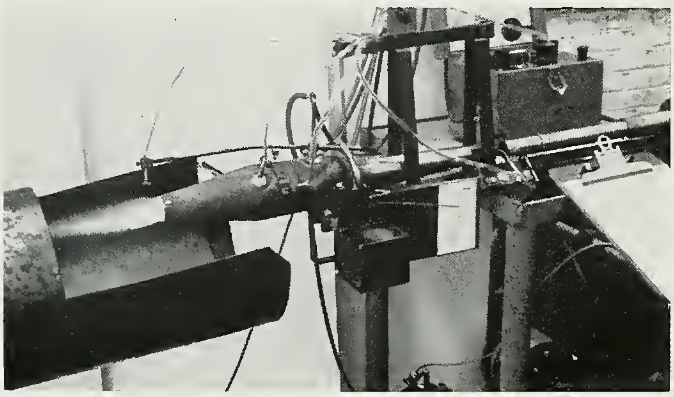
The Afterburner Story

Cross-breeding turbojets with ramjets has produced a modern mutation with inherited characteristics from the past



Success of Ryan-designed ramjet combustion chambers in 1944 attracted Navy attention and led to afterburner research.

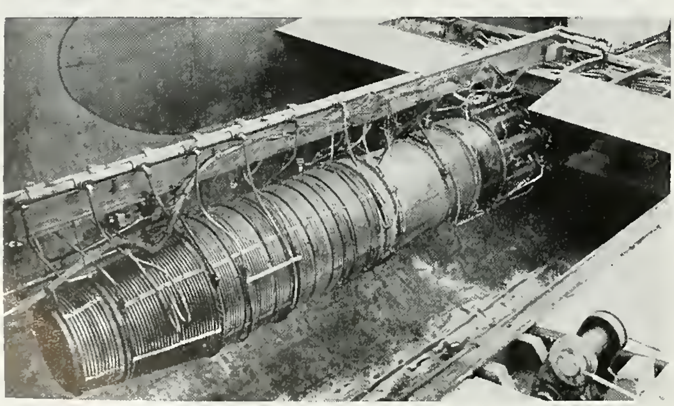
First afterburner built in America by commercial firm was this early Ryan-designed model demonstrated in April, 1946.

Fuel cools the seething walls of this early Ryan-designed afterburner shown in test cell. Idea is used in rockets.

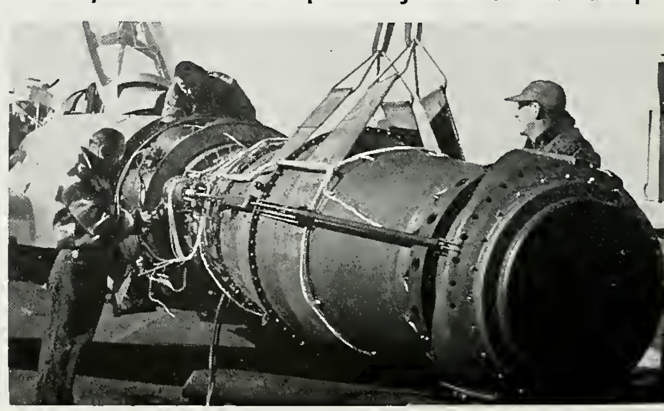
AFTERBURNING is not a new idea. Like jet propulsion, it threads back through history. No individual or organization can be considered the sole pioneer in either achievement. Afterburners, turbojets, gas turbines, steam turbines and internal combustion engines are the brainchildren of dozens of scientists and engineers who labored during the last three hundred years. Each contributed knowledge which makes our present power plants possible.

