Title

Effect of Channel Length on the Force Exerted by Effusing Vapors

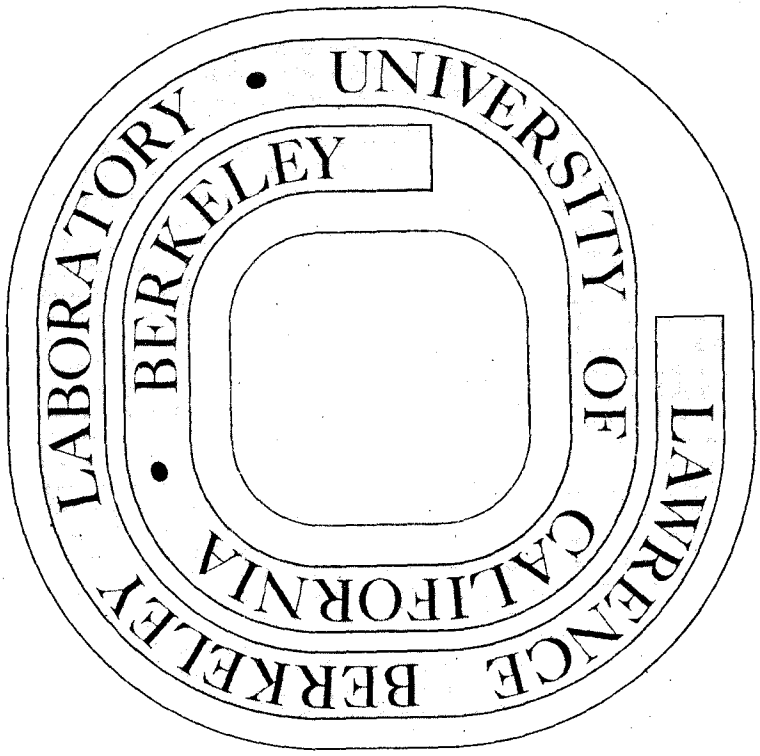
Authors

Schulz, David A

Searcy, Alan W

Publication Date

1962-07-01



UNIVERSITY OF CALIFORNIA

Lawrence Radiation Laboratory
Berkeley, California

Contract No. W-7405-eng-48

EFFECT OF CHANNEL LENGTH ON THE FORCE EXERTED BY EFFUSING VAPORS

David A. Schulz and Alan W. Searcy

July 11, 1962

UCRL-10004 Rev.

EFFECT OF CHANNEL LENGTH ON THE FORCE EXERTED BY EFFUSING VAPORS*

David A. Schulz and Alan W. Searcy

Lawrence Radiation Laboratory and Department of Mineral Technology
University of California, Berkeley, California

July 11, 1962

For molecular streaming conditions, Clausing has calculated values of the ratio K of the number of molecules that escape through an orifice of finite length ℓ to the number that escape through an orifice of infinitesimal length, but the same radius r.[1] Provided that the cosine distribution law is valid, the method is exact and yields values of K that can be calculated to any desired limits of uncertainty.[2]

Clausing has provided an alternate derivation which yields values of the ratio K' that are strictly valid only for ℓ/r vanishingly small but which Clausing declared for $\ell = r$ to be "valid to a very high degree of approximation, and probably so even for $\ell = 4r$."[3] From this approximate equation, Freeman and Searcy have calculated the fraction of molecules that escape through various solid angles made with the orifice axis.[4] By a simple modification, they were also able to calculate the ratio f

---

* This work was supported by the U.S. Atomic Energy Commission.

1. P. Clausing, Ann. Physik 12, 961 (1932).

2. W.C. DeMarcus and E.H. Hopper, J. Chem. Phys. 23, 1344 (1955).

3. P. Clausing, Z. Physik 66, 471 (1930).

4. R.D. Freeman and A.W. Searcy, J. Chem. Phys. 22, 1137 (1954).

of the force of molecules that escape through an orifice of finite ℓ/r to the force if r were the same, but ℓ were zero.[5] Values of f are required for determination of vapor pressures by the torsion effusion, or direct, method.[6,7]

Because of the tediousness of the numerical integrations by Simpson's method, Freeman and Searcy used angular increments of 15 deg in evaluation of K' and f. The practical validities of Clausing's approximate equation and of the numerical integration were demonstrated for values of ℓ/r between 0 and 2 by agreement to within 0.5% in the calculated values of K' with Clausing's K values.

We have extended the calculations of K' and of f to $\ell/r = 10.0$. The calculation was performed on an IBM 704 computer with 0.1-deg intervals in the Simpson method integration, thus bringing the above-mentioned agreement to within 0.1% over the range of ℓ/r from 0 to 4. A further decrease in summation interval by a factor of 10 produced no change in sample ℓ/r calculations, indicating that the limit of precision of this method had been reached.

Detkov[8] has recently claimed that a molecular distribution equation of Vlasov[9] yields better number and force corrections for short orifices than are obtainable from the Clausing approximate equation.

---

5. R. D. Freeman and A. W. Searcy, J. Chem. Phys. 22, 762 (1954).
6. H. Mayer, Z. Physik 67, 240 (1931).
7. M. Volmer, Z. Physik. Chem. Bodenstein Festband, 863 (1931).
8. S. P. Detkov, Zhur. Fiz. Khim. 34, 1634 (1960).
9. O. Ye. Vlasov, Izvest. Vsesoyuz. Teplotekh. Inst. im Feliksa Dzerzhinskogo 44, 1 (1929).

DeMarcus has obtained refined values of $\underline{K}$ from Clausing's exact equation.[10] In Fig. 1 are plotted deviations (in percent) of these values from Detkov's values, K_d, and of our refined values, $\underline{K}'$, from the approximate Clausing equation. Both approximations show maximum experimental deviations of 0.12 in the range of $\ell/\underline{r}$ values up to 2.9. From $\ell/\underline{r} = 2.9$ to the limit of Detkov's calculations, $\ell/\underline{r} = 4$, our approximation gives markedly better agreement.

