DETERMINATION OF THE REASONABLE OR PERMISSIBLE MARGIN OF ERROR IN DISPENSING. V. LIQUIDS.*

BY MARVIN J. ANDREWS.[1]

INTRODUCTION.

In the first paper of this series, it was stated that the different types of prescriptions which the pharmacist is ordinarily called upon to fill may be divided, roughly, into two groups, namely, liquids and solids. The four papers presented to date deal only with the more frequently encountered types of the latter, *viz.:* Powders and Capsules (1); Ointments (2); Suppositories (3); and Pills (4). This, the fifth paper of the series, deals with Liquids.

Liquids called for on prescriptions are usually measured, the volume in most cases, being determined by using either a cylindrical or conical graduate. The possibilities for error in measuring a definite volume of a liquid are greater in number than is commonly held. Fortunately, most of them may be ignored as the error involved is too small to be of practical significance. In fact, only three need be considered for the purpose of this study. They are believed to be, in the order of their importance: (1) the nature of the liquid to be measured, (2) the shape and size of the graduate used, and (3) the personal equation. To determine to what extent each of these factors is responsible for the total deviation from the standard, the studies reported in this paper were undertaken.

EXPERIMENTAL PART.

For the purpose of the study reported in this paper, two series of tests were made. The object of the first was to determine the relationship, if any, between the size and shape of the graduate used and the magnitude of the observed error in the measurement of definite volumes. The object of the second was to determine to what extent the magnitude of error was effected by certain physical properties of liquids, such as color, viscosity, etc.

In the actual performance of these tests, the liquids were measured in both cylindrical and conical graduates by 100 members of the senior class in dispensing pharmacy at the School of Pharmacy of the University of Maryland. In each case the liquid was poured from a quart bottle into the graduate, held in the hand of the dispenser, then transferred to a prescription bottle. The contents of the bottle were again transferred to a tared container and accurately weighed on a chainomatic balance. The temperature of the liquids in both series of tests ranged from 22° C. to 25° C.

Each dispenser was assigned a definite number so the variation in the work of any individual could be followed throughout both series. The weight of all measurements is reported.

SERIES I.

In the first series of tests definite volumes of distilled water were measured by the dispenser in 10-, 25-, 50- and 100-cc. cylindrical and conical graduates.

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[1] In collaboration with A. G. DuMez, Professor of Pharmacy, School of Pharmacy, University of Maryland.

The results of the first series of tests are presented in Table I.

TABLE I.—EFFECT OF SIZE AND SHAPE OF GRADUATE ON MEASUREMENT OF DEFINITE VOLUMES OF LIQUID.

