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**INSTRUMENT AND AUTOMATION ENGINEERS' HANDBOOK**  
**FIFTH EDITION**

**VOLUME II**

# Analysis and Analyzers

**BÉLA G. LIPTÁK**, Editor-in-Chief  
**KRISZTA VENCZEL**, Volume Editor

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# Analysis and Analyzers

**BÉLA G. LIPTÁK**, Editor-in-Chief  
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This handbook is dedicated to the next generation of automation engineers working in the fields of analysis, measurement, control, and safety. I hope that learning from these pages will increase their professional standing around the world. It is also my hope that our knowledge accumulated during the last half century will speed the coming of the age of full automation. I hope that what we have learned in optimizing industrial processes will be used to improve the understanding of all processes. I hope that this knowledge will also help overcome our environmental ills and will smooth the conversion of our lifestyle into a sustainable, safe, and clean one.

**Béla G. Lipták**



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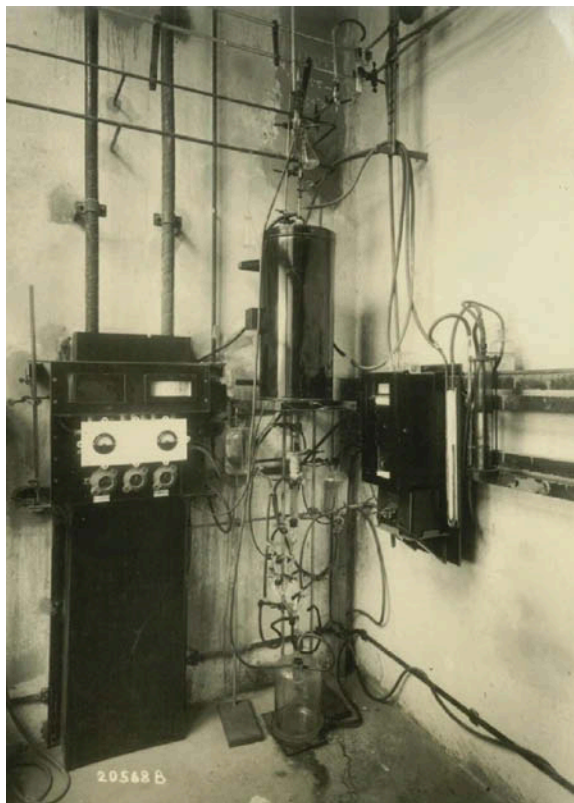
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# INTRODUCTION

I started to work on the first edition of this handbook when I was 25 years old. Today, when you start turning the pages of this fifth edition, I am 80. This book started out as an American handbook on analytical instrumentation, while today it is a reference source used on all five continents. When I started writing the first edition, most composition analysis was done using manual samples that were analyzed by chromatographs in the laboratory and only a few density and pH controllers operated online. Even in the few cases where the analyzers were located close to the process, their sampling systems were complicated and required much maintenance (Figure I.1).



**FIG. I.1**  
*Analyzer installation 50–60 years ago.*

Most of today's analyzers have been moved out of analyzer houses and are mounted online, miniaturized, or are modular, and if they use sampling systems, they are *smart* and automated. They are also provided with wired or wireless communication between the sample system components, the analyzer–sensor, and the control system that controls the unit operation involved.

The role of analyzers in our everyday life is becoming increasingly important and their capabilities and sophistication are exploding. We have found that while using grab samples might be acceptable for product quality control purposes, because of the time it takes to get a sample, transport it to the laboratory, and wait for the results, it is unacceptable for safety or for process control, optimization, and energy conservation purposes. In these applications, the analysis must not only be continuous and online but also smart, rugged, often explosion proof with local display, and low maintenance (Figure I.2).



**FIG. I.2**  
*A typical state-of-the-art, online analyzer transmitter used for the measurement of oxygen. (Courtesy of Emerson, Rosemount Analytical.)*