Values of $\underline{K}'$ and $\underline{f}$ and, for comparison, Detkov's values f_d are presented in Table I. At $\ell/\underline{r} = 4.0$, where our $\underline{K}'$ and Detkov's K_d differ by 1.16%, the values of $\underline{f}$ and f_d differ by less than 0.1% because the force equations are insensitive to the assumed behavior of molecules that travel at high angles to the orifice axis. Deviations of our value of $\underline{K}'$ from the exact equation value reaches -1.14% at $\ell/\underline{r} = 7.0$, and -2.32 at $\ell/\underline{r} = 10.0$. These deviations are within the confidence limits of present effusion measurements,[11] and the force corrections should be closer to the true values than are the corresponding values of $\underline{K}'$.

Table II contains tabulated values of the correction factors calculated in the present work for $\ell/\underline{r}$ from 0.00 to 10.00 in 0.01 intervals.

---

10. W. C. DeMarcus, Oak Ridge Gaseous Diffusion Plant Report K-1302, Part 3 (1957).

11. K. D. Carlson, Argonne National Laboratory Report ANL-6156 (Thesis), April 1960.

Table I. Comparison of correction factors

ℓ/r	Number correction Factor K'	Force correction Factor (This research) f	Force correction factor (Detkov) f_d
0.0	1.00000	1.00000	1.0000
0.1	0.95238	0.96832	--
0.2	0.90922	0.93731	0.9373
0.3	0.86993	0.90730	--
0.4	0.83409	0.87848	0.8784
0.5	0.80128	0.85094	--
0.6	0.77116	0.82473	0.8247
0.7	0.74344	0.79984	--
0.8	0.71784	0.77625	0.7762
0.9	0.69412	0.75390	--
1.0	0.67209	0.73275	0.7326
1.1	0.65157	0.71272	--
1.2	0.63240	0.69376	0.6935
1.3	0.61446	0.67580	--
1.4	0.59763	0.65876	0.6584
1.5	0.58179	0.64260	--
1.6	0.56686	0.62724	0.6267
1.7	0.55275	0.61263	--
1.8	0.53940	0.59873	0.5981
1.9	0.52675	0.58548	--
2.0	0.51472	0.57282	0.5721
2.2	0.49238	0.54918	0.5485
2.4	0.47203	0.52751	0.5269
2.6	0.45340	0.50756	0.5071
2.8	0.43626	0.48913	0.4889
3.0	0.42044	0.47203	0.4722
3.2	0.40577	0.45613	0.4569
3.4	0.39212	0.44129	0.4425
3.6	0.37938	0.42741	0.4293
3.8	0.36747	0.41439	0.4169
4.0	0.35630	0.40215	0.4056
5.0	0.30937	0.35047	--
6.0	0.27341	0.31057	--
7.0	0.24493	0.27881	--
8.0	0.22182	0.25291	--
9.0	0.20268	0.23140	--
10.0	0.18656	0.21324	--

TABLE II

Table of Correction Factors

ℓ/r	K'	f	ℓ/r	K'	f
0.00	1.00000	1.00000	0.40	0.83409	0.87848
0.01	0.99504	0.99682	0.41	0.83068	0.87566
0.02	0.99010	0.99364	0.42	0.82729	0.87286
0.03	0.98520	0.99046	0.43	0.82394	0.87008
0.04	0.98039	0.98728	0.44	0.82062	0.86730
0.05	0.97562	0.98411	0.45	0.81732	0.86454
0.06	0.97089	0.98094	0.46	0.81405	0.86179
0.07	0.96619	0.97778	0.47	0.81082	0.85906
0.08	0.96155	0.97462	0.48	0.80762	0.85634
0.09	0.95695	0.97146	0.49	0.80444	0.85363
0.10	0.95238	0.96832	0.50	0.80128	0.85094
0.11	0.94789	0.96518	0.51	0.79815	0.84826
0.12	0.94343	0.96205	0.52	0.79505	0.84559
0.13	0.93901	0.95893	0.53	0.79197	0.84293
0.14	0.93463	0.95581	0.54	0.78893	0.84029
0.15	0.93029	0.95270	0.55	0.78591	0.83767
0.16	0.92599	0.94961	0.56	0.78291	0.83505
0.17	0.92173	0.94652	0.57	0.77994	0.83245
0.18	0.91752	0.94344	0.58	0.77699	0.82986
0.19	0.91336	0.94037	0.59	0.77406	0.82729
0.20	0.90922	0.93731	0.60	0.77116	0.82473
0.21	0.90512	0.93426	0.61	0.76829	0.82218
0.22	0.90106	0.93122	0.62	0.76544	0.81965
0.23	0.89704	0.92819	0.63	0.76261	0.81712
0.24	0.89305	0.92517	0.64	0.75981	0.81462
0.25	0.88911	0.92216	0.65	0.75702	0.81212
0.26	0.88521	0.91917	0.66	0.75426	0.80964
0.27	0.88134	0.91618	0.67	0.75152	0.80717
0.28	0.87750	0.91321	0.68	0.74880	0.80471
0.29	0.87370	0.91025	0.69	0.74611	0.80227
0.30	0.86993	0.90730	0.70	0.74344	0.79984
0.31	0.86619	0.90436	0.71	0.74079	0.79742
0.32	0.86250	0.90143	0.72	0.73816	0.79502
0.33	0.85884	0.89852	0.73	0.73555	0.79263
0.34	0.85521	0.89562	0.74	0.73296	0.79025
0.35	0.85160	0.89273	0.75	0.73038	0.78788
0.36	0.84804	0.88985	0.76	0.72783	0.78553
0.37	0.84450	0.88699	0.77	0.72530	0.78319
0.38	0.84099	0.88414	0.78	0.72280	0.78086
0.39	0.83752	0.88130	0.79	0.72031	0.77855

TABLE II (Continued)