Dispenser	10 Cc.		25 Cc.		50 Cc.		100 Cc.	
Number.	Cyl.	Con.	Cyl.	Con.	Cyl.	Con.	Cyl.	Con.
1.	9.579	9.555	24.653	24.510	49.457	48.285	98.283	98.052
2.	9.647	9.860	24.615	23.957	49.801	48.653	98.048	99.242
3.	9.855	9.718	24.812	24.474	49.593	48.890	98.439	98.917
4.	9.653	9.410	23.622	25.231	49.417	47.836	96.715	96.637
5.	9.528	9.523	24.550	24.219	50.208	46.385	99.313	98.319
6.	9.729	9.798	24.742	24.354	49.659	46.385	98.902	97.343
7.	9.343	9.948	24.961	24.856	49.835	48.689	98.002	101.368
8.	9.373	9.529	23.444	24.745	49.140	47.379	97.815	93.970
9.	9.691	10.004	24.995	24.501	49.789	50.147	99.046	100.590
10.	9.227	9.182	24.287	22.919	48.841	47.253	97.673	98.600
11.	9.718	9.778	24.716	23.710	50.022	46.766	98.745	95.200
12.	9.455	9.586	24.383	23.721	48.842	48.948	97.804	96.911
13.	9.517	9.584	25.626	24.328	50.023	49.023	98.705	96.561
14.	9.700	9.459	24.704	22.910	49.400	48.177	98.942	93.812
15.	9.401	9.965	24.170	24.462	50.081	49.300	98.773	98.995
16.	9.717	9.632	24.336	23.848	48.964	48.553	98.478	99.201
17.	9.487	9.620	24.340	23.339	48.787	47.335	97.637	100.009
18.	9.674	9.792	24.535	24.669	49.484	50.331	98.548	99.264
19.	9.660	9.533	24.829	25.110	49.333	49.842	99.523	100.424
20.	9.561	9.944	24.170	25.135	50.170	50.036	98.753	99.740
21.	9.475	9.768	23.844	24.729	49.047	49.475	98.534	98.856
22.	9.130	9.484	24.500	24.481	49.312	49.553	97.866	96.409
23.	9.617	9.838	24.765	24.610	50.024	49.784	98.741	98.443
24.	9.617	9.951	24.905	24.604	49.131	49.362	98.400	98.777
25.	9.844	9.600	24.177	23.843	49.152	47.778	97.963	97.034
26.	8.985	8.748	24.418	23.986	49.015	47.681	98.212	94.765
27.	9.620	10.000	24.936	23.584	47.962	47.351	98.311	95.958
28.	9.231	9.145	24.060	23.642	47.910	48.739	97.456	95.683
29.	9.515	9.664	24.830	23.274	49.927	50.154	97.603	98.490
30.	9.600	9.810	24.775	24.476	49.727	49.469	98.353	100.326
31.	9.258	9.081	21.951	24.130	49.154	49.673	98.389	99.169
32.	9.572	9.354	24.655	23.406	49.746	48.444	95.119	95.420
33.	9.661	9.779	24.686	24.867	49.978	50.067	98.871	100.131
34.	9.522	9.843	23.980	23.851	49.537	48.623	98.605	99.491
35.	9.355	9.681	24.880	24.296	48.877	50.013	97.450	96.529
36.	9.284	9.377	24.556	24.252	48.741	48.459	98.537	96.729
37.	9.636	9.417	24.302	23.104	49.365	47.971	100.021	97.117
38.	9.654	9.568	24.445	24.829	50.472	49.367	98.440	98.608
39.	9.385	9.577	24.246	24.476	49.500	51.393	98.250	97.262
40.	9.540	9.601	23.355	24.021	46.653	49.337	97.403	98.365
41.	9.505	9.250	24.542	24.161	48.670	49.170	98.262	96.100
42.	9.476	9.408	23.986	23.359	48.353	47.907	97.661	97.286
43.	9.537	9.454	24.441	23.058	49.400	49.000	98.444	95.646
44.	9.832	9.705	24.920	24.470	49.521	49.221	98.540	96.049
45.	9.349	9.753	24.674	24.247	49.751	49.911	98.623	98.312
46.	9.337	9.337	24.500	21.000	49.298	45.857	97.865	98.800
47.	9.208	9.263	24.620	23.809	47.842	49.876	98.601	93.335
48.	9.567	9.202	24.362	24.107	48.875	49.205	97.904	96.937
49.	9.588	9.571	24.304	23.119	49.344	49.308	98.341	94.980
50.	9.235	9.772	22.684	25.102	49.928	49.272	97.600	96.069

