On the other hand, Bonnevay prefers to distort the left-hand cut away from the physical region. This he does by defining M_2 in the upper half plane by analytic continuation from below the cut $0 \leq s \leq (m-1)^2$. He therefore ends up with a *left*-hand cut consisting of the two parts $-\infty \leq s \leq 0$ and $(m-1)^2 \leq s \leq +\infty$. In this way he avoids troubles arising from a singular kernel, but requires a knowledge of the phase shifts δ_i on the left-hand cut. Of course an *exact* knowledge of the physical region $(4 \leq s < \infty)$ phase shifts gives complete information everywhere; the problem is one of minimizing computational inaccuracies arising from two possible sources.

In our present paper we have specifically excluded the case in which f has second-sheet resonance poles in $u_\pm$, since these lead to extra (logarithmic) singularities in W_-. This case is the one studied by Bonnevay. He deals with the function $f_i^* M_i/k$, which has poles arising directly from f^*, and also the extra singularity in W_-. After performing the continuation described in paragraph 2, these "resonance" singularities are the singularities which lie closest to the physical sheet. Bonnevay proposes an iterative solution of the resultant integral equation in which the resonance contributions are treated as the inhomogeneous term (the residue at the pole being treated as an unknown parameter). The inhomogeneous term is then to be used as the first approximation in the iteration of the homogeneous terms.

It is a sad privilege to acknowledge that a study of Bonnevay's paper has enabled me to remove some initial errors in the present work, by restricting its applicability to cases with no resonance in the domains $u_\pm$. The case with such a resonance is the one explicitly treated by Bonnevay. The two papers therefore complement each other.

As a final remark, an integral equation *somewhat* similar to the Khuri-Treiman equation has been transformed into a *soluble* integral equation by V. V. Anisovich, Zh. Eksperim. i Teor. Fiz. **44**, 1593 (1963) [translation: Soviet Phys.—JETP **17**, 1072 (1963)]. I am grateful to Professor Anisovich for sending me a reprint of the original article.

APPENDIX: ALTERNATIVE FORMULATION

In Eq. (3.9) we have

$$B_1(s_1)=\frac{1}{2F(s_1)\pi}\int_P ds'\beta(s')\int_C \frac{ds_2}{s'-s_2}, \qquad \text{(A1)}$$

where P and C are *non*intersecting contours given in Figs. 6 and 7. It is therefore permissible to perform the s_2 integration first, i.e.,

$$B_1(s_1)=\frac{1}{2F(s_1)\pi}\int_P ds'\beta(s')\ln\left\{\frac{s'-s_-(s_1)}{s'-s_+(s_1)}\right\}_C, \qquad \text{(A2)}$$

where the suffix C on the ln specifies how the imaginary part of the ln is to be evaluated. One can next perform an integration by parts. Thus, define

$$b(s)=\int_4^s ds'\beta(s'). \qquad \text{(A3)}$$

Then

$$B_1(s_1)=\frac{1}{2F(s_1)\pi}\int_P ds'b(s')\left\{\frac{1}{s'-s_+}-\frac{1}{s'-s_-}\right\}_C$$
$$=\frac{1}{\pi}\int_P \frac{ds'b(s')}{\{[s'-G(s_1)]^2-F(s_1)^2\}_C}. \qquad \text{(A4)}$$

Form (A2) is appropriate when treating B_1 as a function of a *real* variable, for then $P \to P_0$. For complex s_1, the distortion of P is necessary, and hence one *cannot* give a unique prescription for the logarithmic kernel for all s_1, with s' restricted to lie on the real range $4 \leq s' \leq \infty$. One can, of course, investigate the function $\hat{B}$ defined in (3.5), but this does *not* have the correct physical limit for $4 \leq s_1 \leq m+1$.

Form (A4) is most appropriate to our problem, and it is easy to see that it leads to the same cuts and discontinuities as presented above. The cuts occur when one or both of s_+ or s_- crosses P (not P_0!), and the discontinuity is then simply the residue at the pole or poles which crossed, viz. $(i/F)b(s_+)$, etc., precisely as found in (3.19).

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K^--p Total Cross Section between 2.7 and 5.2 BeV/c*

A. N. Diddens,† E. W. Jenkins, T. F. Kycia, and K. F. Riley‡
Brookhaven National Laboratory, Upton, New York
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The K^--p total cross section has been measured between 2.7 and 5.2 BeV/c, by means of a transmission experiment. Points with about 3% statistical errors have been obtained at momenta approximately 200 MeV/c apart.

PREVIOUS measurements of the K^--p total cross section at momenta of about[1-3] 4 BeV/c are widely spaced but collectively they are not consistent with a smooth variation of the cross section with momentum. In order to investigate this region more thoroughly, a transmission experiment was undertaken, the results of which are reported.

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† On leave of absence from CERN, Geneva, Switzerland.
‡ Permanent address: Clare College, Cambridge, England.

