.

Without committing himself to Daly's (12) usage, the writer believes that to be the most logical point of departure for a discussion of the terminology of igneous forms. The broader aspects of this classification probably are accepted by all workers in this field. The term *subjacent mass*, while not a new one, calls attention to the unknown genesis, the uncertain form and mode of occurrence, and the confused usage of *bathylith*, *stock*, and *boss*.

With reference to this and the varied usage of *calderon*, the writer again suggests that descriptive language be substituted for technical terms wherever the terminology may not be perfectly clear. Such a procedure would lead to a decrease in misunderstandings, and would end many scientific controversies where they should have begun—with a proper understanding of terms.

THE DALY CLASSIFICATION

The paragraph or term numbers are the same as those used by Daly (12) except in the last discussion. What few terms had been neglected by Daly were fitted easily into his outline without displacing the numbering system. Wherever there is unanimity in usage the term is not discussed. Daly (12) points out variations in usage, most of which the present writer has reproduced without citation.

A. An *injected mass* is an intrusive body almost entirely surrounded by the invaded formations.

I. A *concordant injection* is an intrusion injected along a surface or surfaces of structural weakness (stratification, schistocity, joints nearly parallel to either of the former, etc.) with only slight departures therefrom.

Lahee and Tyrrell restrict the term to injections along the bedding, while Harker (21) states that these injections are guided by surfaces of structural weakness, such as bedding, in which category he certainly would include joints, schistocity, etc.

1. A *sill* is an injection along a surface of stratification or schistocity (rarely along an independent, flat-lying master joint) and was emplaced when the invaded beds lay at low angles to the plane of the horizon.

Harker (21) and Tyrrell use the term in the same manner except that they limit sill injection to unfolded and to plateau regions. Chamberlin and McClintock, Chamberlin and Salisbury, Cleland, Lahee, Lake and Rastall, Pirsson and Knopf, Pirsson and Schuchert, Scott, and Willis limit this form to intrusions between the bedding. Chamberlin and McClintock, Hatch, Holmes, Iddings (27), Pirsson, Pirsson and Knopf, Pirsson and Schuchert, and Scott offer the alternative terms, *sheet* or *intrusive sheet*, as well. Holmes prefers sill, Pirsson and Knopf say sill is usually used, while Pirsson states that sill is the English and Canadian, and sheet, the American usage.

Differentiated sills are a subclass produced by magmatic changes after injection.

Multiple sills are the result of repeated injection of the same kind of magma.

Composite sills are the result of repeated injection of different kinds of magma.

2. An *intraformational sheet* is a tabular intrusion along a surface of unconformity and is sub-parallel to the bedding of one of the invaded formations.

3. A *laccolith* is an injection which has followed a bedding plane, has roughly the shape of a planoconvex or doubly convex lens, has lifted its roof and has transitions to sills in certain instances.

Gilbert, who coined the term, did not include those igneous masses for which a place had been made by the folding forces. Daly (12) thinks that these latter should be included under *phacoliths;* Chamberlin and McClintock, Chamberlin and Salisbury, Cleland, Cross, Grabau, Harker (21), Hatch, Iddings (27), Lahee, Lake and Rastall, MacCarthy, Pirsson and Kopf, and Tyrrell give substantially the same definition, although Harker apparently feels that the floor and roof must actually be observed in order to place the form in this group. Cobb states that the laccolith stopes itself into the overlying formations. Gould, Hobbs, Jaggar, and Keyes include those forms for which a cavity has been made by the folding forces. Pirsson and Schuchert say that the phacelith is a form of laccolith.

Multiple, composite, and *intraformational* laccoliths are similar structures to sills bearing the same designation. *Divided laccoliths* are divided by beds of invaded formations, although the whole injection appears to have been emplaced by a single intrusive act. The term is suggested by Daly (12) to replace the "compound laccolith" of Weed and Pirsson, and the "cedar tree laccolith" of Hatch and Tyrrell.

4. Grout (17) defines a *lopolith* as "a large, lenticular, centrally sunken, generally concordant, intrusive mass, with its thickness approximately one tenth of its width or diameter."

5. A*phacolith* is an injection along the bedding at the crest or trough (39) of folded strata.

Harker (20) introduced the term and thinks that the mechanism of intrusion is similar to that of subsidary masses accompaning laccoliths. Chamberlin and McClintock, Grabau, Holmes, Lake and Rastall, Scott, Tyrrell, and Willis agree that the intrusion is not the cause, but the result of folding. Pirsson and Schuchert, and other authors place this form under the laccolith.

6. *Ribbon injections* (perhaps including *lit-par-lit*) are long, narrow, sillette-like bodies which, like flat nails are driven into the country rock.

II. A discordant injection is intruded across the surfaces of stratification or schistocity.

1. A *dike* (dyke) is an injection which has nearly parallel walls, is narrow

in proportion to its outcropping edge, usually cuts across the bedding, and usually has an angle of dip. When a dike is nearly horizontal it is difficult to distinguish from a somewhat transgressive sill. Dikes may be *simple, differentiated, multiple,* or *complex* in the sense in which these adjectives have been used heretofore. Iddings (27) mentions the alternative term *vein.*

2. *Dike swarm* is the term used by Daly (12) and Tyrrell for a system of sub-parallel dikes.

3. An *intrusive vein* differs from a dike according to Jukes (quoted by Daly) in being more irregular and tortuous in path. A contemporaneous vein "forms part of the igneous rock in which it occurs but belongs to a later period of consolidation" according to A. Geikie (quoted by Daly).

4. *Apophyses* or *tongues* are dike or vein-like bodies which can be traced, either directly or by inference from the field evidence, to larger intrusions as the source from which the material was derived.

Hatch, Holmes, Grout (19) and Lahee, as well as Daly (12), restrict the use of the term to discordant forms. Grabau and Iddings (27) do not.

5. A *ring dike* is a dike of arcuate outcrop, where that shape is believed to be significant. They may be *simple, differentiated,* or *composite.*

6. *Cone sheets* or *cone-sheet complexes* are assemblages of inclined dike-like masses with arcuate outcrops the individual members of which dip toward a common centre. They may be *simple, differentiated, composite,* or *multiple.*

7. A *volcanic neck* is the solid lava occupying a central volcanic vent. It may be conceived of as the "feeder" connecting the magma reservoid with the lava lake within the crater.

Hatch, Holmes, Lahee, Lake and Rastall, Pirsson, Pirsson and Knopf, and Tyrrell follow this usage. Chamberlin and McClintock, Cleland, and Grabau mention the alternative term, *plug.* Iddings (27) includes *stocks* and *cores* under the same definition.

8. A *bysmalith* (26) is an intrusion of laccolithic cross section which has been forced up in a single intrusive pulse and from whose borders the strata dip away at high angles. The dislocation of the capping rocks may be complete or not, but the margins are always faulted.

If the concordance of the intrusion was maintained until the injection had been emplaced, after which faulting produced the present form, there is no logical reason for including the structure among the discordant injections. On the other hand, if intrusion and faulting were contemporaneous, or the former bore a causal relationship to the latter, the form should be classed as discordant.

Chamberlin and Salisbury, Grabau, Grout (19), Harker (21), Holmes, Lake and Rastall, and Scott follow Iddings's (26-27) usage. Pirsson and Schuchert are noncommittal. Pirsson would call this form a laccolith. Harker restricts its usage to forms in plateau regions. Hatch and Iddings (26-27) offer the alternative term *plug.* The latter states that there is a whole trasitional series from the sill through the laccolith to the bysmalith.

9. An *ethmolith* is a plutonic body which narrows downward, and is so situated that the younger beds of the (sedimentary) country rock are bent downward into contact with the igneous body (36).

10. A *sphenolith* is a wedge-shaped intrusion which is partly concordant

and partly discordant, the country rock having been displaced to the point of "overturning" (1).

11. *Askmolith* is the term applied to structures, usually salic, which fill the space left void when a folded shell of rock separates from the unfolded floor below (13).

12. A *harpolith* is a cross cutting body of sickle shape, resembling a phaccolith in form, but not in genesis. It was injected into previously deformed strata and afterward stretched in the direction of maximum orogenic movement (7).

13. *Sole injections* are intrusions, usually mafic, between the immovable basement and the forward-creeping nappe (12).

14. A *chonolith* is an intrusion of irregular shape which occupied a potential cavity created by diastrophic action. The intrusion may or may not be con-concordant.

Daly (11-12), Pirsson, Tyrell, and Willis are of the opinion that it is cross-cutting only; Lahee, that it has a floor; Scott, that it is sujacent. Grout (19) is noncommittal, while Holmes admits its usage as an "omnibus" term.

B. *Subjacent masses* are intrusions of large size which lack any generally accepted genetic explanation and whose form is still a matter of doubt.

I. A *bathylith*, according to Suess, is a discordant intrusion which retains or increases its horizontal dimensions with depth and has, therefore, no visible floor.

Hatch, Holmes, Lahee, and Tyrrell use the term in much the same sense as Daly and Suess. Cleland, Grabau, Grout (19), Iddings (27), Pirsson, and Pirsson and Knopf are noncommittal as to enlargement with depth; Grout (19) suggesting "stromatholith" for forms which are partly or wholly concordant. Chamberlin and McClintock, Chamberlin and Salisbury, Harker, and Scott state that the relations of the lower portions are unknown. Harker desires to use Suess's term in a purely descriptive sense, without implying any of the theoretical considerations at times imputed to the term by its originator. Chamberlin and Link, and Willis believe that the form may be flat along the bottom. Balk and Grout (18) give excellent discussions of the problem.

The whole problem is very complex and a voluminous literature is connected with the various aspects of the subject. The writer does not wish to commit himself as to form and relations at depth, mode of emplacement, or other theoretical considerations.

According to Daly (12) bathyliths may be *multiple, composite, simple,* or *differentiated.*

II. A *stock* is apparently a small bathylith (area less than 50 square kilometers).

A *boss* is a nearly circular stock.

The dimensional limits used above are not always accepted. Grabau, Lake and Rastall, Pirsson and Knopf, and Scott use essentially the above definition. Tyrrell adds the statement that stocks are usually offshoots of bathyliths. Hatch says that a *boss* frequently does not reach the requisite magnitude. Harker (21) mentions the vertical, cylindrical form of *bosses*. Iddings uses *stock, neck* and *core* synonymously. Holmes says that a *boss* is less regular in outline than a *dome* (see below). Cleland, Grout (19), and Pirsson and

Schuchert indicate that the *boss* is the topographic expression of a denuded *stock*.

A *dome* is a stock sides of which slope away quaquaversally at low and gradually increasing angles beneath the invaded formations; rounded extrusions of highly viscous lava squeezed out from a volcano and congealed above and around the orifice instead of flowing away in streams (Holmes).

Daly (12) does not use the term; Hatch, a similar definition; Iddings only the latter part.

C. An *ejected* mass is one which has been extruded above the surface of the ground.

I. A *taprolith* is ejected from a fissure, plateau, linear, or labial vent; a thick flow poured out on the surface through a fault trough or graben, the lava rising along one or more of the faults concerned (Sederholm, quoted by Daly).

Chamberlain and McClintock, Grabau, Hobbs, Lahee, Lake and Rastall, Pirsson and Schuchert, and Willis use *fissure eruptions.*

Areal eruptions are extrusions from deroofed intrusions.

Daly says that he introduced the term into his classification more for completeness than because he is prepared to defend all occurrences which have been described. Pirsson and Schuchert define them as extrusions from deroofed magma reservoirs.

III. Forms ejected from central vents and connected therewith; the familiar schoolbook type of volcanic forms.

a. Rock bodies.

1. A *neck* may be considered conveniently under the discordant forms. *Tuff necks, lava necks*, and *lava-tuff necks* have been recognized according to filling material.

2. An *endogenous dome* is a central protrusion of highly viscous lava, freezing with a final steep-sided domical shape.

An *exogenous dome* is a similar, although larger, structure over a vent or lateral fissure removed from the crater.

3. A *flow* may be of lava, mud, sand, or a mixture. It may be *superfluent, effluent*, or *interfluent*, depending on whether discharged at the summit, through a lateral fissure, or through cavities or weak beds within the cone, in the last case without extrusion at the surface (10).

Block lava (*aphrolith* of Jaggar, *malpais* of Mexico, *les cheires* of France, *AA* of Hawaii, *apalhroun* of Iceland) is composed of assemblages of angular blocks having extremely rough surfaces.

Holmes says that the surface roughness is due to abundant development of large vesicles; Cobb to alternation of halt and advance in the flow of lava. Iddings (27) and Pirsson and Schuchert use the Hawaiian name. Holmes and Cobb are not clear as to what they would call the form were its genesis other than hypothecated.

Ropy lava (*dermolith* of Jaggar, *pahoehoe* of Hawaii, *fladenlava, Plattlava*) is fluent lava consisting of wrinkled, corded, hummocky flows free from jagged or scoraceous masses.

Cobb, Holmes, and Tyrell concur; Hobbs, Iddings (27), and Pirsson and Schuchert use the Hawaiian name.

Tumuli (the *lava blisters* of Tyrrell; *Schollendome;* the *squeeze ups* of Sunset Canyon, Arizona) are swellings or low domical hills from 10 to 20 meters in length and a few meters high. This form is exhibited by basaltic pahoehoe flows and has been elevated by hydrostatic pressure from below.

4. A *volcanic cone* is a mound built around a central vent. It may be of pyroclastic material, lava, or both.

5. *Ejectmenta* are the products of volcanic explosion.

Bombs (*blocks* of Pirsson and Schuchert, and Lake and Rastall) are from the size of an apple upward.

Lapilli (the *cinders* of Hatch) are from the size of a nut to that of an apple.

Chamberlin and McClintock, Chamberlin and Salisbury, Hatch, Holmes, Iddings (27), Lake and Rastall, Pirsson, Pirsson and Schuchert, and Tyrrell accepted this usage. Cobb uses this term, and *tuff* as well, to compromise all volcanic ejectamenta from the finest dust to the size here called *bombs.*

Ashes are from the size of shot or peas to that of nuts.

Dust is the finest material ejected.

Pirsson and Schuchert use the collective term, *cinders,* for ashes and dust.

When consolidated into rock the coarser and more angular fragments are known as *volcanic breccia,* if somewhat sorted as would happen a little distance from the vent, while the finer are called *tuff.* Near the vent, or within it, the coarser material is entirely unsorted and is known as *agglomerate.* Cobb uses breccia and agglomerate as synonyms.

b. Depression forms.

1. A *crater* is a pit forming the normal surface expression of a central vent. The great majority have flaring walls.

2. A *calderon* is a major volcanic basin with the floor many times the area of the vent. Further classification may be made on the basis of (a) completeness of the walls and (b) genesis.

According to the first, a *cirus* is completely walled, and an *amphitheatre,* breached. According to the second, *Explosioncalderen* are the result of volcanic explosions, *Einbruchcalderen,* of subsidence and mixed, of both. The German classification is followed by Pirsson and Schuchert, and Willis, both of whom use explosion caldera and sunken caldera.

Calderon is restricted in usage to what is called here *Explosioncalderen by* the United States Geological Survey, following Dutton. Bergeat, Daly, Jaggar, and Sapper follow this usage. Daly further subdivides caldera into *simple, nested* and *sunken,* the latter being one in which sinking has followed explosion.

Opposed to this usage are those who use *calderon* for what here is termed *Einbruchcalderen.* De Martonne, A. Geikie, Grabau, Haug, Harker (21), Hodge, Kayser, Lyell, Marcelli, Tankadate, and Washington are among this number.

Still another group makes use of the term *volcanic sink* for what is here called *Einbruchcalderen.* Daly, Grabau, and Jaggar are members of this group, the first subdividing volcanic sinks into simple and nested forms.

Apparently the question of the usage of the term *calderon* is as involved as that of the use of *bathylith,* although there is not the complication of genetic uncertainty as well. Wherever confusion of this kind exists, the writer is convined that a return to descriptive language is the final solution.

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OPAL STALACTITES IN SANDSTONE (An Abstract)

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SOME STALACTITES composed of opal were found in a crevice formed by a number of large Pottsville boulders a few miles east of Morgantown. Also a number of smaller ones were found under an outcrop of the Waynesburg Sandstone a few miles west of Morgantown. These stalactites are thought to have been formed by the solution of the silica by water containing some organic acid or acids and the later re-deposition of the silica on evaporation of the water.

DEVONIAN FOLDING IN THE ALLEGHENY PLATEAU

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THE PROBLEM of Devonian folding in the Allegheny Plateau is of considerable importance because of its bearing on the question of the vertical change in intensity of the gentle folds there, and on the question of their possibilities for petroleum production.

It is postulated that the plateau structures were gently folded in the lower Devonian and again at, or near, its close. The evidences upon which this suggestion is based are: (a) the presence of extensive "disconformities" in these parts of the section; (b) the downward increase in the severity of deformation noted in several of the anticlines, especially in northern Pennsylvania; (c) the presence of local areas of intricate folding and faulting in the Devonian outcrops on the Chestnut and Laurel ridges; and (d) the indication of extensive Devonian erosion on the Chestnut ridge anticline—an indication which follows from the recently determined Canadaway age of the outcrops there.

The data now available are too incomplete to lend conclusiveness to any interpretation of the above listed evidences.

TERRACE SANDS (QUICKSANDS) OF THE MONONGAHELA VALLEY

(An Abstract)

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IN EXCAVATING for the men's dormitory of the University at Morgantown, a plastic material was encountered. Its behavior suggested quicksand because of the fact that it was unable to support a portion of the foundation of the dormitory. This same type of material was encountered also in the excavation of the new library in 1931.

The material undoubtedly is a water deposit and possibly has a definite association with the Monongahela River terraces.

This paper is a discussion of the properties and behavior of this deposit.

THE IRON-OXIDE MINERALS (An Abstract)

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THE LITERATURE of the iron-oxide minerals is studied with the view of ascertaining the accredited mineral species as opposed to the substances which do not meet the requirements of a mineral species as defined by the Mineralogical Society of America and the criteria for testing validity of mineral species as defined by H. S. Washington.

The accredited hydrous iron-oxide mineral species are: goethite, lepidocrocite, and limonite. Those discredited the: turgite (mixture), hydrogoethite (variety of lepidocrocite), and xanthosiderite, limnite, and esmeraldite (all of variable composition and similar to limonite in physical properties and therefore included in it).

The accredited anhydrous iron-oxide mineral species are: hematite, magnetite, and an unnamed mineral (ferro-magnetic ferric oxide).

The only discredited anhydrous species is martite (pseudomorph).

The possible existence of ferrous oxide is discussed.

THE SAND FIGURES ON CHLADNI PLATES

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WHEN A FLAT METAL PLATE is clamped at the center and bowed at the edges, it will vibrate in segments. The nodal lines between the segments may be revealed to the eye by strewing sand upon the plate—the sand collecting along the nodal lines. This method of making the lines visible was used first by Chladni in 1787, and the plates are named after him. These plates are usually brass, 10 inches in diameter and 1/16 or 1/32 of an inch in thickness. They may be cut in any shape, but symmetrical forms such as squares, rectangles, circles, or ellipses give regular and calculable sand figures. This discussion will be confined to square brass plates.

If the plate is set in vibration as described above, the resulting figures will be symmetrical about the center and the four corners. In order to produce high notes, it is necessary to hold the clamped plate at some other point near the edge. This double fixation of the plate makes it difficult to produce high notes. We have found that the best method of setting the plate in vibration at a high period is to clamp the plate at some point (not necessarily the middle) and press against the under side of the plate near the edge with the thumb and forefinger of the left hand; then bow at the edge in the space between the thumb and forefinger. An alternative method is to press with the thumb only against the bottom of the plate near the edge and to bow across the edge nearest the thumb.

In Fig. 1 the plate was clamped at one corner, the thumb pressed against the opposite corner, and the bow drawn across the same corner.

In Fig. 2 the figures were formed with the bow, while those of Fig. 3 were produced by using an electric oscillator[1]. With the bow alone Chladni found about 50 different figures for square plates, but with the electrical oscillator several hundred may be produced. The oscillator consists essentially of a vacuum tube circuit arranged to oscillate at audio frequencies. The resulting vibration is passed through a power amplifier and then into a telephone receiver. A nail attached to the center of the telephone diafram transmits the vibration to the Chladni plate.

It will be found that the position of the nail in the plate is very critical—a slight change in any direction will destroy the figure which is forming. The clamp that is sent with the plate is too large and keeps too much of the plate from vibration. This prevents the formation of many figures which otherwise would have been found long ago even with the bow. The remedy is, of course, to use a clamp with a very small binding surface.

Photographic reproductions of the sand curves are shown in Fig. 4. The plates have been coated with carbon black in order to contrast with the white sand. All the plates of Fig. 4 were vibrated electrically.

[1]Colwell, Phil. Mag. vol. 12, Suppl. Aug. 1931, p. 320.

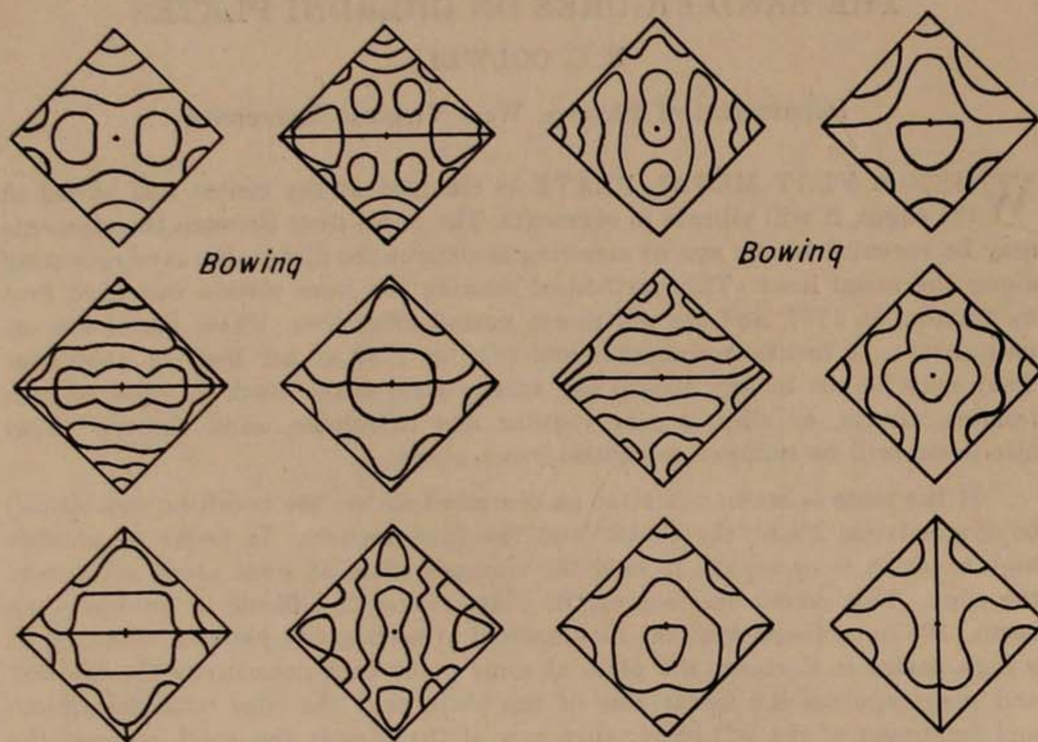

FIG. 1

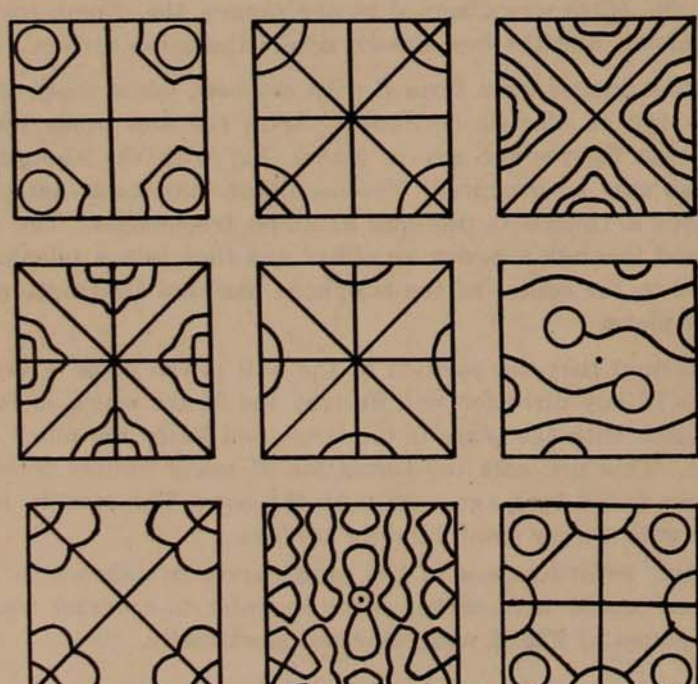

FIG. 2

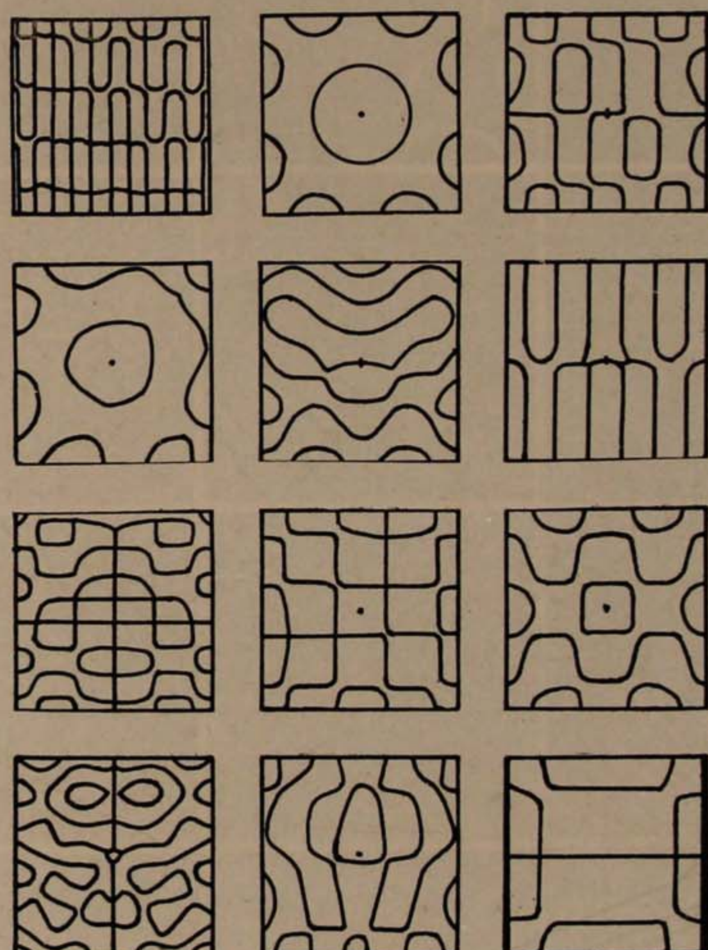

FIG. 3

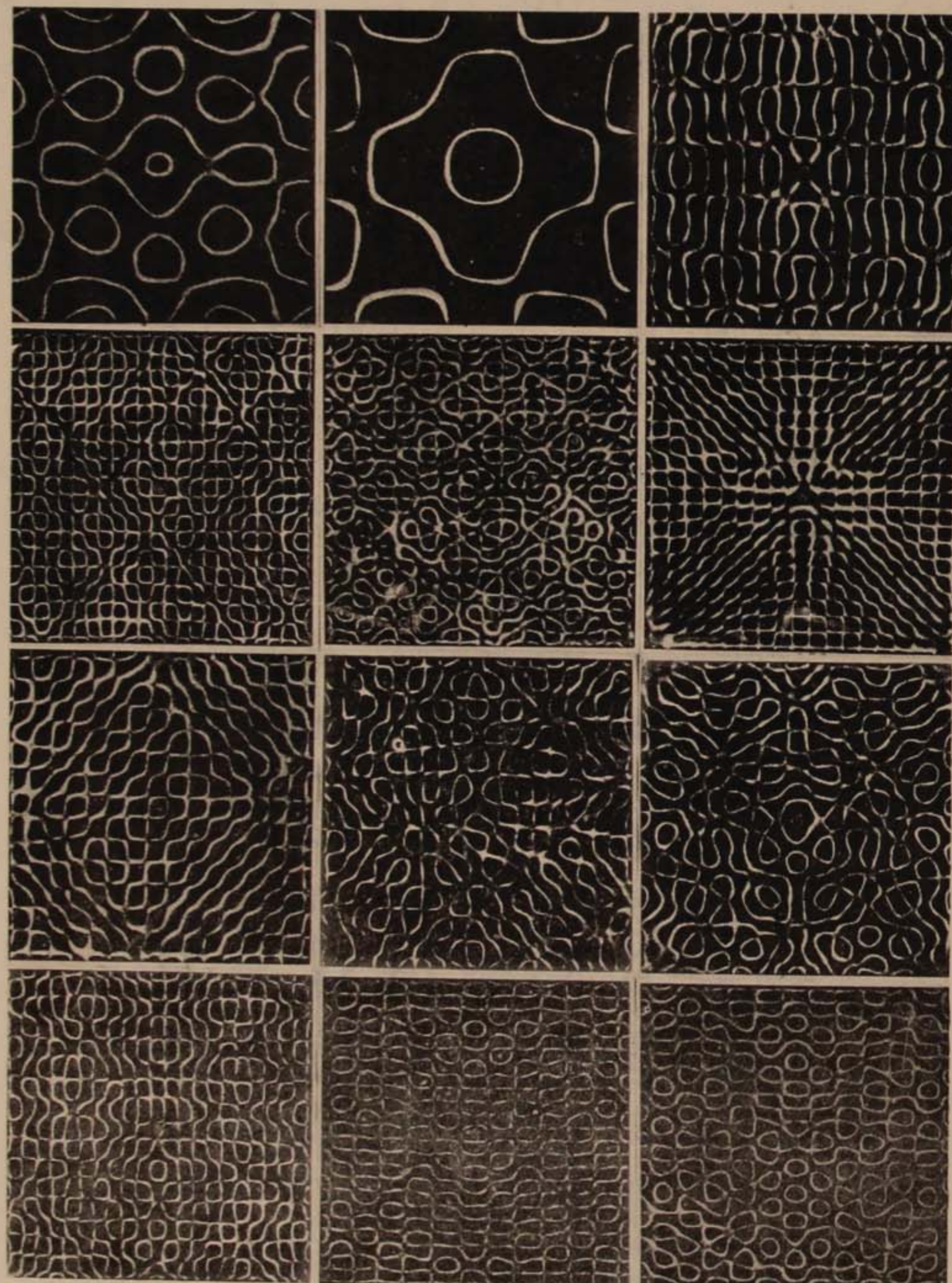

FIG. 4

ELECTRIC TUBE LIGHTS

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HEINRICH GEISSLER, a glass blower and manufacturer of physical and chemical apparatus in Bonn, Germany, began about 1855 to prepare evacuated tubes containing moderate pressures of different gases. These were called "Geissler tubes" by his contemporaries and are found today in nearly all physical laboratories throughout the world (1, 2).

