

steel supplies increased by another 0.8 million tons per month. By the second quarter of 1944, approximately 1.5 million tons were allocated to direct armaments programs, out of a total supply of 2.7 million tons. Even for the peak production levels of mid-1944, the steel supply appears on the whole to have been sufficient and to have left room for further expansion. Only of high quality steels was there a shortage, in particular of electric furnace steel. This last was the only steel product whose production capacity was expanded during the war (from 65,000 to 250,000 tons per month), but the increase appears to have been insufficient for meeting the growing requirements.

The supply of power, despite a considerable expansion of capacity, became tight early in the war. The curtailment of less essential uses began in October 1941. By the winter of 1943-44 the shortage had become so serious that from time to time temporary cuts were made in the allocation of power to the aluminum, nitrogen and other chemical industries, the main consumers of power.

An economy such as that just analyzed is peculiarly unsusceptible to damage to its finished goods industries. Destroyed capital equipment can be replaced out of reserves, destroyed factory space can be made good by drawing on empty factory space, lost man-hours can be made good by making working hours temporarily longer and by taking on more labor. Each and all of these methods were, of course, resorted to by the Germans to offset the effects of air raids. The strain imposed on the economy through an air war may, under such conditions, merely slow down or temporarily halt the process of expansion, without causing an actual diminution of production in the vital industries. An expanding and resilient economy moreover is not merely better adapted to absorb the shock effects of a bombing offensive; it can also afford to take more far reaching measures to immunize itself against future attack. Large scale dispersal schemes, which under more stable conditions would have inevitably involved a loss of production, could be carried through in Germany often at the cost of postponing increases in output. The analysis of the effects of air attacks on the German economy show unmistakably that this economy was not an easy target.

OVER-ALL EFFECTS OF THE AIR OFFENSIVE

Prior to the summer of 1943, air raids had no appreciable effect either on German munitions production or on the national output in general. The area attacks of the RAF did considerable damage to building and caused local delays in production by diverting labor to repair work and debris clearance, and by causing absenteeism and local disorganization. The first big raid on Kiel, for instance, seems to have caused a three weeks' delay in submarine production; and similar small delays were caused by the late 1942 and early 1943 campaigns against submarine production. But considering the nature of the German economy during this period, it is impossible to conclude that either submarine production or munitions output as a whole was any smaller as a result of air raids than it would have been otherwise. The only important bottlenecks at this time occurred in certain sectors of the parts and components industries; and there is no evidence that these industries suffered through air raid damage.

The effects of air raids became more noticeable from the summer of 1943 onward. This was partly due to the heavier weight of the RAF attacks and partly to the appearance of the AAF in major strength. Area raids on the Ruhr caused an estimated 8 percent loss of steel output, but adequate stocks in the hands of industrial users prevented the loss from affecting armament output. The same attacks also created a bottleneck in crankshafts, which may have slowed down the output of tanks and motor vehicles. Raids on the aircraft industry caused an estimated 13 percent loss of total production for the period July through December. The loss from direct damage, however, was less important than the sacrifice in output caused by dispersal and other defensive measures taken as a result of the intensification of the air war. These latter factors explain the relatively great loss of output following the early raids on the aircraft industry compared with the smaller effect of the much heavier later raids. Ball bearing production fell 5 percent below the pre-raid average as a result of attacks in the fall of 1944, but the presence of large supplies forestalled any effect on armament output. The total loss of German armament output from air raids in the latter part of 1943 is estimated at 5 percent.

For the first four months of 1944 the AAF, capable for the first time of carrying out repeated attacks deep into Germany, concentrated its strength on aircraft and ball bearing targets. During the attacks beginning in February, about 90 percent of Ger-

man fighter production capacity was attacked and 70 percent destroyed. Production fell during the first month of the attack but rose phenomenally in succeeding months, despite the continuance of the offensive. The total number of aircraft produced rose from 1,525 in January to 2,475 in July; single-engine fighter output rose from 381 to 1,050. This large increase in output is explained by the adoption of energetic rationalization measures, by drawing on the pipe line of components, and by the fact that a large scale expansion of the industry had been planned previously. To what extent bombing prevented the realization of these plans is difficult to decide. It is possible that production would have been 15-20 percent higher in the absence of bombing.

As a result of continued attacks, the production of ball bearings in the second quarter of 1944 fell to 66 percent of the pre-raid average. An energetic dispersal policy, however, made it possible for production to reach almost the pre-raid average in the third quarter of the year. In the meantime, careful use of stocks, substitution of plain bearings for anti-friction bearings, and redesign of equipment to eliminate the previously luxurious use of bearings, enabled the Germans to prevent the fall in bearing production from affecting the output of finished munitions.

The only other measurable effect of air raids on munitions production was a 5 percent loss in panzer output caused mainly by the RAF attack on Friedrichshafen and a small loss of ammunition output mostly due to area raids. In the absence of these losses, total armament production in the first half of 1944 would have been almost 10 percent higher than it actually was.

The campaigns which carried the promise of decisive results began after D-day. The offensives that started against oil and nitrogen plants in May and June, against the German transportation system in September, and against the Ruhr steel producing area in October, all achieved results fully up to expectations or above them. In addition to these major campaigns, the raids on aircraft plants were continued and attacks were made also against motor vehicle and panzer production.

The attack on oil was concentrated against Germany's synthetic plants. They produced 90 percent of her aviation gasoline and 30 percent of her motor gasoline. Synthetic production (hydrogenation and Fischer-Tropsch) fell from an average of 359,000 tons in June and 24,000 tons in September. The aviation gasoline output of