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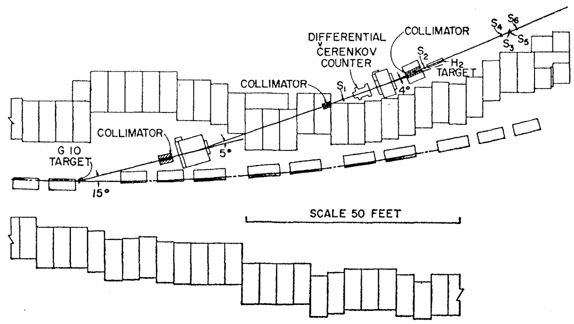

FIG. 1. Experimental arrangement.

The experimental arrangement for the present measurements, on the inside of the Alternating Gradient Synchrotron, is shown in Fig. 1. The secondary beam, produced at 15°, passed through a 1-in.$\times 1\frac{1}{4}$-in. collimator. It was, subsequently, magnetically analyzed and defined by 2-in.-diam scintillation counters S_1 and S_2. The K mesons were identified by means of a gas Čerenkov counter[4] taken in coincidence with S_1 and S_2 to form a K-meson telescope.

The Čerenkov counter was of the differential type using compressed CO_2 as a radiator. The pressure of the gas was set so that for the selected momentum K mesons would emit light at the acceptance angle of 10°. Čerenkov light from electrons, muons, and π mesons was emitted at large enough angles to be collected in the anticoincidence channel. Under the experimental conditions

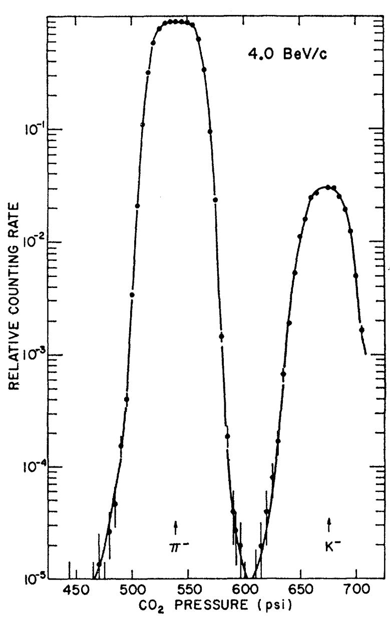

FIG. 2. Pressure curve taken with the gas Čerenkov counter at a momentum of 4 BeV/c.

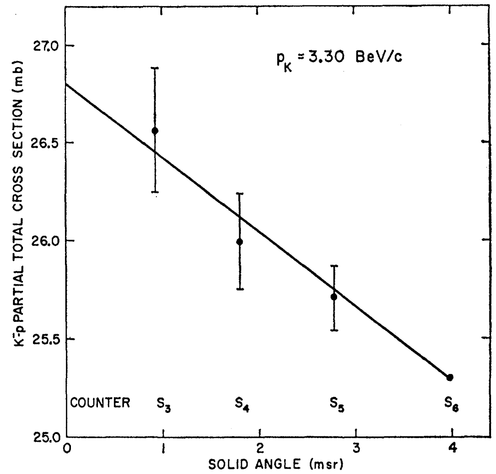

FIG. 3. Typical extrapolation of the partial total cross sections to zero solid angle.

$\Delta\beta/\beta$, the resolution of the counter, was approximately 10^{-3}. Figure 2 shows a typical pressure curve taken at a momentum of 4.0 BeV/c. The fraction of the beam counted in the Čerenkov counter is plotted as a function of the CO_2 pressure. The K^--meson peak is well separated from the π^- meson peak, the contamination of the K's being less than one part in 1000. Similar high selectivity was obtained at all the other momenta. The amount of material presented by the windows and gas of the Čerenkov counter to the beam varied from 11 g/cm^2 at 2.7 BeV/c to 7 g/cm^2 at 5.2 BeV/c. Any K mesons interacting in the Čerenkov counter were swept away by a second bending magnet.

The flux in the telescope varied from 80 per pulse at 2.7 BeV/c to 25 per pulse at 5.2 BeV/c, for an internal circulating beam of 3×10^{11} protons per pulse. The accepted beam, whose absolute momentum was known to $\pm1\frac{1}{2}\%$ and had a spread of 6% full width at half-height, was then incident upon a 47.76-in.-long liquid-hydrogen target, 6 in. in diameter and with 0.007-in. Mylar walls. The K mesons which passed through the

TABLE I. The K^--p total cross sections.