The electric tube sign did not evolve rapidly from the Geissler tube for the following reasons:

(a) The slowness of the development of practical methods for isolating the rare gases neon, argon, helium, etc.

(b) The slowness of the development of electrodes that do not disintegrate rapidly under the impact of the positive gas ions. This disintegration is called sputtering, and is accompanied by an absorption of the gas in the tube, which destroys its usefulness.

(c) The slowness of the development of satisfactory methods for producing and controlling the high voltages required to operate the tubes (2).

D. M. Moore made the first electric tube sign in 1908. It was a sign for the Ingersoll Watch Company in Brooklyn, N. Y., containing carbon dioxide gas at a pressure of about 3 millimeters of mercury and requiring frequent refilling (2).

Moore went to France in 1909 and installed an arch of tubing containing carbon dioxide at the entrance of a famous race course. After his return to the United States Georges Claude, a Frenchman, was the first to discover a practical method for isolating the rare gases neon, argon, helium, etc., and obtained Moore's permission to fill these tubes with neon. Claude took out French patents in 1910. In 1911 he filed for patents in the United States, but they were not granted. He spent considerable time in this country trying to interest the General Electric Company. He finally obtained United States patents in 1914.

In 1923 Macklett and associates of Long Island City, N. Y., first commercialized the neon sign. These men had been students at Cornell University and had worked under the direction of Professor Renseller, who is now associated with the Westinghouse Electrical and Manufacturing Company and is the inventor of the widely-used nickel electrodes for electric tube signs manufactured by this firm.

When a high voltage is placed across a glass tube containing air at atmospheric pressure, no luminous discharge occurs unless the voltage is approximately 12000 to 32000 per centimeter of spark gap, depending on the shape and size of the electrodes used. These high voltages are necessary because of the difficulty of ionization of the gas, and the obstructions the ions meet in their migrations toward the electrodes of opposite sign, when the gas molecules are packed relatively close together (3).

When, however, the gas pressure gradually is reduced, there is noticed first a more regular and uniform spark between the electrodes, even with voltages much too low to cause spark discharges at atmospheric pressure. It is evident that under the reduced pressure the ionization of the gas is accomplished more easily, and that the ions can migrate to the electrodes more readily. As the reduction of the pressure is continued the luminous discharge broadens out and assumes a fuzzy appearance, becoming the well-known Geissler effect at pressures approximately from 2 to 25 millimeters of mercury. These are the pressures ordinarily used in electric tube signs (4, 5, 6).

When a pressure of about 0.5 millimeter is reached the discharge assumes a very marked appearance, shown in Fig. 1. The surface of the negative electrode or cathode is covered by a thin layer of luminosity called the cathode glow; next to this is a dark space called the Crookes dark space; beyond this is a luminous space called the negative glow; next is a second dark region called the Faraday dark space; and between this and the positive electrode or anode there is a luminous region called the positive column. Under certain conditions of current and pressure the positive column shows alternately dark and light spaces which are called striae. The proportion of the space between the electrodes occupied by each of these sections of the discharge depends upon the distance between the electrodes. Any increase in the length of the discharge beyond a few centimeters causes an increase in the length of the positive column, but no increase in the other sections. In electric-tube signs these sections are seen more or less distinctly although the gas pressures in them exceed 0.5 millimeter (4, 5, 6).

The presence of the sections is explained as follows: Consider first the positive ions which, like the negative ions, are formed from gas molecules from whose atoms orbital electrons have been displaced by electrical forces or mechanical collision. These positive ions moving toward the cathode acquire greater kinetic energy between successive collisions close to the cathode than elsewhere in the tube. Therfore most of the ionization of the gas produced by impact of the positive ions takes place at the surface of the cathode and accounts for the cathode glow. The negative ions formed there, which are mostly free electrons, acquire sufficient kinetic energy in passing through the Crookes dark space to ionize by collision in the negative glow, producing the luminosity found there. The Faraday dark space, like the Crookes dark space, is a region of very little, if any, ionization of the gas on account of the loss of kinetic energy by the electrons during their impacts with molecules in the negative glow. The luminous stritations in the positive column probably are separated by distances just sufficient for the electrons to acquire enough kinetic energy to enable them to excite if not ionize the molecules with which they collide (4, 5, 6).

If the exhaustion of the tube is continued, a certain minimum pressure is reached beyond which the voltage necessary to produce a discharge will increase rapidly, as shown in Fig. 2. Evidently a difficulty arises here in the production of sufficient ions to carry the current, which may be attributed to the greatly attenuated condition of the gas. When the pressure falls to about 0.001 millimeter a new phenomenon appears. The sections of the luminous discharge disappear, and a bright fluorescence appears on the wall of the tube opposite the cathode. This is the well-known Crookes effect and is caused by the emission of electrons at high velocities from the negative electrode. These cathrode rays travel in straight lines, cast sharp shadows, cause fluorescence, produce mechanical motion, heat bodies on which the impinge, are deflected by both electric and magnetic fields, and produce X-rays. The passage of the electric current through the tube now consists almost entirely of the stream of electrons from cathode to anode. The electrons are set free from the cathode mostly by the impacts of positive ions; hence at the lowest pressures obtainable it is impossible to make the tube carry an electric current, i. e., to cause a discharge between the electrodes (4, 5, 6).

Investigation of the electric field in the tube with exploring electrodes shows that most of the drop in potential takes place near the surface of the cathode, as shown in Fig. 3. The electrons which are formed in the region of the cathode, principally by impacts of the positive ions, are swept away more quickly than the positive ions on account of their greater mobility. This action results in the formation of a positive space charge close to the cathode, which explains the rapid fall of electrical potential in this part of the tube (6).

Similar phenomena are observed if the air in the tube is replaced by another gas and the pressure gradually reduced (4).

Electric tube lights are employed chiefly for signs, but their wider use for interior lighting in the near future is a possibility. The writer knows of several installations of tube lamps for interior lighting that have increased greatly the business of the concerns owning them as a result of the attractiveness of the soft colors, which are reflected from the ceilings. At present helium offers the nearest approach to white light found among tube lamps. The orange-red glow of the neon tube is well known; so also is the blue light of the tube containing mercury and a gas such as neon, helium, or argon. The latter must be added to carry the current until the mercury evaporates sufficiently, which occurs as the temperature of the tube rises. The well-known green light is produced by argon gas in an amber-colored glass tube. Almost any shade of any color can be produced by using different mixtures of mercury and the rare gases neon, helium, and argon in glass tubes of different colors.

The initial cost of an electric tube sign usually is somewhat lower than for a smaller sign equipped with incandescent lamps, and if properly made its life is much longer. The cost of operation of the tube sign, on an hour-for-hour basis usually is much less than that of the incandescent sign. The tube lamp is operated on 5,000 to 15,000 volts and only a few milliamps, which means a relatively low kilowatt-hour consumption of electrical energy. However, greater attractiveness and longer life are frequently more important factors than cost in deciding in favor of the tube sign.

NOTE: We are indebted to the United Neon Products Company of Huntington for the exhibits of electrodes and electric tube-lights. Tube No. 1 is lead glass, filled with neon at 12 millimeters pressure, and contains Westinghouse nickel barium-coated non-sputtering electrodes. Tube No. 2 is lead glass, filled with mercury and neon at 12 millimeters pressure, and contains Westinghouse nickel electrodes. Tube No. 3 is lead glass, filled with helium at 12 millimeters pressure, and contains Westinghouse nickel electrodes. Tube No. 4 is lead glass, filled with argon at 12 millimeters pressure, and contains Westinghouse nickel electrodes. Tube No. 5 is made of German blue and cream glass, filled with a mixture of neon, argon and helium at 6 millimeters pressure, and contains SVEA metal screen electrodes, mica covered to lessen sputtering. Tube No. 6 is made of German blue and cream glass, filled with a mixture of neon, argon, helium and mercury at a pressure of 6 millimeters, and contains SVEA metal electrodes. Tube No. .7 is lead glass, filled with a mixture of neon, argon and helium at 6 millimeters pressure, and contains Westinghouse nickel electrodes. Tube No. 8 is made of the following kinds of glass (beginning at end marked 8): dark purple, opal, dark blue, clear lead, signal green, Noviol (which is green and filters out violet and ultra-violet light), dark amber, ruby, uranium and dark purple, is filled with a mixture of neon, argon and helium at 6 millimeters pressure, and contains SVEA metal electrodes.

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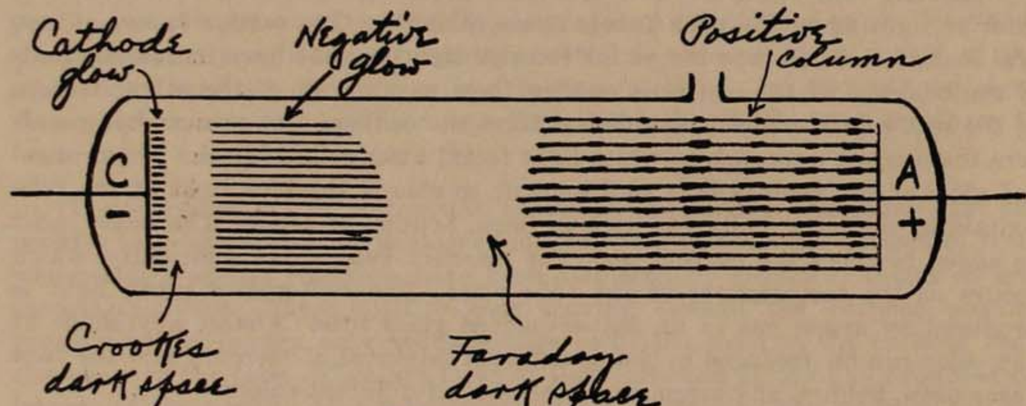

Fig. 1.

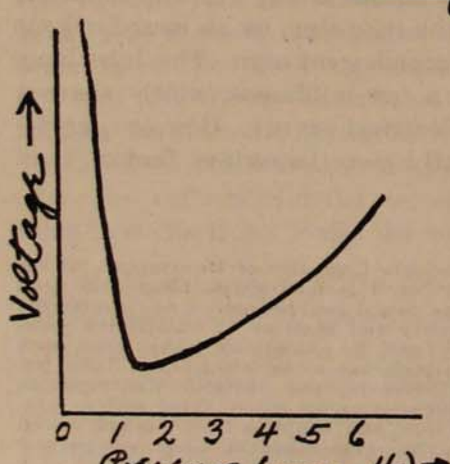

Fig. 2.

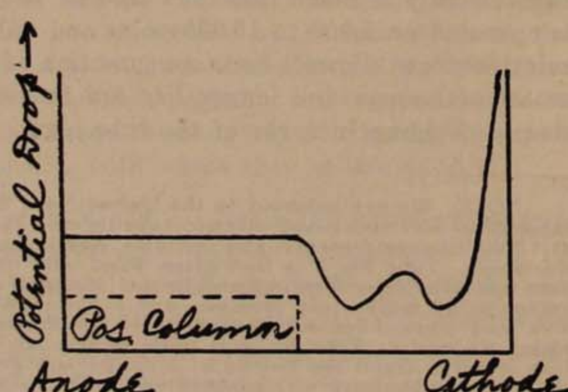

Fig. 3.

UNITS OF TIME

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IT IS VERY DIFFICULT, if not impossible, to give a definition of time itself. It has been said "time exists only in man's imagination." Also, "if the earth were moonless, kept the same face always toward the sun, and had its polar axis perpendicular to its orbit, we would be practically unconscious of time." While it may appear thus to the ordinary person, to the astronomer time is an element, just as essential as space, mass, or force, and is so considered in celestial mechanics. The velocity of light is believed to be an absolute constant of nature, but a time unit must be used to determine this velocity. The constant of gravitation, also a constant of nature, depends upon a unit of time to determine the forces which exist between bodies.

Kepler's laws state that the radius vector of a planet sweeps equal areas in equal times, also that the squares of the periodic times of the planets are proportional to the cubes of their mean distances from the sun. Again we see that time must be used to determine the solution of certain problems.

According to the first law of motion, a moving body on which no force is acting travels in a straight line with uniform speed. Therefore it follows that two intervals of time are equal if a body on which no force is acting passes over equal distances in them.

There is the definition of the equality of two intervals. The difficulty in applying this to find out whether two intervals of time are equal is the impossibility of finding a moving body on which no force is acting. Several forces act on the earth which change its rotational period. Some of these forces increase its period; others decrease it.

There is a very gradual decreasing of the earth's rotation (and consequently a lengthening of the day) because of the friction of the tides. Other forces seem to speed the rotation up until it is fast by as much as 20 seconds over a period of years; and at other times, slow to the same amount. While the earth does not rotate at a constant, uniform speed, its rotation is the best means we have for measuring time intervals.

The most simple unit of time, and the one that can be observed most accurately, is the time required by the earth to turn once on its axis with respect to the stars; or it is the interval between two successive transits of a star over the same meridian. This unit is called the sidereal day and begins when the vernal equinox is on the meridian. The sidereal day is divided into 24 sidereal hours; each hour into 60 sidereal minutes, and each minute into 60 sidereal seconds. The sidereal time at any instant is the number of sidereal hours, minutes, and seconds which have elapsed since the vernal equinox last crossed the meridian. It happens that there is no star exactly at the vernal equinox, and therefore its meridian passage cannot be observed directly; but its position with respect to the stars is known. The positions of all the brighter stars have been determined by a method called right ascension and declination. Right ascension is the position of a body measured eastward from the vernal equinox along the celestial equator and may be as great as 360 degrees; but as a matter of convenience it is denoted in hours, minutes, and seconds of time.

Since 24 hours comprise the entire round of the sky and 360 degrees do the same, one may be used as well as the other.

Declination is the angular distance north or south of the celestial equator. The earth in its revolution around the sun in a year causes an apparent motion of the sun eastward among the stars. In the course of a year this sun apparently circles the entire heavens, or moves over an arc of 360 degrees. In the course of a day it will move a distnce of nearly a whole degree. Now during a sidereal day an arc of 360 degrees, or the entire equator of the heavens, passes the meridian of any given place. Therefore, in a solar day an arc of the equator equal to nearly 361 degrees must pass the same meridian. It is evident from this that the solar day is longer than the sidereal day. This difference amounts to nearly four minutes a day. About the twenty-first of March the sun and the vernal equinox cross the meridian at noon. By the twenty-first of September the vernal equinox crosses the meridian at midnight. Plainly, then, sidereal time will not do for regulating the affairs of ordinary life. As the sun is the natural regulator of the engagements and occupations of man, it is used as the standard, but the solar days are not all of the same length because of two causes: (1) The orbit in which the earth travels around the sun is an ellipse. Motion in it is variable, swiftest about the first of January and slowest about the first of July. (2) The earth rotates on its axis in the plane of the equator, but goes around the sun in the plane of the ecliptic. Even if the sun's motion in the ecliptic were uniform, its motion in right ascension would be variable. Apparent solar time is, therefore, not satisfactory for scientific purposes, and it would be very difficult to construct a clock that would follow it, although a sundial will indicate it. A fictitious sun, therefore, is imagined which moves uniformly eastward along the celestial equator, completing a year in exactly the same time as the real sun. This fictitious sun is the time-keeper for mean solar time and is the kind of time our watches and clocks keep. It is mean noon when it is on the meridian, and the hour angle of the mean sun at any moment is the mean time for that moment. The true sun is sometimes before and sometimes behind the mean sun by an amount which varies from zero to about sixteen minutes. The sun is slowest about February 11 by 14½ minutes, and fastest about November 3 by 16½ minutes. They are together about April 16, September 1, and December 25.

The problem of determining time consists in finding the amount by which the clock is slow or fast as compared with the time it should indicate. The true time must be found from observations of the stars with a transit instrument.

When any star crosses the meridian, the sidereal time should equal the right ascension of the star, and the time elapsing between the transits of any two stars should equal their difference of right ascension. Thus if a star with right ascension of two hours is on the meridian, we know that the vernal equinox crossed the meridian two hours ago; and if a star with right ascension of 118 hours is on the meridian, then it has been 18 hours since the last sidereal noon. Therefore the sidereal time at any instant is equal to the right ascension of any star on the meridian at that instant.

At every working observatory are two clocks, one keeping mean solar time, the other, sidereal time. Let us suppose both clocks regulated to run perfectly. About March 21, when the mean sun and the vernal equinox cross the meridian together, start both clocks at 0 hours, 0 minutes, and 0 seconds. At the next mean noon the mean-time clock will indicate 0 hours, 0 minutes, 0 seconds; but the sidereal clock will indicate 0 hours, 3 minutes, 56.55 seconds. At the next mean noon it will indicate 0 hours, 7 minutes, 53.11 seconds; and so on, gaining nearly four minutes every day. In practice the mean time is found rarely by direct observation, but by comparing the mean-time clock with the sidereal clock.

The rate or error of the sidereal clock is found (as previously stated) by observing the transit of a celestial body. If the time indicated by the sidereal clock equals the right ascension of the body, the clock has no error; and if the time of transit differs from the right ascension, this difference is the amount by which the clock is slow.

Since the sidereal clock gains nearly four minutes a day over the mean clock, in a few months it would be ahead of the mean clock by several hours. Since no clock can be made to run with absolute accuracy, these differences are not taken from the clock but are calculated and published by the Government in the *Nautical Almanac*. These differences are called *Sidereal Time 0 hours Civil Time at Greenwich* and are given for every day in the year. These times are absolutely accurate for all places on the prime meridian, and they can be adapted to any place by applying a constant correction dependent on its longitude.

It was customary formerly to use local time at each place, but with the development of the railroads this was very inconvenient. A system was adopted in 1883 by which the country was divided into four sections or meridian belts; each 15 degrees or one hour of time in width. These belts are called Eastern, Central, Mountain, and Pacific time. The time in the Eastern belt is that of the 75th meridian, making it five hours slower than Greenwich time. Central time is taken from the 90th meridian, Mountain time from the 105th meridian, and Pacific time from the 120th meridian. These last three times are respectively six hours, seven hours, and eight hours slower than Greenwich time. The boundaries between the time belts are irregular, the time changing usually at railroad division points.

I think it is appropriate to mention here the remarkable results obtained by the ancients with the gnomon. This, the most simple of all astronomical instruments, is merely a vertical shaft of known height erected on a horizontal plane. The shadow cast by the shaft is changing constantly, and the length and position of the shadow are noted. During the year the shortest noon shadow is measured; also the longest. By this method they were able to determine the sun's zenith distance when farthest north of the equator; also its zenith distance when farthest south. The mean of the two zenith distances is the angular distance between the equator and the zenith, which is the declination of the zenith or the latitude of the place. Half the difference between the two zenith distances gave them the obliquity of the ecliptic, or the angle at the intersection of the equator and the ecliptic. From the direction of the shadow at noon they determined azimuth. The interval from the shortest noon shadow until the next shortest noon shadow gove them the length of the year, and the changing shadow during the day furnished them with a measure of time.

AN EXTENSION OF THE QUADRATIC BIRATIONAL TRANSFORMATION

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LET $x_1, x_2 \ldots . x_{n+1}$ be the homogeneous coordinates of a point P in S_n (x) and $y_1, y_2, \ldots . y_{n+1}$ be the homogeneous coordinates of a point P′ in S_n (y). Then if we have the set of (n+1) equations

$$Y_i = \varrho F_i(x) \ldots\ldots\ldots\ldots (1)$$

equivalent to the reverse set

$$X_i = \varphi_i(y) \ldots\ldots\ldots\ldots (2)$$

where the F_i are homogeneous functions of degree m in the coordinates x_i and φ_i are homogeneous functions of degree m′ in y_i, then the system of varities

$$\sum^{n+1} \alpha_i F_i = 0 \ldots\ldots\ldots\ldots (3)$$

in S_n which corresponds under (1) to a general (n–1)–flat

$$\sum^{n+1} \alpha_i y_i = 0 \ldots\ldots\ldots\ldots (4)$$

in $S_n(y)$ is called an ***homaloidal system*** of varieties. These conditions imposed upon the system (3) may be stated thus:

(i) the system must be linear and ∞_n;
(ii) n general members of the system must have one and only one free point of intersection, variable with the parameters α_i;
(iii) all members of the system must be rational.

The base locus of the system (3) may consist of varieties of dimensions zero to n–1, which may be incident with each other in any way. This locus, called the F-system, must be sufficient to reduce the general equation of degree m to the form (3).

Cremona transformations in S_n have not been studied extensively, and comparatively few types have been presented. Postulation and equivalence, and generalized characteristic numbers in S_n present a difficulty which will not be dealt with in this paper.

It has been shown* that there are three types of quadratic homaloidal systems in S_3, the F–systems being
(i) a conic and a simple point,
(ii) a line and three simple points,
(iii) a point of contact and three simple points.
It is the purpose of this paper to extend these three types to S_n.

A manifold of r dimensions and degrees s will be referred to as a manifold, and denoted M_r^s; a manifold of n–1 dimensions will be called a variety; and a linear manifold of p dimensions will be called a p–flat: Thus a plane will be referred to as a 2–flat, a quadric in S_3 as a variety V_2^2.

1. The extension of type (i).

Consider a system of rational varieties of degree two in S_n. Let the base locus of this system consist of a general quadratic manifold of dimensions n-2, i. e. M_{n-2}^2, and one simple point P.

*"Cremona Transformations", Hudson, p. 169.

The equation of the quadratic variety in S_n has $\frac{1}{2}$ (n+1) (n+2) terms. The equation of the general quadratic manifold M_{n-2}^2 has $\frac{1}{2}$(n) (n+1) terms and is determined thus by $\frac{1}{2}$ (n) (n+1)−1 linear conditions. If it be required that the manifold M_{n-2}^2 lie entirely on the quadratic variety, the equation of the quadratic variety is subjected to $\frac{1}{2}$(n) (n+1)−1 linear conditions. The simple point P imposed one linear condition on the equation of the variety, so that the number of arbitrary constants remaining in the equation is reduced to

$$\tfrac{1}{2}(n+1)\ (n+2)-[\tfrac{1}{2}n(n+1)-1]-1=n+1$$

Thus the resulting system is linear and ∞^n.

It remains to show that the resulting system satisfies condition (ii). Two varieties of the system intersect in a quartic manifold of dimensions n−2 which breaks up into the fixed base manifold M_{n-2}^2, and a variable manifold of n−2 dimensions and degree two. This manifold intersects M_{n-2}^2 in a manifold of n-3 dimensions and degree two, since it intersects M_{n-2}^2 in the manifold in which it is cut by an (n−1)−flat through M_{n-2}^2. Thus three varieties of the system will intersect in a manifold M_{n-2}^2 and a variable manifold of n−3 dimensions, and degree two. Continuing in this manner, n−1 varieties of the system intersect in the M_{n-2}^2, and a variable curve of second degree in S_n. This curve meets the nth variety in four points, two of which lie on the M_{n-2}^2, since as before, the residual intersection meets M_{n-2}^2 in the points in which it meets the (n−1)-flat through M_{n-2}^2. But one of the remaining two points is fixed at P. Thus there remains one and only one free intersection for n general members of the system, and the system is homaloidal.

2. Analytic treatment of type (i)

As the fixed point of the transformation above, let us choose the point (0,0, . . . 0,1) and as the fixed (n−1)−flat in which the $M_{n-2}^2$is immersed let us choose the flat $X_{n+1}=0$. Now let Q be the hypercone of second degree with vertex at P and standing on M_{n-2}^2. Then Q is a general quadratic function in the variables x_i (i=1,2, . . . n), and the equations of M_{n-2}^2 are $Q=x_{n+1}=0$. Then the equation of the homaloidal system consists of multiples of x_{n+1} and Q, with the term x_{n+1}^2 missing. We thus can write the general form for such a system as

$$x_{n+1}\sum_{1}^{n} a_i x_i + a_{n+1} Qx = 0$$

The equations of the birational transformation are found by setting the coordinates y_i of the image space proportional to any n+1 independent members of this system. Thus:

$$y_i=\varrho x_i x_{n+1} (i=1,2\ .\ .\ n)$$
$$y_{n+1}=\varrho Q\ \ (x)$$

and solving for the x_i we have the reverse set

$$x_i=\sigma y_i y_{n+1}\ \ (i=1,2\ldots n)$$
$$x_{n+1}=\sigma Q^1\ \ (y)$$

where Q′ is the same function in the y_i that Q is in the x_i.

The transformation is a (1,1) point transformation except for points of M_{n-2}^2 and the point P. An (n−1)−flat through P ∞ a quadratic variety which breaks up into a fixed (n−1)-flat $y_{n+1}=0$ and a variable (n−1)−flat. Hence the

F-point P ∞ the P–flat $y_{n+1}=0$. Now let A be a point of the M_{n-2}^2, so that of the coordinates of A, x_{n+1} is missing; and the remaining coordinates satisfy the equation $Q=0$. Under such conditions the set of equations (2) are indeterminant, and we find the homalogue of A as follows. Any line through A can be written

$$x_i x'_n - x_n x'_i = b x'_n x_{n+1} \quad (i=1,2 \ldots . n-1)$$

where the x_i' satisfy the equation of M_{n-2}^2. The transform of this line is

$$y_i y_n^1 - y_n y_i^1 = y_{n-1} y_n^1 - y_n y^1_{n-1} \quad (i = 1,2, \ldots n-2)$$

which is a generator of the cone $Q'=0$. Similarly, a line M_{n-2}^2 a plane generator of the cone Q'; etc. The whole M_{n-2}^2 ∞ the hypercone $Q'=0$. The first Jacobian of this transformation is

$$J = -2x_{n+1}^{n-1} Q(x)$$

which is the P–flat counted n–1 times and the P–cone counted once.