ℓ/r	K'	f	ℓ/r	K'	f
0.80	0.71784	0.77625	1.20	0.63240	0.69376
0.81	0.71538	0.77396	1.21	0.63056	0.69192
0.82	0.71295	0.77168	1.22	0.62873	0.69009
0.83	0.71053	0.76941	1.23	0.62690	0.68827
0.84	0.70813	0.76716	1.24	0.62509	0.68646
0.85	0.70575	0.76492	1.25	0.62329	0.68466
0.86	0.70339	0.76269	1.26	0.62150	0.68287
0.87	0.70105	0.76048	1.27	0.61973	0.68109
0.88	0.69872	0.75827	1.28	0.61796	0.67931
0.89	0.69641	0.75608	1.29	0.61621	0.67755
0.90	0.69412	0.75390	1.30	0.61446	0.67580
0.91	0.69184	0.75173	1.31	0.61274	0.67405
0.92	0.68958	0.74957	1.32	0.61102	0.67232
0.93	0.68734	0.74743	1.33	0.60931	0.67059
0.94	0.68511	0.74530	1.34	0.60761	0.66888
0.95	0.68290	0.74318	1.35	0.60592	0.66717
0.96	0.68071	0.74107	1.36	0.60424	0.66547
0.97	0.67853	0.73897	1.37	0.60257	0.66378
0.98	0.67637	0.73689	1.38	0.60091	0.66210
0.99	0.67422	0.73481	1.39	0.59926	0.66042
1.00	0.67209	0.73275	1.40	0.59763	0.65876
1.01	0.66997	0.73069	1.41	0.59600	0.65711
1.02	0.66787	0.72865	1.42	0.59439	0.65546
1.03	0.66578	0.72662	1.43	0.59278	0.65383
1.04	0.66371	0.72461	1.44	0.59118	0.65220
1.05	0.66165	0.72260	1.45	0.58959	0.65058
1.06	0.65961	0.72060	1.46	0.58801	0.64896
1.07	0.65758	0.71862	1.47	0.58644	0.64736
1.08	0.65556	0.71664	1.48	0.58488	0.64576
1.09	0.65356	0.71468	1.49	0.58333	0.64418
1.10	0.65157	0.71272	1.50	0.58179	0.64260
1.11	0.64959	0.71078	1.51	0.58026	0.64103
1.12	0.64763	0.70885	1.52	0.57873	0.63946
1.13	0.64569	0.70693	1.53	0.57722	0.63791
1.14	0.64375	0.70502	1.54	0.57572	0.63636
1.15	0.64183	0.70311	1.55	0.57422	0.63482
1.16	0.63992	0.70122	1.56	0.57273	0.63329
1.17	0.63802	0.69934	1.57	0.57125	0.63177
1.18	0.63614	0.69747	1.58	0.56978	0.63025
1.19	0.63426	0.69561	1.59	0.56831	0.62874

TABLE II (Continued)

ℓ/r	K'	f	ℓ/r	K'	f
1.60	0.56686	0.62724	2.00	0.51472	0.57282
1.61	0.56541	0.62574	2.01	0.51355	0.57159
1.62	0.56397	0.62426	2.02	0.51239	0.57037
1.63	0.56254	0.62278	2.03	0.51123	0.56914
1.64	0.56112	0.62131	2.04	0.51008	0.56793
1.65	0.55971	0.61985	2.05	0.50893	0.56672
1.66	0.55830	0.61839	2.06	0.50779	0.56551
1.67	0.55690	0.61694	2.07	0.50665	0.56431
1.68	0.55551	0.61550	2.08	0.50552	0.56312
1.69	0.55413	0.61406	2.09	0.50440	0.56193
1.70	0.55275	0.61263	2.10	0.50328	0.56074
1.71	0.55139	0.61121	2.11	0.50216	0.55956
1.72	0.55002	0.60980	2.12	0.50105	0.55839
1.73	0.54867	0.60839	2.13	0.49995	0.55722
1.74	0.54733	0.60699	2.14	0.49885	0.55605
1.75	0.54599	0.60560	2.15	0.49776	0.55490
1.76	0.54466	0.60421	2.16	0.49667	0.55375
1.77	0.54334	0.60283	2.17	0.49559	0.55260
1.78	0.54202	0.60146	2.18	0.49452	0.55146
1.79	0.54071	0.60009	2.19	0.49344	0.55032
1.80	0.53940	0.59873	2.20	0.49238	0.54918
1.81	0.53811	0.59738	2.21	0.49131	0.54806
1.82	0.53682	0.59603	2.22	0.49025	0.54693
1.83	0.53554	0.59469	2.23	0.48920	0.54581
1.84	0.53426	0.59335	2.24	0.48816	0.54470
1.85	0.53299	0.59202	2.25	0.48711	0.54359
1.86	0.53173	0.59070	2.26	0.48607	0.54249
1.87	0.53047	0.58938	2.27	0.48504	0.54139
1.88	0.52922	0.58808	2.28	0.48401	0.54029
1.89	0.52798	0.58677	2.29	0.48299	0.53920
1.90	0.52675	0.58548	2.30	0.48197	0.53812
1.91	0.52552	0.58418	2.31	0.48095	0.53704
1.92	0.52429	0.58290	2.32	0.47995	0.53596
1.93	0.52307	0.58162	2.33	0.47894	0.53489
1.94	0.52186	0.58034	2.34	0.47794	0.53382
1.95	0.52066	0.57908	2.35	0.47694	0.53276
1.96	0.51946	0.57781	2.36	0.47595	0.53170
1.97	0.51826	0.57656	2.37	0.47496	0.53065
1.98	0.51707	0.57531	2.38	0.47398	0.52960
1.99	0.51589	0.57406	2.39	0.47300	0.52855

TABLE II (Continued)