Laboratory momentum (BeV/c)	Center-of-mass total energy (BeV)	$\sigma(K^-$-$p)$ (mb)
2.67	2.49	27.41±0.80
2.88	2.57	26.65±0.90
2.98	2.61	27.76±0.80
3.09	2.65	26.25±0.85
3.19	2.68	26.75±0.80
3.30	2.72	27.00±0.70
3.50	2.79	27.15±0.70
3.71	2.86	26.90±0.70
3.92	2.92	25.95±0.75
4.13	2.99	25.14±0.60
4.34	3.05	25.84±0.65
4.76	3.18	24.74±0.70
5.18	3.30	24.03±0.70

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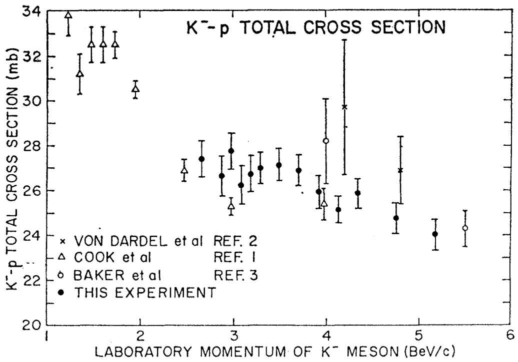

FIG. 4. The experimental results plotted as a function of laboratory momentum.

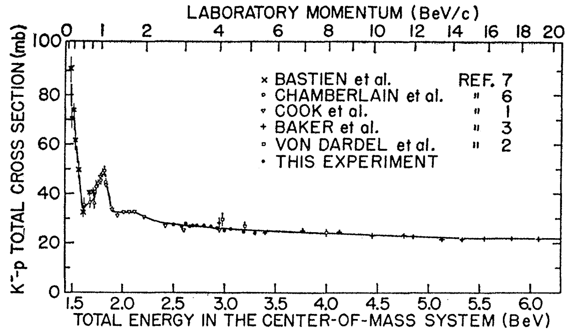

FIG. 5. Summary of K^--p total cross sections as a function of the total energy in the center-of-mass system.

target were detected in four scintillation counters, S_3, S_4, S_5, and S_6. The outputs from these counters were separately taken in coincidence with the telescope and scaled. The counters subtended solid angles at the target of 1 to 4 msr and were large enough to contain the multiple Coulomb scattering of the beam.

The partial total cross sections as measured by counters S_3–S_6 were linearly extrapolated to zero solid angle. Figure 3 shows one such extrapolation. The error bar drawn on the cross section as measured by counter S_5 gives the error in the difference of the cross sections as measured by S_5 and S_6, and similarly for the error bars on S_4 and S_3.[5] These relative errors were used in the extrapolation, but the final statistical error in the extrapolated cross section contains, in addition, the statistical error in the partial cross section obtained from counter S_6.

Some corrections had to be applied to the cross section obtained from the extrapolation to zero solid angle. The largest of these arose from the change in decay rate of the K mesons between the target and the transmission counters, due to the additional energy loss suffered by transmitted K mesons when the target contained liquid hydrogen. At 3.6 BeV/c, for example, this correction amounted to -0.42 mb. The random coincidence rate between the telescope and one of the transmission counters was continuously monitored and found to be very small. The correction to the final cross sections due to this cause was of the order of 0.05 mb.

The density of the liquid hydrogen for the target-full runs was 0.0706 g/cm^3 corresponding to a hydrogen vapor pressure of 15.45 psi. The effective density was estimated to be lower by 0.13% due to the hydrogen bubble density. A 0.35% contraction of the Mylar cell due to the 273°C temperature drop has been taken into account. A final correction was made to the measured cross sections to allow for the residual gas in the target during the target-empty runs. This raised all the values by $0.8\pm0.5\%$, the uncertainty being due to a lack of precise knowledge of the temperature of the residual gas.

The results are tabulated in Table I and plotted in Fig. 4 as a function of the laboratory momentum of the K^- meson, together with previous K^--p total cross sections. The errors are statistical and do not include the systematic error due to the uncertainty in the residual gas density. The new results extrapolate smoothly to the higher momentum points of Baker *et al.* At lower momenta, the data lie slightly higher than those of Cook *et al.*, although there is no significant disagreement. Figure 5 summarizes the present knowledge[1–3,6,7] of the behavior of the K^--p total cross section as a function of the total c.m. energy.

In summary, the results of the present measurements are consistent with a smooth falloff of the total cross section with momentum in the range between 2 and 6 BeV/c. However, the existence of some structure at about 3.5 BeV/c cannot be ruled out and the region is worthy of further study.

We wish to acknowledge the invaluable cooperation of Dr. G. K. Green, M. H. Blewett, and the AGS staff. The technical assistance of George Munoz, Frank Seier, and Oscar Thomas is greatly appreciated.

[5] From the relative position of these four counters—S_4, S_3, S_5, S_6 in sequential order in the beam, but S_3, S_4, S_5, S_6 in order of increasing solid angle—it is clear that only S_3 and S_4 are ordered such that the relative error in their partial cross sections can be calculated exactly from the measured coincidence rates. In this case the effects of the absorption of the beam in S_4 and of the smaller size of S_3 are additive in producing the measured partial cross section. This is not the case for any other pair of counters and, therefore, the error bars drawn in Fig. 3 involve a certain amount of estimation.

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