3. Extension of type (ii)

Consider the general system of rational varieties of degree two in S_n. Let the base locus consist of a general (n-2)–flat and n simple points P_i. An (n-2)–flat cuts such a variety in a general quadratic manifold of n–3 dimensions, whose equation has $\frac{1}{2}n(n-1)$ terms. This manifold thus is determined completely by $\frac{1}{2}n(n-1)-1$ linear conditions. If the (n–2)–flat be required to lie entirely on the general variety in S_n, the equation of the variety is subjected to $[\frac{1}{2}n(n-1)-1]+1$ linear conditions, and the number of terms in the resulting system is reduced to

$$\tfrac{1}{2}(n+1)(n+2)-([\tfrac{1}{2}n(n-1)-1])=2n+1$$

A simple point imposes one condition, and n such points impose n conditions. Thus if the system of quadratic varieties be required also to pass through the n points P_i, the number of terms in the resulting equation is reduced to $2n+1-n=n+1$, and the system is linear and ∞^n.

We have now to consider the matter of free intersections. Two varieties of the system intersect in the (n–2)–flat and in a cubic manifold of dimensions n–2. An (n–1)–flat through the (n–2)–flat and a point of the cubic manifold meets each of the quadratic varieties in the fixed (n–2)–flat and in a variable (n–2)–flat. The intersection of these two variable (n–2)–flats represents the intersection of the (n–1)–flat with the variable cubic manifold, the residual part of the intersection being on the fixed (n–2)–flat. Three of the quadratic varieties thus intersect in the fixed (n–2)–flat and in a variable manifold of dimensions (n–3) and degree six, which breaks up into a manifold of degree two in the fixed flat, and a variable manifold M_{n-3}^4. Similarly, this variable manifold cuts the fixed flat in three linear manifolds of dimensions n–4. Four such quadratic varieties thus will intersect in a fixed (n–2)–flat and in a variable manifold of degree eight, which breaks up into a variable manifold of degree five, and the three linear manifolds which lie in the (n–2)–flat. Continuing in this manner, n–1 quadratic varieties of the system intersect in a curve of order n, which cuts the fixed (n–2)–flat in n–1 points. This curve meets the nth variety in 2n points, of which n–1 are on the fixed flat, and n are at the points P_i. Hence the number of free intersections is

$$2n-(n-1)-n=1$$

and the system is therefore homaloidal.

4. Analytic treatment of type (ii)

If we choose the n fixed points as the vertices of the reference simplex, that is, as the first n points (1,0,0, . . 0), (0,1,0, . . 0), ... then the resulting equation will be free of the terms x_i^2 (i=1,2, . . n). Now let us choose the fixed (n–2)–flat as a flat through the remaining vertex of the reference simplex, and in such a manner that none of the above points lies on it, and so that no r of the points, together with a point of the fixed flat, determines an (r–1)–flat, since then this (r–1)–flat would lie on the variety. We may, however, simplify the equation of the (n–2)–flat to the form A=B=0 in even space, where

$$A = x_1 + x_2 + x_4 + x_6 + \dots + x_{2i} + \dots + x_n$$
$$B = x_1 + x_3 + x_5 + x_7 + \dots + x_{2i} + \dots + x_{n-1}$$

and the equations of the birational transformation may then be written

$$y_{2i} = \rho x_{2i+1} B \ (i = 1,2, \dots n-2/2)$$
$$y_{2i+1} = \rho x_{2i+2} A \ (i = 1,2, \dots n-2/2)$$
$$y_n = \rho x_{n+1} B$$
$$y_{n+1} = \rho x_{n+1} A$$

The inverse of this set of equations is the set

$$x_1 = \sigma [(A' - y_1 - yn) y_{n+1}^2 - y_n^2 B']$$
$$x_{2i} = \sigma y_{2i-1} y_n (y_n - y_{n+1}) \ (i = 1,2, \dots \frac{n}{2})$$
$$x_{2i+1} = \sigma y_{2i} y_{n+1} (y_n - y_{n+1}) \ (i = 1,2, \dots \frac{n-2}{2})$$
$$x_{n+1} = \sigma y_n y_{n+1} (y_n - y_{n+1})$$

where the A′ and B′ are the same functions in the y_i that the A and B are in the coordinates x_i.

The (n–2)–flat A=B=0 corresponds to a quadratic variety

$$A' y_{n+1} - B' y_n - y_n y_{n+1} = 0$$

in the image space. A general (n–1)–flat in S_n (x) goes over into a cubic variety having a double (n–2)–flat $y_n = y_{n+1} = 0$ and n fixed simple (n–2)–flats whose equations are $y_{2i} = y_n = 0$ (i=1, 2, . . . n/2); $y_{2i+1} = y_{n+1} = 0$ (i=1,2, . . . (n–2)/2); and $y_n - y_{n+1} = A' - B' - y_1 - y_n = 0$.

Each of these (n–2)–flats together with the double (n–2)–flat determines an (n–1)–flat which, together with the quadratic variety above, constitutes the principal system.

In odd space we have for the fixed (n–2)–flat A=B=0

$$A = x_1 + x_2 + x_4 + \dots + x_{2i} + \dots + x_{n-1}$$
$$B = x_1 + x_3 + x_5 + \dots + x_{2i+1} + \dots + x_n$$

and the birational transformation is

$$y_i = \rho x_{2i+1} A \ (i = 1,2, \dots \frac{n-2}{2})$$
$$y_{2i+1} = \rho x_{2i+1} B \ (i = 1,2, \dots \frac{n-3}{2})$$
$$y_n = \rho x_{n+1} B$$
$$y_{n+1} = \rho x_{n+1} A$$

which is equivalent to the inverse system

$$x_1 = \sigma(A' - B' - y_1 - y_n)\, y_n y_{n+1}$$

$$x_{2i+1} = \sigma y_{2i} y_n (y_n - y_{n+1}) \quad (i = 1, 2, \ldots \frac{n-1}{2})$$

$$x_{2i} = \sigma y_{2i-1} y_{n+1} (y_n - y_{n+1}) \quad (i = 1, 2, \ldots \frac{n-1}{2})$$

$$x_{n+1} = \sigma y_n y_{n+1} (y_n - y_{n+1})$$

the functions A′ and B′ again being the same functions in the y_i that the A and B are in the x_i.

The discussion of the correspondence in odd space offers nothing new to that which already has been stated in even space.

5. Extension of type (iii)

Consider finally the system of quadratic varieties in S_n having in common a fixed (n–3)–flat of contact, and three simple points.

The general equation of the second degree in (n+1) homogeneous variables may be written in the form

$$\varphi \equiv \sum_{1}^{n+1} a_{ij} x_{ij} = 0$$

Let this contain the fixed (n–3)–flat, $x_1 = x_2 = x_3 = 0$. Then resulting equation takes the form

$$\varphi \equiv \sum_{1}^{n+1} a_{1j} x_1 x_j + \sum_{2}^{n+1} a_{2j} x_2 x_j + \sum_{3}^{n+1} a_{3j} x_3 x_j = 0$$

which has 3n terms. If the varieties have contact with a fixed (n–1)–flat, say $x_1 = 0$, at all points of the common flat, we may write the equation of this tangent flat as follows. Any point on the common flat may be written $(0,0,0,x_4',x_5', \ldots x_{n+1}')$ and the tangent (n–1)–flat at this point is

$$x_1 \frac{d\varphi}{dx'_1} + x_2 \frac{d\varphi}{dx'_2} + \ldots + x_{n+1} \frac{d\varphi}{dx'_{n+1}} = 0$$

Now if this flat is to be the fixed flat $x_1 = 0$, then we must have

$$\frac{d\varphi}{dx'_i} = 0 \quad (i = 2,3,4,) \ldots n + 1)$$

But substituting the values of the point of contact given

$$\frac{\partial\varphi}{\partial x_i} = 0 (i > 3); \quad \frac{\partial\varphi}{\partial x'_2} = \sum_{4}^{n+1} a_{2i} x'_i; \quad \frac{\partial\varphi}{\partial x'_3} = \sum_{4}^{n+1} a_{3i} x'_i$$

thus $a_{2i} = a_{3i} = 0$ for $i = 4,5, \ldots n+1$; and the contact condition thus imposes 2(n–2) conditions on the equation. The number of remaining terms is thus reduced, by the flat, the contact, and the three simple points, to

$$3n - 2(n-2) - 3 = n + 1$$

and the resulting system is linear and ∞^n

We have now to determine the free intersections for n general members of such a system.

Denoting the common (n–3)–flat by F, then two varieties of the system intersect in a manifold M_{n-2}^4 on which F is a double locus, both sheets of the manifold through F being tangent there to the same (n–1)-flat. Hence three varieties of the system intersect in a manifold of order eight, which decomposes into F counted four times, and a manifold M_{n-3}^4, variable with choice of the varieties, F and M_{n-3}^4 intersecting in a manifold of order four and diinmensions n–4. Four varieties of the system thus intersect in F and variable M_{n-4}^4 which in turn meets F in a manifold of order four and dimensions n–5. Similarly, n–1 of the varieties of the system meet in F and in a quartic curve in S_n, the curve meeting F in four points. This quartic curve must pass through the three fixed points of the F–system, and thus of the eight intersections with the nth variety, only one is free.

6. Analytic treatment of type (iii)

The analytic treatment of this transformation is simplified by choosing the (n–3)–flat as indicated in the above section, but requiring that at points of this flat all the varieties touch the (n–1)–flat $x_1+x_2+x_3=0$. This allows us to choose as the three fixed points of the transformation the three varitices of the simplex of reference (1,0,0,. . . 0), (0,1,0,. . . 0) and (0,0,1,0, ... 0). Then the transformation takes the form

$$y_1=\varrho x_2x_3$$
$$y_2=\varrho x_1x_3$$
$$y_3=\varrho x_1x_2$$
$$y_i=\varrho x_i(x_1+x_2+x_3) \quad (i=4,5,\ldots n+1)$$

and the inverse set has the form

$$x_1=\sigma y_2y_3Q$$
$$x_2=\sigma y_1y_3Q$$
$$x_3=\sigma y_1y_2Q$$
$$x_i=\sigma y_1y_2y_3y_i \; (i=4,5,\ldots . n+1)$$

where $Q=y_2y_3+y_1y_3+y_1y_2$

Under this transformation the fixed points go over into (n–1)–flats, and the fixed (n–3)–flat corresponds to the quadric variety Q. The system of quartic varieties is a system of extended Steiner surfaces, the base locus consisting of three double (n–2)–flats which meet in an (n–3)–flat, necessarily triple on the quartic system.

ACCELERATION STRESSES IN A HEAVY WIRE ROPE

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I. DERIVATION OF EQUATIONS

IN A PAPER recently published Professor Boomsliter has discussed the effect of acceleration on the stresses in a wire mine rope.* His results were obtained by combining the weight of the rope with that of the mine car and then considering the rope as weightless. It is the purpose of this work to determine the stresses in a heavy wire rope and to compare the results obtained with those for a weightless rope.

Usually a mine cable is wound on a drum driven by an electric motor. Since these motors are generally of the constant torque type, the drum rotates with approximately constant acceleration at the beginning of the hoist. The shortening of the rope during the hoist and the damping effect of the air resistance both tend to reduce the stress, so that the maximum stress is probably attained near the beginning of the hoist. It will be necessary to calculate the stresses only for a short interval of time after the motion begins and it will be assumed that the amount of rope wound on the drum during this interval will be so small compared with its original length that it can be neglected. With these assumptions the problem is reduced to the study of the stresses in an elastic rope with a given mass attached at its lower end when the top of the rope moves with constant acceleration. The system will be assumed to start from rest with the whole weight of the car supported by the rope.

Let s = length of rope

a = area of cross section of rope

Mg = weight of mine car

δg = weight of unit length of rope

g = acceleration due to gravity

$\propto$ = acceleration of the top of the rope

E = Young's Modulus for the rope

x = distance from top of rope to an element of the rope when there is no strain in the rope

y = displacement of an element of the rope relative to its unstrained position

T = time

The resultant force, F, on an element of length dx will be

$$F = aE\frac{\partial y}{\partial x} - aE\left[\frac{\partial y}{\partial x} + \frac{\partial}{\partial x}\left(\frac{\partial y}{\partial x}\right) dx\right] - \delta g dx$$

and from Newton's Second Law, this force is equal to the product of the mass of the element and its acceleration. Then

$$aE\frac{\partial y}{\partial x} - aE\left[\frac{\partial y}{\partial x} + \frac{\partial}{\partial x}\left(\frac{\partial y}{\partial x}\right) dx\right] - \delta g dx = \delta dx \left(\propto - \frac{\partial^2 y}{\partial T^2}\right)$$

or

$$\frac{\partial^2 y}{\partial T^2} = \frac{aE}{\delta}\frac{\partial^2 y}{\partial x^2} + g + \propto$$

*G. P. Boomsliter, Acceleration Stresses in Wire Rope. West Virginia Engineering Experiment Station, Bul. no. 2.

Letting $c = \sqrt{\dfrac{aE}{\delta}}$

$$\frac{\partial^2 y}{\partial T^2} = c^2 \frac{\partial^2 y}{\partial x^2} + g + \propto$$

Since the initial strain in the rope is that due to its own weight and the weight of the car

$$aE \frac{\partial y}{\partial x} = (s-x)\ \delta g + Mg \text{ when } T = 0.$$

Integrating, and remembering that y = 0 when x = 0, we have

$$y = \frac{gx}{c^2}\left(s - \frac{x}{2} + \frac{M}{\delta}\right) \quad \text{when } T = 0 \text{ and } 0 \leqq x \leqq s.$$

Since the system starts from rest

$$\frac{\partial y}{\partial T} = 0 \text{ when } T = 0 \text{ and } 0 \leqq x \leqq s.$$

Obviously y = 0 when x = 0.
At the bottom of the rope we have, again applying Newton's Second Law,

$$aE \frac{\partial y}{\partial x} - Mg = M\left(\propto - \frac{\partial^2 y}{\partial T^2}\right)$$

or
$$\frac{\partial y}{\partial x} = \frac{M}{\partial c^2}\left(g + \propto - \frac{\partial^2 y}{\partial T^2}\right) \quad \text{when } x = s.$$

Summarizing these results, we have that y must satisfy

$$(1) \quad \begin{cases} \dfrac{\partial^2 y}{\partial T^2} = c^2 \dfrac{\partial^2 y}{\partial x^2} + g + \propto \text{ when } T \geqq 0 \text{ and } 0 \leqq x \leqq s \\[2ex] y = \dfrac{gx}{c^2}\left(s - \dfrac{x}{2} + \dfrac{M}{\delta}\right) \text{when } T = 0 \text{ and } 0 \leqq x \leqq s \\[2ex] \dfrac{\partial y}{\partial T} = 0 \qquad \text{when } T = 0 \text{ and } 0 \leqq x \leqq s \\[2ex] y = 0 \qquad \text{when } x = 0 \\[2ex] \dfrac{\partial y}{\partial x} = \dfrac{M}{\delta c^2}\left(g + \propto - \dfrac{\partial^2 y}{\partial T^2}\right) \text{ when } x = s \end{cases}$$

This problem can be simplified by the substitution

$$y = w + z \text{ where } w = \frac{\propto T^2}{2} + \frac{gx}{c^2}\left(s - \frac{x}{2} + \frac{M}{\delta}\right)$$

Then z must satisfy

$$
(2)\quad \begin{cases}
\dfrac{\partial^2 z}{\partial T^2} = c^2 \dfrac{\partial^2 z}{\partial x^2} & \text{when } T \geqq 0 \text{ and } 0 \leqq x \leqq s \\[2ex]
z = 0 & \text{when } T = 0 \text{ and } 0 \leqq x \leqq s \\[2ex]
\dfrac{\partial z}{\partial T} = 0 & \text{when } T = 0 \text{ and } 0 \leqq x \leqq s \\[2ex]
z = -\dfrac{\propto T^2}{2} & \text{when } x = 0 \\[2ex]
\dfrac{\partial z}{\partial x} = -\dfrac{M}{\delta c^2}\dfrac{\partial^2 z}{\partial T^2} & \text{when } x = s.
\end{cases}
$$

To normalize the solution let

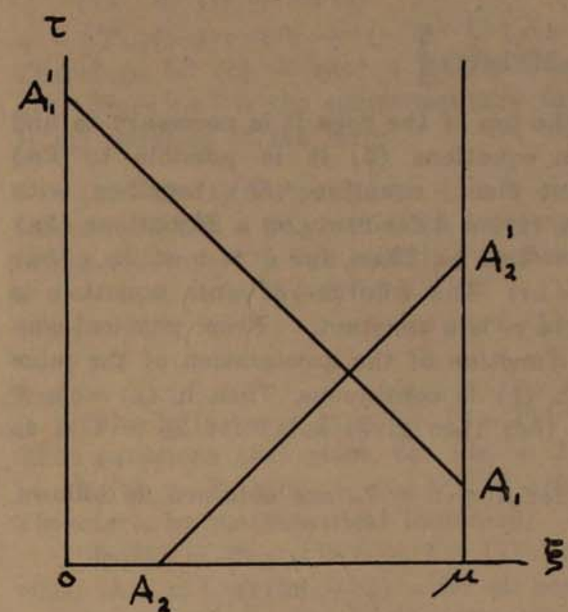
$$
\xi = \frac{\delta x}{M} \qquad t = \frac{\delta c}{M} T \qquad \zeta = \frac{\delta^2 c^2}{\propto M^2} z^2 \qquad \mu = \frac{\delta s}{M}
$$

By means of this transformation (2) becomes

$$
(3)\quad \begin{cases}
\dfrac{\partial^2 \zeta}{\partial t^2} = \dfrac{\partial^2 \zeta}{\partial \xi^2} & \text{when } t \geqq 0 \text{ and } 0 \leqq \xi \leqq \mu \\[2ex]
\zeta = 0 & \text{when } t = 0 \text{ and } 0 \leqq \xi \leqq \mu \\[2ex]
\dfrac{\partial \zeta}{\partial t} = 0 & \text{when } t = 0 \text{ and } 0 \leqq \xi \leqq \mu \\[2ex]
\zeta = -\dfrac{t^2}{2} & \text{when } \xi = 0 \\[2ex]
\dfrac{\partial \zeta}{\partial \xi} = -\dfrac{\partial^2 \zeta}{\partial t^2} & \text{when } \xi = \mu
\end{cases}
$$

II. SOLUTION OF EQUATIONS

Riemann's method is employed in the solution of this problem* Consider an unlimited strip in the $\xi\, t$ – plane where $0 \leq \xi \leq \mu$ and $t \geq 0$. Through any point in this strip two characters of the differential equation can be drawn; namely $t + \xi = m$ and $t - \xi = n$ where m and n are constants. Suppose that the first of these characteristics intersects the boundary in the points A_1 and A_1', where A_1' is the point of intersection that is farthest from the ξ – axis. In a similar manner we obtain from from the second characteristic the points of intersection A_2 and A_2' where A_2' is the point of intersection that is farthest from the ξ – axis.



To simplify the notation let

$\zeta(\xi, 0) = f(\xi) \qquad \zeta(0, t) = h_o(t) \qquad \zeta(\mu, t) = h_1(t)$

$$\left.\frac{\partial \zeta}{\partial t}\right|_{t=0} = g(\xi), \quad \left.\frac{\partial \zeta}{\partial \xi}\right|_{\xi=0} = k_o(t), \quad \left.\frac{\partial \zeta}{\partial \xi}\right|_{\xi=\mu} = k_1(t)$$

Riemann's method gives the following relations:

$$(4) \quad \begin{cases} \left.\begin{aligned} f'(A_1) - h_o'(A_1') &= k_o(A_1') - g(A_1) \\ -f'(A_2) - h_1'(A_2) &= -g(A_2) - k_1(A_2') \end{aligned}\right\} 0 \leq t \leq \mu \\ \left.\begin{aligned} h_1'(A_1) - h_o'(A_1') &= k_o(A_1') - k_1(A_1) \\ h_o'(A_2) - h_1'(A_1') &= k_o(A_2) - k_1(A_2') \end{aligned}\right\} t \geq \mu \end{cases}$$

For the problem here considered

$$\begin{aligned} f(\xi) &= 0 & 0 \leq \xi \leq \mu \\ g(\xi) &= 0 & 0 \leq \xi \leq \mu \\ h_o(t) &= -\frac{t^2}{2} & t \geq 0 \\ k_1(t) &= -h_1''(t) & t \geq 0 \end{aligned}$$

Substituting into (4)

$$\left.\begin{aligned} &(5a)\ k_o(t) = t \\ &(5b)\ h_1''(t) = -h_1'(t) \end{aligned}\right\} 0 \leq t \leq \mu$$

*Riemann-Weber. Differentialgleichungen der Physik. I. pp. 605-609.

$$\left.\begin{array}{l}(5c)\ k_o(t) = -h''_1(t-\mu) + h_1'(t-\mu) + t \\ (5d)\ h_1''(t) + h_1'(t) = -[k_o(t-\mu) + t - \mu]\end{array}\right| t \geqq \mu$$

The stress at the top of the rope is given by

$$(6) \quad E\frac{\partial y}{\partial x} = \frac{1}{a}\left[\delta gs + Mg + M\propto k_o(t)\right]$$

To find the maximum stress in the top of the rope it is necessary to find the maximum value of $k_o(t)$. From equations (5) it is possible to find $k_o(t)$ for all values of t. In the first place, equation (5b) together with $h_1'(0) = g(\mu) = 0$ gives $h_1''(t) = h_1'(t) = 0$ for $0 \leqq t \leqq \mu$. Equations (5a) and (5c) then give $k_o(t) = t$ for $0 \leqq t \leqq 2\mu$. Then, for $\mu \leqq t \leqq 3\mu$, (5d) becomes $h_1''(t) + h_1'(t) = -2(t-\mu)$. The solution of this equation is $h_1'(t) = c_1e^{-t} - 2t + 2(1+\mu)$ where c_1 is a constant. From physical considerations $h_1''(t)$, which is a linear function of the acceleration of the mine car, must remain finite and therefore $h_1'(t)$ is continuous. Then $h_1'(\mu) = c_1e^{-\mu} + 2 = 0$ or $c_1 = -2e^{\mu}$. Equation (5c) then gives $k_o(t)$ for $2\mu \leqq t \leqq 4\mu$ etc.

The values of $k_o(t)$ and $h_1'(t)$ for $0 \leqq t \leqq 7\mu$ are obtained as follows, the a_i^j being constants;

t	$k_o(t)$	$h_1'(t)$
$0-\mu$	t	0
$\mu-2\mu$	″	$a_o^{(1)}e^{\mu-t} - t + 2(1+\mu)$
$2\mu-3\mu$	$a_o^2e^{2\mu-t} + 4(1+\mu)$	
$3\mu-4\mu$	″	$\left[a_o^{(3)}\left(\frac{t-3\mu}{2}\right) + a_1^{(3)}\right]e^{3\mu-t} - 4(1+\mu)$
$4\mu-5\mu$	$\left[a_o^{(4)}\left(\frac{t-4\mu}{2}\right) + a_1^{(4)}\right]e^{4\mu-t} + t - 4(1+\mu)$	″
$5\mu-6\mu$	″	$\left[a_o^{(5)}\left(\frac{t-5\mu}{2}\right)^2 + a_1^{(5)}\left(\frac{t-5\mu}{2}\right) + a_2^{(5)}\right]e^{5\mu-t} - 2t + 6(1+\mu)$
$6\mu-7\mu$	$\left[a_o^{(6)}\left(\frac{t-6\mu}{2}\right)^2 + a_1^{(6)}\left(\frac{t-6\mu}{2}\right) + a_2^{(6)}\right]e^{6\mu-t} - t + 8(1+\mu)$	

It will now be shown that, for $2k\mu \leqq t \leqq (2k+2)\mu$, $k_o(t) = P_{k-1}(t)e^{-t} + (-1)^k[t-(2k+1)(1+\mu)] + 1 + \mu$ where $P_i(t)$ is a polynomial of degree i when $i \geqq 0$ and $P_{-1}(t) = 0$. From the above values of $k_o(t)$ it can be seen that this statement is true when k = 0, 1, 2, 3. Assume that it is true when $k = n$. Then, for $2n\,\mu \leq t \leq (2n + 2)\,\mu$, $k_o(t) = P_{n-1}(t)\,e^{-t} + (-1)^n\,[t-(2n + 1)\,(1 + \mu)] + 1 + \mu$.

Equation (5d) gives for $(2n + 1)\,\mu \leq t \leq (2n + 3)\,\mu$.

$$(7)\quad h_1''(t) + h_1'(t) = -\left\{ P_{n-1}(t-\mu)\,e^{-(t-\mu)} + (-1)^n\,[\,t-\mu-(2n + 1)\,(1 + \mu)\,] + 1 + \mu) \right\}$$

Therefore, $h_1'(t) = c_2e^{-t} + H(t)$ where $H(t)$ is a particular integral of (7). Since c_2e^{-t} is the complementary function of (7), it is readily seen that $H(t)$ must be of the form

$$(8)\quad H(t) = p_n(t)\,e^{-t} + a\,t + b$$

where $p_n(t)$ is a polynomial of degree n, and a and b are constants. Substituting (8) into (7) and equating coefficients gives

$$a\,t + a + b \equiv [(-1^{n+1}-1]\,t + (-1)^{n+1}[-\mu-(2n + 1)\,(1 + \mu)] - 1$$

Then

$$a = (-1)^{n+1} - 1$$
$$b = (-1)^n(2n + 2)\,(1 + \mu)$$

And

$$(9)\quad h_1'(t) = p_n(t)\,e^{-t} + [(-1)^{n+1} - 1]\,t + (-1)^n\,(2n + 2)\,(1 + \mu)$$

Then equations (5c) gives, for $(2n + 2)\,\mu \leq t \leq (2n + 4)\,\mu$

$$k_o(t) = P_n(t)\,e^{-t} + (-)^{n+1}\,[t-(2n + 3)\,(1 + \mu)] + 1 + \mu$$

Therefore, by mathematical induction,

$$k_o(t) = P_{k-1}(t)\,e^{-t} + (-1)^k\,[t - (2k + 1)\,(1 + \mu)] + 1 + \mu$$

when $2k\,\mu \leq t \leq (2k + 2)\,\mu$ for all positive integral values of k.

In general, for $2k\mu \leq t \leq (2k+2)\,\mu$, $k_o(t)$ can be written

$$(10)\quad k_o(t) = \left[\overset{(2k)}{a_o}\left(\frac{t - 2k\mu}{2}\right)^{k-1} + \overset{(2k)}{a_1}\left(\frac{t - 2k\mu}{2}\right)^{k-2} + \ldots\ldots + \overset{(2k)}{a_{k-1}}\right]e^{2k\mu-t}$$
$$+ 1 + \mu + (-1)^k\,[t - (2k + 1)\,(1 + \mu)\,]$$

Then for $(2k + 2)\,\mu \leq t \leq (2k + 4)\,\mu$

$$k_o(t) = \left\{\overset{(2k+2)}{a_o}\left[\frac{t - (2k + 2\,\mu)}{2}\right]^k + \overset{(2k+2)}{a_1}\left[\frac{t - (2k + 2\,\mu)}{2}\right]^{k-1}\right.$$
$$\left. + \ldots\ldots + \overset{(2k+2)}{a_k}\right\}e^{(2k+2)\mu-t} + (-1)^{k+1}\left[t-(2k + 3)\,(1+\mu)\right] + 1 + \mu$$

The following recursion formulas will now be established:

$$\overset{(2k+2)}{a_o} = -\frac{4}{k}\overset{(2k)}{a_o}$$

$$\overset{(2k+2)}{a_n} = -\frac{4}{k-n}\overset{(2k)}{a_n} - \overset{(2k)}{a_{n-1}} \qquad 1 \leq n \leq k - 1$$

$$\overset{(2k+2)}{a_k} = \left[\overset{(2k)}{a_o}\mu^{k-1} + \overset{(2k)}{a^1}\mu^{k-2} + \ldots\ldots \overset{(2k)}{a_{k-1}}\right]e^{2k} + (-1)^{k+1}4\,(k + 1)$$

Equation (9) can be written

$$h_1'(t) = \left\{\overset{(2k+1)}{a_o}\left[\frac{t-(2k + 1)\mu}{2}\right]^k + \overset{(2k+1)}{a_1}\left[\frac{t-(2k + 1)\mu}{2}\right]^{k-1}\right.$$

$$+ \dots\dots + a_k^{(2k+1)} \Big\} e^{(2k+1)\mu - t} + \varphi(t)$$

where $\varphi(t)$ is a polynomial.