51.	9.604	9.004	24.352	22.985	49.055	47.230	98.974	96.120
52.	9.515	10.209	25.003	24.107	49.653	48.348	98.210	99.056
53.	9.476	9.606	24.448	23.504	49.764	49.676	98.479	98.191
54.	9.510	9.842	24.608	24.445	49.744	49.228	98.461	97.565
55.	9.817	10.075	25.416	23.201	49.194	49.006	97.981	97.134
56.	9.601	9.348	24.376	23.210	49.341	48.258	98.003	99.001
57.	9.556	9.406	24.431	23.613	48.353	47.633	98.242	99.705
58.	8.943	9.468	24.347	24.782	49.971	47.843	97.970	98.831
59.	9.638	9.550	24.391	23.562	47.342	48.668	98.003	96.674
60.	9.660	10.301	24.239	23.504	49.396	47.962	98.966	97.748
61.	9.949	9.671	23.998	24.200	47.902	49.941	98.827	97.990
62.	9.777	9.864	24.539	23.121	50.155	48.261	97.050	97.957
63.	9.682	9.038	24.952	24.452	50.065	49.724	98.937	100.421
64.	9.452	9.262	23.641	23.490	49.078	48.531	97.730	100.348
65.	9.708	9.702	24.601	23.556	49.762	49.783	98.551	95.742
66.	9.678	9.910	24.640	24.228	48.741	49.190	98.320	99.311
67.	9.523	9.790	24.503	23.727	49.622	50.169	98.882	98.009
68.	9.501	9.164	24.107	22.746	49.104	47.386	98.816	98.612
69.	9.938	9.726	24.955	24.945	49.940	50.860	99.830	97.723
70.	9.573	9.587	24.872	24.900	49.590	48.976	97.631	96.867
71.	9.912	9.716	24.182	22.911	47.654	49.829	98.506	99.004
72.	9.721	9.543	24.748	22.733	47.820	46.303	98.209	94.402
73.	9.357	9.543	23.126	24.283	47.124	49.100	94.564	98.696
74.	9.453	9.712	24.389	21.795	49.281	48.472	98.872	97.838
75.	9.588	9.739	24.941	24.481	49.502	49.777	98.768	97.594
76.	9.485	9.229	24.633	23.268	49.239	50.036	98.002	98.753
77.	9.483	10.035	24.913	24.076	49.046	48.921	98.470	99.126
78.	9.732	9.451	24.105	24.929	49.835	46.891	98.422	96.770
79.	9.462	9.383	24.314	23.709	49.876	49.834	98.104	98.163
80.	9.589	9.678	24.483	23.771	49.186	49.260	98.683	96.768
81.	9.733	10.028	25.007	23.928	49.644	48.386	99.172	97.804
82.	9.740	9.681	24.510	23.674	48.765	50.984	98.644	99.433
83.	9.667	9.760	24.590	24.184	49.776	47.566	98.238	95.723
84.	9.629	9.630	24.710	24.740	49.386	49.937	98.636	100.388
85.	9.819	10.151	24.814	24.281	49.663	48.447	98.907	100.233
86.	9.637	9.469	24.933	24.912	49.763	48.885	96.876	99.423
87.	9.369	9.365	24.799	24.043	48.065	50.226	97.986	98.149
88.	9.637	9.722	24.988	24.341	48.382	47.635	97.380	97.932
89.	9.466	9.691	24.905	24.307	48.363	45.516	98.780	101.177
90.	9.506	9.512	24.292	24.178	49.374	49.783	98.389	99.905
91.	9.650	9.108	24.777	23.876	48.350	47.031	98.704	94.353
92.	9.991	9.104	24.835	24.202	49.601	47.561	96.550	99.961
93.	9.596	10.228	24.669	24.525	49.128	50.146	98.722	99.547
94.	9.623	9.349	24.763	24.892	49.104	49.582	98.315	97.081
95.	10.651	9.876	24.339	23.653	50.102	46.783	97.014	101.900
96.	9.484	9.806	24.341	24.256	50.653	47.343	98.333	99.502
97.	9.292	9.402	24.349	23.406	49.876	51.437	98.136	96.332
98.	9.154	9.135	24.687	23.778	49.783	48.106	98.268	98.030
99.	9.724	9.630	24.678	24.040	49.386	48.462	98.336	96.668
100.	9.203	9.973	25.067	24.103	49.336	47.286	97.643	94.192
Av. Wt.	9.561	9.606	24.481	23.994	49.258	48.758	98.240	97.881
S. D.*	0.224	0.290	0.503	0.708	0.727	1.203	0.767	1.802
% D[1]	2.34%	3.11%	2.05%	2.95%	1.48%	2.47%	0.78%	1.84%

* Standard Deviation expressed in grams.

[1] Percentage Deviation based on average weight.

The tabulated data given in Table I shows there is an error due to the size and shape of the graduate. The magnitude of error is considerably greater when a conical graduate is used than when a cylindrical graduate is used. With respect to size just the opposite is true, the larger the graduate and the larger the volume measured the smaller the per cent of error. For instance in the measurement of 10 cc. of distilled water in a cylindrical graduate the average error based on the standard deviation amounted to 2.34%. When a 10-cc. conical graduate was used it amounted to 3.11%. That the magnitude of the error is greater when the smaller graduate was used than when the larger graduate was used is shown when the volume measured was 100 cc., and a 100-cc. graduate was used in making the measurements, the average error amounted to only 0.78% in the case of the cylindrical graduate and 1.84% in the case of the conical graduate.