ℓ/r	K'	f	ℓ/r	K'	f
2.40	0.47203	0.52751	2.80	0.43626	0.48913
2.41	0.47106	0.52648	2.81	0.43544	0.48824
2.42	0.47009	0.52544	2.82	0.43462	0.48736
2.43	0.46913	0.52441	2.83	0.43381	0.48648
2.44	0.46817	0.52339	2.84	0.43300	0.48560
2.45	0.46722	0.52237	2.85	0.43219	0.48473
2.46	0.46627	0.52135	2.86	0.43139	0.48386
2.47	0.46532	0.52034	2.87	0.43058	0.48300
2.48	0.46438	0.51934	2.88	0.42979	0.48214
2.49	0.46345	0.51833	2.89	0.42899	0.48128
2.50	0.46251	0.51734	2.90	0.42820	0.48042
2.51	0.46159	0.51634	2.91	0.42741	0.47957
2.52	0.46066	0.51535	2.92	0.42662	0.47872
2.53	0.45974	0.51436	2.93	0.42584	0.47788
2.54	0.45882	0.51338	2.94	0.42506	0.47703
2.55	0.45791	0.51240	2.95	0.42428	0.47619
2.56	0.45700	0.51142	2.96	0.42351	0.47535
2.57	0.45609	0.51045	2.97	0.42274	0.47452
2.58	0.45519	0.50949	2.98	0.42197	0.47369
2.59	0.45429	0.50852	2.99	0.42120	0.47286
2.60	0.45340	0.50756	3.00	0.42044	0.47203
2.61	0.45251	0.50660	3.01	0.41968	0.47121
2.62	0.45162	0.50565	3.02	0.41892	0.47039
2.63	0.45074	0.50470	3.03	0.41817	0.46957
2.64	0.44986	0.50376	3.04	0.41742	0.46876
2.65	0.44898	0.50282	3.05	0.41667	0.46795
2.66	0.44811	0.50188	3.06	0.41592	0.46714
2.67	0.44724	0.50095	3.07	0.41518	0.46634
2.68	0.44638	0.50002	3.08	0.41444	0.46553
2.69	0.44552	0.49909	3.09	0.41370	0.46474
2.70	0.44466	0.49817	3.10	0.41297	0.46394
2.71	0.44380	0.49725	3.11	0.41224	0.46315
2.72	0.44295	0.49633	3.12	0.41151	0.46236
2.73	0.44210	0.49542	3.13	0.41078	0.46157
2.74	0.44126	0.49451	3.14	0.41006	0.46079
2.75	0.44042	0.49362	3.15	0.40933	0.46000
2.76	0.43958	0.49270	3.16	0.40862	0.45922
2.77	0.43875	0.49180	3.17	0.40790	0.45845
2.78	0.43792	0.49091	3.18	0.40719	0.45767
2.79	0.43709	0.49002	3.19	0.40648	0.45690

TABLE II (Continued)

ℓ/r	K'	f	ℓ/r	K'	f
3.20	0.40577	0.45613	3.60	0.37938	0.42741
3.21	0.40506	0.45536	3.61	0.37877	0.42674
3.22	0.40436	0.45460	3.62	0.37816	0.42607
3.23	0.40366	0.45384	3.63	0.37755	0.42540
3.24	0.40296	0.45308	3.64	0.37694	0.42474
3.25	0.40226	0.45233	3.65	0.37633	0.42408
3.26	0.40157	0.45157	3.66	0.37573	0.42342
3.27	0.40088	0.45082	3.67	0.37513	0.42276
3.28	0.40019	0.45007	3.68	0.37452	0.42210
3.29	0.39950	0.44933	3.69	0.37393	0.42145
3.30	0.39882	0.44858	3.70	0.37333	0.42080
3.31	0.39814	0.44784	3.71	0.37274	0.42015
3.32	0.39746	0.44710	3.72	0.37214	0.41950
3.33	0.39678	0.44637	3.73	0.37155	0.41885
3.34	0.39611	0.44564	3.74	0.37096	0.41821
3.35	0.39544	0.44491	3.75	0.37038	0.41757
3.36	0.39477	0.44418	3.76	0.36979	0.41693
3.37	0.39410	0.44345	3.77	0.36921	0.41629
3.38	0.39344	0.44273	3.78	0.36863	0.41565
3.39	0.39278	0.44201	3.79	0.36805	0.41502
3.40	0.39212	0.44129	3.80	0.36747	0.41439
3.41	0.39146	0.44058	3.81	0.36689	0.41376
3.42	0.39081	0.43986	3.82	0.36632	0.41313
3.43	0.39015	0.43915	3.83	0.36575	0.41250
3.44	0.38950	0.43844	3.84	0.36518	0.41188
3.45	0.38885	0.43774	3.85	0.36461	0.41126
3.46	0.38821	0.43703	3.86	0.36404	0.41064
3.47	0.38756	0.43633	3.87	0.36348	0.41002
3.48	0.38692	0.43563	3.88	0.36291	0.40940
3.49	0.38628	0.43493	3.89	0.36235	0.40879
3.50	0.38564	0.43424	3.90	0.36179	0.40817
3.51	0.38501	0.43354	3.91	0.36123	0.40756
3.52	0.38437	0.43285	3.92	0.36068	0.40695
3.53	0.38374	0.43216	3.93	0.36012	0.40635
3.54	0.38311	0.43148	3.94	0.35957	0.40574
3.55	0.38249	0.43079	3.95	0.35902	0.40514
3.56	0.38186	0.43011	3.96	0.35847	0.40454
3.57	0.38124	0.42943	3.97	0.35793	0.40394
3.58	0.38062	0.42875	3.98	0.35738	0.40334
3.59	0.38000	0.42808	3.99	0.35684	0.40274

TABLE II (Continued)

ℓ/r	K^2	f
4.00	0.35630	0.40215
4.01	0.35576	0.40156
4.02	0.35522	0.40097
4.03	0.35468	0.40038
4.04	0.35414	0.39979
4.05	0.35361	0.39920
4.06	0.35308	0.39862
4.07	0.35255	0.39804
4.08	0.35202	0.39746
4.09	0.35149	0.39688
4.10	0.35096	0.39630
4.11	0.35044	0.39572
4.12	0.34992	0.39515
4.13	0.34940	0.39458
4.14	0.34888	0.39401
4.15	0.34836	0.39344
4.16	0.34784	0.39287
4.17	0.34733	0.39231
4.18	0.34681	0.39174
4.19	0.34630	0.39118
4.20	0.34579	0.39062
4.21	0.34528	0.39006
4.22	0.34477	0.38950
4.23	0.34427	0.38895
4.24	0.34376	0.38839
4.25	0.34326	0.38784
4.26	0.34276	0.38729
4.27	0.34226	0.38674
4.28	0.34176	0.38619
4.29	0.34126	0.38564
4.30	0.34077	0.38510
4.31	0.34028	0.38456
4.32	0.33978	0.38402
4.33	0.33929	0.38348
4.34	0.33880	0.38294
4.35	0.33832	0.38240
4.36	0.33783	0.38187
4.37	0.33734	0.38133
4.38	0.33686	0.38080
4.39	0.33638	0.38027