Substituting this expression into (5d) gives

$$\left\{ \frac{k}{2} a_0^{(2k+1)} \left[\frac{t-(2k+1)\mu}{2} \right]^{k-1} + \frac{k-1}{2} a_1^{(2k+1)} \left[\frac{t-(2k+1)\mu}{2} \right]^{k-2} \right.$$

$$\left. + \dots\dots + \tfrac{1}{2} a_{k-1}^{(2k+1)} \right\} e^{(2k+1)\mu - t} + \varphi'(t) + \varphi(t) \equiv \left\{ a_0^{(2k)} \left[\frac{t-(2k+1)\mu}{2} \right]^{k-1} \right.$$

$$\left. + a_1^{(2k)} \left[\frac{t-(2k+1)\mu}{2} \right]^{k-2} + \dots\dots + a_{k-1}^{(2k)} \right\} e^{(2k+1)\mu - t} + \psi_1(t)$$

where $\psi_1(t)$ is a polynomial. Equating coefficients

$$a_0^{(2k+1)} = -\frac{2}{k} a_0^{(2k)}$$

$$a_1^{(2k+1)} = -\frac{2}{k-1} a_1^{(2k)}$$

. . . .

$$a_n^{(2k+1)} = -\frac{2}{k-n} a_n^{(2k)} \qquad 0 \leq n \leq k-1$$

From (5c) and (5d) for $(2k+2)\mu \leq t \leq (2k+4)\mu$

(11) $k_0(t) \equiv 2h'_1(t-\mu) + k_0(t-2\mu) + 2(t-\mu)$

or

$$\left\{ a_0^{(2k+2)} \left[\frac{t-(2k+2)\mu}{2} \right]^{k} + a_1^{(2k+2)} \left[\frac{t-(2k+2)\mu}{2} \right]^{k-1} \right.$$

$$\left. + \dots\dots + a_k^{(2k+2)} \right\} e^{(2k+2)\mu - t} + \psi_2(t) \equiv 2 \left\{ a_0^{(2k+1)} \left[\frac{t-(2k+2)\mu}{2} \right]^{k} \right.$$

$$\left. + a_1^{(2k+1)} \left[\frac{t-(2k+2)\mu}{2} \right]^{k-1} + \dots\dots + a_k^{(2k+1)} \right\} e^{(2k+2)\mu - t} + 2\varphi(t-\mu)$$

$$+ \left\{ a_0^{(2k)} \left[\frac{t-(2k+2)\mu}{2} \right]^{k-1} + \dots\dots + a_{k-1}^{(2k)} \right\} e^{(2k+2)\mu - t} + \psi_1(t-2\mu)$$

where $\psi_2(t)$ is also a polynomial. Equating coefficients

$$a_0^{(2k+2)} = 2a_0^{(2k+1)} = -\frac{4}{k} a_0^{(2k)}$$

$$a_1^{(2k+2)} = 2a_1^{(2k+1)} + a_0^{(2k)} = -\frac{4}{k-1} a_1^{(2k)} + a_0^{(2k)}$$

$$a_n^{(2k+2)} = 2a_n^{(2k+1)} + a_{n-1}^{(2k)} = -\frac{4}{k-n}a_n^{(2k)} + a_{n-1}^{(2k)} \qquad 1 \leq n \leq k-1$$

To derive the formula for $a_k^{(2k+2)}$ it is necessary to make use of the fact that $k_o(t)$ is continuous for $t = (2k + 2)\mu$. This follows from (11) since $h_1'(t)$ has already been shown to be continuous and $k_o(t)$ is continuous for $0 \leq t \leq 2\mu$. Equating the two expressions for $k_o(2\mu)$ gives

$$a_o^{(2)} - 2\mu + 4(1 + \mu) = 2\mu$$

or

$$a_o^{(2)} = -4$$

Similarly for $t = (2k + 2)\mu, k > 0$

$$\left[a_o^{(2k)}\mu^{k-1} + a_1^{(2k)}\mu^{k-2} + \ldots\ldots + a_{k-1}^{(2k)}\right]e^{-2\mu} + (-1)^k\left[\mu - 2k - 1\right] + 1 + \mu$$

$$= a_k^{(2k+2)} + (-1)^{k+1}\left[-\mu - 2k - 3\right] + 1 + \mu$$

or

$$a_k^{(2k+2)} = \left[a_o^{(2k)}\mu^{k-1} + a_1^{(2k)}\mu^k + \ldots\ldots + a_{k-1}^{(2k)}\right]e^{-2\mu} + (-1)^{k+1}4(k+1)$$

III. CALCULATION OF STRESSES

By means of the recursion formulas derived it is possible to find the value of $k_o(t)$ for values of t. Since the expressions for the coefficients become increasingly cumbersome as t increases, a few particular values of μ are chosen and the values of $k_o(t)$ investigated for these values. The results are shown in Table I.

Table I.

$\mu = .01$				$\mu = .1$				$\mu = 1$			
t	$k_o(t)$	t	$k_o(t)$	t	$k_o(t)$	t	$k_o(t)$	t	$k_o(t)$	t	$k_o(t)$
.01	.010	.22	1.596	.1	.100	2.2	.168	1.	1.000	11.5	3.554
.02	.020	.23	1.688	.2	.200	2.3	.425	1.5	1.500	12.	3.179
.03	.050	.24	1.750	.3	.481	2.2	.670	2.	2.000	12.5	2.309
.04	.080	.25	1.818	.4	.725	2.5	1.028	2.5	3.074	13.	1.564
.05	.128	.26	1.866	.5	1.099	2.6	1.321	3.	3.528	13.5	1.094
.06	.176	.27	1.920	.6	1.378	2.7	1.647	3.5	3.608	14.	.598
.07	.241	.28	1.957	.7	1.724	1.8	1.853	4.	3.459	14.5	.112
.08	.306	.29	1.979	.8	1.915	2.9	2.068	4.5	3.450	15.	.341
.09	.386	.30	1.999	.9	2.120	3.0	2.092	5.	2.687	15.5	.900
.10	.462	.31	2.015	1.0	2.135	3.1	2.101	5.5	1.841	16.	1.402
.11	.555	.32	2.014	1.1	2.141	3.2	1.953	6.	1.175	16.5	1.885
12	.643	.33	2.007	1.2	1.956	3.3	1.778	6.5	.837	17.	2.861
.13	.742	.34	1.977	1.3	1.777	3.4	1.483	7.	.265	17.5	3.487
.14	.833	.35	1.954	1.4	1.444	3.5	1.205	7.5	.200	18.	3.628
.15	.938	.36	1.915	1.5	1.165	3.6	.865	8.	.602	18.5	3.485
.16	1.035	.37	1.870	1.6	.793	3.7	.594	8.5	1.212	19.	3.516
.17	1.139	.38	1.802	1.7	.534	3.8	.324	9.	1.677	19.5	2.920
.18	1.232	.39	1.744	1.8	.245	.3.9	.176	9.5	2.483	20.	2.117
.19	1.335	.40	1.672	1.9	.120	4.0	.07	10.	3.258		
.20	1.427	.41	1.596	2.0	.008	4.1	.10	10.5	3.589		
.21	1.520			2.1	.078	4.2	. 71	11.	3.567		

From equation (6) it is seen that the stress in the top of the rope induced by the acceleration is given by

$$(12) \qquad S_1 = \frac{M\alpha}{a} k_0(t)$$

For a weightless cable $\mu = 0$ and the acceleration stress, S_2, can easily be determined. If z_1 is the elongation of the rope due to acceleration only, then from Newton's Laws

$$aE\frac{z_1}{s} = M \left(\alpha - \frac{d^2z_1}{dT^2}\right)$$

or $$\frac{d^2z_1}{dT^2} + \frac{aE}{Ms}z_1 = \alpha \text{ with } \frac{dz_1}{dT} = z_1 = 0 \text{ when } T = 0$$

then $$z_1 = \frac{\alpha sM}{aE} \left(1 - \cos \sqrt{\frac{aE}{Ms}}T\right)$$

and

$$(13) \qquad S_2 = E\frac{z_1}{s} = \frac{M\alpha}{a} \left(1 - \cos \sqrt{\frac{aE}{Ms}}T\right)$$

If $M = 0$, $\mu = \infty$. Then, if $\xi_1 = \frac{x}{s}$, $t_1 = \frac{c}{s}T$ and $\zeta_1 = -\frac{c^2}{\alpha s^2}z$ equations (2) become

$$\frac{\partial^2\zeta_1}{\partial t_1^2} = \frac{\partial^2\zeta_1}{\partial \xi_1^2}$$

$$\zeta_1 = 0 \qquad \text{which } t_1 = 0 \text{ and } 0 \leq \xi_1 \leq 1$$

$$\frac{\partial\zeta_1}{\partial\zeta_1} = 0 \qquad \text{when } t_1 = 0 \text{ and } 0 \leq \xi_1 \leq 1$$

$$\zeta_1 = -\frac{t_1^2}{2} \qquad \text{when } \xi_1 = 0$$

$$\frac{\partial\zeta_1}{\partial\xi_1} = 0 \qquad \text{when } \xi_1 = 1$$

Defining f_1, g_1, $h_{10}(t_1)$, $h_{11}(t_1)$, $k_{10}(t_1)$ and $k_{11}(t_1)$ as f, g, $h_o(t)$, etc, were defined, the following results analogous to (5) are obtained:

$$\left.\begin{aligned} k_{10}(t_2) &= t_1 \\ h_{11}'(t_1) &= 0 \end{aligned}\right\} \qquad 0 \leq t_1 \leq 1$$

$$\left.\begin{aligned} k_{10}(t_1) &= h_{11}'(t_1 - 1) + t_1 \\ h_{11}'(t_1) &= -[k_{10}(t_1 - 1) + t_1 - 1] \end{aligned}\right\} \qquad t_1 \geq 1$$

Then $k_{10}(t_1) = 2 - k_{10}(t_1 - 2)$. Since $k_{10}(t_1) = t_1$ for $0 \leq t_1 \leq 2$ it is readily seen that when $2k \leq t_1 \leq 2k + 2$

$$k_{10}(t_1) = \begin{cases} t_1 - 2k & \text{when k is even} \\ 2k + 2 - t_1 & \text{when k is odd} \end{cases}$$

The acceleration stress, S_3, at the top of the rope is then given by

$$(14) \quad S_3 = \frac{\propto \delta s}{a} k_{10}(t_1) = \begin{cases} \frac{\propto \delta s}{a}\left(\frac{cT}{s} - 2k\right) & \text{when k is even} \\ \frac{\propto \delta s}{a}\left(2k + 2 - \frac{cT}{s}\right) & \text{when k is odd} \end{cases}$$

When μ approaches zero or becomes infinite, S_1 approaches S_3 or S_3 respectively.

TABLE 2

μ	t	$k_o(t)$
.01	.312	2.016
.05	.727	2.085
.1	1.050	2.171
.2	1.407	2.349
.3	1.926	2.510
.4	2.014	2.691
.5	2.365	2.924
.6	2.722	3.113
.7	3.090	3.275
.8	3.464	3.409
.9	3.842	3.524
1.0	4.224	3.618

It is clearly impractical to attempt to find an absolute maximum for $k_o(t)$ for any value of μ, but it is not very difficult to find the first maximum for $k_o(t)$. These maxima are given for some values of μ in Table 2. For values of μ greater than 1 this first maximum is attained in the interval $2\mu \leq t \leq 4\mu$. In this interval

$$k_o(t) = -4e^{2\mu - t} - t + 4(1 + \mu)$$

and this expression has a maximum of

$2\mu + 3 - \log_e 4$ when $t = 2\mu + \log_e 4$

If the mass of the rope is combined with that of the car and the rope considered weightless, equation (13) gives a maximum S_1 of

$$\frac{2(M + \delta s) \propto}{a} = \frac{2M\propto}{a}(1 + \mu)$$

Comparing this result with (12) it is readily seen that this corresponds to a maximum $k_o(t)$ of

$$2(1 + \mu)$$

It is now a simple matter to find the maximum stress at the upper end of the rope. First find μ from

$$\mu = \frac{\delta s}{M}$$

Then find the maximum value of $k_o(t)$ for this value of μ from Table II. Finally, the maximum stress is found by substituting this value $k_o(t)$ in the expression

$$\frac{1}{a}\left[\delta gs + Mg + M\propto k_o(t)\right]$$

The Social Sciences Section

THE RIGHT TO GOLD

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THE MUCH-DISPUTED gold decision handed down by the Supreme Court on February 20, 1935, leads back to lengthy arguments in both constitutional law and economics. It is entirely possible to follow one line of this two-sided argument and arrive at opposite conclusions to those which are found by following the other side to its logical termination. One might find that constitutionally the decision was unjustified and that from an economic aspect it was entirely warranted, or one might find that from all fair interpretations of constitutional law the decision was supportable and to be approved, while from the standpoint of the economic welfare of the country it was the worst thing which could have been done. This underlying assumption must be borne in mind during the ensuing discussion, which will attempt to analyze some economic aspects of the problem.

Since a thorough treatise of both aspects of the decision would be too lengthy, it becomes necessary to asume the correctness of the decision from the legal viewpoint. This need not infer that consent actually is given on this basis, but only that the argument becomes too involved if all aspects are included. The essential starting point of either discussion is similar in that it is based upon the right to have gold. This right is a legal right and an economic right, bearing in mind that the law is but a crystalization of rights and duties which have arisen through custom. If the law gives us a right to gold it is because custom first has given us the right to it; the one is called the legal right, the other, the economic right. From this it might be concluded that once the economic right to gold has been established, the legal right would follow, or vice versa. The law, however, has certain fixed concepts to which it holds, such as the rights and duties of contracting parties. Economics, on the other hand, involves an attempt to explain a changing community of customs and circumstances, and must be flexible enough to change its concepts from time to time. If in this decision of the court the legal viewpoint conflicts with the economic, the reason is involved in the two differences noted.

The fundamental question which is involved in the gold decision is: Has any person a right to gold? This presents the problem of both legal and economic rights and can be extended further back to ask: has anyone the right to contract to pay gold? If an answer to either of these questions could be made in the negative, then a first step toward approval of the court decision has been made. If it can be shown that the original promise to pay gold was ill-advised and that it was based entirely upon a false or misunderstood purpose of gold in modern economy, the argument might be extended to a support of the Supreme Court decision. In order to answer the first questions, the function of gold must be analyzed.

We learn in elementary textbooks on economics that originally gold served as a medium of exchange, a measure of value, and a means of making deferred payments. Because of the physical characteristics of gold, its permanence, portability, acceptability, and divisibility, it became a means of settling debts. When one had goods to sell he did not trade them directly for the goods he needed but he traded them for as much gold as he could bargain for, and so gold became both the medium of exchange and a standard of value measurement. Years ago, as far as our particular economy is concerned, that ceased to be the method of handling trading transactions, and the principal reasons for the change were the dangers of theft from carrying around gold and the trouble that carrying large amounts entailed. Imagine today, for instance, the purchase of a large industrial plant if the purchaser had to provide the payment in metallic gold.

The gold-for-goods economy gave way to a method of early banking. The gold was deposited with a banker who gave a receipt for it. This receipt was a promise to pay gold upon demand and as such resembled our own currency of a few years ago. Business was not done then upon the payment of gold but solely upon the receipt of an instrument which called for the payment of gold. The person who received the banker's note might not desire to cash it but might pass it on. Such a stage then might be called a bank-note economy, but it differed from later and present forms of doing business because there was a deposit of gold for every note outstanding. This was the golden age of the hard-money economists. Were this method of making payments insisted upon today, the national volume of business would be limited to the amount of gold in the country multiplied by the number of times it could be made to turn over within a given period.

Bankers soon found out that they seldom were called upon to pay out the metallic gold. They further were shrewd enough to see that they could earn extra income by loaning their funds beyond their gold holdings. As long as the banker was able to pay out gold upon demand, his credit was good and his notes passed as actual money. This was the starting point of the modern credit method of banking, and from this point gold has served an increasingly smaller part in the world of affairs. From the early use of gold in exchange for goods to the present time the tendency has been for a steadily increasing economy in the use of gold. In most countries gold has passed entirely out of circulation and has been replaced by credit intruments. The process by which circulating medium is extended beyond the one-to-one gold-paper ratio is called inflation.

Inflation is frequently spoken of in terms of dread; it is supposed to have grave implications. These are too well known to bother repeating; they are, however, entirely misstated. There are no dangers of inflation. As far as gold is concerned and the ability to pay all claims upon gold in the metal itself, this country never has been able to meet this demand and there always has been inflation. As soon as the one-to-one ratio has been violated, inflation has occurred. With most of the world carrying on its business with inflated currencies, dangers are hard to indicate; the real dangers exist only in too rapid inflation or deflation. What constitutes rapidity of inflation is not important at this point, but suffice it to say that whatever degree of inflation develops, adjustments over a period of time will take place in the economic system until the first effects of the inflation are removed.

With the tremenduous minimization in the use of gold there has come about an entirely new function for gold in present-day economy. To understand this function one must appreciate the clearing-house principle. Banks that have claims upon their gold presented at another bank in many cases need not pay out any gold, since through the clearing-house the bank itself may have an equal or nearly equal amount of claims upon the first bank. These claims are offset against each other, and no gold is transferred. As goods are bought and sold and debts are contracted and paid, the various claims of one bank against another are offset against each other, and gold is used to settle only those balances which can not otherwise be settled in goods. With the exception of the gold used in industry there is no use for the metal except to settle those balances in present-day economy. The clearing-house principle has lead then to a further minimizing of gold.

In order to balance payments between different parts of this country we no longer ship gold. When, for instance, the Chicago Federal Reserve Bank has more payments to make to the New York Federal Reserve Bank than the New York bank has to make to the Chicago bank, the balances are settled by a transfer of gold holdings. The metal does not move, however, as it formerly did; instead there are situated in Washington the entire gold reserves of these banks or at least the excess of it beyond requirements, and a portion of the gold is placed in the gold-transfer fund. Instead of having gold move from one part of the country to another, the transfer becomes a book-keeping transaction, and only the title to the gold changes. This is indeed caarying the economy in use of gold to the highest degree of perfection, or at least one of the highest degrees of perfection.

As gold gradually has taken on a decreasing usefulness under modern credit methods, its function has changed, as pointed out. Instead of serving to facilitate transactions directly it serves merely to settle balances which many transactions have created and which tend to offset each other in the long run, but which for any short-run period must be settled in some acceptable medium. Because of a majority of necessary qualities which gold possesses, it is that acceptable medium, although others could be thought of which would not be as good but which nevertheless would serve in an emergency. From a personal commodity gold has been transferred into a national commodity; instead of being possessed by individuals for their own use it now is possessed by the national governments for the general use of the entire community.

In the process of replacing gold with credit instruments gold has lost some of its earlier functions. It no longer serves as a medium of exchange, if by that is meant a medium which aids in the exchanging of goods one for another. It does still serve as a medium of exchange of bank credits,—quite a different matter from the early concept of exchange mediums. It likewise serves no longer as a standard of measurement. Goods and services no longer are in terms of how much gold will be paid but in terms of how much money will be given. Even in days when the circulating medium was tied to gold the importance of this relationship was overstated greatly. The reason for this is obvious if one examines the true value of gold itself and its reason for existing.

Monetary gold had value in exchange: i. e., its value consisted in those goods and services which persons would give in exchange for the metal. It appeared that few persons really wanted the gold for their own ornamentation or for their industrial processes, but used it merely to get other commodities which were more useful. The value of gold then was the amount of other goods which could be obtained in exchange, and this value differed with each commodity, and differed even from time to time with the same commodity. The majority of persons accepted gold because they knew that they could obtain the commodities which they desired. As gold disappeared from the markets of the world through the gradual extension of the inflation process this function of gold was taken by the monetary unit of each country. In time the references to the amount of gold became fewer, the amount of gold called for became less, and few ever thought in terms of gold.

Trading transactions were carried out in terms of money which came to be acceptable within a country. Goods were bought and sold, services were contracted for in terms of dollars in this country. The value which once had belonged to gold was transferred to the monetary unit. Money was accepted not because it had any use to the acceptor as so much paper, but because it would be acceptable to others in exchange for goods. The value of the dollar then was the same value that gold had, and it differed as between commodities as as between values of the same commodity at different times. The monetary unit had become acceptable nationally just as gold had become and it circulated because of the willingness of the people to exchange for it. The true value of gold could not be determined until one sought to purchase with it, and likewise the true value of the dollar will be established at time of purchase. To point out that, as long as the dollar is to be paid out in gold in a measured unit of weight, the safety of the dollar is guaranteed, is to miss the entire point of gold usefulness today.

The monetary value of gold today is expressed in terms of the national monetary unit—in our case, the dollar. The value of all other commodities likewise is so expressed. The value of the dollar itself is made up of the commodities which it will purchase, among them gold. From its onetime position of great importance gold through custom has become but one commodity among the many which measure the value of the medium of exchange. It may seem to be an admirable thing to guarantee the payment of the dollar in gold, but when this is done an artificial value is given to gold,—a thing not particularly objectionable; in fact, this is a necessary step in the present-day usage of gold. Most usually foreign trade is pointed out by advocates of a paid-in-gold dollar as the one field in which it is encumbent upon the government to stabilize the price of gold. Holders of this view claim that a devaluation of the monetary unit in terms of gold immediately or in the long run tends to raise the prices of goods entering the country with the devalued currency. To accept this is not to appreciate marketing process.

It should be clear to anyone that the volume of business transacted today could not possibly be done if it were necessary to use metallic gold. If only claims which could be settled in gold in a one-to-one relation were used, modern business would be unable to function. At the close of the last period of prosperity there were about forty billions of credit outstanding based upon a gold reserve strength of around four billions—roughly a ten-to-one ratio. This ten-to-one is held by some to have an aura of sanctity about it. But there are no valid reasons why this ratio could not be increased were the true function of gold more clearly appreciated. With the government's impounding of gold there is given to this country the possibility of vast extension of credit upon a reasonably sound basis. The only gold that is necessary to keep the system in operation is that amount which is sufficient to settle bank balances. The essential point to remember in this is that once the counry had left behind the practice of doing business on a gold-for-gold basis, it never could pay out gold to the majority of those holding claims upon gold.

In order to arrive at the right of a citizen to own gold it has been necessary to show the function which gold holds in our economic life. To do that it becomes clear that a new view of gold must be taken, one that is consistent with present-day practice. A new interpretation was seen to have developed from a new usage of gold. A steady development in economization of the use of gold finally has brought gold to a relatively unimportant place in our economy. Its sole use now is to settle balances between banking institutions. With the vast credit structures reared upon slim margins of gold, it hardly can be said that gold lends stability to the monetary unit. It is so remote from trade that only a wild flight of imagination can conceive it as a standard of measurement or a medium of exchange. The strange thing is that it is worshiped so intensely.

Reasons that are apparent for holding gold in such esteem probably are chiefly three in number. First, there is the force of tradition carried on by those who do not realize that gold has changed its functions. A second reason would be the drastic measures taken by debtor nations which had balances to pay and insufficient gold with which to pay them. This has tended to color the picture in favor of gold. If gold is the acceptable medium for settling balances as between nations then a nation must have gold to pay its debts. It happens that nations contract debts without thinking of the amount of suitable medium they have for paying debts. This situation has been aggravated recently by the inability of the commodity market to furnish some of the settlement for the balances; instead, with an absence of commercial credits, as a result of breakdown in foreign trading, the entire burden of settling debts has fallen upon gold. Ordinarily shipments of goods would supply such a portion of the credits for settling balances that only a small part, if any of the task, would fall upon gold. The scramble of these debtor nations then has made gold seem important. A third reason for worshipping gold has been a fear of an inflation, as it is called. What is meant by that is a fear of the dangers of too rapid inflation.

There are still many persons in this world who are known as hard-money people. They labor under the notion that only hard coin is money and all other forms of money are fiat and false. There are sufficient number of these to draw out all the gold which the country has stored by to handle its trade balances. Other commodities could be substituted for gold in settling balances but these others are handled with more difficulty. It serves the common welfare much better to refuse to pay out these few the gold they demand in order to protect the great credit structure and to make possible the volume of business which is now carried on because of that credit structure. Monetary gold has become a national commodity and no longer a personal one; it serves the national welfare and has little to contribute to the increase of individual welfare.

Gold has been nationalized as a matter of government policy. This is a step in the direction of recognizing officially the new position into which economic forces have thrust gold as a matter of historic development. Monetary gold is no longer needed for the individual to carry on his affairs; instead he has the approved unit of money. Without returning to a gold regime which would cramp all economic expansion, the paper and credit substitutes for gold will bring to the buyer just as much as the gold itself would do. Impounding gold is but an acknowledgment of the real function of gold.

The difficulty with the present court decision was twofold. There was first the problem of the impounding of gold and second the devaluation of the dollar in terms of gold. Those that were suing were demanding a return of the same amount of gold that was in the dollar originally, but since they parted not with gold in the first place but only with claims upon wealth, it is only fair that they should not be paid back in greater claims upon wealth. That takes care of the payment in money equivalent to the former gold value. To pay them back in the metal would open the way for a drain upon our gold reserves which would satisfy the minority and jeopardize the majority; to pay back claims upon wealth than were given up would not be sensible. If there has been a hardship it has fallen upon the few, although that hardship in most cases is overstated.

The other question was: has anyone the right to promise to pay gold? In the older viewpoint of the function of gold this promise was considered as a matter of good business. Future demands upon gold were not forseen nor was its true function appreciated. In making the new function of gold a recognized part of government policy, the country unfortunately has forced certain businesses and itself to break its own promises and contracts. This is, however, a matter of the constitutionality of the decision; such matters as the sacredness of contracts. From an economic standpoint the decision can be endorsed most heartily. In present-day economic life the general welfare is best served by governmental impounding of gold, and the conclusion follows that *individuals should have no right to gold.*

To summarize: It has been pointed out that steadily, over a period of years, gold has become less and less important in the operation of the economic system under which we live. Today it finally has left all visible channels of trade and serves in the background merely to settle bankers' balances. Money in the forms of credit intruments has taken the place of gold and has made possible the vast volume of business now carried on in the world. Recognizing this new function of gold, governments have nationalized the metal, causing it to serve the greatest good to the largest number of persons. Only the minority that ever demanded the metal suffer and this suffering is more imaginary than real, for that which is given to them instead, brings the commodities they require. Only in this manner can gold serve its most useful purpose.

To prove certain points it has been necessary to discuss the values of gold and of money and to point out that these values were the same for both: namely, the amount of commodities which they would bring in exchange. These values were shown to be a result of economic forces acting upon price levels. It was shown further that money was not necessarily claims upon gold but claims upon general wealth, only a small part of which is gold. Since one does not acquire money by contributions of gold in most cases, he is not entitled to claim gold when the act of claiming jeopardizes the country's use of the gold. An ignorant minority, by demanding gold for hoarding, could cause consternatnion to the rest of the country, and recognizing this, the government has impounded all monetary gold and has refused to pay out the metal to individuals. The decision of the Supreme Court recognized the new function of gold and on the basis of economics is to be approved.

