

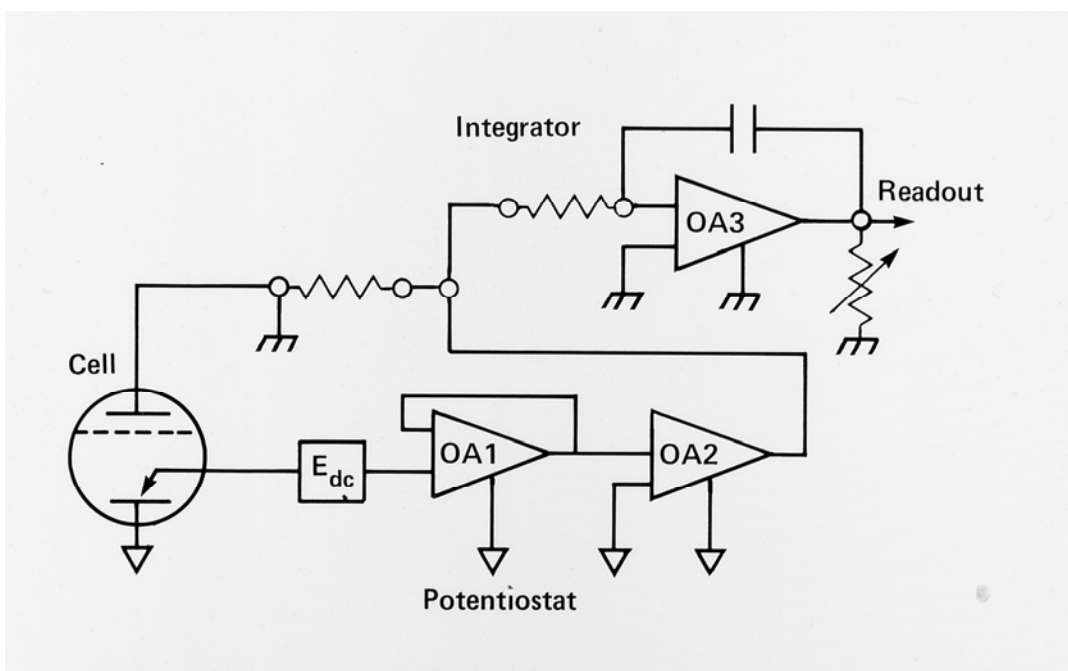
# A Short History of the Use of Philbrick Operational Amplifiers in Chemistry

by

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The use of operational amplifiers in chemical instrumentation originated at the University of Washington during the 1950s in the group of Professor A. L. Crittenden in the Department of Chemistry. About 1953, one of his students, Glenn Booman, in his Ph.D. thesis work, developed an instrument for electrolytic potential control and current integration, which used high-gain differential amplifiers that he built from scratch from a circuit diagram in the book, *Electronic Analog Computers*, by Korn and Korn (1). Booman's work was published in 1956 (2).

A typical circuit configuration that was used, in its modern form with op amps, is shown in the figure below:



In this arrangement, the Potentiostat, via amplifier OA2, controls the potential between the reference ( $\rightarrow$ ) and working electrode in an electrolysis cell, while current flows between the working and auxiliary electrodes. It is thus a simple feedback controller. Amplifier OA1, termed a "Voltage Follower," provides a high impedance connection to the reference electrode and reference voltage source,  $E_{dc}$ . In some experiments, only the current is measured. In others, the current is integrated as shown here using amplifier OA3 and its feedback capacitor.

After Booman departed from Washington for the Idaho Nuclear Engineering Laboratory, Evan Morgan and I, in our subsequent thesis work, continued these experiments at Washington. Meanwhile, Booman in Idaho also had continued work on electrochemical instrumentation, and had “discovered” the commercial availability of operational amplifiers from George A. Philbrick Researches, Inc. He informed us and our group and we all quickly adopted them. In my instrument, I used a K2-X op amp for potential control and a K2-P chopper op amp to stabilize the Korn and Korn dc integrator amplifier (3). In 1957, Booman published (4) a circuit similar to that pictured above using all Philbrick op amps, and it marked the first use of commercial, modular op amps in chemical instrumentation.

When Booman’s paper appeared, it sparked an explosion of interest in the use of op amps among electrochemists who, in general, were fond of building their own instruments, and especially because at that time there was a lack of commercially-available fast potential controllers and other electrochemical measuring devices. At the American Chemical Society in San Francisco, in April of 1958, Professor Donald DeFord of Northwestern University presented a tutorial paper on the variety of uses of Philbrick op amps, much of it based on Philbrick company literature. This paper (5) and Booman’s became frequent references for chemists working with op amps. As the technology quickly advanced through the late 1950s and 1960s, many electrochemists designed circuits with Philbrick USA-3s, P2s (6), and op amps of other manufacturers. It was an exciting time for chemists interested in electronics and what op amps could do.

## References

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3. J. E. Harrar, Thesis, University of Washington, 1958.
4. G. L. Booman, *Analytical Chemistry*, **29**, 213 (1957).
5. D. D. DeFord, Paper Presented at the 133<sup>rd</sup> National Meeting of the American Chemical Society, San Francisco, CA, April, 1958.
6. J. E. Harrar, F. B. Stephens, and R. E. Pechacek, *Analytical Chemistry*, **34**, 1036 (1962).