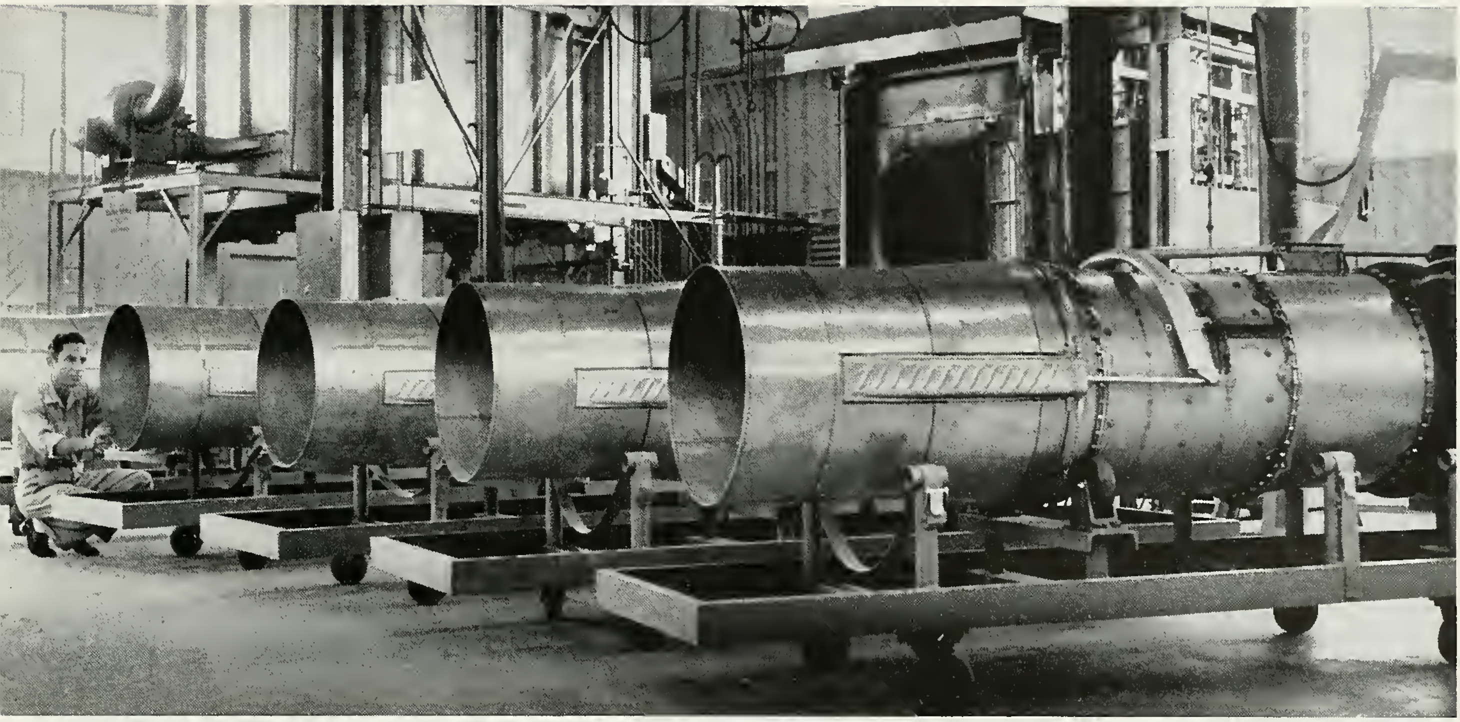
In spite of an obscuring smog of claims, it can be observed

In 1946, NACA conducted first altitude-wind tunnel tests of afterburner using original design and G-E's TG-180 turbojet.



Pratt and Whitney Aircraft have been building afterburners for six years and are now producing them for J-57 turbojets.





Ryan is currently building six different afterburners for three major companies. These are for Westinghouse J-46 jet engines.

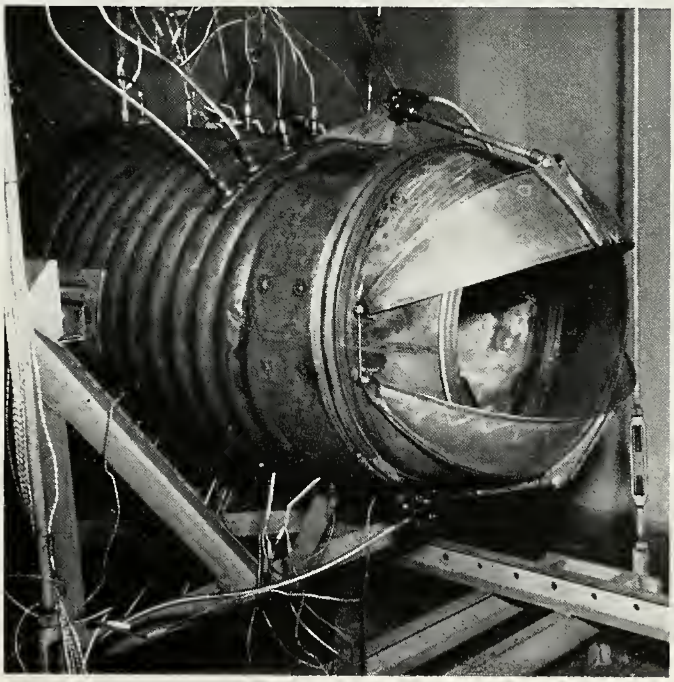
that a number of organizations in the United States performed significant work leading to modern afterburner designs. These would include the National Advisory Committee for Aeronautics (NACA), Ryan, Solar, General Electric, Westinghouse, Wright Aeronautical, Pratt and Whitney Aircraft, Allison and others.