THE INFLUENCE OF SOPHOCLES' *PHILOCTETES* ON MODERN LITERATURE AND LITERARY CRITICISM

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THE *PHILOCTETES* occupies a different position in relation to literary criticism than any other Sophoclean drama. It has been commended highly by some critics, especially the French, and rated very low by others, while those who have admired or criticised it adversely have done so for very different reasons. The subject was a favorite one in antiquity, being treated not only by the three great Greek tragedians (8) but by five other tragic and two comic writers. The first reference to the play in English literature is that of Ascham in his *Toxophilus*: "As Vlysses in Sophocles very plainlye doth saye vnto Pyrrhus, as concernyng Hercules shaftes to be carried vnto Troye, 'Nor you without them, nor without you they do ought'." Scaliger gave it a very high rank. Fenelon's prose paraphrase in the twelfth book of his *Télémaque* excited such interest in the play in France that it was performed often in French seminaries. Chataubrun in his travesty attempted a number of improvements on Sophocles, among them that of giving Philoctetes a daughter Sophie, with a governess, in order that Neoptolemus might fall in love with her (24). La Harpe's version was less ridiculous, but he confesses that it is only the skeleton of Sophocles' tragedy which he has retained from the original (16) "Ce n'est pas du Sophocle tout pur, mais du Sophocle tout sec." His "improvements" are in the direction of complicating the plot. He evidently thought that the modern French theatre required more than three characters on a desert island.

Adverse criticism of this drama has been directed principally against Philocetes' expressions of physical pain. Cicero had insisted that no real hero could so degrade himself as to utter lamentations or to show any outward manifestations of pain and had cited the Philoctetes as a notable example in which this principle was violated (4). In the same strain Adam Smith objects to the scenes wherein Philoctetes "moans, cries, and goes through the most hideous contortions," saying that we despise a man whom we hear cry out under bodily pain (27). So also to Bulwer-Lytton this seemed to be the blot of the play. The sympathy which must be elicited by physical pain is coarse and inconsistent with true tragedy, and when Aristophanes in the *Frogs* ridiculed Euripides for getting sympathy for his heroes by their rags, he ought not to have omitted censure for Sophocles for the rags and sores of Philocetes (3). C. W.

Collins thinks that there is a fundamental difference between Greek and Anglo-Saxon feeling in regard to the expression of physical suffering which prevents Philioctetes from being a hero to Anglo-Saxons (5) Winckelmann in a reference to the Laocoön group started a discussion concerning the dramatic propriety of expressing by loud cries the sense of physical pain. He said that Laocoön suffers like the Philoctetes of Sophocles in that there is no indication of a loud cry, only a subdued groan of anguish (19). Lessing shows that the hero of the Greek drama does indulge in loud shrieks and cries, and that this was not inconsistent with the best Greek feeling. In his analysis of the aesthetic problem involved Lessing shows that he is completely able to disengage himself from a narrow conventional viewpoint and to apply fundamental principles. By showing the nature of Philoctetes' suffering, the nature of his resistance to it, and the nature of the effect of his cries on Neoptolemus, he not only justifies Sophocles' method but shows its necessity in the dramaturgy of the play (18).

While Lessing by careful logical analysis justified the cries of Philoctetes, the French praised them and said that they would not dare to do it. Diderot exclaims: Je ne me laisserai point de crier à nos Francais: La vérité, la nature, les anciens! Sophocle, Philoctete! Le poète l'a montré sur la scène couché a l'entrée de sa caverne et couvert de lambeaux déchirés. Il s'y roule, il y éprouve une attaque de douleur. . . (2).

Other critics have displayed no interest in the æsthetic problem involved in the hero's cries, but have censured the moral tenor of the play. Charles Gildon in showing the superior moral value of Shakespeare to Sophocles asserts that the Philoctetes is incapable of being reduced to any significant moral (11). The drama he thinks, has no great or noble thoughts and is impotent to arouse either terror or pity (12). Bulwer-Lytton thinks that the plot is vitiated not only by the expression of physical pain but also by the fact that it rests upon a base and ignoble fraud (2). Courdaveaux criticised Sophocles for not having adopted the more moral and religious version of the legend according to which Philoctetes was punished, not for approaching inadvertently the sanctuary of the goddess but for breaking his oath never to reveal the tomb of Heracles (6). He himself, however, suggests the answer to this criticism when he states that it was this form of the myth which Homer had used. Courdaveaux cited also Dio Chrysostom (8) to the effect that Sophocles had degraded the character of Ulysses, whom Aeschylus had represented as having all the grandeur he possessed in the *Iliad* (6). The French critic thought that Neoptolemus was a poor substitute for the brave and generous Diomede whom tradition had given to be Ulysses' companion and whom Aeschylus had so used (6).

Most critics, however, instead of finding defects in the ethical tone of this drama, have admired the poet's skill in the analysis of character and in the interplay of diverse personalities. Macaulay thought that there is more character in the *Philoctetes* than in any play in the Greek language, "two or three of Euripides' best excepted" (29), while William Cory was of the opinion that the character of Neoptolemus surpassed anything in Euripides (30). The critics generally have been enthusiastic, at times almost ecstatic, in their praise of this character. Arthur Fairbanks thinks that the main interest of the play is centered not in Philoctetes but in Neoptolemus (10). Symonds declares that nothing more beautiful can be conceived than the moral revolution in the character of this young hero (28). Goodell in his "Athenian Tragedy" thinks that there is no finer figure of a frank, high-minded youth, and that not even Browning has proclaimed more distinctly the doctrine of individuality than does Sophocles when he causes Neoptolemus to exclaim: "All is offence when a man hath forsaken his true nature, and is doing what doth not benefit him."*

Others have been attracted chiefly by the romantic suggestiveness of the play. Walter Pater thought that if the drama were written now it might figure for the strangeness of its motive and the perfectness of its execution as typically romantic (23), and Mackail calls it a romance "in something of the same sense in which the term is applied to Shakespeare's *Winter Tale*, *The Tempest*, and *Cymbeline*", i. e., it unrolls a story rather than sets or solves a problem; "it deals with a sort of life that actually happens" (20). I do not think, however, that this is the sense in which the play is romantic. This element comes in chiefly through the love of nature which pervades it. It was for this reason that Bowles admired it and compared the romantic imagery of it to that in *The Tempest* and *A Midsummer Night's Dream* (25). Emerson says: "Beautiful is the love of nature in the Philoctetes. But in reading those fine apostrophes to sleep, to the stars, rocks, mountains and waves, I feel time passing away as an ebbing sea. I feel the eternity of man, the identity of his thought" (9) Norwood points out that the feeling of romantic desolation makes itself felt in the opening words of Odysseus (22) and is maintained throughout in "a magnificent picture of Philoctetes' life amid the animals, birds, and desolate landscape of his island-home" (22). Lessing perhaps was the first to compare Philoctetes to Robinson Crusoe. He thought that the Greek hero with his suffering and complete desolateness was better calculated to excite our sympathy than the rugged, healthy, and industrious hero of Defoe's tale (18). Kont (15) asks whether Paul de Saint-Victor (26) took this hint from Lessing for his ingenious parallel between Philoctetes and Robinson Crusoe. Alexander Harvey says that Philoctetes has more subtleties in its implications and more tragedy in its action than anything Defoe ever thought of. He compares the situations and atmosphere of the Greek play with the *Treasure Island* of Stevenson, Odysseus corresponding to Long John Silver, Neoptolemus to Jim Hawkins, and Philoctetes to Benn Gunn (13). He thinks that everything which is in *Treasure Island* is in the Greek play, but such a comparison is fantastic, for all that is the same in the stories are a few of the accidentals of the action. To say that the play and the novel are one piece because they both have islands, ships, storms, heat, and cold, is to ignore the psychological element which, of course, matters most and which, in spite of a very few superficial resemblances, is radically different in the two productions.

It is the romantic love of nature in the *Philoctetes* which prompted Thomas Russell, in the latter part of the eighteenth century, to compose one of the best English sonnets written in the period between Milton and Wordsworth.

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*Lines 902, 3. Jebb's translation.

On this lone isle, whose rugged rocks affright
The cautious pilot, ten revolving years
Great Paean's son, unwonted erst to tears,
Wept o'er his wound: alike each rolling light
Of heaven he watched, and blamed its lingering flight;
By day the sea-mew screaming round his cave
Drove slumber from his eyes; the chiding wave
And savage howling chased his dreams by night.
Through his rude grot he heard a coming oar,
In each white cloud a coming sail he spied;
Nor seldom listened to the fancied roar
Of Oeta's torrents, or the hoarser tide
That parts famed Trachis from the Euboic shore (21).

This suggests a comparison with the better-known sonnet of Wordsworth:

When Philoctetes in the Lemnian isle
Like a Form sculptured on a monument
Lay couched; on him or his dread bow unbent
Some wild Bird oft might settle and beguile
The rigid features of a transient smile,
Disperse the tear, or to the sigh give vent,
Slackening the pains of ruthless banishment
From his loved home, and from heroic toil.
And trust that spiritual Creatures round us move,
Griefs to allay which Reason cannot heal;
Yea, veriest reptiles have sufficed to prove
To fettered wretchedness that no Bastile
Is deep enough to exclude the light of love,
Though man for brother man has ceased to feel.

Russell's sonnet gives a more adequate picture of the real situation of Philoctetes on Lemnos than does that of Wordsworth, where it is not so much the outcast, his sufferings and his undaunted hope that we see, as it is a bit of Wordsworthian philosophy on the sympathy of nature. In Russell's picture everything is focused upon the hero himself, and the imagery and diction combine to produce a perfectly clear and unified impression.

In 1866 a metrical drama, *Philoctetes*, was published under the name of William P. Lancaster. It was published five years later by Strahan, under the name of John Leicester Warren. The poet later inherited the title and bore the name Lord de Tabley. The chorus of this drama is composed of Lemnians, as in Aeschylus and Euripides, whereas in Sophocles it is composed of the companions of Neoptolemus, thus emphasizing the loneliness of the hero as superimposed upon his physical sufferings. Lord de Tabley further sacrifices Sophocles' advantage by introducing a romantic theme, the love of the shepherdess Aegle for Philoctetes. So too in Chateaubrun's adaptation there was the romantic love theme, Sophie, the daughter of Philoctetes, exciting the love of Neoptolemus and furnishing him a chief motive for helping her father. The English poet also has relieved the hero's loneliness by representing him as attended by a faithful old servant, Phimachus. There are a number of imitations of Aeschylus' Prometheus, and the malignity of the gods is stressed everywhere, the general tone of the drama being that of extreme skepticism. Ulysses is represented as being a worse character than in Sophocles' play. There are practically no verbal reminiscences or correspondences in scenes. Ulysses appeals directly to Philoctetes, intending to use Neoptolemus (called Pyrrhus in the drama) only as an assistant, but Neoptolemus baulks the design of his chief by supporting the hero. This calls forth bitter and ironic reproaches from Odysseus, followed by a short stichomythic passage. The Aegle episode is full of tender sentiment, and here the departure from Sophocles is most marked. Philoctetes is moved to his change of purpose by the appartition of Hercules, and it is by his love for his friend, rather than as the result of a direct command, that he decides to go to Troy. Thus Lord de Tabley somewhat disguises the *deus ex machina* and seeks to provide a better motive for Philoctetes' change of mind. In the lines

> And the baby feeds,
> Milks at the breast and smiles, and oweth not
> Allegiance yet to knowledge that shall make
> The fair earth bitter to his wiser eyes

there is probably a reminiscence of two lines of the Ajax:

> en to phronein gar meden hedistos bios,
> heos to chairein kai to lypeisthai mathes (554, 5).

The story of Ixion probably was due to a passage in a chorus of Sophocles' *Philoctetes* (vv. 676-680.).

The simplicity of diction in the *Philoctetes* has heightened the general impression of naturalness and simplicity which the play has made on most literary critics and scholars. Diderot, who contrasted the naturalness of Greek tragedy to the conventionality of the French drama, cited the speech of Philoctetes to Neoptolemus as an example in point (7) (vv. 927 ff.). Diderot paraphrases this speech in Paradoxe sur le comédian (7). J. E. Schlegel also takes the Philoctetes as the basis of comparison between Greek and French tragedy.* Lewis Campbell thought that the play was marked by studied ease and vernacular freedom, "reminding the English reader of those poems of Shelley—such as Julian and Maddalo—in which, without losing poetical grace and finish, he reflects the tone of actual conversation." Several critics have expressed their feeling that this is the most modern of all Sophocles' plays. La Harpe said that it was the only ancient play with a perfectly universal appeal (that of human suffering), and therefore the only one which could be reproduced on the modern stage (17), while it was with special reference to the *Philoctetes* that Bulwer-Lytton observed of Sophocles' dramaturgy that its effects are so tangible that his plays could be presented tomorrow in "Paris—London—everywhere" (3).

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WHAT EVERY AMERICAN CITIZEN SHOULD KNOW

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IT MAY BE ASSUMED that there are few ideal citizens in any country, and that among these few there probably is none who would claim that he possessed all the information necessary for complete citizenship, nor is the possession of information a guarantee for good citizenship. Proper attitudes also are essential. But these are not the chief consideration of this paper. There is no substitute for knowledge, especially during these critical years. And if the mere enumeration of some of the topics with which the citizens should be familiar serves no other purpose than to call attention to some of the problems with which any realistic system of education should concern itself, this paper will have served its purpose.

It will be recalled that the long battle for free, non-sectarian, tax-supported schools was won about a century ago in this country. The idea underlying this decision was that a democracy must be based on an intelligent and informed citizenry. That the assumption of democracy were erroneous may be gathered from the following statement from Barnes' *World Politics in Modern Civilization**, "Democracy rested upon the following conditions and assumptions: a simple unchanging agricultural society; few and rudimentary political problems; the local nature of political issues; the laissez-faire theory of government, which contend that the best government was that which governed least; the real intellectual equality of men; the equal fitness of all to vote and hold political office; the development of ardent popular interest in politics and the suffrage as soon as the right to vote was secured by the masses; the capacity and inclination of the people carefully to scrutinize the candidates and platforms before casting their ballots; the unique capacity of the common people to sense injustice and to launch great moral reforms." Not one of these assumptions now is known to have been correct. Nevertheless, once having turned the government over to the people, we now must educate them to their responsibility—or ride with them to our common ruin. H. G. Wells has said that the history of the next 20 years will be a race between education and catastrophe, and that is probably not an exaggeration.

One of the first things that the intelligent citizen should realize is that we are living in a changing world. Not only are things changing at an unprecedented speed today, but fundamental changes already have been brought about during the last 50 or 60 years. We hardly need mention such recent innovations as the automobile, the aeroplane, the radio, and wireless. What their ultimate effect on society will be we can perceive only vaguely as yet. And these are only a few of many recent innovations. But consider such fundamental facts as the disappearance of the frontier with its free lands, the stabilization of the American populaton, the decline of our foreign trade (due to agricultural and industrial development in foreign countries), the concentration of wealth in the hands of a small class, and the tremendous strides of technology. These developments have put the American farmer, the American laborer, and the American industrialist—yes the American consumer—into entirely new conditions and situations. Some of our problems are entirely new. They never have called for solution before; and there are therefore no precedents to follow. What folly, then, to carry old attitudes and prejudices into the new day! Only an open well-informed mind is adequate to tackle the problems of today and tomorrow.

If we turn our eyes to the world at large we behold the same rapid changes. Only 17 years ago we fought to make the world safe for democracy. Today one democracy after another is crumbling, and their places are taken by dictatorships. We fought to end war; and what have we? War stares at us from every direction. We wanted to break up the autocratic German government and her powerful military machine. But instead, we see today a Hitler and a rapidly developing military power that probably will exceed the former, both in size and in military spirit.

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*P. 149.

A second thing that the citizen should understand is our economic condition. He should know what is meant by capitalism: what its essential elements are; how it has developed; what it has achieved; and how it has become a hindrance to progress. He should understand what is meant by the term "economy of abundance," that technological progress during the last 10 or 20 years has been so rapid that it now is possible, at low cost, to provide all the material necessities (and luxuries) of life for all the people in this country. The exasperating thing is that we are slow in working out an adequate system of distribution. Apparently a new day of plenty and of peace wishes to be born, but, to use a figure from Upton Sinclair, those who should assist in the birth are trying to strangle the child in the womb.

In the third place he should appreciate the threat of dictatorship. Not only are dictatorships spreading over the maps of Europe and Asia, but we have nearly all the essential elements and conditions for its spread in our own country. Democracies with their rights and privileges for the individual develop in times of an expanding economy; in times when there are opportunities to acquire farms and businesses and jobs for all who have the intelligence and who wish to work. Such were the conditions in this country during the last century or two, and such were the conditions in Europe till the World War. The war caused wholesale destruction of wealth and the disruption of old traditions and institutions and trade relationships. Wealth had become highly centralized, and technological progress caused widespread unemployment and distress. The middle class was sinking protestingly to the level of the proletariat. And under this system of a contracting economy and universal disillusionment and misery the demagogues found a fertile field. By appealing to the hopes and fears of the dispossessed and threatened classes, and by whipping up the patriotic sentiments of the masses, they induced majorities of the voters in various countries to abdicate their political power and to turn it over to the leaders.

Here in the United States we had another period of prosperity during the twenties, but since 1930 the condition and attitudes that make for fascism have developed rapidly. Let me quote from the phamplet on "Fascism" that was prepared recently by the Christian Social Justice Fund. It states that "the potential strength of the Fascist movement lies among: the students who come from middle-class backgrounds but can find no middle-class jobs; the white-collar, professional, and small business groups who have lost their positions and their independence but not their pride and their attachment to past privileges; the farmers whose economic security has been destroyed but who remain blindly loyal to the traditions of a pioneer era; the conservative workers who are compensated for poverty and want by the memory of the equality of opportunity which existed in America 60 or 70 years ago; the reactionary trade-union leaders who have a vested interest in the jobs; and the great mass of unemployed of all classes who in their desperation will follow any gospel or any man that promises enough and denounces enough."

Communism, too, should be understood, not only as a threat but also as a promise.

Conversely, it should be plain that socialism does not threaten to create a dictatorship, but that it is thoroughly compatible with democracy.

What should the citizen know about war? This much certainly, that it is a very complicated problem. The causes for modern wars are numerous and the results are unpredictable. For countries that are as favorably circumstanced as the United States they are likely to be futile. How can the seven percent of the human beings who reside in this country expect to gain much more of the wealth of this planet? They already have more than their share of the goods of this world. Frank H. Simonds says that in the past men have fought for religious liberty, for political freedom, and for racial unity. In the future the "peacemakers must present some alternative to war by which nations suffering from economic inequalities can be assured access to the essential raw materials and minerals without which they cannot keep their industries running. Otherwise the less fortunate will continue their preparations for war as the sole means of escape." Will the Germans, the Italians, and the Japanese choose slow starvation in preference to war? These are the nations that suffer from economic inequality, and they are also the most militaristic nations today. What is the solution? That war is not an isolated problem which can be solved without reference to other problems is manifest. Communists and socialists are contending that the only possible solution lies in the abolition of the capitalistic system and its replacement by a co-operating society based on the community of the human race. As the *Christian Century* stated some months ago, capitalism holds war as the clouds hold lightning. The citizen will have to know much about economic, political, social, psychological, and international affairs before he can deal intelligently with the problems of war and peace.

Nor can the citizen afford to ignore utterly the subject of religion—in spite of the fact that theoretically religion in this country has been separated strictly from government and politics. Just recall that one of the strong arguments against Alfred E. Smith in the presidential campaign of 1928 was his affiliation with the Catholic Church, and that Upton Sinclair was defeated for the governorship of California last year largely by the use that his opponents made of the subject of religion. To define religion as "a yearning for social justice and righteousness" would probably satisfy the liberals and radicals, but hardly the conservatives. Such an interpretation leads directly to an opposition of some of our most powerful and best established institutions—such as capitalism and war. The doctrine that one should try to please God rather than man may lead the thoughful citizen into grave difficulties, particularly since the Supreme Court has ruled—in the Macintosh case—that Congress is the supreme interpreter of the will of God.

Another subject that should be understood is propaganda. Hosts of people are carried away by subtle propaganda not only in times of international tension and war but also in times of peace. Why are such terms as "reds", "radicals", and "communists" so much used and so much feared? Why is socialism, which aims to meet the needs of the average man, so poorly understood? Why have we heard so much about the merits of private ownership of public utilities and so little about public ownership of public utilities? Why are we such strong believers in the superiority of the white race? Why do millions of people still believe in the "Christian Epic"? Why has the ultimate consumer so much difficulty in learning of the relative merits of the various brands of cloth, foods, drugs, cosmetics, etc.? The answer to all these questions, and many others, is, of course, propaganda.

One fundamental conception may be of great help to the average citizen; it is the struggle for power that is going on everywhere. There have been shifts of power in the past as, for example, when the monarchs of the national states displaced the feudal lords and the ecclesiastical authorities toward the end of the Middle Ages, or when the middleclass—the bourgeoisie—displaced the ancient nobility during the seventeenth and eighteenth centuries. So today the common people—the proletariate—everywhere are struggling to obtain control not only of the political states but also of the economic systems. True, the national states, controlled by small groups of powerful capitalists, are struggling fiercely against each other; but within each state a determined class struggle for power is going on relentlessly. It may be that the capitalists who control the modern states may lead their states into conflicts with other states in order to divert the masses from their real interests.

Probably many, if not all, of the important developments that we shall witness during the coming generation will be related in some manner to this struggle for power.

We already have stated that any realistic system of education should concern itself with some such problems as we have mentioned. Not that other subjects should be neglected totally, but the training for citizenship must be emphasized far more than it has been in the past. The traditional study of American government is not enough. The mere knowledge of how our government is organized will not equip the student with the information which he will need as a citizen. He should learn to understand the day and the age in which he lives, and he should learn how he personally can function most effectively in that age. In order to do that he must form reading habits, and he must know something about the sources of information—magazines, research and civic organizations, publishing houses, and book reviews. The time probably is at hand when the average citizen will have plenty of leisure time on his hands, and some of that time can be spent both profitably and pleasurably in reading along lines here indicated.

We stand, as I see it, at the threshold of a new age. By acting wisely and courageously we may inaugurate in this country an era of peace and prosperity for all, the like of which the world never has seen before. Or, by letting things drift, or by acting unwisely, we may enter a period of dictatorships and wars that will ruin all that we hold most dear.

THE INFLUENCE OF DEMOCRACY UPON NINETEENTH-CENTURY ENGLISH HISTORIOGRAPHY

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THE NINETEENTH CENTURY aptly has been termed a period of surpassing import (1). It was the day of the different revolutionary upheavals in France, Germany, Italy, and the Low Countries; the day of the Greek Revolution which made Great Britain, France, and Russia the champions of Hellenic liberty; and also the day of Chartist demonstrations, Whigs and Tories, and the famous Reform Acts of 1832, 1867, and 1884 in Great Britain. Inasmuch as these stirring events influenced the lives and thoughts of many, it is interesting to observe the extent to which they likewise influenced the pens of the more prominent English historians of this period.

Henry Hallam (1777-1859) is credited with having inaugurated a generation of Whig History, especially with his *Constitutional History of England.* This work made its first appearance in 1827, almost upon the eve of the agita-
tion of Whig History, especially with his *Constitutional History of England.*
so the day when Hallam's own Whig party was out of power; and the day of the reign of Charles X, the last of the reactionary Bourbon rulers of France, soon to be overthrown by the Revolution of 1830. Though an extreme Right Whig, hating political and ecclesiastical tyranny, Hallam had no confidence in the wisdom of the people and believed the Reform Act of 1832 had gone too far. His *Constitutional History of England* was a sustained attack upon the Tudor and Stuart despotisms and a glorification of the Revolution of 1688 (2). In this work he claimed that England's government, through all its history, had been a mixed or limited monarchy, of a type established by Celtic and Germanic tribes, in preference to Eastern despotism, Roman tyranny, or small republican polity; also that England, more fortunate than the rest of the nations had obtained—

> "in the fifteenth century, a just reputation for the goodness of her laws and the security of her citizens from oppression."

Then he followed this with a list of limitations upon English royal authority (3).

John Lingard (1771-1851), George Grote (1794-1871), and Thomas Babington Macauley (1800-1859) really belonged to the historical school of the eighteenth century. Armed with strong and active prejudices when they approached their respective subjects, they sometimes interpreted the evidence of the sources in the light of their own political or philosophic opinions (4). Lingard, though a Roman Catholic clergyman, condemned highly-orthodox Roman Catholic Queen Mary (1553-1558) for her high-handedness as a ruler (5). He also called her successor Elizabeth (1558-1603) irresolute, mean, and irritable; and also suggested that her personal morality was bad (5). To him the execution of Charles I was—

> "an awful lesson to the possessors of royalty, to watch the growth of public opinion, and to moderate their pretensions in conformity with the reasonable desires of their subjects" (7).

His ten-volume *History of England* was written between 1817 and 1830, the closing years of Tory rule of England.

Macaulay was a Whig of mixed Scottish Covenanter and Quaker descent (8). While a student in Cambridge he had learned to detest Tory government (9), and after the passage of the Six Acts (1819), he became an out-and-out Whig (10), honestly believing the principles of his party represented the Alpha and the Omega of political misdom (9). In 1824 he began writing for the Edinburgh Review; and in 1830, when William IV came to the throne, he was returned to Parliament (11). From his study of the seventeenth century he developed the opinion that his day was bringing in another crisis similar to that precipitated by the Stuart kings in their conflicts with Parliament. Therefore, according to him, the only remedy lay in a return to the principles of the Puritans as set forth by the Whig party of his own day (12) . He was, however, no supporter of Puritan theology. He had too much Whig distrust of the fanatical to recognize any grandeur in Puritan character. His only interest in Puritanism was in the political conduct of its followers (13). In 1847, after losing his seat in Parliament, he began to write his *History of England from the Accession of James Second,* his best-known work, one in which he defended the Whig theory of government and depicted William III as a hero (14). The first volume came from the press in 1848, the year of revolutionary disturbances in Continental Europe. His death in 1859 unfortunately prevented his carrying out his plan of bringing the narrative down to his own time (15).

He began this work with a statement of his plan, which was to write a history of England from the accession of James II down to "a time which is within the memory of men still living." He would also show the errors which, within a few months, alienated a loyal gentry and priesthood from the Stuarts; and how a new settlement was effected; and how—

> "under that settlement, the authority of law and the security of property were found to be compatible with a liberty of discussion and of individual action never before known;"

and how, from this union of order and freedom came unsurpassed prosperity and increased prestige for England (16). Incidentally, we might observe that his own party, in those days of conflict with the Stuarts, played a large part in the events he described. As a true Whig he also attacked the claims of divine right, using biblical material to show that monarchy was not a divinely created institution, and that such a claim, if proposed during the Middle Ages, would have been regarded as heretical (17). To him, James II is the villain of this great historical drama (18).

Macaulay's strong pro-Whig stand also is shown clearly in his criticism of Hallam's *Constitutional History of England,* which is pronounced the most impartial work he ever had read (19). To him democracy was simply a government of a numerous middle class, and nothing else (20). He showed this same attitude in his Speech on Chartism, delivered May 3, 1842, just after the presentation of the second Chartist petition. Here he expressed his approval of their demands for the secret ballot and for the abolition of the pecuniary qualification for members of Parliament, and stated that he might consent to a compromise on the proposition of yearly Parliaments, but he sharply disapproved of the demand for universal manhood suffrage. He held this demand incompatible with all forms of government, with property, and with civilization itself (21). For the same reason he, in a letter to the biographer H. S. Randall, refused to list Thomas Jefferson among the benefactors of mankind (22).

Grote began writing his *History of Greece* in 1822, during the decade of the Greek Revolution, which had aroused the fervor of students of classical literature. Opposing the Tory views shown by Mitford in his *History of Greece* (completed in 1810), he wrote an article for the Westminster Review in 1826, in which he challenged them. From 1833 to 1841 he sat for London House of Commons and sought to lead the government further along the road of democratic reform. Defeated for re-election in 1841, he devoted the remainder of his time to the writing of his *History of Greece*. As an ardent believer in democracy, he showed enthusiastic sympathy with the Greeks in their revolution, also with the revolutionary disturbances in the rest of the Continent (23). He showed the ancient sophists as the great liberal teachers of Greece, and according to one writer he really wrote "a sort of idealised England (24). He most warmly defended the democracy of ancient Athens and denied the charges of fickleness (25). To him the great social and political results of Greek history were due to the prevalence of democracy among its city-states. His work is "a great political pamphlet in twelve volumes in vindication of democratic principles" (26).