ℓ/r	K^2	f
4.40	0.33590	0.37974
4.41	0.33542	0.37921
4.42	0.33494	0.37869
4.43	0.33446	0.37816
4.44	0.33399	0.37764
4.45	0.33351	0.37711
4.46	0.33304	0.37659
4.47	0.33257	0.37607
4.48	0.33210	0.37556
4.49	0.33163	0.37504
4.50	0.33116	0.37452
4.51	0.33069	0.37401
4.52	0.33023	0.37350
4.53	0.32977	0.37299
4.54	0.32930	0.37248
4.55	0.32884	0.37197
4.56	0.32838	0.37146
4.57	0.32793	0.37096
4.58	0.32747	0.37045
4.59	0.32701	0.36995
4.60	0.32656	0.36945
4.61	0.32610	0.36895
4.62	0.32565	0.36845
4.63	0.32520	0.36795
4.64	0.32475	0.36746
4.65	0.32430	0.36696
4.66	0.32386	0.36647
4.67	0.32341	0.36598
4.68	0.32297	0.36549
4.69	0.32252	0.36500
4.70	0.32208	0.36451
4.71	0.32164	0.36403
4.72	0.32120	0.36354
4.73	0.32076	0.36306
4.74	0.32033	0.36258
4.75	0.31989	0.36210
4.76	0.31946	0.36162
4.77	0.31902	0.36114
4.78	0.31859	0.36066
4.79	0.31816	0.36018

TABLE II (Continued)

ℓ/r	K'	f	ℓ/r	K'	f
4.80	0.31773	0.35971	5.20	0.30143	0.34169
4.81	0.31730	0.35924	5.21	0.30105	0.34126
4.82	0.31687	0.35876	5.22	0.30066	0.34083
4.83	0.31645	0.35829	5.23	0.30028	0.34041
4.84	0.31602	0.35782	5.24	0.29990	0.33999
4.85	0.31560	0.35735	5.25	0.29952	0.33956
4.86	0.31517	0.35689	5.26	0.29914	0.33914
4.87	0.31475	0.35642	5.27	0.29876	0.33872
4.88	0.31433	0.35596	5.28	0.29838	0.33830
4.89	0.31391	0.35549	5.29	0.29800	0.33788
4.90	0.31349	0.35503	5.30	0.29762	0.33747
4.91	0.31307	0.35457	5.31	0.29725	0.33705
4.92	0.31266	0.35411	5.32	0.29687	0.33663
4.93	0.31224	0.35365	5.33	0.29650	0.33622
4.94	0.31183	0.35319	5.34	0.29612	0.33580
4.95	0.31142	0.35273	5.35	0.29575	0.33539
4.96	0.31100	0.35228	5.36	0.29538	0.33498
4.97	0.31059	0.35182	5.37	0.29501	0.33457
4.98	0.31018	0.35137	5.38	0.29464	0.33416
4.99	0.30978	0.35092	5.39	0.29427	0.33375
5.00	0.30937	0.35047	5.40	0.29390	0.33334
5.01	0.30896	0.35002	5.41	0.29354	0.33294
5.02	0.30856	0.34957	5.42	0.29317	0.33253
5.03	0.30815	0.34912	5.43	0.29281	0.33213
5.04	0.30775	0.34868	5.44	0.29244	0.33172
5.05	0.30735	0.34823	5.45	0.29208	0.33132
5.06	0.30694	0.34779	5.46	0.29172	0.33092
5.07	0.30654	0.34734	5.47	0.29136	0.33052
5.08	0.30614	0.34690	5.48	0.29099	0.33012
5.09	0.30575	0.34646	5.49	0.29064	0.32972
5.10	0.30535	0.34602	5.50	0.29028	0.32932
5.11	0.30495	0.34558	5.51	0.28992	0.32892
5.12	0.30456	0.34515	5.52	0.28956	0.32853
5.13	0.30416	0.34471	5.53	0.28921	0.32813
5.14	0.30377	0.34427	5.54	0.28885	0.32774
5.15	0.30338	0.34384	5.55	0.28850	0.32734
5.16	0.30299	0.34341	5.56	0.28814	0.32695
5.17	0.30260	0.34298	5.57	0.28779	0.32656
5.18	0.30221	0.34255	5.58	0.28744	0.32617
5.19	0.30182	0.34212	5.59	0.28709	0.32578

TABLE II (Continued)

ℓ/r	K'	f	ℓ/r	K'	f
5.60	0.28674	0.32539	6.00	0.27341	0.31057
5.61	0.28639	0.32500	6.01	0.27309	0.31022
5.62	0.28604	0.32462	6.02	0.27277	0.30987
5.63	0.28569	0.32423	6.03	0.27246	0.30952
5.64	0.28535	0.32385	6.04	0.27214	0.30917
5.65	0.28500	0.32346	6.05	0.27183	0.30882
5.66	0.28466	0.32308	6.06	0.27151	0.30847
5.67	0.28431	0.32270	6.07	0.27120	0.30812
5.68	0.28397	0.32231	6.08	0.27089	0.30777
5.69	0.28363	0.32193	6.09	0.27058	0.30742
5.70	0.28328	0.32155	6.10	0.27027	0.30708
5.71	0.28294	0.32118	6.11	0.26996	0.30673
5.72	0.28260	0.32080	6.12	0.26965	0.30639
5.73	0.28226	0.32042	6.13	0.26934	0.30604
5.74	0.28193	0.32004	6.14	0.26903	0.30570
5.75	0.28159	0.31967	6.15	0.26872	0.30536
5.76	0.28125	0.31929	6.16	0.26842	0.30502
5.77	0.28092	0.31892	6.17	0.26811	0.30467
5.78	0.28058	0.31855	6.18	0.26781	0.30433
5.79	0.28025	0.31818	6.19	0.26750	0.30400
5.80	0.27991	0.31781	6.20	0.26720	0.30366
5.81	0.27958	0.31744	6.21	0.26689	0.30332
5.82	0.27925	0.31707	6.22	0.26659	0.30298
5.83	0.27892	0.31670	6.23	0.26629	0.30265
5.84	0.27859	0.31633	6.24	0.26599	0.30231
5.85	0.27826	0.31597	6.25	0.26569	0.30198
5.86	0.27793	0.31560	6.26	0.26539	0.30164
5.87	0.27760	0.31524	6.27	0.26509	0.30131
5.88	0.27727	0.31487	6.28	0.26479	0.30098
5.89	0.27695	0.31451	6.29	0.26449	0.30064
5.90	0.27662	0.31415	6.30	0.26420	0.30031
5.91	0.27630	0.31379	6.31	0.26390	0.29998
5.92	0.27597	0.31343	6.32	0.26360	0.29965
5.93	0.27565	0.31307	6.33	0.26331	0.29932
5.94	0.27533	0.31271	6.34	0.26301	0.29899
5.95	0.27501	0.31235	6.35	0.26272	0.29867
5.96	0.27469	0.31199	6.36	0.26243	0.29834
5.97	0.27437	0.31164	6.37	0.26213	0.29801
5.98	0.27405	0.31128	6.38	0.26184	0.29769
5.99	0.27373	0.31093	6.39	0.26155	0.29736