Undoubtedly, the first afterburner in America was built by NACA in 1944. This research was conducted in the NACA's Lewis Flight Propulsion Laboratory and began with the delivery of the nation's first turbojet engine—General Electric's I-A.

Ryan Aeronautical Company began afterburner research in the following year, under contract with the Navy's Bureau of Aeronautics. Ryan produced the first commercially-built afterburner in this country at that time and demonstrated it on

(Continued on Page 20)

Early version of "eye-lid" nozzle which Ryan pioneered for afterburners. This is the system most widely used today.



Scheduled for use with J-47 jet engines, these afterburners are built by Ryan and designed by General Electric Company.

THE AFTERBURNER STORY

(Continued from Page 3)

April 25, 1946. The engine used was the General Electric I-16 which was also the jet power plant for the composite-engined Ryan FR-1 Fireball fighter—the Navy's first plane to have a jet engine.

During this period, the large aircraft engine manufacturers were concentrating their talents on basic turbojet designs. They soon brought their resources to bear on afterburner problems. They have undoubtedly contributed most to the present models of these thrust-boosting mechanisms by developing currently-used designs through their engineering staffs.

Afterburning is such an old idea that it is impossible to know who first thought of it. Among engineers, afterburning is more accurately known as "reheating." In England, the afterburner is called a reheat engine. Reheating is defined as "appreciably improving the efficiency of an engine by reheating the working fluid after it has partially flowed through the engine." Actually, afterburning is a well known thermodynamic technique, capitalized upon by hordes of inventors, and stretching back almost to the very first heat engine devised.

Not long after James Watt produced the first practical steam engine in 1764, reheating was incorporated into its design. The steam was reheated between expansions in the cylinders in order to extract more mechanical energy from it. The same strategy was resorted to after Sir Charles Parsons introduced his commercially successful steam turbine in 1884. Reheating has been universally used as a means for increasing steam turbine power plant efficiency by adding heat to the steam after it has partially flowed through the engine.

Sir Frank Whittle, of England, described the same principle in the "dual thermal cycle" engine which he patented in 1936. This device employed a diesel engine and compressor to supply air and combustion products to a turbine which drove the main compressor. The turbine exhaust was used to obtain jet propulsive effects. Whittle proposed "adding heat to the turbine exhaust before final expansion in order to provide further thrust for carrying temporary overloads."

On August 27, 1940, an all-metal monoplane designed by the Italian engineer, S. Campini of the Caproni Company, made a ten-minute flight from Forlanini airport in Milan. With the possible exception of German man-carrying, rocket-propelled vehicles, this was the first plane to accomplish jet propelled flight. Campini used a piston engine, probably a radial Isotta Fraschini, to power a compressor which supplied air to the combustion chambers of his jet engine. In his plans for later versions of this aircraft and engine, he envisaged the advantages of burning fuel in the tail-pipe to attain increased thrust.

In 1940, Sir Frank Whittle produced the first successful turbojet power plant. The design employed an air compressor, powered by an integral gas turbine which is driven by the exhaust gases from the combustion chambers. In his achievement, Whittle drew heavily upon the accomplishments of others who preceded him. These included Englishman John Barber, who patented the first gas turbine in 1791, Sir Charles Parsons, developer of the axial flow compressor, America's Dr. Sanford Moss, who built the first turbosupercharger at General Electric, Swiss Dr. Adolph Meyer who produced the first modern gas turbine in 1930 and many others.