Edwin A. Freeman (1823-1892) also was interested in politics and was an enthusiastic follower of Gladstone. In his *History of the Norman Conquest*, written in the year of the Reform Act of 1867, he showed himself an enthusiastic supporter of democratic institutions. According to him the Norman Conquest was but "a temporary overthrow of our national being," bringing in only a new dynasty and a new nobility but failing to expel or transplant any part of the English nation (27). This work of five volumes ended with the accession of Edward I,

> "a king who well loved the powers of his Crown, but who knew that the strength of a king lies in the strength of his people" (28).

John Richard Green (1837-1882) was reared in a Tory circle, but was inclined to political liberalism from his early days. While in school he wrote an essay upon Charles I, in which he showed that monarch on the wrong side in his clash with Parliament (29). He left Oxford with the intention of becoming the historian of the Church of England, but later decided to become the historian of England (30). In 1874 he wrote his *Short History of the English People*, in the introduction to which he stated that his work was a history not of kings or conquerors but of the people; his preference was for the incidents of constitutional, intellectual, and social advance "in which we read the history of the nation itself." For this reason he devoted more space to Chaucer than to Crecy, to Caxton than to the Wars of the Roses, and to the Methodist revival than to the escapades of the Young Pretender (31). He also showed this same preference for the people in the longer work, the *History of the English People*, which appeared from the press between 1877 and 1880. This work opens with a strong democratic tone and eulogy of the Teutonic people who settled Anglo-Saxon England (32). We notice also that these volumes were written during the days of the diplomatic crisis over the Near Eastern Question and debates in the English press over the work of the Congress of Berlin, 1878.

We shall start our study of the Tory group with Sir Archibald Alison (1792-1867), a man hailed by Gooch as a new champion of Toryism (33). As a Tory he contributed several articles to Blackwood's Magazine, wherein he opposed the Reform Bill of 1832 and attempted to prophesy many evils which democracy threatened. In 1833 he went to Paris to seek examples of his claim that popular convulsions lead to military despotism (34). According to him—

> "Democracy cannot exist and never has existed for long in an old society. It must either destroy the community or be destroyed itself" (35).

In his *History of Europe*, written between 1833 and 1848, he expressed sympathy with the oppressed, but claimed that the French Revolution had developed a new set of perils which, for all states with a popular form of government, brought in the obvious risks of the destruction or subduing of all influence of knowledge, virtue, and worth. To him—

> "This evil is of far more acute and terrible kind than the severity of regulation, or the weight of aristocratic oppression" (36).

William Mitford (1744-1827) published his *History of Greece* during the decade of the Greek Revolution. He claimed that, had ancient Athens had a government so constituted as to be capable of a wise and steady administration, men would not have been lacking to direct the business of an empire. But—

> "Of all forms of government, democracy is not only the most capricious, but the most selfish."

Let us recall also that when Mitford was writing these volumes there were many Tories living who recalled quite well the excesses of the French Revolution and Reign of Terror. With this fact in mind, the statement in his work that the Greek practise of ostracism filled that ancient land with discontented exiles who were always a source of trouble to Greece, is indeed interesting (37). It was these same excesses of the French Revolution, by the way, which prompted him to write this work (38).

William Stubbs was another Tory, as well as an Oxford product. According to his biographer he was never a partisan, even though a man of strong convictions and loyalties (39). His treatment of the overthrow of Richard II and coronation of Henry IV is conservative in tone (40). He did not hail this event as a triumph of democratic forces in England (41).

Thomas Carlyle (1795-1881) was a man too radical for his position as a clergyman, and too impatient for the task of a teacher. He hated democracy as a self-cancelling business; and he hated parliamentary reform and the Whigs for backing it (42). His *History of the French Revolution* appeared in 1837, during the period of the Orleans Monarchy in France. In this work he preached abroad man's rights and man's weaknesses. (43). The French Revolution to him meant the destruction of imposture, also of some monarchs, and "five millions of mutually destroying men" (44). This work was followed by his lectures on "*Heroes and Hero-Worship*, in which he asserted that the history of what man has accomplished in this world is, fundamentally, the history of the great men who have worked here (45). At no time did he show himself democratic in sympathy. He is truly the hero-worshipper.

Generalizing upon the English historians we have noticed, we can observe readily that they are of a group belonging to the literary field more so than those of any other country. They had a highly literary style in their writings and were prone to exhibit their feelings rather strongly at times (46). A large percentage of these men were clergymen and of the faculties either of Oxford or of Cambridge. They nearly all are opposed to universal manhood suflrage. Even the most liberal of the group favor, at the most, a middle-class democracy, or else democracy in the abstract. The Tory writers show themselves conservative chiefly because of their fear of anarchy. All these men show themselves as patriotic Englishmen. As a general final statement, we may conclude that the effect of democracy upon nineteenth-century English historiography has been to give it the tone of political pamphleteering.

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INVESTIGATORS AND INTERPRETERS

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FROM THE VIEWPOINT of this paper there are two great sets of forces or factors in human society: those which maintain and conserve civilization and those which cause or help civilization to go forward. These two sets of forces are both indispensable to what modern people at least think of as a satisfying life. In both discussions it is a case not of one or the other but a case of one plus the other. The intelligent scientist only undertakes to determine how, when, and how much one set of factors is operative, and how, when and how much the other set of factors is operative, in the bringing about of certain consequences.

In this paper we deliberately and definitely are limiting our consideration to a partial analysis of those processes or conditions which we generally speak of as social progress, not at all denying that the conservation and maintenance of what has been achieved by society in the past are also of much moment to human welfare. We desire to state plainly at the outset that our inquiry shall be concerned largely with human welfare and how it may be increased.

Any society, large or small, needs to have a fairly even balance of the conservative and the progressive or liberal principles, with the activities appropriate to each. A well-organized and reasonably wholesome social group will have few or no extremists whom we may call ultra-conservative on the one hand and radicals on the other. For ultra-conservatives or reactionaries are too much like Lot's wife, whose gaze was longingly and persistently backward and who turned into an inanimate pillar of salt as a consequence. A society dominated by ultra conservatives would be, at best, little better than animal groups who live on an instinctive or traditional basis. Four hundred million Chinese, with their worship of the past, are an illustration.

On the other hand, a society dominated by out and out radicals would be not only an unhappy and inadequate society but probably would contain the seeds of its own destruction; its leaders forgetting that it is much easier to tear down than to build up. Any thoroughly revolutionary society, such as France in the last decade of the 18th century, or Russia from 1917 to 1923, is a good illustration. The only reason why these two societies were not destroyed more completely was the fact that after a relatively short time more constructive and more peaceful leaders and processes got the upper hand. We may say that while now and then, in human history, revolutionary and radical movements have seemed inevitable and generally have produced some valuable results, these valuable results have been secured at a tremendously high price in destruction of human life, property, and good will.

If it is now clear that in this paper we are not dealing with radicalism or conservatism but with certain aspects of social and intellectual liberalism or progressivism and the factors associated with these tendencies, perhaps our perspective is established. We shall proceed to a few comments on what is Progress, or, how shall we distinguish between a progressive and a non-progressive social group? We shall attempt no hair-splitting definitions or distinctions, realizing that the concept or connotation of the word "progress" varies widely with different individuals and different social groups.

We can not, however, leave the matter without some more specific consideration; for much of what we have to say later in this paper must take its meaning from the content which we put into this term Progress. Deriving our ideas partly from some of our able students in the sociological field and partly from our own common-sense reasoning, we shall state a few salient characteristics of a progressive society admitting that this attempt may be unsatisfactory. When, however, so much of our thought and effort in these modern days is given over to a "getting ahead", trying to live better than our more old-fashioned parents did, being up to date, etc., it would seem an appropriate function of the intelligent citizen to ask now and then—are these goals or objectives which we so earnestly pursue worth the price we pay for them?

A progressive society is one which has, in a substantial degree, many or most of the following characteristics:

1. Little or no illiteracy.

2. An equitable (not equal) distribution of material wealth. For example a nation like our own at present, in which one half the population is below, on, or near the poverty line, lacks one essential of a progressive society. Denmark, Switzerland, Sweden, even England, are far ahead of us in this respect.

3. A population as large as the natural physical resources and the state of the mechanical arts makes possible, with an adequate living standard.

4. Widespread interest in and cultivation of the physical, biological, and social sciences.

5. Freedom of the press, of speech, and of religion. America, so far, ranks high in this respect.

6. A system of universal public education that makes possible the full cultivation of all valuable personal qualities, also vocational training and citizenship training for all.

7. Public-health organization which is effective and comprehensive.

8. Adequate institutions for all physical and mental defectives.

9. No unemployment of normal adult workers.

10. An eugenics program based upon both human sympathy and rigid biological science.

11. As high development of the fine arts as is consistent with the native capacity of the people and the financial resources available.

12. The socialization of the basic natural resources. This does not necessarily mean government or public ownership of these resources, but it does mean at least sufficient social control over them to prevent such abuses as wanton destruction or waste of forest and soil and mineral resources for private profit, whether that private profit goes to a small farmer or to a large corporation. Many nations, especially the four Scandinavian countries, already have reached this goal without becoming socialistic or communistic.

13. Adequate measures for child welfare and for protection of women in industry.

14. To sum up, we may say that in a genuinely progressive society the crucial test of any social program or activity is: how, or how much, does or will this program or activity definitely add to the sum total of human well-being and happiness, in all its varied aspects? The most basic and comprehensive objective any progressive society can have is so to order its affairs that the greatest possible number of human beings will be enabled to live up to their fullest possibilities, physical, mental, emotional, moral, and social.

If the above descriptive analysis of a progressive society be even approximately correct, we readily see that nearly all societies have a long way yet to go before our progressive ideals of more complete and happier living are realized. Nevertheless we are on the way toward these goals, but we can not make, and never have made, much headway toward them without conscious, definite, creative effort on the part of some human beings.

The fundamental thesis of this paper is that there are two groups of persons who have been and now are chiefly responsible for social progress. We may call these the investigators and the interpreters. The remainder of our discussion will have to do with more specific inquiries related to this thesis.

Who are the investigators? It is our purpose to include in a tentative and partial list only those whose achievements have received or should receive some definite recognition. We shall make brief comment on each group as it is named.

The physical scientists. Our human world would be much more the poorer without astronomers, physicists, chemists, and geologists. Even though the secrets of chemistry, when found out, may be used either to destroy human life, or to enrich human life, as in the arts of peace, we all know that many of our every-day satisfactions and necessities are based upon chemical research. Indeed the new discoveries in this field are now coming into use so rapidly that it often is said that the chemical industries may lead the way out of our present depression, as did the automobile industry after the depression of the early 1920's.

The investigators in the field of physics have made vital contributions to the material, economic, and social advancement of mankind. Especially in the fields of transportation and communication have their activities been epoch-making, as well as in the electrical industries. The great developments in communication by radio are marvelous in their scientfic ingenuity and far-reaching in their sociological and cultural effects.

The scientific geologists have helped us discover and utilize rich natural mineral and agricultural sources that primitive mankind allowed to lie unused for thousands of years.

The investigators and research workers in the biological sciences have brought to the aid of struggling humanity hitherto unknown and unused knowledge of plant and animal life which has helped us to understand some of the great problems of heredity and to rescue the study of human anatomy and physiology from the shackles of tradition and superstition. How great this service has been to sick and suffering humanity was impressed freshly upon my mind by listening recently to a physisian's address on "Chinese Medicine." The ignorant and barbarous practices that still prevail among the vast majority of the 450 million chinese are almost unbelievable, including the custom of driving a steel needle into a sick man's flesh and internal organs, sometimes six inches deep. If the patient dies, of course it is (in the minds of the Chinese) not the wound that causes the death but the failure of the medicine man to conquer the evil spirits.

The investigators in the social science field are the newcomers. Some critics say they have not even yet arrived, and that we should not even use the term social sciences, but use a more modest and general term, "the social studies," as is the practice of some of our colleges of education. It must be admitted that the economists, political scientists, and sociologists have not yet developed their techniques and their objectives as fully as have the older physical and biological sciences. It is the position of the writer of this paper, however, that the social sciences are definitely in the making. Perhaps they never will catch up with their elder brothers who have the start on them. When we make a critical survey of the forward steps in social science during the last quarter-century, especially at such institutions as the University of Chicago, the University of Minnesota, Harvard University, the University of Wisconsin, the University of Michigan, and several other graduate schools, the conclusions of fair-minded persons must be that some real results have been obtained in the objective, non-emotional study of significant human relationships. Indeed the progress has been so rapid that much of the research technique used 20 years ago already has been thrown into the discard. Not all this progress has been made by so-called "research workers"; an important part of it has come from the reactions or throw-backs from social workers and others who test out theoretical interpretations in such highly practical problems as the causes and treatment of crime, poverty, and family instability.

This brief presentation of the social values of the work of investigators is sufficient to indicate that our men and women who have the ability and the inclination to delve into the processes and problems of physical nature and of human society are large factors in the forward push which we generally call progress. But there is another group of workers who perhaps are contributing an equal amount to the improvement of civilization. This group we choose to call "the interpreters", and to them we now turn our attention.

The functions of the interpreters perhaps are more difficult to explain than are the functions of those engaged in scientific research. In the writer's judgment, however, the two groups are of about equal importance so far as human welfare is concerned. The interpreters are, so to speak, the go-betweens, the men and women who know science in their field, but are not very much engaged in actual research processes. They stand between the genuine scientists and the rank and file of the population. They are enthusiastically interested in passing on and interpreting to the people the results of the more technical processes of investigation and research and also the ideas of creative thinkers who can not be classed as scientists, at least in the modern sense. They develop special skills and techniques that are useful in the interpreting process. They have sufficient understanding of the mental capacities of different population groups to enable them to work successfully at the great task of helping the findings of science actually to function in the improvement of human welfare.

Perhaps the largest group of interpreters comes from the profession or occupation usually known as teaching. Not all teachers now or in the past are or have been interpreters as we are using the term. From very early times however, at least as far back as the ancient Hebrews, Greeks, Romans, and Egyptians, there have been outstanding teachers who had the skill and personality to impart ideas and to transfer emotional enthusiasms to their followers. Among these are great religious teachers, Hosea, Amos, Micah, Isaiah, Jesus, and St. Paul. Gifted with creative insight into spiritual realities they also had the ability to pass on to others new ideas and fresh passions for truth and justice. Martin Luther, St. Augustine, John Wesley, Calvin, Harry Emerson Fosdick, and others should be named in this list.

In present-day life most of our teacher-interpreters busy themselves with their work of making understandable to their students and the general public the rather technical and abstruse findings of the investigators in their respective fields, whether in the physical, biological, or social sciences. All our colleges and universities of any size have one or more of these skillful interpreters who are real joys and sources of inspiration to their students. Also there are many real interpreters among elementary and secondary-school teachers.

Inventors are another important group of interpreters, whether the invention be material or spiritual. Edison's work in the applications of electricity to varied human needs, Marconi's achievements in wireless, Kettering's invention of the automobile self starter, Morse's development of the telegraph, Whitney's of the cotton gin are only a few of those who have added to human welfare by their genius in helping make the connections between the physical sciences and vital human needs. To be sure each of these men had a host of predecessors, helpers, and co-workers; nevertheless his own achievements were notable.

In the biological sciences, especially in the fields of medicine and surgery, the honor list is indeed a long one. It includes those who have discovered and developed such boons to humanity as vaccination for small pox, anesthesia and anti-sepsis in surgery, diphtheria and typhoid immunization, and other public-health measures such as the control of bubonic plague and cholera. Not every physician or surgeon is an interpreter in the sense we use the term; but those who take their professional opportunities with enthusiasm and earnestness and have the requisite native or acquired ability are interpreting the sciences of biology, chemistry, physiology, anatomy, and psychology to the vital benefit of their fellow-humans.

In the field of the social sciences the interpreters are found in the ranks of the college and university teachers, the social workers, the economists and political scientists in the services of the government, and in certain groups of the legal profession, especially among the judges. To mention only a few outstanding examples: in social work Jane Addams, sometimes called Chicago's greatest citizen, invented the American social settlement; and now nearly a thousand of these exceedingly useful institutions permeate our city life as wholesome influences. Mary E. Richmond, a pioneer in social case-work, was able to interpret sociology, economics, and psychology to thousands of young men and women who have become leaders in social-work activities.

Several hundred of our most able economists and political scientists, now in government service, are helping make practical, every-day applications of their facts and ideas accumulated through years of patient study and research. Even though much of their work may be experimental and more or less transitory in its effects, the fact remains that their services are indispensable and quite likely will be continued to an increasing degree.

Among the lawyers and judges who are able and effective interpreters of the law in terms of human welfare we may mention Judge Lindsey, who invented and developed the juvenile court, one of our most valuable legal and sociological institutions. Judges Holmes, Brandeis, Stone, and Cardozo of the United States Supreme Court are among the men who have given a social and human interpretation to the constitution rather than being sticklers for precedents and technicalities in constitutional interpretations.

Another valuable group of interpreters is found in our legislative bodies. Among our 48 state legislatures and our 531 members of Congress at Washington a considerable number of men have come forward with genuine contributions of skill and initiative in sensing the nature of some of our new and complex problems, and in framing laws and building public sentiment to support forward-looking legislation. It must be admitted that in dealing with complicated social problems we never can forecast the results with as great accuracy as the physicist can forecast the speed of falling bodies; but this complexity and uncertainty, always present in dealing with social problems, is not sufficient reason for attempting, in as intelligent a manner as we know, to use the knowledge we do possess rather than superstition, custom, or tradition to solve problems. All science is experimental, and social science doubly so.

Still another group of interpreters of great value to modern society is to be found among our administrators. In business, in politics and government, in education, in the church and elsewhere are large numbers of men who have developed a skill and technique in the handling of other men and in forming sound judgements quickly.

In business administration we have superintendents, managers, foremen, and other ranks. In a university are the president, deans, and heads of departments. In a government are the president or prime minister, cabinet members, and subordinate administrators. Men and women who have a genius for administrative work and enjoy it go toward the top. Those who can not stand the gaff of criticism or who have an inadequate understanding of human nature and of social trends are likely to fall by the wayside.

Real administrators are of tremendous value to society, financially and otherwise; witness the salaries paid and other concrete evidence. If they do their work from a social as well as a profit standpoint, it is only fair that society should pay them well; for they are. to an unusual degree, go betweens or interpreters in our complicated life. They must get things done and maintain reasonable peace and harmony between conflicting elements. They must, without becoming hypocrites, be "all things to all men."

In America today one of our most influential groups of interpreters comes from the journalistic profession. From the times of Horace Greeley and before, great editors have done splendid work in sensing the significant social situations and have used great skill, courage, and resourcefulness in interpreting political, economic, and other conditions and problems to their readers. Pulitzer, Medill, Watterson, Greely, Villard, Kent, and a host of others are in this group. Fortunately, so far, we have almost complete freedom of the press in the United States. Unfortunately we now seem to be running into a period when this cherished freedom may have substantial limitations placed upon it. In fighting for the maintenance of the largest possible degree of freedom of the press the journalists and publishers in a very real sense are fighting the people's battles; for a controlled press such as now prevails in Italy, Germany, Russia, and probably Japan would mean a tragic backward step for the intellectual and social welfare of our American people. Our schools and departments of journalism throughout the country are large factors in increasing the proportion of intelligent, socially-minded editors who look at their jobs not only as a profit-making business but also as a profession with public-welfare responsibility.

If investigators and interpreters are essential to social progress, how shall we increase their numbers? One way of finding and encouraging more of our potential investigators and interpreters is by constantly revising our processes of higher education, carefully experimenting with such projects as tutorial work, seminars, more expert and painstaking guidance of superior students, and by not organizing our educational processes primarily or only for the benefit of the average or below-average student. Our geneticists tell us that the effort and money expended upon students of higher abilities will bring more valuable results to society than equal amounts expended upon students of low-grade ability. All available evidence points strongly toward the soundness of this statement.

A more clear-cut distinction between the functions of teaching and those of research in our universities is another need to be met if we would discover and develop our investigators and interpreters. Many a potential investigator is forced to be a mediocre teacher; and some excellent teachers do inferior "research" work because they are led to believe that is the only way to academic recognition. The policies of Oberlin College in giving equal recognition to the research man of proved value and the teacher of proved value; and the proposed plan of President Hutchins to merge the University of Chicago and Northwestern University, making one a research institution and the other a teaching institution, are cases in point.

Another and a most fundamental prerequisite to be met if we would have more and better investigators and interpreters is the providing to a much larger degree of general economic security than exists hardly anywhere in the world today. Many personalities who have it in them to make large contributions to human knowledge and welfare now are paralyzed and discouraged in their efforts at training, and even if trained there is little outlet for their best talents. Unemployment, when on the large scale that exists today, throws a wet blanket on unnumbered thousands who in a more wholesome society, not a luxurious society, would delight in self-expression of great value to themselves and to humanity.

THE PRE-HELLENIC INHABITANTS OF GREECE AND ITALY

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WOULD IT NOT greatly interest historians, philosophers, and artists—the whole world, in fact—to know to what race belonged the admirable sculptors, sages, orators, military chiefs, and great politicians of ancient Greece?" asks Pittard.

"Yet we are quite in the dark about it. We can only guess, and of what value are guesses? We may well ask ourselves how it was possible that a question of such importance left those who went before us entirely indifferent. When we see what profit certain anthropo-sociologists would extract from ethnic characters, it cannot be unimportant to discover to what stock the Greeks of the great period may have belonged. We must not shrink from repeating that if such a discovery is now impossible the blame lies at the door of classical archaeologists. A part of their education needs beginning over again"(1).

Nothing, indeed, concerning any phase of the life of the ancient Greeks is so uncertain and debated as their racial type or types, and this, as Pittard says, is owing partly to the fault of older archaeologists who dug only for treasures, but in a greater measure to the paucity of definite statements from the literary sources, which, meager though they are, had not been collected and scrutinized up to 1924. The writer of this paper, however, at the suggestion of Professor W. A. Oldfather, gathered all the evidence available from the literary sources, art and archaeology, and nomenclature, and presented part of the results of his study in a doctoral dissertation, at the University of Illinois, in the spring of 1926. As he read the secondary sources, he was struck with the diversity of opinion among careful scholars, and it seemed to him it would not be out of place to collect this material and publish it as an appendix to his book. On further consideration it appeared better to present some of the most important opinions in this paper. As far as possible, the chronological order is observed, and the opinions will be given as nearly as possible in the words of their authors.

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1. Eugene Pittard, Race and History, translated by C. C. Collum, 295, (New York, Knopf. 1925). Much more has been done by way of skeletons and skulls, however, than Pittard would have us believe. Clon Stephanos to whose work I refer below (note 20) has gathered a great quantity of skulls, etc., in Athens and other places in Greece, Cf. Achilles Rose, Christian Greece and Living Greek, 278-279 (New York, Peri Hellados, 1898). A fuller treatment of the skulls and skeletons found in Crete and elsewhere will be given in the author's forthcoming book.

As might be expected, there is greater uniformity of opinion concerning the peoples of the pre-Hellenic Greece than of the Greece of the later times, though even with the earlier period a wide diversity will become readily apparent (2).

Knox, writing in 1862, is of opinion that "to the Scandinavian (3) blood the aboriginal hordes, whether European or Asiatic Greek or Italian, owed the occasional beauty of their complexion; that matchless hue which Homer compared to the colour of the elephantine bone, fresh from the turner (4)" This writer implies that the Aegean peoples were of a different race. Says he: "All traces of the Scandinavian and Celtic seem to have left Greece. The mingled Italian races, the product of many others, seem fast reverting to a primitive race, (5) which occupied Italy before Rome was founded."

Tylor classifies the pre-Hellenic peoples as dark-whites (6) and connects them with the Assyrians, Phoenicians, later Greeks, and Romans (7). Says he: "They have a dusky or brownish-white skin, black or deep-brown eyes, black hair, mostly wavy or curly, their skulls vary much in proportion though seldom extremely broad or narrow while the profile is upright, the nose straight or aquiline, the lips less full than in other races." (8).

Keane classes the "Pelasgians" with the "Hellenes" and makes both blonde: "They <sc. the Berbers> were not merely the allies but the kinsmen of those blue-eyed and light-haired peoples (Pelasgians, Teucrians, Hellenes, Itali, Etruscans), who in the time of Rameses II descended from the islands of the Mediterranean on lower Egypt, and who were expelled by Rameses' son and successor, Seth II of the 19th dynasty" (9).

Abbot thinks "there is no reason to suppose that the change from Pelasgians to Hellenes was brought about by the introduction of a new or alien element into the population" (10).

Sergi concludes that "as residence under the Equator has produced the red-brown and black coloration of the stock, and residence in the Mediterranean the brown colour, so Northern Europe has given origin to the white skin, blond hair, and blue or grey eyes" (11). He further believes (p. 166) that the Pelasgians were a Mediterranean branch of (167) African origin.

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2. The opinions on Homeric and Classical Greeks were presented in another paper before the American Philological Association at the meeting which was held in Iowa City, Dec. 1930.
3. Robert Knox, The Races of Men[2], 402 (London, Benshaw, 1862).
4. Compare Odyssey 18, 196.
5. Ibidem, 471.
6. Edward Tylor, Anthropology, 107 (N. Y., D' Appleton, 1893; really 1881.)
7. Ibidem, 108.
8. Ibidem, 109. See also 75 where he states that, "the dark-whites, Assyrians, Phoenicians, Persians, Greeks, Romans, did not start but carried on the forward movements of culture." Breasted, quoted below (note 61) agrees with Tylor and includes even the Egyptians.
9. A. H. Keane, Ethnology, 384 (Cambridge: At the University Press, 1896). M. Grant, The Passing of the Great Race[4] 159 (Scribners, 1924), speaks of the "little brunette Pelasgians."
10. E. Abbot, A History of Greece, I, 35, also 29 (London, Longmans and Green, 1901).
11. G. Sergi, The Mediterranean Race, 284, (N. Y. Scribners, 1901). Compare ibidem, 165-172. The problem of the cause of coloration is not so easy as Sergi would make us believe. But we cannot enter upon it here.

According to Ridgeway, "that the makers of the Mycenean civilization were a dark-complexioned people, is strongly attested by the legends. The great monuments of Mycenae, Tiryns and the Heraeum of Argolis all are associated with the dynasty of Danaus" (12). "A melanochrous race had dwelt in Greece from a remote antiquity . . . the ancient Pelasgians" (13).

Says Taylor: "The ethnology of Greece is obscure, but it is probable that the pre-Hellenic autochthones belonged to the Iberian race, and that the Hellenic invaders were of the same type as the Umbrians and Romans" (14). "The Iberian race was probably of dark complexion with black hair and eyes" (15).

"When the Achaeans came to Greece," Tucker thinks, "there was already and there had long been in possession a people of another stock, shorter, darker, less physically powerful—conveniently called 'Pelasgians'," (16).

"It is possible indeed," remarks Burrows, "that the name Phoenikes or 'Red Men' was first applied by the invading Greeks to all the brown-complexioned people among whom they came, and that was only later restricted to the Semites of Canaan" (17).

According to Kabbadias, "when for the first time there came to these lands peoples who broke off from some of the branches of the so-called Aryan or Iaptic or Indogermanic race, people, that is, Greek, they met in these lands other peoples who had settled there from antiquity. These were 'Eteocretans', Lycians, Carians, 'Leleges', 'Pelasgi,' etc. (845). According to the craniological studies that took place, these peoples that dwelt there in pre-historic time . . . were of somewhat shorter stature than the present Cretans, and were more dolichocephalous than the present Greeks and Cretans. These were of a reddish color such as perhaps were the inhabitants of Caria, Lycea and consequently, those of Crete."

Woodruff classifies the Aegean peoples as "Semites," adding: "The olive or brown types clustered around the Mediterranean have been grouped into a distinct non-Aryan branch (20) . . . Mediterranean or Neolithic type—what we have called Semites—men of short stature, long head, long oval refined face which does not have prominent cheek bones" (21).