The error due to the personal equation is naturally indefinite. In fact, it was found to be impractical to attempt to measure it separately. The error is revealed by a definite trend in a series of measurements made by an individual rather than by the observation made on a single measurement. For example, in the series of measurements made by dispenser number 1 it will be observed that a majority of the measurements here were high when compared with the average, while those of dispenser number 10 were below the average.

No effort was made to determine what the personal equation was in these cases so that an accurate statement cannot be made concerning its nature. In some cases it may have been the result of defective vision, in others it may have been due to natural carelessness, in other instances it may have been due to using the upper meniscus at times and at other times the lower meniscus for making measurements, or to some other trait of the individual making the measurements.

The results presented in Table I are summarized in Table II, which follows. This table shows the actual number of measurements falling within the standard deviation and multiples thereof. Furthermore, the table shows the per cent of measurements falling within any one group, since the total number of measurements made in each case was exactly 100.

TABLE II.—SUMMARY OF RESULTS PRESENTED IN TABLE I.

Liquid to Be Measured.	Volume Measured in Cc.	Shape of Graduate Used.	Average Weight in Gm.	Standard Deviation in Gm.	Number of Measurements Falling within 1 × S. D.	2 × S. D.	3 × S. D.	4 × S. D. or Over.
Distilled Water	10	Cyl.	9.561	0.224	78	19	2	1
Distilled Water	10	Con.	9.606	0.290	70	25	5	0
Distilled Water	25	Cyl.	24.481	0.503	85	9	4	2
Distilled Water	25	Con.	23.994	0.708	68	30	0	2
Distilled Water	50	Cyl.	49.258	0.727	74	22	3	1
Distilled Water	50	Con.	48.758	1.203	69	26	5	0
Distilled Water	100	Cyl.	98.240	0.767	83	12	3	2
Distilled Water	100	Con.	97.881	1.802	67	28	5	0

The second series of tests was conducted to determine the effect of certain physical properties of liquids on the measurement of a definite volume. With this object in view the following liquids were selected:

(1) Elixir of Iron, Quinine and Strychnine, N. F., as a green colored liquid; (2) Syrup, U. S. P., as a viscous clear liquid; (3) Milk of Magnesia, U. S. P., as an opaque liquid; and (4) Castor Oil, U. S. P., as an oily liquid.

To obtain comparative data, the same cylindrical and conical graduates used in measuring the 100 cc. of Distilled Water in the first series of tests, were used in this series. The results of the second series of tests are given in Table III.

TABLE III.—EFFECT OF CERTAIN PHYSICAL PROPERTIES OF LIQUIDS ON THE MAGNITUDE OF ERROR.