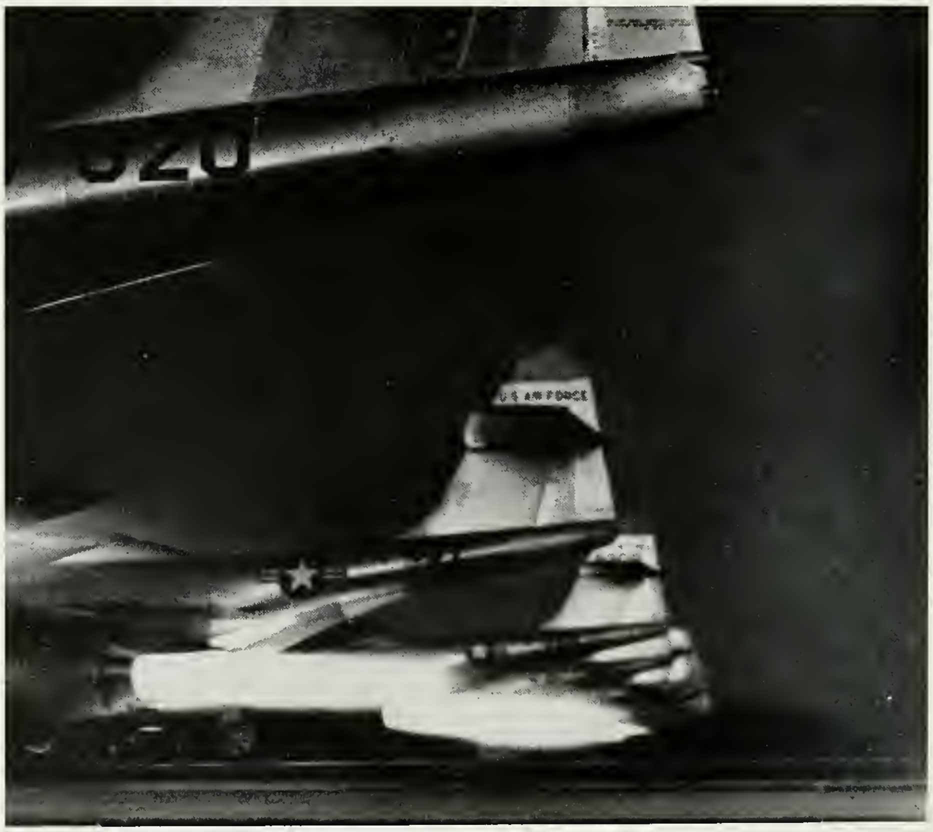
In 1908, the French engineer, Lorin, unveiled an original design employing a reciprocating engine which exhausted through a discharge funnel to produce propulsive reaction. His device encompassed the three basic requirements of a thermal jet engine: means for compressing air, adding heat, and expanding the resultant gas-air mixture.

The American inventor, Lake, patented a thrust augmentor in 1909 which demonstrated the aspirating effect of speeding exhaust gases and the added propulsive thrust obtained by this form of augmentation. These, and many other discoveries were important contributors to Whittle's solid achievement.

Another factor influenced Whittle's success. Many previous attempts to construct a successful gas turbine failed because it was not possible to operate at temperatures high enough to develop more than enough power to run the air compressor alone. Metallurgical advances overcame these obstacles to pave the way for the Whittle engine.

Under the cloak of wartime secrecy, the Whittle engine was flown to the United States and taken to the General Electric Company. Primarily because of Dr. Sanford Moss' work with the turbosupercharger, which involves a number of problems similar to those encountered in jet engines, General Electric was commissioned to build the first American turbojets.

In 1944, the NACA began work on the first U. S. afterburner, using General Electric's first turbojet engine, the I-A, as a power plant. Afterburning was contemplated as an effective means for augmenting thrust. There was more reason to use a reheat cycle in connection with turbo-



With tongues of flame lashing from their twin afterburners, Northrop F-89 Scorpion interceptors prepare for a night sortie. Afterburners provide a "double dose of benzedrine" for boosting these planes above 45,000 feet to unleash rocket salvos.

jets than with steam turbines because the technique imposed no additional temperature or centrifugal stresses upon the engine's vital components. Heat energy was added to convert pressure to velocity in order to obtain greater thrust.

In the NACA's first model, it is interesting to note that the basic requirements of efficient diffusion from turbine outlet to burner inlet, proper fuel preparation, and flame shelter, or holding regions, were recognized. Although combustion was successfully initiated, internal losses were so high and combustion efficiency so low that the maximum thrust realized was only 100 pounds.

In 1945, a blower rig was established in which afterburner inlet conditions were simulated by forcing air through a preheater, inlet diffuser and afterburner by a blower system. Numerous designs were tested in this rig, leading to the configuration which was tested with the General Electric TG-180 engine in 1946. A thrust increase of 40 percent was obtained.

The first altitude wind tunnel tests of afterburners were made in NACA's laboratory in 1946. These were begun with an afterburner-equipped TG-180. A number of configurations were investigated and successful operation was accomplished at 30,000 feet altitude with increases of thrust of over 100 percent at high simulated Mach numbers.