"The islands of the Aegean," states Myres, "have been mainly peopled by members of the Mediterranean race, small of stature, with oval face and rath-

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12. Ridgeway, The Early Age of Greece, I, 284 (Cambridge University Press, 1901).
13. Ibidem, 683.
14. Isaac Taylor, The Origin of the Aryans³, 18 (London, Walter Scott, 1906).
15. Ibidem, 89.
16. T. G. Tucker, Life in Ancient Athens, 6 (Macmillan, 1906).
17. D. M. Burrows, The Discoveries in Crete, 141 (London, John Murray, 1907). P. Kabbadias, Proistorikḗ Achaeologia, 486, note 2, agrees with Burrows. Says he: "Originally it meant simply the land whose inhabitants were more red-faced 'Phoenikes' (Phoenicians) in contradistinction to the neighboring Greek peoples whose color was more white, etc. See also J. Bury, A History of Greece², 77, (Macmillan, 1924): "The Greeks knew these bronzed Semitic traders by the same name, Phoenikes, or 'Red Men', which they had before applied to the Cretans. This led to some confusion in their tradition." See also Wace, note 53.
18. Ibidem, 484, 485, 486.
19. Ibidem, 486, note 2.

er long head, small hands and feet, and brunette complexion, with dark eyes and black wavy hair" (22).

"It is in the North Africa," says Marrett, "that we must probably place the original hotbed of that Mediterranean race, slight and dark with oval heads and faces, who during the Neolithic period colonized the opposite side of the Mediterranean, and threw out a wing along the warm Atlantic coast as far north as Scotland, as well as Eastwards to the Upper Danube" (23).

Hall asserts that "the Mediterranean peoples have always been and are to this day more or less allied to each other racially. In reality the brunette Italian and Greek of today are racially far more closely related to the Palestinian and Egyptian than the Celt, the Slav, or the Teuton, although they speak and for 3,000 years past, have spoken the languages akin to those of their neighbors . . . (24). The Minoans were a brunette race resembling the modern Italians more than any other people, with ruddy skins, dark brown to black hair, and 'Caucasian' features" (25).

According to Beloch, the Eteocretans had "black hair" (26).

Meyer remarks: "Perhaps we have to do here with two different populations, the one ruling and the other the subjected one" (27). "The Busks also were dolichocephalous, and likewise, for example, the old Cretans" (28).

Speaking of the Aegeans, Powers states that "they were not Greeks in

20. The people that the "Achaeans" and Dorians found in Greece is thought by some to have been of "Aryan", and by others, of "Semitic" origin, terms antiquated now in the ethnological studies. Le Compte de Gobineau, Essai sur L'Inégalité des Races Humaines, vol. 2, 1, (Paris, Didot, 1884) says "The aboriginal Greece presents a population half Semitic, half aborigine." C. Stephanos, La Grece au point de vue natural, ethnique, etc., Dict. Encyclop. des Sciences Medicales, series 4, v. 10, 409 (Paris, 1884), disagrees with him. Says he: "According to the agreement of the data at our disposal, it is very probable that the tribes that went under name of Pelasgi were of Aryan origin." See also **ibidem**, 408. So does evidently Gladstone in his Studies on Homer in the Homeric Age, vol. 1, 151-153 (Oxford University Press, 1858). D. C. Hogarth, Philip and Alexander of Macedon, 5 (London, Murray, 1897), thinks the "Pelasgi" were "largely composed of that race to which the Bryges and many other European tribes pertained . . . whose final home is Phrygia. This race was Aryan, but in the eyes of the Hellenes, barbarian." H. Kiepert, Lehrbuch der Alten Geographie, 172-241 (Berlin, Reimer, 1897), calls them "Semitic," who immigrated into Greece. C. Thirwell, A History of Greece, vol. 1, 67 (N. Y., Harpers, 1845, in two large volumes), thinks that the Achaeans were originally no other than the ancient Pelasgic inhabitants of Phthia, and M. Duncker, Geschichte des Altertums[5], vol. 5, 18-19 (Leipzig, Duncker and Humbolt, 1881): "Dodona was accordingly at once the seat of the Pelasgians and the Hellenes." Paul Kretchmer, Glotta, 14(1925),308, considered the Pelasgians "the first Indo-Germanic immigrants who blended with the original (Urbevölkerung) Anatolian population." But this question will have to be treated more fully elsewhere.
21. E. E. Woodruff, Expansion of races, 325 (New York, Rebman, 1909).
22. J. L. Myres, The Dawn of History, 171 (N. Y. Hold, 1911).
23. R. R. Marrett, Anthropology, 104 (N. Y. Hold, 1911).
24. H. R. Hall, Ancient History of the Near East, 5 (London, Methuen, 1912). The same is found also in the sixth edition, 1924, page 5.
25. **Ibidem**, 51.
26. K. J. Beloch, Griechische Geschichte[2], vol. I, 75 (Strassburg, Trubner, 1912).
27. Edward Meyer, Geschichte des Altertums, vol. 1, 799 (Stuttgart and Berlin, Gottasche Buchhandlung, 1913).
28. **Ibidem**, 877.

complexion or build or temperament. They seem to have been dark-complexioned and short of stature, while the early Greeks were tall, blue-eyed, and fair" (28a).

"Among the ancient Minoans," says Dussaud, "dolichocephaly dominated without dispute; but the individual brachycephals perhaps, are not completely lacking (défaut) (29). Those characteristics (caractéres) brown skin, black wavy hair, dolichocephaly, short stature, permit us to compare the ancient Minoan to the Mediterranean race which survived, more or less mixed in some islands of western Mediterranean, and for that reason, are called today Ibero-insular" (30).

Ripley states that "Stephanus (31) asserts the Pelasgi to have been brachycephalic, while Zampa (32) as positively affirms the contrary view" (33). Peake thinks that this is because in the Cyclades the peoples were of a different race from that of the mainland: "All immigrants from this quarter < sc. Asia Minor> into Crete, even early in the Bronze Age, seem to have been of the Alpine type . . . Until the latter part of the Bronze Age the culture of the Aegean is markedly different from that of the Greek mainland. This difference in culture and the lack of communications between people who were near neighbors, seem to argue a difference of race. Until certain Cretan settlements were made in the Middle Minoan Period, the only inhabitants of the Balkan Peninsula were of the Alpine race. This is not strictly true of Thessaly and some parts of the North" (34).

Fimmen considers the type of the Keftiu in the Egyptian paintings as "unsemitic": "Forehead and nose profile are as a rule shown in straight line. The Keftiu are beardless and wear full hair, which frequently falls down in several braids over the shoulders. There are often reproduced a prominent forelock or several small locks on the hair of the head, a fact which makes them < sc. the Keftiu > particularly striking" (35).

Evans writes as follows: "The elder person with . . . (*ibidem*, note *a*) . . . his high brachycephalic head and aquiline nose seems as already observed, to represent the old Anatolian strain of Minoan Crete" (36). "The Minoan figures are tinted with a pale ochreous hue, but besides these are fragments of others of a more swarthy skin color, while the steatopygous rump, abdominal prominence and prognathism displayed by some of these are clearly

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28a. H. H. Powers, The Message of Greek Art, 12 (The Chautauqua Press, 1913).

29. R. Dussaud, Les Civilisations Prehelleniques dans le Basin de la Mer Egee[2], 446 (Paris, Genthner, 1914).

30. Ibidem, 447. Günther (see note 49 below) calls this race "the Western or Occidental race."

31. C. Stephanos, as cited above (note 20), 432. Stephanos himself says 11 years later, that he recognizes two types. See Comptes Rendus du Congress International D'Archaeologie, 225 (Athens, Greece, Hestia, 1905): "The other characters of the skull and of the rest of the skeleton lead us also to the conclusion that at the pre-Mycenean times of the Archipelago we are not in the presence of one and the same race.

32. I have no access to Zempa's work

33. W. Z. Ripley, The Races of Europe, note to 407.

34. H. Peake, "Racial Elements Concerned in the Siege of Troy." Journal of Royal Anthropological Institute, 45 (1916), 158. Compare also ibidem, 109.

35. D. Fimmen, Die kretsch-mykenische Kultur, 185, (Leipzig, Taeubner, 1921).

36. A Evans, The Palace of Minos, vol. I, 272 (London, Macmillan, 1922).

negroid. Another of the dark-skinned figures is seen in a grotesque attitude squatting like a frog. . ." (37). "It is possible, however, that we have here to do with members of some African race under negroid influence rather than with actual niggers. . ." (38), "a raven lock evidently belonging to the wearer of the jewel" (39).

Botsford comments that, "the Cretan's black hair fell over his shoulders in long curls" (40). "Women dressed their 'black hair' elaborately" (41).

In a more recent work Peake enlarges upon his former statement (42): "The original people of the Greek mainland like the bulk of the present population seem to have been of that Eastern Alpine or Dinaric type scarcely distinguishable from the bulk of the population of Asia Minor. These are tall, dark people, with small but broad heads which are very high and somewhat conical at the top, though sometimes the excessively flattened occiput gives the impression that the head has been sliced from the top of the forehead to the back of the neck. . . these were the only inhabitants of the bulk of the penisula until coastal settlements were made by the Cretans, some in the second Middle Minoan period. .. . The original inhabitants of Crete seem to have been typical members of the Mediterranean race but during the early Minoan times we find a few broad-headed people arriving in the east of the island and gradually spreading over the eastern half" (43).

Glotz, whose French edition appeared in 1923, writes as follows: "It seems to have been established by Sergi and his school that in the pre-historic times, before the arrival of the Indo-Europeans, there was in existence a Mediterranean race, with a long head, an oval face, short stature, dark skin and wavy black hair. In Europe the Iberians and the Egyptians belonged to this type (44). Asia Minor, on the other hand, was inhabited by a decidedly brachycephalic population. Were the Aegeans a branch of either of these or were they a cross between the two?" (45) More than a hundred skulls from Cretan sites have been available for measurement. A large majority are dolichocephalic . . ." (46). "The bulk of the Cretans were of Mediterranean stock. . . The revolution which was to bring to an end the Bronze Age and the Minoan civilization was preceded by a marked change in the population. There was a tremendous falling off in the number of long heads, the proportions being reduced from two-thirds to one-eighth, and a corresponding increase of short-heads and medium-heads. Such a change could be due only to one cause, an invasion of short-headed warriors. It marks the arrival of the Hellenes" (47).

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37. Ibidem, 310.
38. Ibidem, 312.
39. Ibidem, 526.
40. G. W. Botsford, Hellenic History, 14 (N. Y., Macmillan, 1922).
41. Ibidem, 14.
42. See note 34 above.
43. H. Peake, The Bronze Age and the Celtic World, 108 (London, Benn, 1922).
44. So does Breasted (see note 61 below) and Kroeber (see note 50 below).
45. G. Glotz, The Aegean Civilization[5], translated M. R. Dobie and E. M. Riley,[57] (N. Y., Universitaires de France, 1923).
46. Ibidem, 58.
47. Ibidem, 58-59. In the French edition, 75.

Günther thinks that in Greece as well as in Asia Minor, "an occidental civilization (westrassische Gesittung) ended with the invasion of the Nordic tribes. The occidental race has a brown skin which gives one the impression of suppleness often of velvetlike smoothness. In regard to color it < i. e. the hair > is dark, dark brown, or black."

Kroeber makes the Mediterranean race a branch of the Caucasian and connects the former with the Egyptians, Cretans, "and other Aegeans; the Semitic strain of the Babylonians; the Phoenicians and Hebrews; and a large element in the populations of classic Greece and Italy as well as the originators of Mohamedanism" (50). "The Minoans were a Caucasian people of Mediterranean race" (51).

Wace, after remarking that the Keftiu present bearers in the Egyptian tombs "have a considerable likeness, both in their appearance and in their style of the frescoes themselves, to the Cup Bearer of the Cnossus fresco" (52), states further on: "The Greek tradition of the prominence of 'Red Men' in prehistoric times in Greece and their introduction of the alphabet, and other signs of civilization, could be taken as a reference to Cretans" (53).

Green considers the peoples of the Minoan world as "small dark men" (54).

According to Dixon, "Greece appears to have had a more mixed population which comprised factors of both Proto-Australoid and Proto-Negroid types. Yet as early as the Iron Age the Alpine seems to have been in predominance as far south as Athens. That the Dorian Invasion brought into Greece a people primarily of this type seems very probable, although perhaps under leaders who were largely of Caspian type" (56).

De Morgan recognizes several strata among the pre-Hellenic population. After stating that in Crete and Cyprus the first inhabitants were Eneolithic and that they introduced the knowledge of copper" (57), he says further:

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48. H. F. R. Gunther, Rassengeschichte des deutschen Volkes[2], 387 Munchen, Lehmann, 1923). His latest edition (13th, 1928) is not accessible to me. He has treated the subject less fully in his book, The Racial Elements of European History, translated by G. C. Wheeler, 23-29; 152-172, of the later Greeks (N. Y. Dutton, no date but about 1926), and more fully in his Rassengeschichte des hellenischen and des rom. ischen Volkes (München, Lehmann, 1929).
49. Ibidem, 77. By "Occidental Race" Günther (25) means the "Mediterranean Race" Dussaud (see note 29 above) calls this race 'Iber-insular'. This last was Deniker's term. See Günther, 25.
50. A. L. Kroeber, Anthropology, 505-506 (N. Y. Harcourt Brace, 1923). See also note 17 and 61.
51. Ibidem, 457.
52. A. J. B. Wace, The Cambridge Ancient History, I, 176 (Cambridge: At the University Press, 1923).
53. Ibidem, 178. See also under Burrows and Kabbadias, notes 17-19.
54. A. W. C. Green, The Achievement of Greece, 24, 27, (Cambridge, Harvard University Press, 1923).
55. By "Caspian" type Dixon means the people who are dolichocephalic, hypsicephalic, leptorrhine. See 17 and 31. This type differs from the Alpine, whom he classifies as brachycephalic, hypsicephalic, leptorrhine, and the Mediterranean whom he classes as dolichocephalic, chamaecephalic, leptorrhine. Dixon takes the Caspians as blonde (317). He distinguishes eight fundamental types of mankind (21).
56. Ibidem, 35.
57. Jacques de Morgan, Prehistoric Man, translated by J. H. Paxton an[illegible] C. Cullum, 292 (Knopf, 1925; preface dated January, 1923).

"The earliest archeological evidence in our possession relating to these colonists < sc. the Enelithic > leads us to believe that they emigrated from continental Asia and not, as I myself thought, from Europe, and also that this migration took place in the course of the fourth millennium before our era. Then the Pelasgians appeared on the scene, bringing with them into this environment new conceptions foreign to Asia. While they occupied the Hellenic peninsula in Europe these tribes must also have advanced as far as the Asiatic islands and mainland among other highly evolved populations, which in no case can be confounded with the Pelasgic tribes. There was farther the progressive invasion by a new element known as the Aegean. Two physical types were in evidence from somewhere about the second millennium before our era: the one dolichocephalic—the earlier of the two—which had already furnished the Minoan civilization; the other and more recent, brachycephalic, which must have been the author of Mycenean culture, and was related to the tribes that in those times inhabited Thrace and the banks of the Danube. The colonists were not, properly speaking, Hellenes, but Thraco-Phrygians, closely related to the Greeks. From this stock came the Armenians, who, after having crossed the Bosporus, probably proceeded from west eastwards in a direction contrary to that taken by all other invasions, and who, towards the sixth century B. C., settled on the plateau of Erzerum and in the Ararat district." (58).

"In all the Mediterranean area," says Buxton, "there are indications that the aboriginal population was akin to the present Mediterranean race. The invaders from Asia changed the population at various times from Neolithic period onwards" (59).

Pittard states that "low stature and dolichocephaly characterize the primitive Cretan folk as they characterize the presentday population of part of the Mediterranean basin, notably of southern Italy" (60).

After speaking of the "dark-haired, long-headed" Mediterranean race, Breasted adds: "To this type belonged the Egyptians (notwithstanding their tanned skins), doubtless also the Semites and of course the great bulk of the population of Greece, Italy, and Spain, long lossely called 'Aryan' because of their speech which of course has no necessary connection with the race" (61).

Blegen distinguishes three strata, two of which were non-Indo-European. The first was the Mediterranean, from undatable beginnings to about 3000 B. C., the second, the Early Helladic(an Anatolian stratum which overran and absorbed the first (62). The Indo-European arrived in Greece at about 1900 B. C. for the first time. Says he: "These people were, of course, not yet Greeks as the term is understood in its later significance, but they undoubtedly formed the persistent basic stock" (63).

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58. Ibidem, 294.
59. L. H. Dudley Buxton, The Peoples of Asia, 87 (Knopf, 1925).
60. Eugene Pittard, as cited above, 301. See also Kabbadias, above.
61. J. H. Breasted, The Conquest of Civilization, 113 (Harpers, 1926).
62. Carl W. Blegan, American Journal of Archaeology 27 (1923), 157. Mary H. Swindler, Ancient Painting, 94 (Yale Press, 1929), summarizes his views.
63. Idem, A. J. A. 32 (1928), 154. See Jean Charbonneaux, L' Art Egeen, 5 (Paris-Bruxelles, Van Oert, 1929). The Indo-Europeans, according to him, entered Greece ca. 2000 B. C., Crete ca. 1450 B. C. This subject cannot be discussed here.

Günther would have the Nordic race start from the middle of Europe in the Neolithic period. "But the Hellenes were not the first waves of people of the Nordic race which had arrived in Greece. Kretchmer (64) has shown that one could distinguish in Greece three strata of population: (1) one stratum that was non-Indo-Germanic, (2) the Prot-Indo-Germanic, which coincides with the Minoan or Cretan civilization, (3) the Indo-Germanic, which was founded through the Hellenes who migrated there" (65).

Swindler considers the civilization of the mainland in the Helladic I as essentially Cretan and non-Greek" (66).

Summing up now, we see that nearly all the writers quoted take the pre-Greeks to have been dark, mostly short, of the Mediterranean race. These are Tylor, Sergi, Ridgeway, Taylor, Tucker, Burrows, Kabbadias, Woodruff, Myres, Marrett, Hall, Beloch, Powers, Dussaud, Evans, Botsford, Peake, (tall, eastern Alpine or Dinaric for Greece proper), and Swindler. Knox is indefinite as to color; so are Abbott, Hogarth, Thirwall, and Kiepert. But probably the writers that think pre-Greeks Semites take them as brunettes.

Keane thinks of the Pelasgians and the Etruscans as blonds. Hogarth and Breasted consider them Aryan (the last as dark); Gobineau, Kiepert, and Woodruff as Semitic; Fimmen, un-Semitic; Thiewall, Dunker, and Abbot think the Pelasgians to have been the same as the Achaeans. To Stephanos the Pelasgians were brachycephalic; to Zampa dolichocephalic.

Meyer recognizes two strata, one ruling, the other ruled.. Stephanos, Dussaud, and Glotz find two types of skull—long and short; Peake, with small but broad heads. Kroeber makes the Mediterranean race a branch of the Caucasian, Breasted of the Aryan race. Ripley thinks that the Greek mainland was Alpine, Crete, Mediterranean. Peake likewise distinguishes an Eastern Alpine or Dinaric type for Greece, and a Mediterranean for Crete.

Evans sees an Anatolian strain (brachycephalic), an African, and a Mediterranean strain. Dixon thinks that Greece had a Proto-Australoid and a Proto-Negroid element, also (later) an Alpine and a Caspian element. De Morgan recognizes the Aeneolithic stratum (from Asia Minor); the Pelasgic (from Europe); and the Aegean, the last of two types: one dolichacephalic, the earlier of the two; the second was brachycephalic and was closely related to the Greeks. Buxton takes the original population to have been akin to the present Mediterranean race and that it was changed by the invasion of a people from Asia beginning with the Neolithic period. Glotz sees a Mediterranean people which changed with the arrival of the Greeks. Sergi takes the Greeks to have been of Mediterranean strain. Günther would bring the Nordic element to Greece in the Neolithic period. Kretchmer distinguishes three strata, one non-Indo-European, one prot-Indo-European, and one Indo-European. Blegen distinguishes three strata, the first two of which were non-Indo-European.

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64. Paul Kretchmer, "Die protindogermanische Schicht", Glotta 14 (1925), 319.
65. H. F. K. Günther, Rassengeschichte des hellenischen und des römischen Volkes, 11 München, Lehmann, 1929).
66. Opera citata, 95.

It would take us beyond the scope of this paper to discuss and criticize these views. They will be discussed elsewhere. It will be seen at a glance that most of these opinions, especially the earlier ones, are based on entirely insufficient evidence. Suffice it to say here that, judging from the monuments so far as color is concerned, nowhere in pre-historic Greece until about 1500 B. C. (67) have there been found blue eyes and blond hair, but on the contrary dark hair and brown skin and eyes. The skin of the women, however, is represented as somewhat lighter (68), to distinguish them from men, but that does not indicate racial distinction, and is mostly conventional and owing partly to the sheltered life of the women (69).

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67. R. H. Richardson, Greek Sculpture, 36 (American Book Co. 1911), speaking of the ivory statuette of the bull-leaper found in Crete, which had copper wire with gold foil for hair, takes it to represent fair complexion: "The youth was blond like Achilles." J. L. Myers, Who Were the Greeks? 198-199 (University of California Press, 1930), takes this and other ivory statuettes as fair, and includes also the Snake Goddess in the Boston Museum. According to him these intended to represent "yellow or (at most) reddish hair." Sir Arthur Evans, A. B. S. A., viii (1902), 72 does not seem to take them for blondes. Evans tells us that even the loin cloth was made of thin gold plate. Miss G. M. A. Richer, Handbook of the Classical Collection, 21 (1903), who mentions the holes in the head of the statue mentioned by Richardson, does not take it to represent a blonde type. I do not think it represents a blonde type, but the evidence from the ivories with parallels from those of other peoples, and also from the chryselephantine statues, will be discussed fully in my book.

68. See G. Glotz, as cited above, 60: "Minoan painters always represented their men with bronzed complexions, their women with white skins." See also G. Glasgow, The Minoans, 35, (London, Jonathan Cape, 1923); Mary H. Swindler, as cited 83, 84, 89, 135. This custom is thought to have been acquired by the Greeks from the Egyptians. See Glotz, 306; Swindler, 136; J. Charbonneaux, L'Art Egéen 17 (Paris, G. Van Aest, 1929).

69. H. R. Hall, Aegean Archaeology, 190 (London, Warner. 1915), speaking of the Chariot Drivers in a Tiryns fresco (fig. 74 of his; 175 of Swindler's), suggests that the white persons are men who have led a sheltered life. But his suggestion is not accepted by Swindler, 100, and Richter, 42, who take them to be women. This problem will be treated fully elsewhere with parallels from paintings of other nations, particlarly the Egyptians and the later Greeks. Even in the early Greek pottery, e. g. from Daphne in Egypt (Swindler, 128), we have white for the flesh of women and brown for that of men.

The same convention applies to the epithet Leucolenos of Homer, which the writer of this paper has treated in his doctoral dissertation, 13, note 5, where references may be found. See also Buxton, as cited, 24, note 1, for a remarkable artificial bleeching done by the women of the Gilbert Islands a few months before their marriage, by means of avoiding light and of rubbing their skins with cocoa-nut juice and massaging them. But of course they do not become blonde, yet they become "pale with the dark paleness of some Spanish lady."

WHAT IS INTELLIGENCE?

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THE PURPOSE of this discussion is threefold: (1) to comment briefly upon some of the current conceptions as to what intelligence is; (2) to offer in the form of a suggestion certain rather definite levels of intelligence; and (3) to arouse further discussion as to a more logical and understandable use and meaning of the term intelligence.

In a survey of the Index of Psychological Abstracts for December, 1920, McFadden found that the subject of *intelligence* ranked fourth in the number of citations, being outnumbered only by: (1) the child, (2) education, (3) tests. It seems therefore that there has been considerable importance attached to this phase of mental life, and also that it merits much further study and research.

The definitions given for the term intelligence are both great in number and varied in meaning. I shall confine my discussion to only a very few of the more prominent factors found in these definitions. Probably the most common one found in the vast array is that of *capacity for adaption to novel situations.* Another definition is *mode of behavior.* It is also defined as both *level of mental development* and *capacity for mental development.* Others define it as *acquired knowledge.*

Capacity for adaptation seems very inadequate, since there are no established criteria for adequate adaptation. The lowest forms of animal life apparently adapt themselves adequately to their simple environment. Man makes at least a fairly adequate adjustment to his more complex environment. Yet no one is willing to admit that these lower animals have the same intelligence as man.

Adaptation is not an adequate criterion of intelligence from also another viewpoint if we are to accept the results of intelligence tests, as for instance many criminals and even patients in hospitals for mental diseases make high scores, and yet society classifies them as maladjusted. Even restricting the meaning of the word intelligence to conscious processes does not fully span the gap unless we hold, as some do, that those classified by society as maladjusted are not normally conscious, and are not able to make the finer discriminations as to conduct and, therefore, are not accountable for their behavior. This might be relatively easy in case of the mentally diseased, but most certainly it would not apply to certain classes of criminals. Therefore it seems that the *capacity for adaptation to environment* is not at all satisfactory unless there be established rather definite levels for different types of animals and also for the various environmental classes of society; and unless there be set up a specific standard as to what constitutes adequate adjustment within each level, and then whenever the term intelligence is used, the level under discussion should be mentioned or clearly implied. But this would lead to unlimited confusion not only in the realm of the lower animals, but also in the human race, for although we like to think that "all men are created free and equal," nevertheless we find a great variety of environmental levels among the different peoples of the world, and adequate adjustment in one level is very different from adequate adjustment in another.

Then there is the definition that intelligence is *acquired knowledge*. But under it how shall we classify the illiterate who has had little or no opportunity to acquire knowledge, but who may have a potential capacity for development equal or superior to some who have had opportunity to acquire knowledge? For example, the type of people whom Mrs. Cora Stewart Wilson found in her well-known "Moon-Light Schools" of Kentucky. Miss Stewart, as she was then known, found that the illiteracy was due not so much to lack of intelligence in the sense in which the term generally is understood as to lack of opportunity to obtain knowledge. Surely the criterion of *acquired knowledge* or, perhaps, the lack of acquired knowledge would not be a fair index in measuring the intelligence of this type of people. It is accepted generally that training and superior education improve one's score in intelligence tests, even in those non-language or performance tests that are intended to measure innate intelligence regardless of education and environment, but a distinction should be made between intelligence and acquired knowledge or training. Of course if this specific meaning were to be applied to the word to the exclusion of all other implications, it would clarify the situation, but although acquired knowledge may be a means of measuring intelligence, it is confusing to make it synonymous with intelligence.

Confusion of the meeting of intelligence arises also when it is used synonymously with mental age at one time and with I. Q. at another: i. e., we sometimes refer to intelligence as a level of development, as when the intelligence of the child is compared with that of the adult in terms of age levels or mental age. At other times it is referred to as a level of potentiality or capacity to develop, as when we speak of a child three years of age having an I. Q. of 120, and since we say that the I. Q. is relatively constant, that same child will have approximately the same I. Q. when he is sixteen years old. Although it may be understood rather generally that mental age represents the actual degree of mental development as compared with the normal adult, while I. Q. merely represents the rate of development, there is confusion nevertheless in the use of the two terms.

Capacity to learn seems to be the most logical definition from two standpoints: first, this ability to learn apparently increases from the lowest forms of animal life to the adult human being; second, from the practical standpoint the use of the word in school, industry, and in all survival relations seems to infer either directly or indirectly the individual's ability to make new associations.

As a matter of procedure followed in practically all our intelligence testing, whether it be in the public schools, in the colleges and universities, in psychological clinics, or in industry, it is very largely a testing of informational content or, in other words, a testing of what has been learned, rather than any attempt to seek out any innate characteristics independent of and isolated from training. It is true, at least in the public schools and in higher institutions of learning, that we are testing only those who have had an opportunity to obtain knowledge; and as said before, acquired knowledge, where there has been ample opportunity to learn, is itself a fairly good index of one's intelligence.