Elixer I. Q. S. Cyl.	Elixer I. Q. S. Con.	Syrup. Cyl.	Syrup. Con.	Milk of Magnesia. Cyl.	Milk of Magnesia. Con.	Castor Oil. Cyl.	Castor Oil. Con.	Dispenser Number.
103.912	105.721	126.239	130.634	94.277	95.533	81.218	94.358	1.
104.616	105.169	125.316	128.371	101.501	93.585	90.491	87.204	2.
104.352	103.355	118.564	129.030	93.607	92.510	89.362	84.856	3.
104.251	104.403	123.108	126.035	94.705	101.491	89.300	82.680	4.
104.318	106.825	125.292	126.832	97.774	99.214	85.930	90.081	5.
103.256	101.860	122.514	129.866	94.000	93.933	84.333	84.352	6.
104.318	100.819	126.471	122.857	98.027	89.337	86.222	93.861	7.
101.712	101.838	124.300	124.772	92.631	88.506	89.515	85.641	8.
104.643	103.834	125.084	129.579	93.107	99.102	89.801	87.405	9.
103.953	100.100	126.656	120.159	93.239	88.941	89.086	80.474	10.
104.229	101.246	124.049	123.073	95.097	100.287	92.100	87.673	11.
104.054	102.125	125.450	122.511	90.924	90.785	91.311	84.130	12.
104.375	105.640	127.315	128.417	99.762	100.747	86.416	87.381	13.
103.088	100.714	125.833	127.586	92.725	93.730	84.803	86.960	14.
104.122	103.030	124.522	130.190	91.873	93.310	88.876	82.388	15.
104.451	105.937	125.141	130.632	91.260	92.836	91.340	92.253	16.
103.743	102.488	123.965	123.376	93.453	94.687	87.587	90.040	17.
104.442	104.002	121.520	126.646	97.266	96.361	86.889	91.420	18.
104.882	107.639	124.420	127.288	99.424	94.666	85.829	86.264	19.
104.455	107.165	124.510	133.900	93.595	101.015	90.888	88.206	20.
103.505	106.843	121.258	123.896	92.909	91.051	89.712	89.914	21.
104.383	103.567	127.533	129.635	95.747	96.066	91.535	90.416	22.
104.417	107.950	128.727	132.664	98.576	96.087	89.151	89.097	23.
103.758	103.323	124.188	132.217	92.377	93.932	95.985	97.780	24.
103.455	98.961	125.296	121.748	94.776	94.764	91.856	89.042	25.
101.128	103.885	124.703	128.611	92.271	96.410	81.262	84.076	26.
104.200	105.251	124.510	129.791	93.438	97.810	80.374	89.891	27.
103.290	101.965	125.746	123.473	93.091	91.271	87.200	85.853	28.
102.850	103.075	124.602	125.312	94.425	95.168	83.950	82.057	29.
104.991	103.581	122.672	132.161	98.744	100.002	84.442	85.214	30.
102.492	104.034	120.040	125.252	92.776	91.035	85.150	83.727	31.
103.902	102.730	123.021	125.508	90.431	93.059	82.224	79.224	32.
104.053	101.387	127.582	134.551	93.784	93.823	88.900	88.389	33.
104.392	102.056	127.613	126.704	97.487	98.066	93.470	84.637	34.
103.792	103.585	124.763	125.242	93.981	91.906	87.990	88.673	35.
104.267	108.794	123.323	127.172	93.381	92.345	77.756	78.931	36.
103.580	103.600	122.779	124.210	92.234	96.937	78.873	74.778	37.
106.219	103.783	124.039	129.918	94.546	98.823	82.670	84.768	38.
104.002	104.135	121.910	127.921	96.919	93.900	81.307	86.300	39.
104.379	105.932	123.700	125.678	94.222	98.302	91.318	81.351	40.
103.973	104.077	120.211	120.660	95.040	90.997	90.588	83.593	41.
103.472	104.082	124.862	123.270	97.088	92.449	78.413	99.688	42.
103.874	98.793	123.566	126.066	94.700	94.738	87.579	87.730	43.
104.048	103.592	124.363	128.529	92.859	93.882	88.885	81.158	44.
103.728	103.366	123.234	127.907	93.537	100.837	83.584	82.365	45.
103.920	102.187	121.090	122.183	92.327	90.486	86.873	83.277	46.
104.056	102.192	127.164	125.773	91.200	91.680	88.609	83.551	47.
103.881	105.031	124.634	127.411	93.643	94.768	87.549	79.439	48.
101.942	105.649	123.814	127.059	94.200	94.830	86.533	81.672	49.
100.130	104.144	125.064	125.902	97.102	91.874	87.589	97.041	50.