In 1947 and 1948, work on fuel systems, flame holders and exhaust nozzles was continued in the altitude wind tunnel and on static test stands. In these tests, the widely used fuel-spray bar system and familiar V-gutter flame holder design was developed. Since 1948, NACA has continued to pursue experimental research on afterburners in expanded facilities.

During 1944, Ryan launched a company-sponsored confidential research project to develop a successful ramjet combustion chamber for use with helicopter rotor blades. In this work, Ryan engineers constructed experimental combustion chambers and tested them by burning fuel within them in a high velocity stream of air. The chambers were fired on a test stand which measured the reactive thrust developed.

Essentially, a ramjet is a compressorless jet engine which involves the same problems of igniting fuel in a high velocity air flow, maintaining combustion and developing thrust that are found in the afterburner. At the conclusion of the ramjet combustion chamber work, in 1944, Ryan submitted a report which attracted the favorable attention of the Navy's Bureau of Aeronautics. The report pointed out the advantages which might be gained by using the thrust augmentation technique with the General Electric I-16 engine which Ryan was then installing in FR-1 Fireball fighters for the Navy. In response, the Navy awarded Ryan a contract to develop what was to be the first commercially-built afterburner in the United States.

Under the direction of engineer Dan Sanborn, Ryan started this work with data gleaned from the ramjet evaluations plus manufacturing experience obtained in building tail-pipes, and other high temperature components, for the jet-propelled Fireballs. Early Ryan afterburner models employed a fixed nozzle arrangement. This was soon changed to an adjustable type. Ryan was first to develop the "eyelid" type of variable nozzle, widely used today, as the practical means for controlling the exit area of the afterburner. Early Ryan photographs show the original examples of this type of adjustable nozzle which maintains a balanced flow of gas through the system when the afterburner is operating or dormant.

Because metals then available were inadequate for sustaining the extreme temperatures which afterburning imposed, Ryan engineers devised a regenerative fuel system for the afterburner. By circulating the fuel around the afterburner, prior to its combustion, the afterburner walls were cooled and the fuel was preheated so that it burned more efficiently. Although this innovation has not been carried forth into present day afterburners, it has been used to good avail in rocket and ramjet engine designs.

During this period, Ryan tested various types of ignition systems and fuel injection arrangements, measured the extreme temperatures encountered in the afterburner flames and evaluated high temperature alloys for these tortuous applications. This work outlined the extremely sensitive relationship between the temperatures, pressures and velocities in afterburner operation. It showed that the afterburner and turbojet must be designed as an integral unit if high performance is to be realized.

It is significant that when security restrictions were eased, Ryan was the first company to release "the afterburner story." In a five-page story, illustrated with diagramatic sketches, Ryan gave the public the first military-approved information on the afterburner, its function and advantages for aviation.

Since those days, afterburning has come a long way. And, the organizations which have brought it along are the companies who build turbojet power plants and jet components. To produce afterburners in quantity, the prime engine manufacturers have turned to Ryan — which combines intimate knowledge of afterburner development and engineering with long experience as a leader in production of high-temperature components for piston and rocket, as well as jet, engines.

Afterburning is an old idea. Countless inventors and engineers have contributed knowledge to this idea. But, today's afterburners are successful because highly trained staffs of engineers, working in companies like General Electric, Westinghouse, Wright Aeronautical, Pratt and Whitney Aircraft and Allison, have taken this heritage, integrated it with modern science and further developed this remarkable structure.

Noted Air Force Engineer Named Chief Designer

Col. Paul H. Kemmer, USAF ret., who helped develop virtually every well known Air Force plane through World War II as one of the key men in engineering activities at Wright Field, has been appointed to the newly created post of chief designer in the Ryan engineering division.