By these examples I merely wish to emphasize that there is sufficient confusion as to the meaning of the term intelligence to render it quite meaningless, not only to those who have not been trained specifically in this field, but also to those who claim a more or less scientific knowledge of the subject. Spearman after discussing some uses made of the term says: "The reason is now evident enough why all search for the meaning of 'intelligence' has, even with the greatest of modern psychologists, always ended in failure. It is simply that, in point of fact, this word in its ordinary present-day usage *does not possess any definite meaning.* It can be readily made to comprise, no doubt, anything that was classically attributed to the 'intellect.' But commonly it is stretched to an undetermined distance further downward. Neither its utterers nor its hearers appear to have behind it any clear idea whatever."

Although capacity to learn is, after all, the very thing in which we are most vitally concerned in practical, everyday life, and more especially in education, a further analysis and knowledge of this capacity as the material with which we have to work undoubtedly would modify greatly and facilitate the present methods in education and training. Spearman further states that "it is certainly strange . . . that tests of a cognitive power could not be devised any better for first settling what sort of power is required to be tested."

Any definition involving the idea of capacity, whether it be a capacity for learning, for adjustment to novel situations, to carry on abstract thinking, or for mental development implies that there is something that has capacity. To say that intelligence is a mode of behavior implies that there is something that behaves. But what is it that behaves or causes certain behavior in one situation and a different kind of behavior under different conditions? Hobbes of the British Imperial School first postulated mind as a function of the body, but behavior is an abstraction that does not exist in isolation. As Dockeray states, "the individual and his mind cannot be separated."

It is not my purpose here to inject into this discussion the problem of mind and what it is, but it seems to me that as long as we talk about intelligence, we are implying intellect as a faculty very much as did the faculty psychologists, perhaps not quite to the extent that they held each faculty separate and more or less independent of the others, but nevertheless there seems to be some such implication in the use of the term. In fact, we are apparently not far from the idea held by Aquinas in the thirteenth century, that intelligence is the exercise of the faculty, intellect. It has been thought generally that faculty psychology had been abandoned, but is there not grave danger that we may be bordering upon merely a substitution of the word intelligence for what was formerly thought of in intellect? It may be and probably is true that intelligence emphasizes the exercise of the intellect almost, if not quite, to the exclusion of any thought of the faculty as such, but it certainly implies the existence of a faculty to be exercised. Dockeray states further that "when the naturalist says that nest building is an instinct, he has, perhaps, classified this behavior sufficiently for his purpose, but when the student of psychology uses the term, we must ask him what he means." In other words, where the psychologist stops with the descriptive term intelligence as though it were the final step or the last word in explanation, there is just the place where he really should begin to explore.

The point which I am trying to make is that we probably have not gone far enough in one direction or have gone too far in the wrong direction in attempting to analyze intelligence. The various descriptive terms such as intelligence, memory attention, imagination, and many others serve well in popular discussions, but they are merely descriptive and refer "to some aspect or artificial classification of the process of organic" or mental adjustment to a situation.

In this respect the behaviorists have made an earnest attempt to define and explain the nature of intelligence, even though their explanation by no means is accepted universally. All psychologists are not willing to accept quite such an extreme mechanistic point of view that intelligence is merely a mode of behavior resulting from a stimulus-response type of reaction, and yet it is taken for granted in our tests that sensitivity, speed, and accuracy are criteria of intelligence.

"The recent work of cytologists and experimental geneticists is certainly such as to strengthen our faith in mechanism, and at the same time it reveals a delicacy of organization that raises in our minds a caution against a too ready acceptance of a grossly materialistic mechaism. The laws of life must be found in life, not in mechanism."*

I accept many of the mechanistic principles of adjustment in both man and lower animals, but this "delicacy of organization" is again just the place where research should begin instead of letting the problem pass as solved merely by using the descriptive term intelligence as the last word.

Woodworth factetiously quotes as follows: "First psychology lost its soul, then it lost its mind, then it lost consciousness; it still has behavior, of a kind." And now, I may add, there seems to be considerable doubt as to its retaining its behavior.

I shall not attempt here an analysis of what constitutes intelligence except to suggest a division into rather broadly-defined levels, beginning with the very genesis of the lowest forms of animal life and continuing up to the highest forms of mental life as found in man. Bergson postulates two levels when he states that intelligence and instinct "represent two divergent solutions, equally fitting, of one and the same problem . . . while instinct and inteligence both involve knowledge, this knowledge is rather *acted* and unconscious in the case of instinct, *thought* and conscious in the case of intelligence. But it is a difference rather of degree than of kind." Kirkpatrick postulates four types of intelligence; viz., physiological, sensory-motor, representative, and conceptual. I shall refer later to three of these.

My thesis here differs little from Bergson's except that I wish to emphasize a little more that intelligence begins with the lowest forms of animal life. Each successive stage after the first, in general, superimposes upon but is not independent of the lower levels. Theoretically, all above the first have a beginning in the lowest level, although in a very rudimentary degree.

I am suggesting seven rather distinct levels of development, the first of which I shall call the*generative* stage as it applies to the very genesis or inception of a new life from the preceding generation before it begins to take on a new or definite form in the embryonic state.

*Peterson.

The second is the *organizing* level as it applies to the growth and developmental processes throughout the animal kingdom including man. This level is very similar to what Kirkpatrick calls *physiological intelligence.* Kirkpatrick explains his point of view as follows: "Physiological intelligence is shown especially in nutritive and growth process. At first thought it seems incongruous to speak of physiological processes as intelligent. When, however, we view intelligence in an entirely objective way as the adaptation of*means to ends,* we find good reason for looking upon physiological processes as highly intelligent.

"As a builder, physiological intelligence is not surpassed by the greatest mechanic or architect. A tree with its beauty and strength may well compare with any structure planned by an architect, and the human body as a machine is far superior to any as yet constructed by man. The engineer who tears down an old bridge and erects a new one while trains are running over it has performed a remarkable feat, but not so great as that performed by physiological intelligence in directing the processes of growth in which a large number of complex organs are torn down, built up, and increased in size without any interference whatever with their activities or the harmony of their working. Discriminative and selective activity, which chooses from the various substances introduced into the body just the right elements for the building of each organ, is certainly comparable in accuracy to the perceptive judgment of the human builder."

I have quoted Kirkpatrick to emphasize the statement that at least an important difference between the intelligence of man and the reaction of lower animals is one of degree rather than of kind.

The third level is the *tropistic* and is probably the beginning of what technically may be termed true "behavior" in the sense of responses to stimuli or other forms of motivated reaction. It applies to those forms of behavior characteristic of animals not possessing nerve tissue or a nervous system.

The fourth stage is the *reflexive* level. It applies to the types of response that obtain by means of nerve tissue or a nervous system, and differs from the tropistic chiefly in the promptness and complexity of the reaction rather than in its fundamental nature. It functions chiefly in the regulatory processes of the body, directing the organic and defensive reactions. This is practically the same as that designated by Kirkpatrick as the *sensory-motor* type of intelligence.

The fifth level is termed *instinctive*, which is so often difficult to differentiate from the so-called pure intelligence as found in man. It is observed more obviously in its pure form in some insects and higher vertebrates. We accept the criticism in part, at least, that some of the behavior of lower animals may be explained by other means than that of rational intelligence, but it is nevertheless a form of intelligence, the difference being quantitative rather than qualitative. There has been so much controversial discussion over this point that I shall not attempt to discuss it further here.

The sixth level is that of *habituated intelligence.* In nature of the reactions this is very much like the preceding. The chief difference usually given is that instinctive behavior is innate, and habituated behavior is acquired. In everyday life they are very similiar and practically indistinguishable; however, instinctive behavior generally is considered more deeply-seated.

Rational intelligence is the seventh or last level and is virtually the same as that which Kirkpatrick defines as "conceptual intelligence"; it "includes what is usually described in psychology as thinking processes, such as abstraction, generalization, conception, judgment, and reasoning . . . it functions by means of past experience instead of present stimulations . . . It involves a finer analysis of situations and a separation of elements, not only from any particular situation, but from any combination in which they have been experiencd. It involves a re-grouping of elements, not as they are found grouped in objects and situations, but according to similarities and in relations by which purposes may be served."

Reflex and instinct as modes of behavior, as they are popularly conceived, are therefore manifestations of rather definite levels of intelligence.

As said before, these different levels are cumulative, and each includes all the preceding levels: i. e., rational intelligence includes all the other six levels.

In summarizing, I have tried to point out (1) that the term intelligence has so many different applications that it has become almost meaningless, (2) that further research should be made in order to analyze and know more about the thing we are attempting to train and develop. In other words, the point where we leave off by using the descriptive term, intelligence, is just the point where we should begin to explore and attempt to find a more scientific definition and explanation as to its nature; (3) a suggested classification of the various levels of intelligence as folows: (1) generative, (2) organizing, (3) tropistic, (4) reflexive, (5) instinctive, (6) habituated, (7) rational.

THE TEACHING OF BIOLOGY IN THE FIRST-CLASS HIGH SCHOOLS OF WEST VIRGINIA

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THE BIOLOGICAL SCIENCES have been taught in North America for more than a hundred years. They found their way into the curriculum of the better equipped academies as early as 1800 through the teaching of botany. It was not until 1825 that zoology first was taught in these institutions. These courses were poorly arranged, and laboratory work was unheard of.

Several texts in anatomy and physiology changed the emphasis from natural history and classification to problems of morphology and internal anatomy. This appeared as early as 1870. About 1890 the laboratory study of types appeared. This soon was supplanted by a study of the physiology of plants and animals.

The period from 1910-1920 is known as the Period of Correlation and Application of Biology. In this period biological principles were applied to the betterment of mankind. The trend was toward the unification of biologic principles, but no text appeared in this decade that unified these principles.

With the publication in 1926 of H. C. Morrison's "The Practice of Teaching in the Secondary Schools" came a new concept of the term unit. This was the beginning of a renaissance in the teaching of biology. Biology, which formerly had been considered merely a study of individual organisms, their structure, habits, and adaptations, now found itself a study of processes and principles to which all living things reacted and of how these organisms reacted to them.

Not only biology but many courses in our curriculum have felt this stimulus, this impulse to vitalize themselves, to adapt themselves to this changing world. At the present time a committee of state-wide educators, appointed by the State Department of Education, are revising the State Course of Study for schools from elementary to senior high school. The course of study for biology will be revised. Many counties at the present are working out complete courses of study in biology.

The question arises: what is the status of the teaching of biology in the West Virginia high schools as compared with that of other high schools of the country?

It was with this in mind that the author made a survey, of which this paper is a report of the findings. The purpose was to determine the actual conditions and practices existing with reference to the teaching of biology in the first-class high schools of West Virginia.

The data were collected through an extensive questionnaire sent to the biology teachers of 210 white, first-class, 3, 4, and 6-year high schools in the state. Replies were received from 99 high schools or 47%. As the questionnaire was extensive it can be assumed that those replying represent a cross section of the best of West Virginia biology teachers.

The study was divided into four phases; the preparation of the teachers, the teaching load, methodology, and the teachers' professional interests.

Preparation: The majority of the teachers had taught more than 5 years; 18% had taught 1 or 2 years, while only 2.2% had taught more than 20 years. The mean number of years of teaching experience was 7.2 years. Although only 6.7% of the teachers were teaching for their first year, 18.3% were teaching biology for the first time. Thus the mean number of years of teaching experience in biology was 5 years. Forty-one percent of the teachers had taught biology since they had started teaching.

Only 4 kinds of degrees were held by the teachers. Sixty-six percent held Bachelor of Arts degrees while 34% held Bachelor of Science degrees. Of the 38 B. S. degrees 8 were B. S. in Agriculture, 5 were B. S. in Home Economics, and 4 were B. S. in Education. Five held Bachelor degrees in both Arts and Science.

Twenty-six of the teachers held masters' degrees. The majority of these were Master of Science and 32% of these were teaching in the larger high schools (enrollments 401-up). Thirty-two colleges and universities are represented by the biology teachers, of which 13 are located within the state. West Virginia University has conferred 33 ⅓% of all the degrees held.

A considerable number indicated that they were working on advanced degrees, although it was not asked for on the questionnaire. If we assume that several teachers had graduate work but made no note of it, then a large majority of the teachers are taking such advanced work. Twenty-one percent of those holding masters' degrees were women. However, only 23.3% of the biology teachers in the state reporting were women, so that the percentage holding masters' degrees is about the same.

Exactly 50% of the teachers have selected biology as their first teaching field, while the others indicated it as their second field.

Teaching loads: 48 different types of teaching combinations were found that ranged from the teaching of biology solely, as was found to be the case in 19% of the schools, to the teaching of 5 widely separated subjects, as was found in 6.9% of the schools. Biology with chemistry and biology with general science were the two most common combinations. Other biological subjects taught were botany, physiology, and hygiene.

Thirty-one percent of the teachers taught 3 different subjects. A very small group taught 5 different subjects, while 19% taught only one subject.

The schools were put into 3 groups according to their enrollment: Group I, schools with an enrollment up to 150; Group II, schools with an enrollment of 151-400; Group III, schools with an enrollment of from 401 upward. In Group I, the mean number of teaching combinations or preparations was 3.9, in Group II it was 3.04, and in Group III it was 1.92. In Group I 54.5% of the teachers were either administrators or coaches. In Group II 35.8% were also coaches or administrators, which in Group III only 8% were coaches or administrators.

The majority of the schools had 60-minute periods. A few had 50-minute periods and one school had only 40-minute periods.

A teacher frequently finds it necessary to teach subjects other than those in which he is primarily interested and despite efforts on the part of the State Department to limit teaching to only those fields in which the individual is well qualified, and a teacher frequently is called upon to teach subjects in which he is poorly qualified. In *Teachers' Training Bulletin No. 7*, published by the State Board of Education (4), a teacher's certificate in biology should contain, in addition to 59 hours of general requirements, 24 semester hours of biology, 6-8 hours of chemistry, and a specified number of hours in other teaching fields such as agriculture, home economics, mathematics, physical education, and general science. Twenty-seven percent of the teachers were teaching subjects that were not listed as subjects related to biology teaching.

The majority of the teachers taught 5 classes and had no other duties other than their co-curricular activities.

Thirteen percent of the teachers had no co-curricular activities. Of these 27.2% were administrators, 9% coaches, 9% teaching 6 classes, and the remaining 54.8% made no mention of other work.

Forty-three percent of the teachers were sponsors or advisors of one activity, 33.7% sponsored 2 activities, and 10.3% were sponsors of 3 activities.

The activity listed by the greatest number of teachers was that of class advisor. It was represented by 34% of those engaging in one or more activities. Fifteen percent of the teachers sponsored science clubs. A majority listed athletics and physical education, but as most of these teachers were engaged as coaches or physical education instructors, this was not considered co-curricular for them. Some of the more widely distributed clubs were dramatics, Future Farmers of America, and nature study. Twenty-nine distinct co-curricular activities were listed. *Methodology*: The stress placed upon the different methods of teaching was considered an important factor. In order to determine this a method was selected that had been used by Hunter (3). The teachers were asked to indicate by figures 1, 2, 3, etc., up to 8, the emphasis being placed upon the following methods: textbook, reference and reports, individual laboratory, demonstration, discussion, field work, projects, and other methods. These figures then were reversed so that a method that had been given a rating of one was counted as 8 and so on down to one. The total for each method as compared with the grand total for all the methods gave the following percentages:

Discussions	18.2%
Textbook	17.5
Individual laboratory	13.8
Reference and reports	13.7
Demonstration	11.5
Field work	11.1
Projects	9.7
Other methods	4.5

Other methods included lecture, oral reports, and conferences.

Sixty-one percent of the teachers followed a single text. Some of these teachers supplemented this with other texts. Sixteen percent of the teachers used many texts. These were following one workbook or study plan that was flexible enough to use for a wide range of texts. Several of the teachers admitted having no study plan, but the majority of the teachers either were following a well-established course of study or were working on a course of study in biology for their school.

Those teachers who indicated their plan of work followed the plan of dividing their course up into a study of plants, animals, and the human body. Of those schools using a single text, 61% used texts built around a study of plants, animals, and man, while 39% followed a text that approached biology from the standpoint of function and principles and not facts about individual organisms.

The most widely used text was the New General Biology by Smallwood, Reveley, and Bailey. It was used in more schools than all other texts combined. Eleven texts were listed.

An attempt was made to determine the relative emphasis placed upon the different types of laboratory work. More than 70% of the teachers combine individual laboratory with demonstration. A few confined their laboratory entirely to demonstration, while 10% had individual laboratory. Those using only demonstration explained this fact by the lack of equipment in their school. One teacher stated that he had no laboratory work at all.

Twenty-four percent of the teachers had all their laboratory separate from their class work. The majority of these had 2 regular periods each week, although a few had only one.

Professional interests. An attempt was made to determine the type and extent of outside reading related to biology that was done by biology teachers.

The majority read far more scientific magazines regularly than they did occasionally. Four and seven-tenths percent of the teachers admitted that they read none. These were teachers from small schools where they had several subject preparations and consequently lacked time for much outside reading. One teacher stated that he read 15 periodicals regularly. The mean number of magazines read regularly was 1.69. The most widely-read were Popular Science, Nature Magazine, The National Geographic, and School Science and Mathematics. Twenty-eight journals and scientific magazines were listed.

The majority of teachers were members of one or more scientific or professional societies. Thirteen percent belonged to none at all; 45.3% belonged to the S. E. A. and 21.3% to the State Academy of Science. 10 teachers listed membership in the N. E. A. Approximately 24 societies were represented.

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THE ABILITY OF COLLEGE STUDENTS TO EVALUATE

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ON A PREVIOUS OCCASION the writer presented the results of an experiment conducted upon 818 college students in an attempt to discover the extent to which they might be permitted to grade their own work. In the study reported[1] he showed that when the instructors' grades were used as the criteria, which for traditional reasons seemed fair, he found that "of the total number of pupils participating, 58 percent agreed in the marks which they assigned with the instructors' rating: 38 percent disagreed by one letter; 3 percent by two letters; and a few by as many as three letters."[2] The better students tended to under-rate themselves slightly while the poorer ones over-rated themselves badly as was shown by "the fact that the instructor gave 440 percent as many F's as his students, 517 percent as many D's, 80 percent as many C's, 74 percent as many B's, and 191 percent as many A's."[2] He stated at that time that it seemed "doubtful if college students can be expected to arrive by their own reasoning at evaluations of their own work that would approach satisfactory agreement with the instructors' evaluations."[2] The question then was raised, "Is this only another way of saying that teachers' marks are unreliable?"

To answer this question the following experiment was conducted. In this case an intensive study of a limited sampling of (312) cases was used rather that an extensive statistical study of a large number. It was hoped to find the reasons why students failed to evaluate correctly. In this connection it seems well to caution against a common fallacy found among investigators who are prone to give a tendency a name and then at a later time prove the tendency by the name which had been applied to it. To illustrate we call the tendency gravity which causes things to move towards the center of the earth. Later when asked why the Ohio river flows towards the Mississippi, we say in true Q. E. D. fashion that this is caused by gravity. In like manner we posit a term "intelligence," meaning one's ability to do certain rational things in high or low order, and then say that poor students underrated themselves because of intelligence when in reality their low status as college students may be due to their inability to evaluate their work. They do not, really, know when they are good or bad. They are unable to see the quality in the articles read. In short, inability to evaluate explains their scholarship status.

In this experiment the criterion for grouping will be the average grade given by the instructors at Marshall College for the cases studied during the nine-week period under investigation. This eliminates the question of the reliability of my grading and at the same time avoids the error indicated above which might be present if "intelligence" were used.

[1]W. Va. Acad. of Sci., Fairmont, May 5-6, 1933.

[2]Woods, R. C. 1934. Can college students grade their own work? Jour. Higher Ed., 5:274-5.

A given unit of work was selected in each class studied, and three tests were designated covering the same work, as follows: a multiple-choice test was designed so as to include only items of memory level; a true and false test was used which covered both memory and thought items; and the third test was a best answer test designed to measure thought as opposed to memory. All three tests were timed sharply, and the best answer and multiple choice were conducted in such a manner that after the allotted time was up an additional 50 percent was allowed. The possible score was the same in both best-answer and multiple choice tests. This proved ample to study the question of the time factor. As in the previous experiment I carefully evaluated the work of the students before the experiment and then asked each one to evaluate his own work. In addition to the statements of the catalogue concerning grade meanings I spent two days explaining to them the criteria for good work in my courses, redefining the grades into meaningful descriptions to aid them in making their estimates, without intimating the ultimate use to be made of these estimates.

The following tables indicate the results obtained:

TABLE 1—*Evaluating the estimated grades*

Group	My estimate correlated with				Their estimate correlated		
	True false	Best answer	Multiple choice	Their	True false	Best answer	Multiple choice
Upper third	.94±.008	.89±.014	.87±.016	.82±.022	.73±.031	.72±.032	.85±.018
Middle third	.93±.009	.88±.015	.85±.018	.46±.052	.51±.049	.46±.052	.58±.044
Lower third	.96±.006	.91±.011	.86±.017	.35±.058	—.12±.065	—.13±.066	.38±.055

N=104

TABLE 2—*Comparisons of the tests*

Group	B. A. T. F.	M. C. T. F.	B. A. M. C.	N=104
U	.92±.001	.89±.014	.91±.011	
M	.71±.033	.73±.031	.72±.032	
L	.88±.015	.90±.013	.89±.014	

TABLE 3—*Increasing time fifty percent. Effect on their estimates*

	Best answer		Multiple Choice		
	Sharp limits	Extended	Sharp	Extended	N=104
M	.72±.032	.78±.026	.85±.018	.87±.016	
U	46±.05	.50±.017	.58±.044	.61±.042	
L	—.13±.066	.10±.065	.38±.055	.40±.056	

TABLE 4—*Effect of increasing time on test scores*

Test	Sharp limits		Extended	
	Mean	Sigma	Mean	Sigma
Best answer	10.23±.16	2.44±.016	11.47±.14	2.15±.014
Multiple choice	10.79±.11	1.67±.01	11.78±.11	1.60±.01

N=312

TABLE 5—*Classification in college (medians were used)*

Test	Group I	Group II	Group III
	Soph N 132	Juniors Seniors N 120	Soph N 60
B.. A. Sharp	10.5	11.2	10.9
B. A. Extended	10.8	10.3	10.9
M. C. Sharp	11.5	11.9	12.8
M. C. Extended	11.8	12.1	13.9

Conclusions which seem justified from these .data based upon the 312 cases studied are:

1. The poorer students tend to over-rate themselves, which is another way of saying they under-evaluate quality. This was shown not only in my estimates but in their own estimates when compared with tests designed to show memory versus thought functions (Table 1).

2. That the tests were fairly valid criteria was shown by their inter-correlation (Table 2).

3. Time apparently played a minor part, if any, since increasing the time 50 percent affected but slightly the correlation coefficients, means, and sigmas (Table 3, 4).

4. Classification in college had no effect except to raise the medians in each group studied in approximately the same ratio (Table 5).

5. Poorer students' estimates seemed better when memory was involved and poorest in reasoning. In short they evaluate their work by the quantity they remember, not the quality (Table 1).

6. Since this tendency is less pronounced among better students we may conclude that inability to see quality is the basic reason for poor pupils being poor and good pupils being better.

7. In theory at least the college instructor seeks ability to do with material rather than memory of material. Hence one must conclude again that "it is extremely doubtful in the face of this study if college students can be expected to arrive by their own reasoning at evaluations of their own work" and that the thing which makes this true is probably the underlying reason why they are poor. They cannot evaluate. They do not know when they are clear on the meaning of the material studied. They accumulate but do not evaluate.

THE RELATION OF INTELLIGENCE QUOTIENTS TO COLLEGE GRADES

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THIS PAPER is a report and an interpretation of a study of the relation of intelligence quotients to college grades in the case of 127 freshmen who entered West Virginia Wesleyan College last autumn. The intelligence quotients of the class, determined by the Advanced Otis Group Intelligence Scale, range from 159 to 57 and conform very closely to the normal curve of distribution. The median is 118, the mean 115, with a S. D. of 21. Forty-one I. Q's were above 130, with 14 above 140; 27 were below 100, with 7 below 80.

These students earned during the first semester, 1934-1935, 100 A-grades, 230 B-grades, 291 C-grades, 95 D-grades, 28 E-grades, and 21 F-grades. These grades obviously do not approximate the conventional 7-23-40-23-7 distribution. They constitute roughly a 13-30-38-13-6 distribution. Perhaps our freshmen were given too many A-grades and B-grades. But departure from the conventional ratio of distribution does not prove the point. I quote President Conant of Harvard in his latest report to the Board of Overseers: "In last year's graduating class 37 percent of the candidates for the bachelor's degree were successful in achieving honors . . . Under ideal conditions we should hope to graduate all those admitted"[1]. Clearly Harvard grades must represent a still more extreme degree of concentration on the higher levels than do ours. To return to our statistics: individual semester averages range from 91 to 60; the mean is 77, with a S. D. of 7.22.

What relation exists between these I. Q's and semester-grade averages? They show a positive correlation of 0.51, with a P. E. of 0.045. This is a marked but not a high degree of positive relationship.

The following table represents the relation in terms of distribution of semester-grade averages between those above the average I. Q. of 115 and those below it. Here the relation of high intelligence to high grades, and of lower intelligence to lower grades, is obvious. The upper half monopolizes the A-averages, has three-fourths of the B-averages, and only one-ninth of the D-averages.

TABLE 1— *Average semester grades in upper and lower halves of group*

Group	90-100	80-89	70-79	60-69
Upper half I. Q. range 159-116 I. Q. average 132	6	32	24	2
Lower half I. Q. range 114-57 I. Q. average 97	0	11	36	16

Table 2, presenting an analysis of semester grades made in individual courses, points to the same conclusion. Here it is apparent that the number of

[1]See p. 314 for ft. note 1.

TABLE 2—*Semester grades in individual courses*

Group	A	B	C	D	E	F	Group Average
Higest quarter I. Q. range 159-138 I. Q. average 139	48	85	54	9	1	2	83
Next to highest quarter I. Q. range 131-118 I. Q. average 125	26	66	69	17	4	2	79
Next to lowest quarter I. Q. range 118-103 I. Q. average 109	13	52	84	29	8	8	72
Lowest quarter I. Q. range 103-57 I. Q. average 86	13	27	84	40	15	9	69

A-grades and B-grades diminishes sharply with decreasing intelligence, while the number of D-grades, conditions (E), and failures (F) increases sharply with decreasing intelligence. In the highest quarter there are four times as many A's as D's, E's, and F's taken together. In the lowest quarter there are less than one-fifth as many A's as D's, E's, and F's taken together. The highest quarter has more A's than the lower half and more B's than the lower half, while the lowest quarter has more D's than the upper half, three times as many E's as the upper half, and more than twice as many F's as the upper half. The average grade in percentage for the highest quarter is 83; for the next to the highest, 79; for the next to the lowest, 72; and for the lowest, 69. Clearly these I. Q's and college grades tend to rise or fall together.

On the other hand there are numerous striking exceptions to this tendency of I. Q's and semester grades to be high or low together, as follows: Two pupils has a common I. Q. of 141; the semester average of the one was 90, and of the other 77. Two others have a common I. Q. of 126; the semester average of one was 81, and of the other 63. Two others have a common I. Q. of 118; the semester average of one was 85, and of the other 66. Two others have a common I. Q. of 95; the semester average of one was 86, and of the other 61.

Some further exceptions: Six students have an average semester grade of 90 or 91; their I. Q's are 151, 151, 144, 141, 125, and 123. Two others have a common semester average of 82; the I. Q. of one is 150, and of the other 84. Two others have a common semester average of 76; the I. Q. of one is 148, and of the other 78. Two others have a common semester average of 72; the I. Q. of one is 123, and of the other 61. Of course this low I. Q., based on one test only, may not be reliable. If it is reliable it indicates only a student of the tortoise type, incapable of brilliant bursts of speed under the stop-watch, but unusually industrious and persistent. A final example: A student with a semester average of 80 has an I. Q. of 65, the lowest in the whole group except two. Another student has a semester average of 81 and an I. Q. of 159, the highest in the whole group. In other words, two pupils 94 points apart in ability are but one point apart in achievement.

One final exception: The group studied contained 63 men and 64 women. The average I. Q. for the men was 114.98, and for women 114.85. The women carried 399 courses, and the men 372. Despite their heavier schedule, the women surpassed the men in achievement, as shown in Table 3.

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