PICTURE OF THE MONTH

Whirlwind Formation at a Burning Oil Supertanker in the Gulf of Mexico

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1. Introduction

Atmospheric vortices have been observed to occur in the vicinity of man-made and natural fires. Such vortices are produced in forest fires (Graham 1955), refinery explosions (Hissong 1926), gas well fires (Dessens 1963), volcanic eruptions (Thorarinsson and Vonnegut 1964), area conflagrations in cities (Ebert 1963), bonfires (Glaser 1959; Minsinger 1980), and experimental oil burners (Church et al. 1980).

On Saturday, 9 June 1990, the 885-ft Norwegian supertanker *Mega Borg* exploded in the Gulf of Mexico at 0600 UTC. The explosion occurred while crude oil was being transferred to a smaller tanker, and produced two fatalities. During the continuing crude oil spill from the *Mega Borg*, fire went out of control for several days until firefighting ships finally put it out.

While visiting my family in Houston, Texas, I saw in *The Houston Chronicle* a news photo (Fig. 1) of whirlwind formation from the supertanker fire. It is worth documenting here, because it is very rare that burning oil spills cause whirlwinds over the ocean. The purpose of this note is to describe briefly the whirlwind phenomenon, and to compare this observation to similar ones made elsewhere.

2. Visual observation

Figure 1 vividly illustrates two simultaneous whirlwinds in the downstream plume. The location of the burning wreckage of the *Mega Borg* (far to the left and out of Fig. 1) was 28.33°N, 94.08°W, or about 54 nautical miles southeast of Galveston, Texas. These whirlwinds were very similar to those observed by Hissong (1926) at an oil tank fire, Thorarinsson and Vonnegut (1964) in the thermal plume from the Surtesy volcano, and Church et al. (1980) in experimental oil burners.

3. Physical mechanisms on the formations of atmospheric vortices

Church et al. (1980) offered a step-by-step explanation of vortex generation processes. They observed the three following types of vortices generated by the experimental oil burners: 1) large, counterrotating vortices in the downstream plume, 2) intense small-scale vortices resembling very strong dust devils seen at the surface on the downwind side of the plume, and 3) very large columnar vortices produced when the lower portion of the plume goes into rotation as a whole. Based on their observations and physical reasoning, Church et al. hypothesized that there were three mechanisms producing the concentration of vorticity for these three types of vortices. These mechanisms are tilting and stretching of horizontal vorticity present in the environmental wind field, generation of vorticity within the plume by the action of buoyancy and drag forces, and convergence of preexisting background vorticity from the environment.

According to Steve Campbell, the *Houston Chronicle* photographer who took this news photo, vortices emanated periodically from burning oil slicks and wavered over the water for a few minutes before dissipating. The time interval between formation of successive vortices was approximately 20–30 s. The approximate distance between successive vortices was about 50 ft.

Mechanism 1 of Church et al. (1980) may be the one responsible for the formation of columnar vortices in the downstream plume. In the presence of environmental wind shear (as revealed by the sloping plume in Fig. 1), the thermal plume probably acquired cyclonic and anticyclonic rotations on its right and left sides from the tilting and stretching of initially horizontal vortex tubes near the ocean surface. The photographer was unable to determine the sense of rotation in either the plume or the columnar vortices in Fig. 1 from his vantage point. However, it seems likely that vortices on the right downwind side were cyclonic, while the vortices on the left downwind side were anticyclonic.