P. H. Kemmer

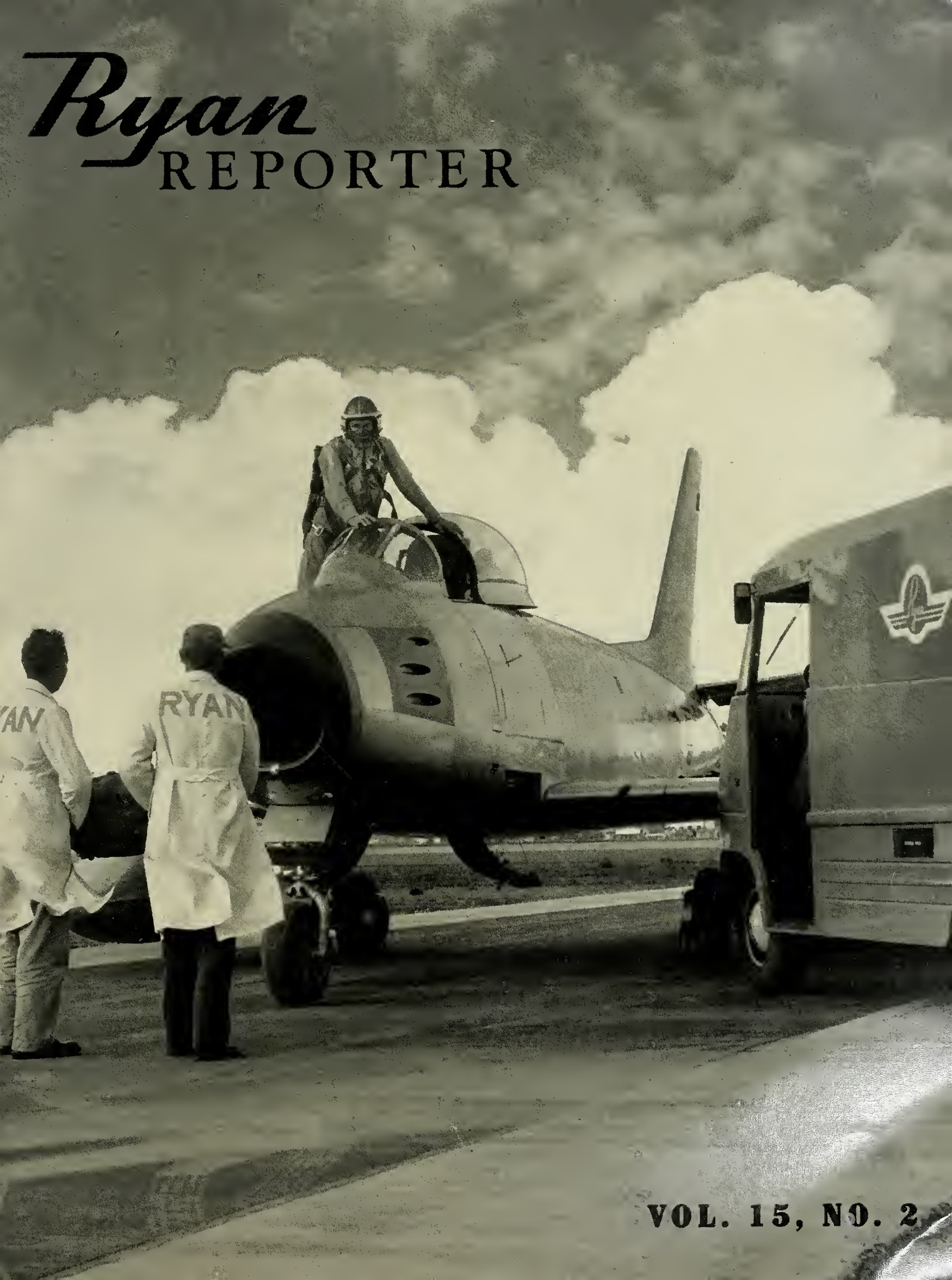
He will guide the broad design aspects of engineering projects and will originate long range plans for future technical activities under Bruce Smith, director of engineering.

A pioneer in aviation, he began his career as a flying cadet in the aviation section of the Signal Corps in 1917 after studying mechanical engineering at the University of Michigan. He won his wings in March, 1919, and for two years was in civilian life as a draftsman and designer for the old Winton and Packard motor car companies, the Dayton Wright airplane company, and Westinghouse. After service as a civilian aeronautical designer at McCook Field, Ohio, he returned to active duty in 1921 and rose to colonel in 1942. He retired Jan. 31, 1949.

Much of his military activity dealt with research, development and engineering to improve aeronautical equipment. The Air Corps assigned him to New York University, the Air Corps Engineering School, and the California Institute of Technology, where he received the master of science degree in aeronautical engineering in 1933.

Since retirement from the Air Force, he has been an aeronautical consultant with private firms, most recently with Owens-Corning Fiberglas Corp. in connection with the use of fiberglass-reinforced plastics for aircraft construction.

Ryan REPORTER



VOL. 15, NO. 2