TABLE II (Continued)

ℓ/r	K'	f	ℓ/r	K'	f
6.40	0.26126	0.29704	6.80	0.25015	0.28463
6.41	0.26097	0.29672	6.81	0.24988	0.28434
6.42	0.26068	0.29639	6.82	0.24961	0.28404
6.43	0.26039	0.29607	6.83	0.24935	0.28375
6.44	0.26010	0.29575	6.84	0.24909	0.28345
6.45	0.25982	0.29543	6.85	0.24882	0.28316
6.46	0.25953	0.29511	6.86	0.24856	0.28286
6.47	0.25924	0.29479	6.87	0.24830	0.28257
6.48	0.25896	0.29447	6.88	0.24803	0.28228
6.49	0.25867	0.29415	6.89	0.24777	0.28198
6.50	0.25839	0.29384	6.90	0.24751	0.28169
6.51	0.25810	0.29352	6.91	0.24725	0.28140
6.52	0.25782	0.29320	6.92	0.24699	0.28111
6.53	0.25754	0.29289	6.93	0.24673	0.28082
6.54	0.25726	0.29258	6.94	0.24647	0.28053
6.55	0.25698	0.29226	6.95	0.24622	0.28024
6.56	0.25670	0.29195	6.96	0.24596	0.27996
6.57	0.25642	0.29164	6.97	0.24570	0.27967
6.58	0.25614	0.29133	6.98	0.24545	0.27938
6.59	0.25586	0.29101	6.99	0.24519	0.27910
6.60	0.25558	0.29070	7.00	0.24493	0.27881
6.61	0.25530	0.29040	7.01	0.24468	0.27852
6.62	0.25503	0.29009	7.02	0.24442	0.27824
6.63	0.25475	0.28978	7.03	0.24417	0.27796
6.64	0.25448	0.28947	7.04	0.24392	0.27767
6.65	0.25420	0.28916	7.05	0.24366	0.27739
6.66	0.25393	0.28886	7.06	0.24341	0.27711
6.67	0.25365	0.28855	7.07	0.24316	0.27683
6.68	0.25338	0.28825	7.08	0.24291	0.27655
6.69	0.25311	0.28794	7.09	0.24266	0.27627
6.70	0.25284	0.28764	7.10	0.24241	0.27599
6.71	0.25256	0.28734	7.11	0.24216	0.27571
6.72	0.25229	0.28703	7.12	0.24191	0.27543
6.73	0.25202	0.28673	7.13	0.24166	0.27515
6.74	0.25175	0.28643	7.14	0.24141	0.27487
6.75	0.25148	0.28613	7.15	0.24117	0.27459
6.76	0.25121	0.28583	7.16	0.24092	0.27432
6.77	0.25095	0.28553	7.17	0.24067	0.27404
6.78	0.25068	0.28523	7.18	0.24043	0.27377
6.79	0.25041	0.28493	7.19	0.24018	0.27349

TABLE II - 2 (Continued)

ℓ/r	K'	f	ℓ/r	K'	f
7.20	0.23993	0.27322	7.60	0.23052	0.26268
7.21	0.23969	0.27294	7.61	0.23030	0.26242
7.22	0.23945	0.27267	7.62	0.23007	0.26217
7.23	0.23920	0.27240	7.63	0.22985	0.26192
7.24	0.23896	0.27212	7.64	0.22962	0.26167
7.25	0.23872	0.27185	7.65	0.22940	0.26142
7.26	0.23847	0.27158	7.66	0.22917	0.26117
7.27	0.23823	0.27131	7.67	0.22895	0.26091
7.28	0.23799	0.27104	7.68	0.22873	0.26067
7.29	0.23775	0.27077	7.69	0.22851	0.26042
7.30	0.23751	0.27050	7.70	0.22828	0.26017
7.31	0.23727	0.27023	7.71	0.22806	0.25992
7.32	0.23703	0.26997	7.72	0.22784	0.25967
7.33	0.23679	0.26970	7.73	0.22762	0.25942
7.34	0.23655	0.26943	7.74	0.22740	0.25918
7.35	0.23631	0.26916	7.75	0.22718	0.25893
7.36	0.23608	0.26890	7.76	0.22696	0.25868
7.37	0.23584	0.26863	7.77	0.22674	0.25844
7.38	0.23560	0.26837	7.78	0.22652	0.25819
7.39	0.23537	0.26810	7.79	0.22631	0.25795
7.40	0.23513	0.26784	7.80	0.22609	0.25770
7.41	0.23490	0.26758	7.81	0.22587	0.25746
7.42	0.23466	0.26732	7.82	0.22565	0.25722
7.43	0.23443	0.26705	7.83	0.22544	0.25697
7.44	0.23420	0.26679	7.84	0.22522	0.25673
7.45	0.23396	0.26653	7.85	0.22500	0.25649
7.46	0.23373	0.26627	7.86	0.22479	0.25625
7.47	0.23350	0.26601	7.87	0.22457	0.25601
7.48	0.23327	0.26575	7.88	0.22436	0.25577
7.49	0.23304	0.26549	7.89	0.22415	0.25553
7.50	0.23280	0.26523	7.90	0.22393	0.25529
7.51	0.23257	0.26498	7.91	0.22372	0.25505
7.52	0.23234	0.26472	7.92	0.22351	0.25481
7.53	0.23212	0.26446	7.93	0.22329	0.25457
7.54	0.23189	0.26420	7.94	0.22308	0.25433
7.55	0.23166	0.26395	7.95	0.22287	0.25410
7.56	0.23143	0.26369	7.96	0.22266	0.25386
7.57	0.23120	0.26344	7.97	0.22245	0.25362
7.58	0.23098	0.26318	7.98	0.22224	0.25339
7.59	0.23075	0.26293	7.99	0.22203	0.25315