104.220	100.849	127.508	125.815	92.304	95.114	92.705	86.443	51.
104.221	105.980	126.184	131.553	94.949	96.272	88.733	86.021	52.
104.251	98.261	125.672	134.053	96.126	99.537	87.221	94.999	53.
105.263	106.625	123.988	127.516	101.291	93.279	88.736	95.194	54.
104.257	103.140	120.802	123.582	96.449	95.500	86.825	86.491	55.
104.013	106.221	121.343	125.064	94.508	97.651	88.382	80.959	56.
106.003	104.612	122.952	129.540	89.383	94.970	87.486	91.723	57.
104.583	104.248	127.944	125.593	98.427	96.228	90.490	88.451	58.
103.788	107.811	125.285	125.868	92.978	94.715	94.942	89.894	59.
102.384	104.025	117.325	124.333	91.980	94.233	84.364	87.272	60.
102.681	99.258	123.321	125.324	88.832	89.121	91.836	84.651	61.
103.377	107.395	126.056	132.802	94.200	97.115	87.321	89.336	62.
106.615	104.880	126.326	130.639	95.236	94.993	87.749	93.265	63.
105.527	104.623	120.935	125.761	100.304	94.160	83.647	88.772	64.
103.265	101.985	122.343	122.693	96.382	99.416	89.280	85.191	65.
103.527	99.563	124.384	122.876	91.104	96.403	91.630	84.180	66.
104.051	106.786	124.678	130.639	94.507	93.300	85.676	81.684	67.
105.357	106.001	125.565	123.774	99.909	94.948	96.776	87.603	68.
103.902	103.663	124.621	126.795	93.430	93.915	85.690	87.116	69.
104.778	105.370	125.859	129.509	99.742	95.432	83.529	84.965	70.
103.690	102.844	125.231	122.525	95.461	94.111	87.325	79.603	71.
103.672	100.578	118.993	121.108	93.729	90.062	96.146	97.798	72.
104.872	104.530	124.484	125.028	93.606	96.050	84.382	88.743	73.
105.477	103.923	123.120	123.579	93.428	94.127	87.175	86.262	74.
104.452	104.038	122.561	128.706	96.711	96.045	84.589	91.220	75.
104.005	105.483	126.936	122.363	95.369	98.710	91.365	94.323	76.
103.714	104.935	125.758	133.774	94.805	94.350	92.787	81.604	77.
104.162	105.057	125.101	127.424	98.728	94.779	86.487	89.463	78.
103.610	101.683	126.802	123.945	93.347	97.996	86.170	81.147	79.
103.334	101.810	126.740	123.543	95.250	95.584	91.765	88.502	80.
104.536	104.403	124.763	129.183	98.730	94.618	96.881	81.361	81.
105.631	103.457	120.999	125.440	95.672	97.335	88.461	87.732	82.
104.727	100.157	123.364	127.942	95.661	92.308	85.395	95.156	83.
105.006	104.987	127.376	129.519	96.100	94.585	95.601	82.397	84.
103.679	105.343	124.122	124.110	100.375	101.652	88.649	88.760	85.
105.104	106.424	123.428	124.300	94.899	99.031	85.031	87.515	86.
105.643	103.707	121.417	127.986	93.390	98.470	88.463	74.383	87.
104.325	100.955	122.765	125.045	95.588	94.613	87.637	91.687	88.
103.762	100.040	125.502	127.800	95.347	92.327	88.473	89.579	89.
103.624	105.794	118.640	121.091	93.493	97.000	85.368	84.652	90.
104.133	106.505	124.335	130.632	94.240	101.964	88.912	89.571	91.
104.876	105.122	126.255	129.312	96.400	101.782	87.251	90.784	92.
103.272	103.505	123.035	129.669	96.662	100.734	91.328	96.646	93.
104.018	106.061	128.643	126.387	97.483	95.602	88.151	99.648	94.
104.051	99.018	125.340	128.006	94.307	94.328	85.337	87.934	95.
104.688	104.350	129.288	125.665	95.670	99.775	81.565	84.572	96.
103.672	104.531	129.780	129.822	92.445	91.839	86.861	75.121	97.
103.676	98.521	122.793	120.471	90.347	90.370	80.845	85.813	98.
103.395	103.320	122.176	127.747	93.527	95.846	94.033	86.527	99.
104.783	107.346	120.760	121.229	100.674	95.201	86.130	86.941	100.
104.049	103.752	124.298	126.753	94.895	95.254	87.742	87.017	Av. Wt.
0.926	2.329	2.368	3.333	2.644	3.151	3.938	5.087	S. D.*
0.89%	2.24%	1.91%	2.63%	2.79%	3.31%	4.49%	5.85%	% D.[1]

* Standard Deviation expressed in grams.

[1] Percentage Deviation based on average weight.

The foregoing tabulation shows that errors are made in measurement and therefore the deviation from the standard is affected by the nature of the liquid measured. The magnitude of the error observed was in the following order: Distilled Water, Elixir of Iron, Quinine and Strychnine, Syrup, Milk of Magnesia and Castor Oil. The physical properties responsible for the great part were found to be color and viscosity.

The data presented in Table III reveal that color in a liquid has a tendency to increase the magnitude in error made in measurement, for example: the average error for 100 cc. of Distilled Water measured in a cylindrical graduate is 0.78%, while that of the green-colored liquid, Elixir of Iron, Quinine and Strychnine is 0.89%.

A similar effect was observed with respect to viscosity. In the case of Distilled Water the average error was 0.78% as previously stated, whereas the average error found in the measurement of Syrup was 1.91%, and for Castor Oil was 4.49%.