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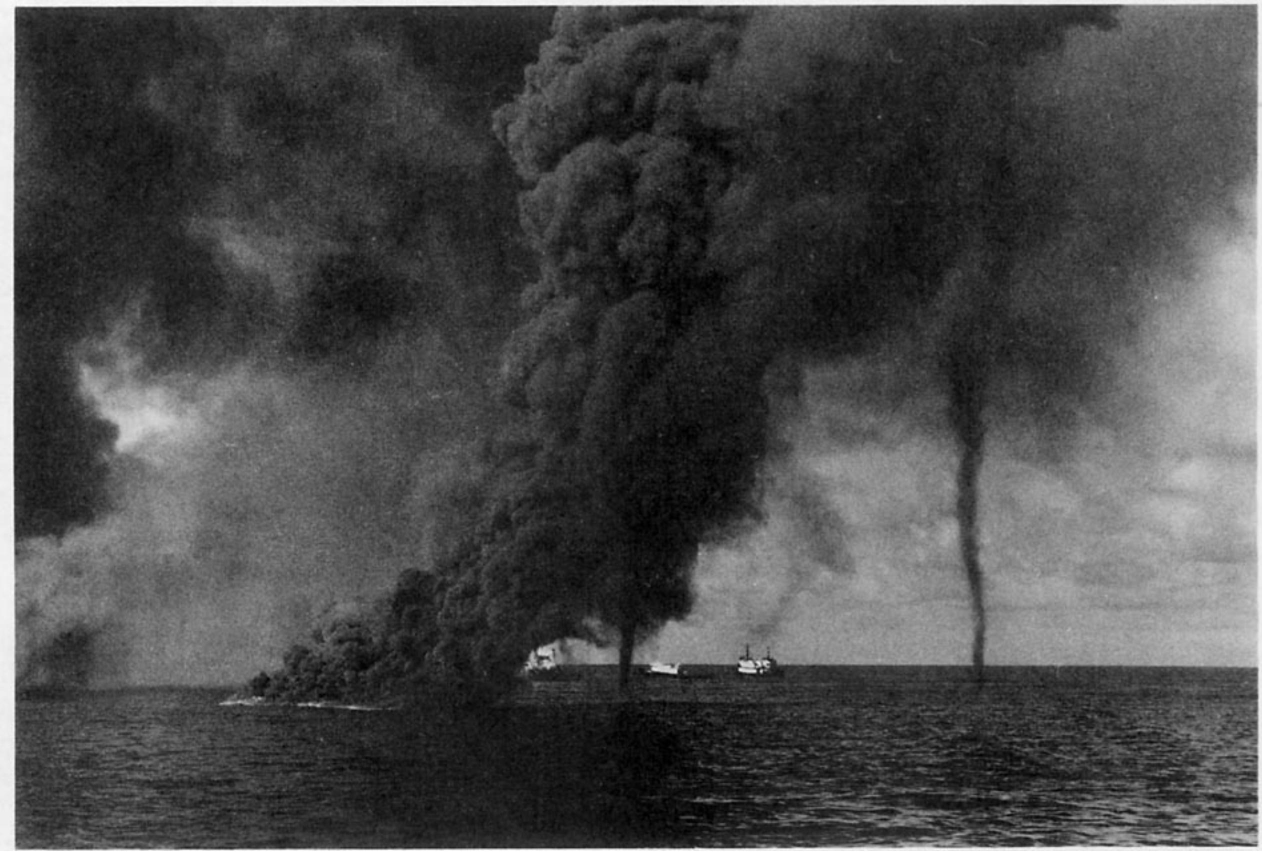

FIG. 1. Two simultaneous vortices generated by the burning oil slicks near the wrecked Norwegian supertanker *Mega Borg.* This photo was taken between 1700 and 1800 UTC 12 June 1990, 3 days after the explosion. The U.S. Coast Guard and firefighting ships are in the background. (Photo by Steve Campbell, courtesy of *The Houston Chronicle.*)

In Church et al.'s controlled oil-burning experiment, the nearby surface was complex and the ambient wind field probably contained significant vertical vorticity. In contrast, Fig. 1 shows that the wind field over the nearly smooth, uniform ocean surface was probably very uniform in the horizontal. In this sense, the *Mega Borg* fire was the "cleaner experiment."

How smoke gets into the vortex cores is not obvious. Since there does not appear to be any smoke being drawn into the cores from a surface inflow layer (Fig. 1), there are only two other alternatives, according to Snow (1991, personal communication):

a) Smoke persists in the core as the vortex moves downstream from the parent plume. This implies little, if any, vertical motion in the core.

b) Smoke is being drawn down from aloft. This implies a two-celled vortex structure, with an inner core of downdraft. Two-celled structure has been observed in dust devils (Sinclair 1973) and laboratory vortex chambers (Church et al. 1979).

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