TABLE II (Continued)

ℓ/r	K'	f	ℓ/r	K'	f
8.00	0.22182	0.25291	8.40	0.21374	0.24385
8.01	0.22161	0.25268	8.41	0.21355	0.24363
8.02	0.22140	0.25245	8.42	0.21336	0.24341
8.03	0.22119	0.25221	8.43	0.21316	0.24319
8.04	0.22098	0.25198	8.44	0.21297	0.24298
8.05	0.22078	0.25174	8.45	0.21278	0.24276
8.06	0.22057	0.25151	8.46	0.21258	0.24254
8.07	0.22036	0.25128	8.47	0.21239	0.24233
8.08	0.22016	0.25105	8.48	0.21220	0.24211
8.09	0.21995	0.25082	8.49	0.21201	0.24189
8.10	0.21974	0.25059	8.50	0.21182	0.24168
8.11	0.21954	0.25036	8.51	0.21162	0.24146
8.12	0.21933	0.25013	8.52	0.21143	0.24125
8.13	0.21913	0.24990	8.53	0.21124	0.24104
8.14	0.21892	0.24967	8.54	0.21105	0.24082
8.15	0.21872	0.24944	8.55	0.21086	0.24061
8.16	0.21852	0.24921	8.56	0.21068	0.24040
8.17	0.21831	0.24898	8.57	0.21049	0.24018
8.18	0.21811	0.24875	8.58	0.21030	0.23997
8.19	0.21791	0.24853	8.59	0.21011	0.23976
8.20	0.21771	0.24830	8.60	0.20992	0.23955
8.21	0.21751	0.24807	8.61	0.20973	0.23934
8.22	0.21730	0.24785	8.62	0.20955	0.23913
8.23	0.21710	0.24762	8.63	0.20936	0.23892
8.24	0.21690	0.24740	8.64	0.20917	0.23871
8.25	0.21670	0.24717	8.65	0.20899	0.23850
8.26	0.21650	0.24695	8.66	0.20880	0.23829
8.27	0.21630	0.24672	8.67	0.20862	0.23808
8.28	0.21610	0.24650	8.68	0.20843	0.23787
8.29	0.21591	0.24628	8.69	0.20825	0.23767
8.30	0.21571	0.24605	8.70	0.20806	0.23746
8.31	0.21551	0.24583	8.71	0.20788	0.23725
8.32	0.21531	0.24561	8.72	0.20769	0.23705
8.33	0.21511	0.24539	8.73	0.20751	0.23684
8.34	0.21492	0.24517	8.74	0.20733	0.23663
8.35	0.21472	0.24495	8.75	0.20715	0.23643
8.36	0.21453	0.24472	8.76	0.20696	0.23622
8.37	0.21433	0.24450	8.77	0.20678	0.23602
8.38	0.21413	0.24428	8.78	0.20660	0.23581
8.39	0.21394	0.24407	8.79	0.20642	0.23561

TABLE II (Continued)

ℓ/r	K'	f	ℓ/r	K'	f
8.80	0.20624	0.23540	9.20	0.19924	0.22753
8.81	0.20606	0.23520	9.21	0.19907	0.22734
8.82	0.20587	0.23500	9.22	0.19890	0.22715
8.83	0.20569	0.23480	9.23	0.19873	0.22696
8.84	0.20551	0.23459	9.24	0.19856	0.22677
8.85	0.20533	0.23439	9.25	0.19839	0.22658
8.86	0.20516	0.23419	9.26	0.19823	0.22639
8.87	0.20498	0.23399	9.27	0.19806	0.22620
8.88	0.20480	0.23379	9.28	0.19789	0.22601
8.89	0.20462	0.23359	9.29	0.19773	0.22582
8.90	0.20444	0.23339	9.30	0.19756	0.22564
8.91	0.20426	0.23319	9.31	0.19739	0.22545
8.92	0.20409	0.23299	9.32	0.19723	0.22526
8.93	0.20391	0.23279	9.33	0.19706	0.22508
8.94	0.20373	0.23259	9.34	0.19690	0.22489
8.95	0.20355	0.23239	9.35	0.19673	0.22470
8.96	0.20338	0.23219	9.36	0.19657	0.22452
8.97	0.20320	0.23199	9.37	0.19640	0.22433
8.98	0.20303	0.23179	9.38	0.19624	0.22415
8.99	0.20285	0.23160	9.39	0.19607	0.22396
9.00	0.20268	0.23140	9.40	0.19591	0.22378
9.01	0.20250	0.23120	9.41	0.19575	0.22359
9.02	0.20233	0.23101	9.42	0.19558	0.22341
9.03	0.20215	0.23081	9.43	0.19542	0.22323
9.04	0.20198	0.23061	9.44	0.19526	0.22304
9.05	0.20181	0.23042	9.45	0.19510	0.22286
9.06	0.20163	0.23022	9.46	0.19493	0.22268
9.07	0.20146	0.23003	9.47	0.19477	0.22250
9.08	0.20129	0.22983	9.48	0.19461	0.22231
9.09	0.20111	0.22964	9.49	0.19445	0.22213
9.10	0.20094	0.22945	9.50	0.19429	0.22195
9.11	0.20077	0.22925	9.51	0.19413	0.22177
9.12	0.20060	0.22906	9.52	0.19397	0.22159
9.13	0.20043	0.22887	9.53	0.19381	0.22141
9.14	0.20026	0.22867	9.54	0.19365	0.22123
9.15	0.20009	0.22849	9.55	0.19349	0.22105
9.16	0.19991	0.22829	9.56	0.19333	0.22087
9.17	0.19974	0.22810	9.57	0.19317	0.22069
9.18	0.19957	0.22791	9.58	0.19301	0.22051
9.19	0.19941	0.22772	9.59	0.19285	0.22033