The large error in the case of Castor Oil is no doubt due to the fact that the refractive index of Castor Oil is so near that of glass that the adherence of the oil to the sides of the graduate is not detected and not sufficient time is allowed by the dispenser for complete drainage.

Milk of Magnesia while not a liquid in the true sense of the word is nevertheless generally dispensed by volume rather than by weight, hence it must be measured. It was therefore included in this series of experiments. The comparatively large error found in this instance was no doubt due to the adherence of a considerable amount of the magnesium hydroxide to the inside of the glass graduate from which it was impossible to drain it, but could be readily seen. The average error amounted to 2.79% as compared with that of Distilled Water which was 0.78%.

The results of Table III are best summarized in Table IV.

TABLE IV.—SUMMARY OF RESULTS PRESENTED IN TABLE III.

Liquid to Be Measured.	Volume Measured in Cc.	Shape of Graduate Used.	Average Weight in Gm.	Standard Deviation in Gm.	Number of Measurements Falling within 1 × S. D.	2 × S. D.	3 × S. D.	4 × S. D or Over
Distilled Water	100	Cyl.	98.240	0.767	83	12	3	2
Elix. I. Q. & S.	100	Cyl.	104.049	0.926	79	14	5	2
Syrup	100	Cyl.	124.298	2.368	69	25	6	0
Milk of Magnesia	100	Cyl.	94.895	2.644	73	20	7	0
Castor Oil	100	Cyl.	87.742	3.938	72	21	7	0
Distilled Water	100	Con.	97.881	1.802	67	28	5	0
Elix. I. Q. & S.	100	Con.	103.752	2.329	70	25	5	0
Syrup	100	Con.	126.753	3.333	68	28	4	0
Milk of Magnesia	100	Con.	95.254	3.151	65	30	5	0
Castor Oil	100	Con.	87.017	5.087	70	24	6	0

To make it possible to compare the results given in Tables I and III with similar data that may have been published, but which have not been expressed in terms of the standard deviation, the per cent deviation from the average weight has been calculated and is given in Table V.

TABLE V.—PERCENTAGE OF ERROR COMPUTED FROM DATA IN TABLES I AND III.

Liquid to Be Measured.	Volume Measured in Cc.	Shape of Graduate Used.	Average Weight in Gm.	Number of Measurements Falling within 1%.	2%.	3%.	4%.	5%.	6%.	7%.	8%.	9%.	10% or More.
Distilled Water	10	Cyl.	9.561	4	5	11	24	22	13	9	8	2	2
Distilled Water	10	Con.	9.606	11	9	19	14	14	11	7	5	6	4
Distilled Water	25	Cyl.	24.481	27	29	24	9	4	2	2	1	0	2
Distilled Water	25	Con.	23.994	13	9	18	16	10	13	7	6	4	4
Distilled Water	50	Cyl.	49.258	55	33	8	2	1	1				
Distilled Water	50	Con.	48.758	29	23	30	7	6	4	1			
Distilled Water	100	Cyl.	98.240	89	9	0	2						
Distilled Water	100	Con.	97.881	38	34	18	7	3					
Elix. I. Q. & S.	100	Cyl.	104.049	82	12	5	1						
Elix. I. Q. & S.	100	Con.	103.752	38	26	18	9	7	2				
Syrup	100	Cyl.	124.298	45	27	18	4	5	1				
Syrup	100	Con.	126.753	30	18	24	14	9	4	1			
Milk of Magnesia	100	Cyl.	94.895	30	26	18	9	7	6	4			
Milk of Magnesia	100	Con.	95.254	29	20	12	12	11	7	7	2		
Castor Oil	100	Cyl.	87.742	22	20	11	11	15	3	2	6	3	7
Castor Oil	100	Con.	87.017	19	10	17	13	4	7	9	3	5	13

NOTE: All percentages are calculated from the average weight. 1% = 1% or less; 2% = from 1% plus to 2%; etc.

For the purpose of comparison with previously published data it is also desirable to have information showing the percentage of the total measurements in which the error falls below certain magnitudes, the latter being expressed in terms of per cent. The following table is intended to accomplish this purpose.

TABLE VI.—TABLE SHOWING THE MAXIMUM PER CENT OF ERROR IN 90% OF THE MEASUREMENTS RECORDED IN TABLE V.

Shape of Graduate.	Distilled Water. 10 Cc.	25 Cc.	50 Cc.	100 Cc.	Elix. I. Q. & S. 100 Cc.	Syrup 100 Cc.	Milk of Magnesia 100 Cc.	Castor Oil 100 Cc.
Cyl.	8%	5%	3%	2%	2%	3%	5%	8%
Con.	8%	8%	5%	3%	4%	5%	6%	10%

CONCLUSIONS.

1. The factors largely responsible for the errors made by pharmacists in the measurement of specified volumes were found to be three in number. These are in the order of their importance: (1) The nature of the liquid to be measured, (2) the shape and size of the graduate used, and (3) the personal equation.

The error due to the personal equation naturally cannot be predicted with any degree of accuracy as it depends entirely upon the idiosyncrasy of the individuals making the measurements. In some instances it may far exceed one or both of the other two factors but in all of the measurements made in the foregoing series of tests it exceeded twice the standard deviation in less than 7 per cent of all cases.

2. From the data obtained in the tests made it would seem that twice the standard deviation is a reasonable margin of error for the measurement of the volume of liquids. A margin of this magnitude will permit the acceptance of the following:

Shape of Graduate.	10 Cc.	Distilled Water. 25 Cc.	50 Cc.	100 Cc.	Elix. I. Q. & S. 100 Cc.	Syrup 100 Cc.	Milk of Magnesia 100 Cc.	Castor Oil 100 Cc.
Cyl.	97%	94%	96%	95%	93%	94%	93%	93%
Con.	95%	98%	95%	95%	95%	96%	95%	94%

REFERENCES.

(1) Andrews, Marvin J., JOUR. A. PH. A., 22, 755 and 838 (1933).
(2) Andrews, Marvin J., *Ibid.*, 23, 350 and 421 (1934).
(3) Andrews, Marvin J., *Ibid.*, 23, 1003 (1934).
(4) Andrews, Marvin J., *Ibid.*, 23, 1117 and 1210 (1934).

UNITED STATES PATENTS GRANTED FOR MEDICINES DURING THE PIONEER YEARS OF THE PATENT OFFICE.*

BY LYMAN F. KEBLER.[1]

The word "patent" means open, not secret. A patent cannot be granted for a medicine of secret composition. The term "Patent Medicine" applied to a medicine of secret composition is a misnomer. The term in general conveys an erroneous impression. Many think that all proprietaries, foods and drugs, and medicines in package form, are of secret composition and consequently plain frauds. It is true that some outright medical frauds have been and still are perpetrated on the suffering sick. And this is true even in the case of a goodly number of medicines for which patents have been granted. Patenting a product does not preclude telling fairy tales about it. In fact, the therapeutic claims contained in the description of some of the patents for medicines are grossly false and fraudulent, as will be pointed out later.

SOME INTERESTING PHASES IN PATENTING MEDICINES.

Secret medicines with their air of mysticism have held sway for the ages in all lands. The alchemistic era produced some of the most phony ideas in the matter of the philosopher's stone being a universal medicine and panacea. Secret medicines made marked advances during the time of iatrochemistry, when Paracelsus (1493–1541), with his *lapis infernales*, held sway, and John R. Glauber (1610–1770), the distinguished physician-chemist and discoverer of Glauber's salt, played such prominent parts. Glauber not only discovered the salt named after him but ascertained its medicinal virtues and sold it at a handsome profit under the name *sal mirabile*, for many years. It is claimed that he made a living selling secret medicines.

England set a precedent in granting patents to medicines. Among the earliest may be mentioned "Dr. Bateman's Pectoral Drops" (1726), "Dr. James' Fever Powder" (1747), "Ann Pike's Ointment for the Cure of Cutaneous Eruptions" (1760), and "Gale's Spa Elixir" (1782). The Ann Pike Ointment is probably one of the most glaring of frauds. It is a mixture of pomatum, lard, deer suet, calomel, Jesuits' bark, quicksilver, turpeth mineral, tutty powder, flowers of brimstone and "wood sut." The patent alleges that it is a "Grand Antidote for the Itch and All

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* Section on Historical Pharmacy, A. PH. A., Washington meeting, 1934.

[1] Former Chief of Drug Division, Bureau of Chemistry, United States Department of Agriculture.