TABLE II (Continued)

ℓ/r	K'	E
9.60	0.19269	0.22015
9.61	0.19254	0.21997
9.62	0.19238	0.21980
9.63	0.19222	0.21962
9.64	0.19206	0.21944
9.65	0.19191	0.21926
9.66	0.19175	0.21909
9.67	0.19159	0.21891
9.68	0.19144	0.21873
9.69	0.19128	0.21856
9.70	0.19112	0.21838
9.71	0.19097	0.21821
9.72	0.19081	0.21803
9.73	0.19066	0.21786
9.74	0.19050	0.21768
9.75	0.19035	0.21751
9.76	0.19019	0.21733
9.77	0.19004	0.21716
9.78	0.18989	0.21699
9.79	0.18973	0.21681
9.80	0.18958	0.21664
9.81	0.18943	0.21647
9.82	0.18927	0.21630
9.83	0.18912	0.21612
9.84	0.18897	0.21595
9.85	0.18882	0.21578
9.86	0.18866	0.21561
9.87	0.18851	0.21544
9.88	0.18836	0.21527
9.89	0.18821	0.21510
9.90	0.18806	0.21493
9.91	0.18791	0.21476
9.92	0.18776	0.21459
9.93	0.18761	0.21442
9.94	0.18746	0.21425
9.95	0.18735	0.21408
9.96	0.18716	0.21391
9.97	0.18701	0.21374
9.98	0.18686	0.21357
9.99	0.18671	0.21341
10.00	0.18656	0.21324

FIGURE LEGEND

1. Percent deviation of K' and K_d from K.

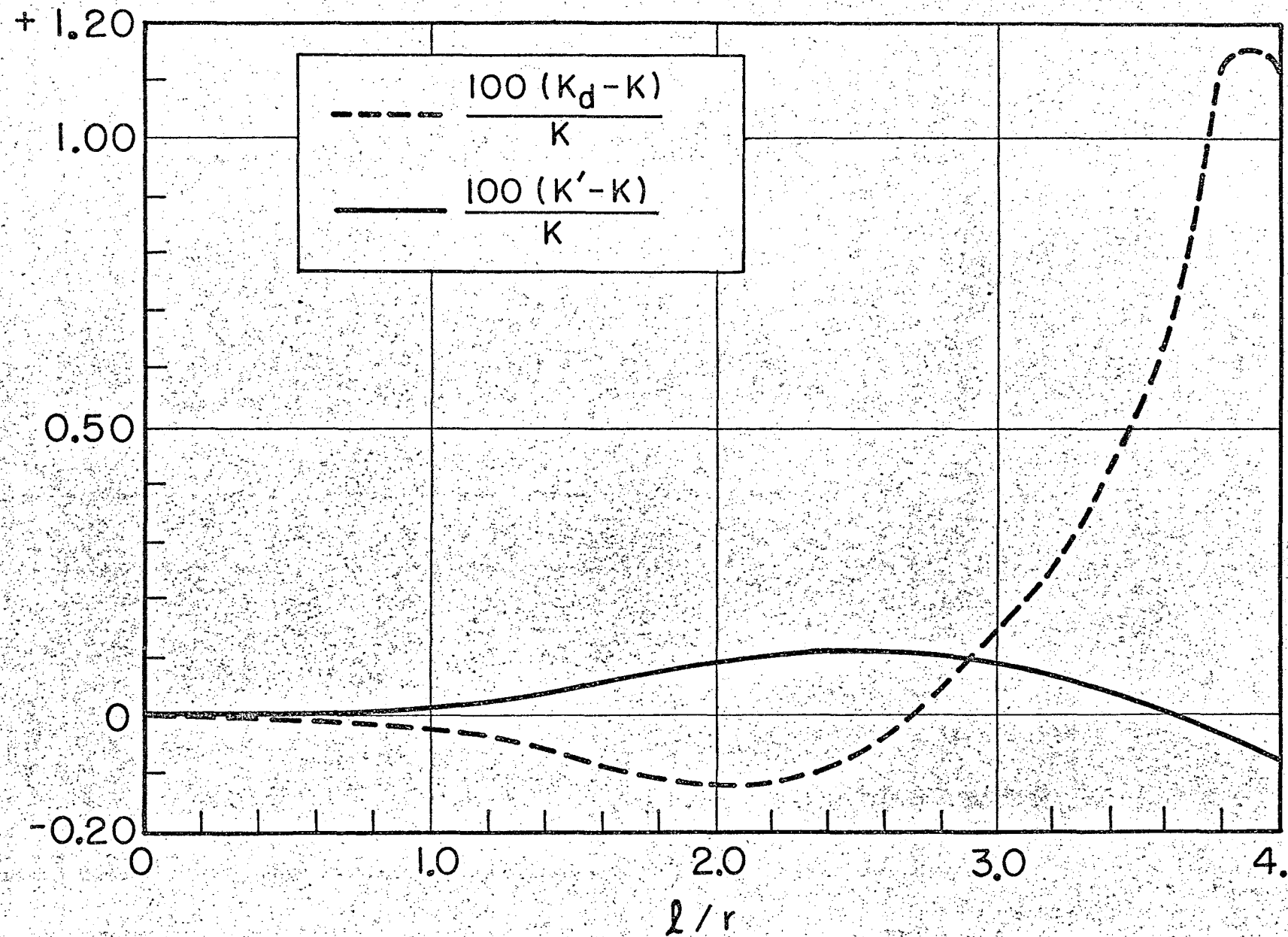


Fig. 1.

UCRL-10004 Rev.

61316-1